DECISIONMAKING AIDS FOR RURAL LAW ENFORCEMENT SERVICES IN THE GREAT PLAINS

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Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
DOCTOR OF PHILOSOPHY
December, 1978

DECISIONMAKING AIDS FOR RURAL LAW ENFORCEMENT

SERVICES IN THE GREAT PLAINS

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ACKNOWLEDGMENTS

I wish to express my appreciation to my major adviser, Dr. Gerald A. Doeksen for his confidence in me and his guidance and assistance on this and other research efforts during my time at Oklahoma State University. Valuable assistance and cooperation was also received from the other members of my committee, Dr. Michael Edgmand, Dr. Harry Mapp, Dr. James Nelson, and Dr. Robert Oehrtman. Also, my appreciation is extended to Dr. Thomas F. Hady, Dr. Melvin R. Janssen and other members of the Economic Development Division, Economics, Statistics, and Cooperatives Services, United States Department of Agriculture for the support and assistance received.

I thank Ginny Gann and her staff for the accuracy and quick turnaround on key punch work. Appreciation is also extended to Mrs. Karina Flynn, Mrs. Linda Howard, Mrs. Vicki Melton and Ms. Judy Stengle for their typing services.

Many thanks are due to my fellow graduate students and other friends who all contributed to the successful completion of this degree.

A special thanks to my parents Fred and Mary Schmidt for the substantial amount of encouragement during my pursuit of advanced degrees.

My greatest debt is to my wife, Norma, who continually provided emotional support throughout the rigors of graduate work. She

seldom complained about the many sacrifices while I was engaged in graduate studies. Carolyn, our daughter, must also be cited for her sacrifices and ability to help Norma through the difficult times. I hope our unborn child does not have to sacrifice so much.

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CHAPTER I

INTRODUCTION

Local government officials are confronted with many decisions concerning services to be provided by the public sector. These decisions include; (1) what services are to be provided, (2) how much is to be provided, and (3) the organizational framework for service delivery. Demand for various publicly produced services influence what and how much is provided. Demand may also affect organizational structure, since a particular geographical location or a particular population group may be involved. Availability of funds influences all three of these decisions. Once the decision is made to provide a service, alternative organizational arrangements must be evaluated. In order to make these decisions, local government officials need access to relevant and useful information pertaining to demand for a service, cost data, and alternative organizational structures.

Decisionmakers in rural areas typically have not had access to as much information and analysis as is often available to larger units of government. Eddleman [18, p. 960] states that: "Specific answers to problems concerning the time, place, form, type, and institutional structure of public service investment program alternatives must be provided to decisionmakers in rural areas." Not only do decisionmakers in rural areas lack relevant information on which to base decisions, but most of them perform the necessary governmental duties on a part-time basis. This leaves little time to collect and analyze data pertinent to issues to be decided. Thus, any attempt to assist decisionmakers in developing relevant information must yield procedures which are as easy to use and as accurate as possible.

Police Services

The issue of police service in rural areas of the Great Plains has become increasingly important in recent years. Many Great Plains communities and open country areas have little or no police service except that provided by the county sheriff's department.

Several factors have contributed to rural residents' concerns over low levels of police service. These factors include: (1) rural residents are demanding services already available in more urbanized areas, including police service, (2) increased investment in farm buildings and machinery have created a large potential dollar loss due to theft or vandalism, and (3) the number of crimes reported in rural areas appears to be steadily increasing [57]. Decisionmakers are in need of information on demand for police service as well as costs and quality of service for alternative methods of providing these services.

The overall objective of police service is to preserve the peace in a manner consistent with existing laws. Several activities are performed by police agencies in order to accomplish this objective. Direct services include: (1) responding to calls for service, (2) patrol activities, and (3) investigation of incidents. Indirect services include: (1) detention, and (2) laboratory analysis of evidence [43].

From the decisionmakers' viewpoint, the objective of police service should be met within the budget constraint. The level of service must be sufficient to meet the needs of area residents, thus avoiding either excessive or inadequate expenditures. Different costs and quality of service are associated with potential locations for the service. The trade-offs between costs and quality of service between potential officer locations needs to be investigated. Frequency of patrol activities influences costs of providing police service. Different organizational arrangements exist for providing police service. Each delivery system has a cost associated with it. Providing local officials with this type of information would enhance decisions related to police services.

Objectives

The overall objective of this study is to develop a set of procedures which would aid local officials in their decisions concerning police services in rural areas. These procedures could be used by decisionmakers in the development of basic information with which to evaluate alternative police service delivery systems. Specific objectives were:

1. Develop a procedure to estimate the number of calls for police service in a community and/or open country areas;
2. Develop a procedure to estimate annual capital and operating budgets for alternative police service delivery systems;
3. Provide information on financial assistance, volunteer reserve officer organizations, and officer training programs;
4. Develop a procedure to select various locations for police officers and provide quality of service and cost information for these locations; and

5. Develop a procedure to determine an efficient patrol route for various officer locations and the associated costs.

Three alternative police service delivery systems were considered in this study. These were: (1) individual communities establishing or expanding their own police department, (2) establishing a police department shared by two or more closely located communities, and (3) contracting with another entity (e.g. county sheriff) to provide police services.

Study Area and Data

A study area (Figure 1) in Western Oklahoma was selected for this analysis. This area was chosen as a result of a research project initiated by the U. S. Department of Agriculture. The project was designed to provide research input on problems faced by decisionmakers in the Great Plains area. The counties selected exhibit typical Great Plains conditions such as sparse population, large number of small towns, and agriculture the primary economic activity.

Sources of calls for police services include crimes, traffic related incidents and public service items. Data pertaining to the frequency of each type of call were obtained from a number of sources. Information on number and type of crimes occurring in the 40 county study area during 1974 and 1975 was obtained from Uniform Crime Reports (UCR) for the State of Oklahoma [39]. Frequency data for crimes not reported in this source were obtained from sheriffs' and police chiefs' records in the study area. One county and four towns had records for 1971 through 1974, while two counties and all towns had records for 1975. Traffic related incidents include traffic accidents and tickets for violations.

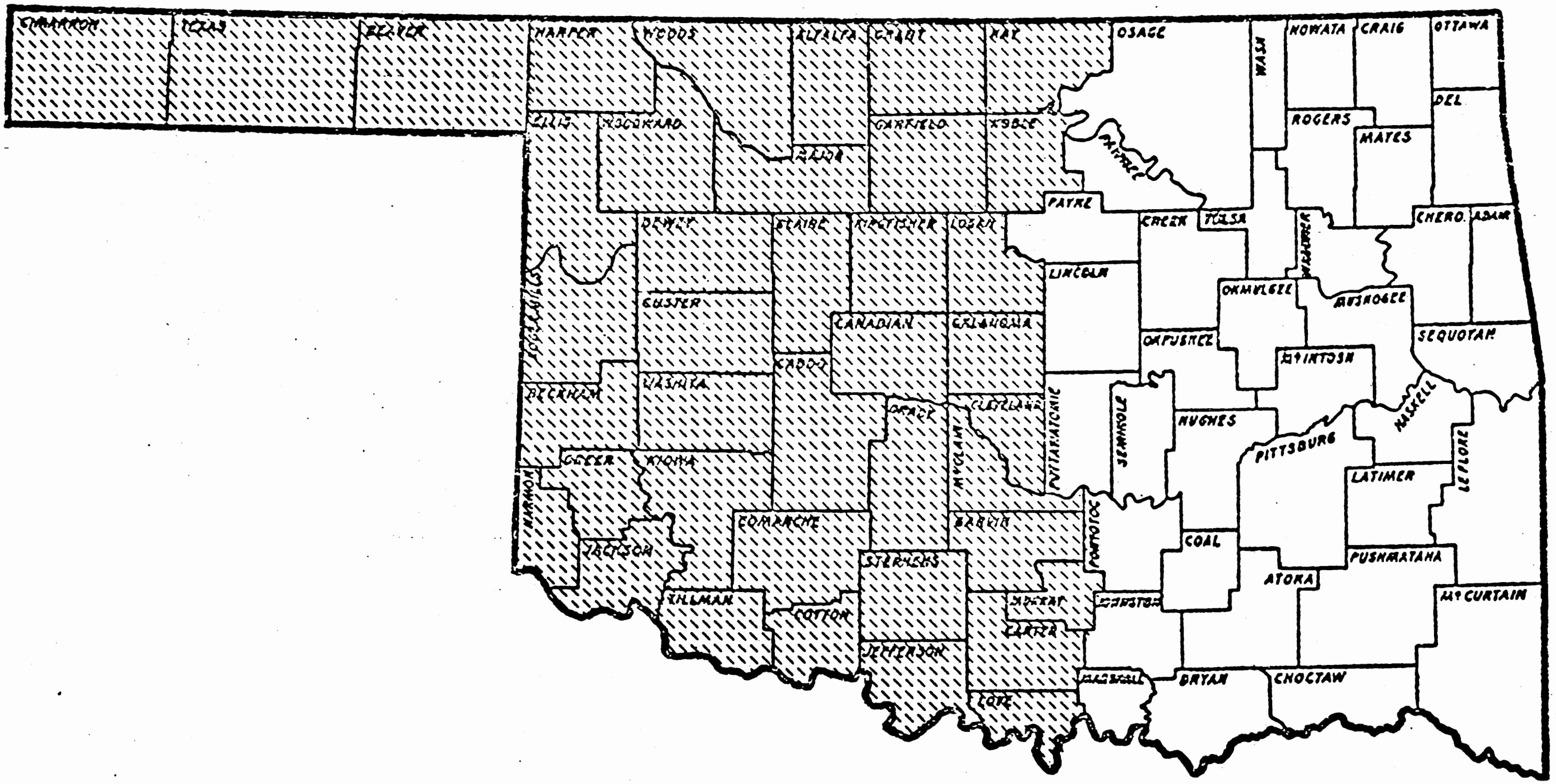

Figure 1. Counties Included in Study Area

The number of traffic accidents investigated in Western Oklahoma municipalities during 1972 and 1973 were obtained from the Oklahoma Department of Public Safety [40]. Information on annual number and types of traffic tickets was obtained from four municipal police chiefs. These four police chiefs and two county sheriffs also provided data pertaining to the number and type of public service calls. It should be noted that frequency data for this study only reflects those incidents reported to or observed by the police. Many incidents go unreported either by the police agency or citizens [43] and cannot be accounted for in this study.

The data sources given above were used to compile information for two types of police service areas. One type was the open country area which depends primarily upon the county sheriff for police services. The other type was the municipality which usually depends upon a municipal police agency for policy services.

Operating procedures and equipment inventories were obtained from personal interviews with sheriffs and police chiefs in the study area. Mileage and operating expenses were compiled from police department records, surveys [36] and public records. The sheriffs also provided mileage and frequency data for court related duties. Other information pertaining to rules and regulations for law enforcement agencies was obtained from the Oklahoma Crime Commission [37].

Organization of the Study

The chapters in this study are organized around the specific objectives. Chapter II is comprised of a discussion of previous research efforts that have made some contribution toward the development of decisionmaking aids in the area of police services. Chapter III contains the development of procedures to estimate the number of calls for police service for the two types of service areas. An application of this procedure is made for Grant County, Oklahoma. A budget procedure is developed in Chapter IV. This procedure along with user oriented forms which facilitate application of the technique, allows decisionmakers to estimate annual capital and operating costs under alternative service delivery systems and levels of coverage. An application to Medford, Oklahoma, illustrates the use of the procedure. A general transportation model is used in Chapter V to select optimum officer location combinations of various number of officers under a county-wide law enforcement system and alternative objectives. Quality of service indicators are associated with these officer location combinations as well as costs of operation. This analysis is performed for Grant County, Oklahoma.

A vehicle scheduling model is presented and used in Chapter VI to design efficient patrol routes, given the officer locations developed in Chapter V. A summary, conclusions, and implications of the study are presented in Chapter VII.

CHAPTER II

REVIEW OF LITERATURE RELATED TO DECISIONMAKING AIDS FOR POLICE SERVICES

Decisionmaking aids for rural police services are needed by local officials. Development of such aids has been relatively slow [24], partially because of the difficulties in measuring output for police services. Aids need to be easy for decisionmakers to use and understand, yet, these aids must be comprehensive enough to provide a sufficient amount of relevant information on the problem under consideration.

Critical problem areas concerning police services were identified for the development of decisionmaking aids. These were: (1) an estimate of the number of calls for police service, (2) cost of alternative levels and systems of police service, (3) location of these services, and (4) efficient patrolling patterns.

Before discussing research studies related to each of these problem areas, the public goods aspect of police services is discussed. Police services are usually produced by the public sector and possess characteristics of a public good. For this reason, research on police services present some analytical problems.

Police Services as a Public Good

Police service is basically collectively consumed, which makes it a public good. In general, public goods are characterized by jointness in consumption and high exclusion costs [23]. Joint consumption implies that the public good affects the utility function of each member of society. In addition, the consumption by one individual does not reduce the consumption by anyone else [47]. Such jointness exists for a collective good whenever the marginal social cost of providing the good to another person, once it is already provided to someone, is zero. However, to be consistent with Pareto optimality, when the marginal social cost of a good is zero, the only price for that good is zero. This implies that profit maximizing entrepreneurs would not undertake production of such a good, since no profit could be made at that price. Thus, the public good must be collectively produced with a zero or nominal price [23].

High exclusion costs are also characteristic of a public good. When joint consumption exists, exclusion of any potential consumer is impossible or requires considerable resources. It is precisely this high cost of preventing an individual from jointly consuming the good without proper payment that interferes with the market system and brings about externalities [23].

The characteristics discussed above are completely exhibited by "pure public goods." Police services exhibit a limited degree of public good characteristics. Police services are usually publicly produced and include some joint consumption. Exclusion of individual consumers is not easy and usually some police protection is desired for all members of society [23]. Some police services (e.g. private investigation services, protective services, etc.) are privately produced. Markets and prices exist for these types of services.

Characteristics of public goods cause problems when measurement of demand for these goods is attempted. Both conceptual and empirical problems arise when selecting meaningful quantity measures and appropriate variables for an equation. Ideally, a basic unit of measurement should be defined and then the number of units consumed per unit of time could be measured. However, public goods have both quality and quantity characteristics, yet usually no observable direct money prices. For this reason, proxies for quantity, quality and quantity value must be found [23].

The problem discussed above is especially perplexing where a public good such as police service is involved which is partially designed to prevent something from happening. In most cases measuring something that might have happened, but did not is extremely difficult [23].

Estimating Demand for Police Service

Local government decisionmakers are continually faced with decisions as to whether a service is to be provided and, if so, how much is to be provided. With regard to police service, the general viewpoint is that some level of police service should be provided. Given this viewpoint, decisionmakers must determine how much service is desired. To assist them, an estimate of demand for police service would be helpful. Several approaches have been used in an attempt to estimate demand for public services. These include (1) studies of expenditure patterns for various types of public services [2, 3, 6], (2) studies of the electorial process and voting behavior on public finance issues [5, 15], and (3) studies of adapting demand formulations used for privately consumed goods [9, 46]. All of these approaches are confronted with a variety of empirical problems due to the characteristics of public services.

Public expenditure models appear to be better suited to analyzing observed public expenditure outcomes and investigation of general public choice hypotheses rather than estimating demand or demand functions per se. Voting behavior models are limited in their application, since it requires a direct vote on public service provision. For police services this does not usually occur. In addition, voting results for a single ballot can generally only provide relative magnitudes of demand parameters. Absolute magnitude estimation would require analysis of two or more referenda that involved different levels of public provision of the service [14]. The adaptation of demand formulations used for privately consumed goods to estimate demand for specific public services has encountered limited success. The major stumbling block occurs in specifying meaningful quantity measures. Very few public services have basic units with reasonably well defined physical characteristics. Because of these empirical difficulties, proxies for quantity are usually selected [23].

This author is unaware of any cases in which the first two approaches have been used to estimate demand for public services. The last approach, in spite of empirical difficulties, has been attempted. A few user oriented decisionmaking aids have been developed. Some of these specific studies are discussed in the following paragraphs.

Chapman [9] attempted to estimate a classical demand function for police service. A simultaneous equation model was constructed, which related: (1) arrest rates to property and violent crimes, (2) police labor to arrest rates, (3) police wages to police labor, and (4) the crime rate to police labor. The police labor equation was designed to represent the demand for police as a function of the price of police, assuming a perfectly elastic supply of police labor. Data for 77 California cities was used in a two-stage least squares technique to derive parameter estimates. Chapman's [9] equation for police labor was expressed as a function of the police wage, rapes per capita, murders and assaults per capita, burglary, robbery and grand theft per capita, property value per capita, percent manufacturing employment and the percent of the labor force taking public transportation to work. In general, the signs of the coefficients are those normally expected. From the equation, per capita police labor increased as crimes per capita (rape, murder, assault, burglary, robbery, grand theft) and per capita property values increased. Inverse relationships were exhibited for the police wage, manufacturing employment and use of public transportation. Positive relationships would be expected between police labor and increases in crimes and property values. The negative sign for the wage rates is unsettling but the coefficient for this variable was not significantly different from zero at a .10 level of significance. The other negative signs were interpreted as the effects of lower unemployment and decreased demand for traffic control activities.

Another demand formulation for police services was developed by the St. Louis, Missouri Police Department [46]. Variables selected for the model were those that were thought to represent the community's demand for police services. Chosen variables were: St. Louis Police Department Index crimes, Federal Bureau of Investigation (FBI) Part I crimes, radio calls for service, total reported traffic accidents, and personal injury and fatal traffic accidents. This type of formulation reflects the feeling that the level of crime and police activity are indicators of demand for police service. Using this formulation, separate linear regressions were computed for each of the five indicators listed above, from times series data for the years 1948-1966 [23].

Morris and Tweeten [30], in an attempt to determine the economic cost of crime in different city sizes, found a highly significant, positive relationship between the crime rate and the number of police per capita. A simultaneous equation system was formulated which related crime rates to police number per capita and other characteristics of cities and police number per capita to lagged values for crime rate and police numbers, as well as characteristics of the cities. The model was applied to data from 754 cities with population ranging from under 25,000 to over 1 million inhabitants. Coefficients derived for the model were used to determine police numbers by city size which would hold the crime rate at the sample average rate. Costs were estimated by using average and actual rates of pay.

Munson and Biere [31] developed an explanatory model to account for the variation in crime rate in 1970 among 33 rural oriented cities in Kansas. Parameters for the model were estimated using regression analysis. Explanatory variables used were: population, density of population, family income, and demographic composition of the population (i.e., age, sex, and racial composition of each city). All coefficients were significant at the .05 level and the equation explained 68 percent of the variation in crime rates. Positive relationships were enhibited between the crime rate and population, population density and demographic composition. The crime rate was inversely related to family income. This equation was used to determine the effect of increasing city population on the crime rate.

Even though Munson and Biere [31] did not intend to relate the crime rate to the demand for police service, they did indicate, after further analysis, that expenditures for police service was positively correlated with the crime rate. They concluded that citizens react defensively to crime by increasing expenditures on crime control, i.e. police services.

Given the studies cited above, several observations can be made. One is that most of the analyses concerning police service applies to urban areas. Another observation is that the occurrence of crime can be explained using regression techniques and characteristics of an area as explanatory variables. Finally, the idea surfaces, that citizens react to increasing crime rates by their willingness to spend more money on police services. This is a particularly important observation, since it would indicate that the number of calls for police service could be used as a proxy for demands for police service. Thus, by developing predictive equations for the number of calls for service, local decisionmakers would gain some insight into the need for police service in the community. Also, they would be able to evaluate manpower and equipment needs to handle the estimated level of calls for service.

A Budget as an Aid to Local Decisionmakers

A budget as used in this study, is defined as a plan for the future in which all items of costs and returns are estimated. A complete budget makes it possible to estimate net income or loss expected for alternative plans. Hirsch [23] in discussing the budget in regard to decisionmaking, states:

> Consistent with the economic approach to public decisionmaking is program budgeting, a planning and management process which applies notions of economic efficiency to public decisionmaking. It involves choice among alternatives in order to achieve the most cost-effective use of resources; involving achievement of the greatest effectiveness for given costs and given effectiveness at minimum costs (p. 310).

Issues in program budgeting related to police services have been addressed in a few studies of urban police services. Chapman et. al. [8] attempted to establish relationships between police department output and input behavior. This information could then be used for local government budget decisionmaking involving interagency allocations. A property crime function was estimated using 1960 data from 82 California cities. This equation was used to predict the number of property crimes expected for the city of Los Angeles between 1956 and 1970. Data for Los Angeles was not used in developing parameter estimates. The predictions were compared to actual property crime rates for that period. Measures of prevented property crimes and crime rates were obtained. This ratio was used along with components for punishment (felony arrest rate) in the development of a measure of police output for police inputs. Having developed a measure of output, a production function for police service was formulated. The measures of police output are used by the authors of the study as input into resource allocation and budgeting decisions.

Sinclair [50] performed an analysis of contractural arrangements for police services in several Michigan communities. This study investigated the institutional aspects which influenced existing contractural arrangements, and the variation in costs per patrol hour purchased by communities.

No previous studies were found which attempted to develop budgeting techniques for police services in rural areas. However, Childs [10], Doeksen et. al. [17], and Schmidt et. al. [48] have developed and used budgeting techniques very successfully for many community services in the Great Plains. These budgets were designed to assist local decision-makers in evaluating alternative service delivery systems.

Location of Police Services

The geographical location of a service can affect the quality and cost of the service. This is especially true for an emergency service such as police service. Assuming response time of a police officer influences the actual or at least perceived quality of service, then officer locations which lower response time provide a higher quality of service. Cost of the service is affected since the distance traveled to provide the service might be reduced if certain locations are chosen. Decisionmakers need to be aware of the influence of service location decisions on the quality and cost of the service.

Some empirical studies were found which addressed the problem of locating ambulance facilities in rural areas [12, 16]. However, no studies were found which dealt with location of police officers. Part of this lack of research is probably due to the nature of police service. Police service is usually characterized as service rendered by an officer in a car, moving throughout a designated area. When a call for service is received, the officer moves to the location of the call, handles the call and then continues to move around the assigned area. Thus, much of the research work [7, 46] done has concentrated primarily on allocation of police manpower, delays in responding to calls for service due to a large number of calls, and effects of different patrol strategies. These items fall more into the patrol function of a police agency which is discussed in the next section.

Most existing police service research pertains to urban areas. The circumstances under which police services must be delivered in urban areas versus rural areas differ substantially. This negates translation of results of urban studies to rural areas. A major difference in conditions under which police service must be delivered between rural and urban areas is that the population density in rural areas is much lower. Under these conditions, miles traveled becomes a more crucial factor in the delivery of police service.

Potential officer location(s) should be evaluated in terms of reduced response time and reduced miles. This is particularly true where county-wide law enforcement is contemplated. A model is presented and applied in Chapter V which provides this type of information for decisionmakers.

Police Patrol

One police function designed to help accomplish objectives of police service is patrolling. This involves the movement of an officer over a specified area. Usually patrolling activities are associated mainly with the deterrence of crime aspects of police service.

Larson [28] developed a simulation model which can be used to evaluate various patrol strategies for an urban area. The simulation model of the dispatch-patrol system appears to be helpful in evaluating alternative operating policies. Incidents are generated throughout the area under study. Each incident is assigned a priority number which indicates the seriousness of a call. As the incidents are generated, an attempt is made to assign a patrol unit to the incident. If an assignment cannot be made due to unavailability of a patrol unit, then this incident is placed in a queue. The queue is depleted as patrol units become available.

Larson's model [28] was designed to provide performance criteria related to two classes of administrative policies: (1) patrol deployment strategies, and (2) dispatch and reassignment policies. Specific policies related to these two variables can be simulated and evaluated by development of statistics on length of dispatcher queue, patrol unit travel times, workload of individual patrol units, etc. Various policies can then be compared based upon the statistics generated by the simulation model. The model has been used in large metropolitan areas such as New York and Boston.

The model is flexible enough that parameters more suitable to other areas may be used. However, data requirements for developing these parameters are extensive. Data needs include: arrival rates and time of call for service, response time, and service time for all police activities. This information is usually only available from individual police departments and would involve a substantial amount of primary data gathering. Also, Larson's [28] model fails to associate dollar costs with patrol operations. Such costs would appear to be very important to decisionmakers.

Shoup and Mehay [49] estimated production functions for deterring property crimes through police patrols. Data for 52 cities in Southern California were used to develop equations for Part I property crimes, total crime, visible arrest, and total arrests. These variables were regressed on independent variables representing patrol inputs and service conditions. The authors then employed these production functions to estimate the number of crimes deterred. A benefit-cost analysis was performed in order to evaluate the deterrent effect of additional one-man patrol units.

Kakalik and Wildhorn [25] attempted to develop some decisionmaking aids for police patrol. Data from six large metropolitan departments were obtained for functions and activities of the patrol force; costs, manpower use and operation; patrol tactics and operation, and a host of other internal operating items. These data were used to develop aids for determining patrol force strength, equitable distribution of patrol services by police district and tour of duty, and operational policies and tactics for police patrol.

Wilson [56] developed a procedure for the geographical and chronological distribution of a patrol force of a given size according to relative need for police service. The relative need for each area was determined from "hazard formulas" based upon situations and conditions that induce or may result in the commission of a crime, or any occurrence requiring police attention. This procedure was applied in Wichita, Kansas and San Antonio, Texas.

As with the bulk of the other literature cites in this review, police patrol analysis has concentrated on urban related problems. Conditions are such in rural areas that problems for these areas must be treated as unique. In addition, very few of the studies considered costs in their analysis. Most treated the patrol force as a given resource which needed reorganization in order to improve effectiveness. Cost information related to efficient patrol routes for a service area would be very useful to decisionmakers in rural areas. Alternatives related to the frequency of patrols as well as manpower needs could be evaluated. A procedure designed to provide this information is presented in this study.

CHAPTER III

ESTIMATING THE NUMBER OF CALLS FOR POLICE SERVICES

Calls for service include any reported or observed activity which requires some type of response from an officer. An estimate of the number of calls for service for the next planning period is important in evaluating manpower and equipment needs to handle these calls.

Development of estimation procedures for calls for police service required two models. Each model represented a different type of service area. The two service areas were: (1) a municipality and (2) the open country. This approach was taken to allow call for service estimates to be made for individual or combinations of the two types of service areas.

Types of Service Areas

Open country service areas include small communities and rural areas of a county that lack local police protection. The sheriff's department responds to calls for service in these areas. Over 90 percent of the crimes reported in these areas are property crimes [39]. Traffic monitoring and vehicular accident investigation in open country areas is primarily conducted by the Oklahoma Highway Patrol.

Municipalities are incorporated towns with 10,000 or less population, and their own police departments. The town police agency handles calls for service occurring in these areas. Crimes reported in these areas are also primarily property crimes [39], but unlike open country areas, traffic monitoring and vehicular accident investigation is usually handled by the local police department.

Types of Incidents

Several types of incidents result in calls for police service. For this analysis, occurrences were classified into three types. These were: (1) crimes, (2) traffic related incidents, and (3) public service items. Using the Uniform Crime Reporting (UCR) system, crimes were divided into Part I and Part II offenses. Part I offenses include homicide (murder or manslaughter), forcible rape, robbery, felonious assault, breaking and entering (burglary), larceny (theft), and motor vehicle theft. Part I offenses were further separated into violent and property crimes. The first four Part I offenses constitute violent crimes, while the last three are property crimes. Part II offenses include other assaults, arson, forgery and counterfeiting, fraud, embezzlement, possession of stolen property, vandalism, carrying or possessing weapons, prostitution, sex offenses, narcotic drug laws, gambling, offenses against family and children, driving under the influence, liquor laws, drunkenness, disorderly conduct, vagrancy, suspicion, curfew violations and loitering, runaway, and all other offenses. Public service items include escorting a funeral parade and other similar activities. Traffic related incidents include vehicle accidents and traffic tickets. County sheriffs court related duties (i.e., serving warrants, subpoena, notices, etc.) were not considered as part of his calls for service. Only those calls from the general public are included.

Data were gathered on the number of calls for service occurring in each service area. The Uniform Crime Reports [39] were used to obtain data on Part I crimes occurring in open country areas and municipalities. Frequency of Part II offenses and public service activities were obtained from sheriffs' and police chiefs' records. Police chiefs also provided data on traffic tickets issued. The number of traffic accidents investigated was obtained from the Oklahoma Department of Public Safety [40]. Data on variables which related to certain characteristics of a service area (i.e., population, percent white males, percent males between 15 and 35 years of age, total county population, population density, total county population density and percent non-white) were collected from Bureau of Census [55] reports and Oklahoma Employment Security Commission [38] reports. Variables reflecting service area characteristics were used as independent variables in an ordinary least squares procedure to test their significance and ability to explain the variation in calls for police service. Models selected for estimating equations are discussed in following sections.

Predictive Procedure--Open Country Areas

The predictive procedure to estimate calls for police service for open country areas, includes predictive equations for violent crimes, property crimes, Part II offenses, and public service calls (Table I).

Violent crimes were estimated as a function of service area population and percent of males aged 15-35. The violent crimes equation explained approximately 24 percent of the variation in the number of violent crimes. Coefficients for service area population and percent of males aged 15-35 in the service area, and the calculated F for the model were significant at the .01 level.

TABLE I

COEFFICIENTS ESTIMATED FROM OPEN COUNTRY AREA DATA, WESTERN, OKLAHOMA

Dependent Variable	Intercept	Independent Variable POP[a]	PMAGP[b]	$\bar{R}^2$	Calculated F
Part I					
Violent crime	-18.7720* (-2.39)[c]	0.0011** (3.19)	1.8567** (3.04)	.236	13.222** (.0001)[d]
Property crime	9.8661 (0.76)	0.0136** (10.01)	--[e]	.560	101.414** (.0001)
Part II	3.3994**	0.0024**	--	.210	9.76** (.0038)
Public Service	1.5677	0.0052**	--	.490	32.72** (.0001)

Source: Oklahoma Uniform Crime Reports and sheriffs' records.

*Indicates statistical significance at the .05 level.

**Indicates statistical significance at the .01 level.

[a]POP = total population of a service area.

[b]PMAGP = percent of service area population that is male and between the ages of 15-35.

[c]Numbers in parenthesis under coefficients indicate calculated t-value.

[d]Numbers in parentheses under calculated F-values indicate probability level of calculated F exceeding tabular value.

[e]This characteristic was not included in the model. Models tested using this independent variable did not improve results or indicate that PMAGP was a significant variable for equations other than violent crime.

Property crimes were estimated as a function of service area population. The predictive equation for property crime in open country areas explained 56 percent of the variation in the number of property crimes occurring in these areas. The coefficient for service area population was significant at the .01 level, as was the calculated F value for the model.

Service area population was used as the independent variable for predicting the number of Part II offenses and public service activities. The independent variable was significant at the .01 level in both models. The percent of variation explained by this independent variable was 21 percent for the Part II model and 49 percent for the public service model. Both models had calculated F values which were significant at the .01 level.

The estimated number of calls of police service for a given open country area can be obtained by substituting the value of the independent variable for the service area into the four equations and summing the results. The equations are relatively simple and data should be available on variables needed to apply the models. Other variables (e.g. total county population, population density, and racial composition) representing service area characteristics were considered in alternative predictive models, but failed to improve results.

Predictive Procedures--Municipalities

The predictive procedures for calls for service in municipalities include the same types of calls as open country areas except that traffic related calls are added. Coefficients computed from data on municipal service areas are presented in Table II.

TABLE II

COEFFICIENTS ESTIMATED FROM MUNICIPAL DATA, WESTERN, OKLAHOMA

Dependent Variable	Intercept	Independent Variable POP[a]	$\bar{R}^2$	Calculated F
Part I				
Violent crime	1.1778 (0.081)[b]	0.0013** (7.17)	.280	51.407** (.0001)[c]
Property crime	2.9087 (0.42)	0.0141** (15.92)	.664	253.306** (.0001)
Part II	3.3994** (2.73)	0.0024** (3.12)	.210	9.76** (.0038)
Traffic				
Tickets	-131.8047 (-0.89)	0.1775 (1.39)	.240	1.95 (.2977)
Accidents	-12.2107** (-5.80)	0.0267** (30.27)	.865	916.138** (.0001)
Public Service	1.5677 (1.07)	0.0052** (5.72)	.490	32.72 (.0001)

Source: Oklahoma Uniform Crime Reports, Municipal police chiefs' records, and Department of Safety records.

**Indicates statistical significance at the .01 level.

[a]POP = total population of municipal service area.

[b]Numbers in parentheses under coefficients indicate calculated t-values.

[c]Numbers in parentheses under calculated F-values indicate probability level of calculated F exceeding tabular value.

All of the predictive models for municipal service areas had population as the independent variable. This variable was highly significant in all regression equations except for the traffic tickets equation. The amount of variation explained by each of the models was: violent crimes, 28 percent; property crimes, 66 percent; Part II crimes, 21 percent; traffic tickets, 24 percent; accidents, 87 percent; and public service, 49 percent. All models except that for traffic tickets had highly significant calculated F-values. A public agency's emphasis on traffic monitoring would have been useful in explaining the number of traffic tickets, but this was unquantifiable. Again, these models are simple to apply and data should be available to the decisionmaker.

As with the open country model, estimates of the number of calls for police service for a particular service area can be made by substituting service area population into each equation and solving. Once an estimate for each type of call is made, the estimates are summed to obtain an estimate of the total number of calls for police service. This model can be used for towns with an existing police department or a municipality which desires to establish one.

Combination of Police Service Areas

Occasionally it may be desirable to make estimates of the number of calls for police service for a combination of areas. For instance, if a county-wide law enforcement system was under consideration, then estimated calls for service for the whole country, both open country areas and communities, would be desirable. Making an estimate of the number of calls under this situation would simply entail application of the predictive procedure to the appropriate areas to be included in the planned service area. Then by summing the estimated number of calls for each type of call and area, an estimate for the planned county-wide service area could be obtained.

Application of Estimating Procedures

Use of the estimating procedure is best illustrated by presenting an example. The example applies the procedure to a county-wide service area which includes both open country and municipal areas. This example illustrates the flexibility of the procedure to estimate the number of calls for combined police service areas.

Grant County in Oklahoma was used in this example. County population in 1977 was approximately 7,202. Municipal populations are: Medford (county seat; 1,311), Pond Creek (908), Lamont (480), Wakita (428), Nash (296), Deer Creek (204), Manchester (166), Jefferson (129) and Renfrow (39). The open country area for which estimates of calls for service are to be made has a population of 3,241 people.

Form I (Figure 2) was developed to facilitate decisionmakers' use of the estimating procedure. Using this form, estimates of the number of calls for service can be made for the open country, for the municipalities, and finally for the county-wide service area consisting of open country and municipalities.

Estimates for Open Country Areas

Estimating the number of calls for police service for the open country area requires the application of the appropriate predictive models (Table I) in conjunction with the service area characteristics. Open country population is 3,241 and 9.58 percent were males aged 15-35.

FORM I--Estimate of the number of annual calls for police service from specified service area

A. Open Country Service Area

1. Part I Offenses:

a. Estimated number of violent crimes: [(violent crime population factor) 0.0011 x (population in service area) 3,241] + [(violent crime age group factor) 1.8567 x (percent males aged 15-35 in service area) 9.58] - [(constant) 18.7720] = 3

b. Estimated number of property crimes: [(property crime population factor) 0.0136 x (population in service area) 3,241] + [(constant) 9.8661] = 54

2. Estimated number of Part II offenses: [(Part II population factor) 0.0024 x (population in service area) 3,241] + [(constant) 3.3994] = 11

3. Estimated number of other calls: [(other calls population factor 0.0052 x (population in service area) 3,241] + [(constant) 1.5677] = 18

4. Total Open Country Calls (1a + 1b + 2 + 3) 86

B. Municipal Service Area

1. Part I Offenses:

a. Estimated number of violent crimes: [(violent crime population factor) 0.0013 x (population in town) 1,311] + [(constant) 1.1778] = 3

b. Estimated number of property crimes: [(property crime population factor) 0.0141 x (population in town) 1,311] + [(constant) 2.9087] = 21

Figure 2. User Form Incorporating Call for Service Estimating Procedure

FORM I--Cont.

2. Estimated number of Part II calls:

   [(Part II population factor) 0.0024 x (town population) 1,311] + (constant) 3.3994] = 7

3. Traffic related calls:

   a. Estimated number of tickets: [(tickets population factor) 0.1775 x (town population 1,311] - [(constant) 131.8007] = 101

   b. Estimated number of accidents: [(accidents population factor) 0.0267 x (town population) 1,311] - [(constant) 12.2107] = 23

4. Estimated number of public service calls:

   [(Public service calls population factor) 0.0052 x (town population) 1,311] + [(constant) 1.5677] = 8

5. Total Municipal Calls (1a + 1b + 2 + 3a + 3b + 4) 163

C. Combined Service Area

[Total open country calls 86] + [Total municipal calls (i.e., all municipalities included) 339] = 425

Figure 2. (Continued)

Using these data and performing the calculations yields an estimated 86 calls for the open country area (Figure 2). If an estimate is desired for a selected open country area within a county, then the total number of calls for the open country area should be allocated according to the proportion of the total open country area population that the smaller area represents.

Estimates for a Municipality

Performing similar procedures for Medford yields an estimate of the number of calls for police service. Only calculations for Medford are shown (Figure 2), but the same procedures were used for the other municipalities. Calculations for Medford yielded an estimated number of calls of 163. Estimates (not shown) for the other towns were: Pond Creek-71, Lamont-22, Wakita-20, Nash-16, Deer Creek-14, Manchester-12, Jefferson-12, and Renfrow-9. The sum of the estimates for each town yields a total of 339 calls for police service for the municipalities.

Combinations of Police Service Areas

An estimate of the number of calls from a combined service area is obtained by adding together the estimate for municipalities and the open country area. Total number of calls from the municipalities was 339 while the total for the open country was 86. Adding these two estimates together yields 425 calls for service for the county-wide service area.

Estimating calls for police service for other service area combinations is possible by using the estimation procedure presented. For instance, if two or more closely located towns were considering joint provision of police services, then individual estimates could be made for the participating towns and the sum of these estimates would represent the estimated number of calls for police service for that service area configuration. Possible combinations of towns and/or open country areas for which call for service estimates can be made are virtually unlimited. The major restriction is that sufficient data exist for the proposed areas which fulfill the data requirements of the estimating procedure.

Summary

Ordinary least squares procedures were used in this study to develop estimating procedures for the number of calls for police service for rural areas. Separate predictive models were developed for open country areas and municipalities. These procedures can be applied to individual police service areas or combinations of police service areas to estimate the number of calls.

Decisionmakers in rural areas can use the procedures developed in this chapter to evaluate the ability of their current level of police service to handle the estimated number of calls. Similarly, municipalities considering establishment of their own police agency can obtain an estimate of the number of calls for service. Some decisionmakers in rural areas have access to information pertaining to the number of calls for police service from their local area. Given the relatively low values of $\bar{R}^2$ for some of the predictive equations, it might be advisable to gather local data on calls for service. However, if no local information on calls for police service is available, then predictive procedures developed in this study can be used, keeping in mind the limitations.

CHAPTER IV

ESTIMATING COSTS FOR ALTERNATIVE RURAL LAW ENFORCEMENT SYSTEMS

Costs of providing a service are uppermost in decisionmakers' minds. Access to cost information pertaining to alternative organizational frameworks to provide a service is essential in the decision-making process. Budgeting techniques were used to develop an estimating procedure for annual capital and operating costs under alternative law enforcement delivery systems. This procedure allows decisionmakers to compare costs of alternative systems and levels of service.

Costs of an adequately staffed and equipped police department are difficult to ascertain. No functional standards exist which define an adequate department. Part of the assistance provided to decisionmakers by this study is the identification of items that should be considered when estimating costs of alternative police service delivery systems. Items included in the budgets reflect suggestions from knowledgeable people in the area of law enforcement. However, decisionmakers using the procedure may add or delete specific items as dictated by local conditions.

Capital Items

Law enforcement capital items fall into two major categories: department items and detention facilities. Department capital items include investigation, office and communications equipment, vehicles, and weapons and related items. Detention facilities include a lock-up facility and related items. Costs and life expectancy data were obtained from dealers selling these items. Law enforcement equipment dealers [13, 29, 51], office equipment dealers [52], and communications equipment engineers [53] were very helpful in providing needed data. Various State [37] and Federal [32] agencies provided information pertaining to contract purchasing of vehicles and regulations.

Tables in the following sections identify suggested items of equipment and unit costs. Each suggested item has a function in a law enforcement agency. This function may be provided at some basic level or a higher level. Two prices are given for most items to reflect these two levels. Recommended quantities of department items vary mainly by agency size (i.e., number of officers). For this reason, quantity guidelines are usually given on a per officer basis. Using the unit prices and quantity guidelines, a procedure is developed whereby total costs for department items for a particular size department can be estimated. Total costs for detention facilities are based upon average construction costs per square foot, inmate capacity, and recommended square footage per inmate.

Department Items

Vehicle. An adequately equipped police vehicle is one of the most expensive capital items (Table III). Prices contained in this study are for 1976. Users should obtain current price information.

Suggested equipment for a patrol car include flashing lights, siren, door emblems, fire extinguisher, spotlight and first aid kit. It should

TABLE III

COSTS OF A NEW PATROL CAR AND SUGGESTED EQUIPMENT, 1976

Items	Minimum	Above Minimum
Base price	$4,274.90	$4,372.90
Toplights	84.25	181.00 (rack)
Siren	84.50	212.00[a]
2-door emblems (magnetic)	52.60	52.60
Fire extinguisher	18.50	27.00
Spotlight	30.00	42.00
First aid kit	33.00	33.00
Total	$4,577.75	$4,920.50

Source: Oklahoma State Board of Public Affairs, State contract terms and price list, contract number 0035, Motor Vehicles, 1976 Model Year and law enforcement equipment dealers.

[a] This price includes a built-in public address system.

be emphasized that this list of patrol car equipment is only a suggestion and items may be removed or added as dictated by local conditions. As indicated in Table III, total cost of an equipped patrol car in 1976 was between $4,578 and $4,921.

Police patrol cars can usually be purchased through a state contract or from a local dealer. Occasionally, state contracts for automobiles are awareded to dealerships which handle cars for which no local service is available. In these instances the purchaser may encounter difficulty in obtaining service and parts. Buying a car locally may facilitate service maintenance required to keep a patrol car in good running condition.

Investigation Equipment. Access to modern investigation aids is essential to the fulfillment of the investigation function. Suggested items and their costs are listed in Table IV. Many other types of investigation equipment are available, but items displayed in Table IV represent a basic investigative package. The main focus of these items is investigation of larceny and burglary.

Office and Communications Equipment. Basic office equipment needs and costs should also be considered in determining costs of law enforcement services (Table V). Occasionally government surplus items are made available to local entities who can obtain serviceable equipment at prices below new equipment prices.

The desk and chair are primarily for the use of the person in charge of the police service. At least one file cabinet is necessary to keep forms, records and other necessary paper work. A typewriter and calculator are two essential office machines for reports,

TABLE IV

SUGGESTED INVESTIGATION EQUIPMENT AND ASSOCIATED COSTS, 1976[a]

Items	Minimum	Above Minimum
Fingerprint Kit	$ 40.00	$ 88.00
Narcotics Kit	49.50	59.00
Post mortem Kit	9.45	9.45
Breathalyzer	875.00	1,995.00
Camera (Polaroid Land)	89.90	159.00
Tape recorder (cassette)	76.00	76.00
Theft detection powder	3.00	3.00
Plaster casting kit	69.50	87.50
Total	$1,212.35	$2,476.95

Source: Law enforcement equipment dealers.

[a]These basic items were recommended by police chiefs and sheriffs in the study area.

TABLE V

SUGGESTED OFFICE EQUIPMENT AND ASSOCIATED COSTS, 1976

Items	Minimum	Above Minimum
Desk and chair	$189.90	$244.95
File cabinet (4 drawer, w/locks)	70.60	112.70
Typewriter and stand	243.50	267.90
Chair	12.50	24.95
Calculator (hand)	25.00	50.00
Office table	75.00	110.00
Total	$626.50	$810.50

Source: Office equipment dealers.

correspondence, etc. Other equipment may be added as local conditions warrant.

Good communications are essential for adequate and safe police services. Response time, calls for assistance, and coordination are all dependent upon a proper communication system. Cost of a dependable communication system varies largely with the size of the police department and of the area to be covered.

A base station (control station or repeated base) would usually be located in the law enforcement agency's office, and each patrol car would have a mobile radio unit. The tower for municipal departments can usually be located at the police department office, while the taller tower for the sheriff's department is usually installed at a separate site. Installation and one year of maintenance costs are estimated at 17 percent of the equipment costs.

Costs shown in Table VI are applicable to an agency purchasing a base station, tower, a mobile radio for one patrol car, and including the installation and maintenance charge. The base station equipment shown in Table VI should be of sufficient capacity for most law enforcement agencies in the study area. A communications engineering firm should be consulted for specific design and requirements.

<u>Firearms and Auxiliary Equipment</u>. Adequate armament is considered essential for an officer's safety and enforcement of law and order. Each officer on duty should have a handgun, night stick and handcuffs with him at all times. Access to a shotgun or rifle is also recommended. Prices for these and a few additional pieces of equipment are presented in Table VII.

TABLE VI

CAPITAL COSTS FOR A BASE/MOBILE REPEATER COMMUNICATIONS SYSTEMS, 1976

Agency and Item	Cost
Municipality:	
VHF control station	$ 2,500
VHF mobile radio unit/patrol car	1,700
60 ft. bracketed tower	800
Installation and maintenance	850
Total	$ 5,850
County Sheriff:	
VHF repeater base[a]	$ 4,500
VHF mobile radio/patrol car	1,700
150 ft. guyed tower[b]	6,000
Installation and maintenance	2,074
Total[c]	$14,274

Source: Systech Corporation, Oklahoma Statewide Telecommunications Plan for County and Municipal Law Enforcement Agencies, Oklahoma Crime Commission.

[a] A repeater system gives extended communications range.

[b] A 150 ft. guyed tower was recommended for most counties. Taller towers were recommended for a few counties due to terrain. Cost estimates for taller towers can be found in Appendix Table B2.

[c] The total cost does not include the cost of an emergency generator which would add approximately $3,000 to county communications system costs.

TABLE VII

SUGGESTED FIREARMS AND AUXILIARY EQUIPMENT AND RELATED COSTS, 1976

Items	Minimum	Above Minimum
Firearms:		
Shotgun (12 gauge)	$ 97.50	$ 107.50
Rifle (bolt action)	105.47	160.31
Handgun	133.60	230.18
Other equipment:		
Night stick	7.00	7.00
Handcuffs	15.25	20.00
Flashlight	6.49	6.49
Radar Unit	1,082.50	1,395.00
Gun lock (electric)	32.15	32.15

Source: Law enforcement equipment dealers.

Uniforms. A distinctive uniform not only identifies a police officer but also provides a high level of visibility which may produce some degree of crime deterrence. Various styles and color uniforms are available to meet the identification and visibility objectives.

Suggested uniform items and their costs are displayed in Table VIII. Each officer should have a complete uniform which includes a minimum of four shirts (two long-sleeve and two short-sleeve) and two pairs of pants. Cost of cleaning may be paid by either the law enforcement agency or the individual officer. If the agency pays, then a cleaning cost (annual) should be added to the cost of the operation.

Detention Facilities

Detention facilities include any structure used by a law enforcement agency for long or short-term detention of arrestees. Short-term detention usually entails holding a person for a short period of time until a decision is made as to disposition of the arrestee. A lock-up facility used primarily for short-term detention would not require as many amenities as a long-term facility where a prisoner may be held for longer periods of time while awaiting trial or serving a sentence.

Many local police agencies have some type of short-term lock-up facility, but most of these agencies depend upon county, state or federal detention facilities for long-term detention. Construction of new jail facilities is a very expensive endeavor. Average construction costs per square foot for long-term detention facilities were between $65 and $70 nationally in 1976 [33]. National correctional facility construction standards call for a minimum of 70 square feet per single occupancy cell plus 35 square feet of day space per inmate [33]. One

TABLE VIII

SUGGESTED UNIFORM ITEMS AND RELATED COSTS, 1976

Item	Quantity	Minimum	Above Minimum	Average
Shirt				
Longsleeve	2	$ 8.40	$ 8.40	$ 8.40
Shortsleeve	2	7.55	7.55	7.55
Pants	2	17.00	23.00	20.00
Parka	1	45.90	47.20	46.55
Shoes	1	22.40	25.60	24.00
Hat	1	10.30	15.30	12.80
Tie	1	1.50	1.75	1.53
Badge	1	6.00	20.70	13.35
Whistle and hook	1	2.25	3.35	2.80
Name bar	1	2.76	8.16	5.46
Insignia	2	4.30	5.75	5.03
Belt[a]	1	49.45	54.05	51.75
Total		$177.81	$220.81	$199.32

Source: Law enforcement equipment dealers.

[a] Includes belt, holster, cuff case and night stick holder.

hundred five square feet per inmate would cost between \$6,824 and \$7,350 per inmate capacity plus the construction costs of any administrative area. Given these estimated construction costs, establishment of a detention facility for each police agency would be a heavy financial burden for most smaller communities. Reliance on a county lock-up facility appears to be a more feasible alternative.

Operating Items

Salaries

Municipal police department budgets from selected towns in Oklahoma indicated that salaries account for approximately three-fourths of the annual police budget. A similar situation existed among county sheriff's departments [36]. Average annual salaries for full-time law enforcement officers are presented in Table IX, and vary considerably among different service area populations. Average salaries were higher for larger service area populations.

In addition to officers' salaries, pay for support staff (e.g. dispatchers, secretaries, filing clerks, etc.) need to be considered. Most law enforcement agencies had officers and secretaries performing dispatch duties. Officers would normally work evening and night shifts while secretaries handled daytime calls. Dispatchers, secretaries and filing clerks would likely receive an annual salary consistent with minimum wage rates. For all salaries paid, some charge must be made for such items as social security taxes, unemployment compensation and other benefits. Normally, 15 percent of the annual salary is sufficient to cover these costs.

TABLE IX

AVERAGE ANNUAL FULL-TIME LAW ENFORCEMENT OFFICERS' SALARIES, BY SERVICE AREA POPULATION, NORTHERN OKLAHOMA DEVELOPMENT ASSOCIATION, 1976

Agency	Service area population		
	Under 10,000	10,000-39,999	40,000 and over
Sheriff's Dept.			
Sheriff	$8,628	$9,240	$12,282
Undersheriff	7,761	7,744	10,353
Deputies	6,823	7,096	8,887
	Under 3,000	3,000-9,999	10,000 and over
Municipal Dept.			
Chief	7,767	9,468	17,880
Asst. Chief	7,050	8,078	12,675
Patrolman	6,305	6,622	8,595

Source: 1976 NODA survey of law enforcement agencies.

Vehicle Operation

Annual operating cost of a vehicle is comprised of fixed and variable costs. Items such as insurance, tag, and inspection sticker are considered fixed costs (Table X). These costs are incurred annually in order to permit legal operation of a vehicle and they are the same whether or not the vehicle is driven.[1/] Gas and maintenance activities, which are a function of miles driven are considered variable operation costs. Data on frequency and costs of annual vehicle operation were obtained from sheriff's and police chief's records.

County sheriffs' departments tend to incur most of their vehicle mileage in the fulfillment of duties other than answering calls for service. Civil duties not considered calls for service include posting public notices, delivering court orders and summons and similar activities. Criminal duties not included in call for service estimates include follow-up investigation of incidents, serving criminal warrants and subpoenas and related activities. An average of approximately 20 civil and 103 criminal activities per 1,000 population was computed from study area data. An average of about 43 and 41 miles per civil and criminal activity, respectively, was computed from sheriff's department records (Table XI). These estimates are used to estimate mileage for sheriff's department vehicles.

Municipal law enforcement agencies normally incur the majority of vehicle mileage while performing patrol duties and answering calls

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[1/] Insurance rates may be affected by the anticipated annual mileage driven.

TABLE X

AVERAGE VEHICLE OPERATING EXPENSES, GREAT PLAINS STUDY AREA, 1976

Item	Average
Fixed Items:	
Insurance[a]	$40.00
Tag[b]	2.50
Inspection Sticker	2.00
Total	$44.50
Variable Items:	
Gas (miles per gallon)	10 mpg
Oil change (2,500 miles or 30 days)	$10.00
Tune up (5,000 miles or 60 days)	$35.00
Tires repair (every 60 days)	$3.50

[a]Liability insurance at municipal rates

[b]Costs reflect municipal rates. County sheriff and deputies furnishing their own car would have to pay regular tag rates.

TABLE XI

AVERAGE ANNUAL RATE OF ACTIVITY AND MILES PER ACTIVITY FOR SHERIFF'S DEPARTMENT, GREAT PLAINS STUDY AREA

Activity	Average rate of activity[a]	Average miles per activity
Civil activities	20.22	42.82
Criminal activities	102.76	51.06

Source: Grant and Major County sheriff's records.

[a]Analysis based upon number of activities per 1,000 population (i.e., No. of activities ÷ Population x 1,000).

within their jurisdiction. Some mileage is incurred due to the transport of prisoners to a lock-up facility, usually the county jail. Municipal patrol mileage is a function of the number of patrol officers, number of police vehicles, city size, and emphasis by the agency on patrol activities. In general, the greater the number of officers, cars, size of jurisdiction, and emphasis on patrol activities the more mileage a municipal agency would incur.

Data on monthly municipal patrol mileage (MMPM), number of patrol officers (NOFF) and number of patrol cars (NPC) were collected from seven communities. These data along with the square miles (SQM) within the city limits of each community were used in a regression analysis to develop a predictive procedure for municipal patrol mileage. The estimated equation was:

$$\begin{aligned} MMPM = {} & \underset{(-2.04)}{1740.64} + \underset{(3.93)}{549.23}\ (SQM) + \underset{(4.07)}{2381.38}\ (NPC) + \underset{(1.04)}{324.17}\ (NOFF) \end{aligned}$$

The equation explained approximately 96 percent of the variation in monthly patrol mileage, and the calculated F value was significant at the .05 level. Numbers in parenthesis indicate t-values for the coefficients. Estimated parameters for square miles and number of patrol cars were significant at the .05 level.

Municipal users of the procedure can supply the appropriate values for the number of square miles in the service area, the number of patrol cars, and the number of patrol officers. By substituting these values into the predictive equation and solving, an estimate of monthly mileage can be obtained. Multiplying the monthly estimate times 12 yields an annual mileage estimate. This estimate represents mileage for the whole agency. If more than one patrol car is used then some assumption must be made as to the amount of mileage incurred by each vehicle.

Application of Budget Procedure

Forms were developed which incorporates the information compiled on capital and operating costs. Separate forms were designed for capital and operating costs to assist users of this information. A meaningful way to illustrate the cost estimation procedure is to give an example based upon a request from a town in Oklahoma. Decisionmakers in Medford, Oklahoma sought cost information on alternative methods of providing police services. Leaders indicated an interest in having cost estimates for various levels of police coverage under alternative methods of providing the service. Characteristics of Medford were discussed previously.

Individual Municipality Establishing a Police Department: 24 hours, 7 days/week

An alternative to be considered by Medford decisionmakers was establishing a police department. An alternative level of service to be considered was 24 hour service, seven days a week, with a single patrol unit (i.e., one officer on patrol during each 8 hour shift). Using Appendix B, Table XVI, the minimum number of officers required to provide 24 hour coverage is slightly over 4 full-time officers (4.2). A form (Figure 3) was developed to record this information as well as provide other basic data needed to complete the budget procedure.

Capital Costs--Vehicle. One car is needed for each single or double (i.e., two officers in one vehicle) patrol unit on the heaviest manned shift. In this example, only one officer is on duty each shift.

FORM II--Service area data and decision sheet

1. Service area and population Medford - 1,290

2. Level of desired police service:

   ✓ a. 24 hours/day - 7 days/week ___ d. 40 hours/week

   ___ b. 16 hours/day - 7 days/week ___ e. 20 hours/week

   ___ c. 8 hours/day - 7 days/week

3. Number of officers/shift 1.

4. Number of officers required for desired level of service (see Appendix B, Table XVI for manpower guidelines) 4.2

5. Number of cars required: (allow one car for each single or double patrol unit on heaviest manned shift). 1

6. Mileage

   a. Estimated municipal patrol mileage:

      1. Monthly mileage = [Sq. miles factor 549.23) x (Sq. miles in city limits 0.9)] + [(No. of police cars factor 2381.38) x (No. of police cars 1)] + [(No. of patrol officers factor (324.17) x (No. of patrol officers 4)] - [constant factor 1740.64] = 2,432

      2. Annual mileage = [(Monthly mileage 2,432) x (12 months)] = 29,184

   b. Estimated mileage for Sheriff's duties:

      1. Civil activities mileage = [(Average rate of civil activities 20.22) x (population 42.82 ÷ 1,000)] x [Average miles per activity ______] = ______

      2. Criminal activities mileage = [(Average rate of criminal activities 102.76) x (population ______ ÷ 1,000)] x [Average miles per activity 51.06] = ______

Figure 3. User Form Developed for Recording Service Area Data and Basic Calculations Needed in the Budget Procedure

FORM II--Cont.

3. Total annual mileage = [Civil activities mileage _____] + [Criminal activities mileage ______] = _______

7. Life expectancy of police vehicles: [80,000 miles] ÷ [annual patrol mileage 29,184] = [life expectancy of police vehicles 2.74]

Figure 3. (Continued)

Thus, only one car is needed. The minimum equipped patrol car (Table III) is $4,577.75. The expected useful life of the car can be expressed either in terms of years or mileage. The expected mileage of one patrol car for a jurisdiction of 0.9 square miles, one patrol car, and four patrol officers is 2,432 miles per month (Figure 3) or 29,184 miles per year. According to knowledgeable people in the field of law enforcement, a car should not be kept past 80,000 miles. Thus, a 3 year expected life (80,000 ÷ 29,184) could be used to amortize the total vehicle cost. Applying the appropriate annual amortization factor (Appendix B, Table XVII) for the 3 year expected life with a 6 percent interest rate would yield the annual capital cost (4,577.75 x 0.37411) for the vehicle of $1,713 (Figure 4--Item 1). A 6 percent interest rate was selected to represent a rate for municipal tax exempt bonds.

Capital Costs--Investigation Equipment. Providing the new department with a basic set of investigation equipment would require a total expenditure of between $1,212.35 and $2,476.94 (Table IV). Assuming the purchase of a minimum set of investigation equipment and applying the amortization factor using a life expectancy of 10 years and a 6 percent interest rate would yield an annual capital cost of $165 (Figure 4).

Capital Costs--Communications Equipment. The communications items and related costs given in Table VI provide the basis for estimating this expense. The cost of equipping each car with a mobile radio unit can be determined by multiplying the number of police cars to be operated times the cost per mobile radio. In the example, only one mobile radio unit is required for the one patrol car at an initial cost of

FORM III--Procedure to estimate annual capital costs

Service Area Medford

1. Vehicle(s):

   a. (No. of vehicle(s) 1) x (cost/vehicle $4,577.75)
   = (initial vehicle(s) cost $4,577.75)

   b. (Initial vehicle(s) cost $4,577.75) x (amortization factor* 0.37411) = annual vehicle capital costs $1,713

   *Appropriate amortization factor for life expectancy (3 years) and an assumed rate of interest (6 percent); see Appendix B, Table XVII.

2. Investigation equipment: (cost of equipment $1,212.35) x (0.13587 amortization rate corresponding to assumed interest rate and 10 year repayment period) = $165

3. Communications equipment:

   a. (Cost of tower –) + (Cost of control station $2,500) = (Total base unit cost $2,500)

   b. (Cost of mobile radio unit $1,700) x (No. of patrol cars 1) = (Total cost of mobile units $1,700)

   c. [(Total base unit cost $2,500) + (Total cost of mobile units $1,700)] x .17 = (Installation and maintenance cost $714)

   d. Sum of 3a + 3b + 3c = Initial communications equipment cost $4,414

   e. (Initial communications equipment cost $4,414) x (amortization factor 0.13587 for assumed life expectancy* and interest rate) = annual communications equipment costs $668

   *A reasonable life expectancy for this equipment is 10 years.

Figure 4. User Form Incorporating Annual Capital Cost Estimating Procedure

FORM III--Cont.

4. Office equipment: (cost of equipment $626.50) x (0.13587 amortization rate corresponding to assumed interest rate and 10 year repayment period) $85

Firearms and auxiliary equipment:

a. Items needed by each officer

Firearms: individual officer (No. of officers 4) x (cost/handgun $133.60) = (total cost for handguns $534)

Auxiliary equipment: (No. of officers 4) x (cost/night stick + handcuffs + flashlight $28.74) = total cost for individual officers items $115

b. Items available to officer(s)/shift 1) x (cost/shotgun or rifle $97.50) = (additional weapons cost $97.50)

Auxiliary equipment: (No. of vehicles/shift 1) x (cost/gunlock $32.15) = (total gunlock cost $32.15). (Cost of radar unit $1,082.50). (Total gunlock cost $32.15) + (cost of radar unit $1,082.50) = (Total additional items $1,114.65)

c. Total

Firearms: (Total cost of handguns $634) + (total cost of additional weapon(s) $97.50) x (amortization factor for assumed rate of interest and 20 year life expectancy 0.08718) = (annual capital costs for firearms $55)

Auxiliary equipment: (total cost for individual officer items $115) + (total cost for additional items $1,114.65) x (amortization factor for assumed rate of interest and 8 year life expectancy 0.16104) = (annual capital cost for auxiliary equipment $198)

d. (Annual capital cost for firearms 55) + (annual capital cost for auxiliary equipment 198) = (annual capital costs for firearms and auxiliary equipment) $253

Figure 4. (Continued)

FORM III--Cont.

6. Uniforms: (No. of officers 4) x (cost/uniform/officer $199.32) x (amortization factor corresponding to an assumed rate of interest and 3 year life expectancy 0.37411) = (annual capital costs of uniforms) ________

7. Office space: (cost of building -) x (- amortization rate corresponding to assumed interest rate and 40 year repayment period)

8. Annual capital cost summary:

a. Vehicle		$1,713	
b. Equipment			
1. Investigation equipment	$165		
2. Communications equipment	$668		
3. Office equipment	$85		
4. Firearms and auxiliary equipment	$253		
5. Total equipment costs		$1,171	
c. Uniforms		$298	
d. Office space		$0	
e. Total annual capital costs			$3,182

Figure 4. (Continued)

$1,700. In addition, the cost of a tower and a base station need to be added to the cost of the mobile radio to obtain a total initial communications equipment cost of $4,200. Taking 17 percent of this amount for installation and maintenance and adding it to the equipment cost yields a total cost of $4,914 (Figure 4). Once initial communications equipment cost has been estimated, an annual cost can be determined by multiplying the appropriate amortization factor (Appendix B, Table XVII) for an assumed life expectancy and rate of interest, times the initial cost. Performing these calculations on Form III yields an annual cost of $668 (Figure 4).

Capital Costs--Office Equipment. A set of new office equipment for the new department would cost between $626.50 and $810.50 (Table V). Using the lower cost for office furniture and applying the amortization factor corresponding to an assumed interest rate of 6 percent and a 10 year life expectancy would yield an annual capital cost for office equipment of $85 (Figure 4--Item 4).

Capital Costs--Firearms and Auxiliary Equipment. Due to differing life expectancies for firearms and auxiliary equipment items as well as differing quantity requirements, calculation of annual capital cost for this category is slightly more complicated. In an attempt to simplify the procedure, it was broken down into three steps. First, the cost of firearms (hand gun) and auxiliary items (night stick, handcuffs, and flashlight) needed by each officer is calculated by multiplying the cost of each item (Table VII) times the number of officers in the department. Second, the cost of firearms (shotgun or rifle) and auxiliary equipment (gunlock, radar unit) needed only by the officer(s) on duty was computed.

Finally, total cost of firearms, both for individual officers and for the officers on duty can be amortized over a 20 year life expectancy with a 6 percent interest rate. Applying the appropriate amortization factor to the total cost for firearms yields an annual capital cost of $55 (Figure 4--Item 5c). Similarly, the annual cost of auxiliary equipment both for individual officers and those on duty, can be amortized over an 8 year life expectancy at a 6 percent interest rate. Completing these calculations yields an annual capital cost for auxiliary equipment of $198 (Figure 4--Item 5c). Adding the individual annual capital costs ($55 + $198) yields the annual capital costs for this category of $253 (Figure 4--Item 5d).

Capital Costs--Uniforms. Total uniform costs are estimated by multiplying the number of officers on the police force times the average uniform costs per officer (Table VIII). For the example, total costs for uniforms would be $797.28. Applying the appropriate amortization factor for a 3 year life expectancy and a 6 percent interest rate yields an annual capital cost for uniforms of $298 (Figure 4--Item 6).

Capital Costs--Office Space. Construction costs for office space for the police force can be estimated by using a cost of construction applicable for the local area and amortizing this cost over a 40 year period at an appropriate interest rate. However, for this example, it will be assumed that office space is available in an existing, city owned building for use by the police department (Figure 4--Item 7).

Total Annual Capital Costs. Total annual capital costs are estimated by summing the costs for each of the individual categories.

For the example, total annual capital costs are \$3,182 (Figure 4--Item 8e).

Annual Operating Costs--Salaries. In this example, four officers are to be hired. Assuming one of the officers is designated as the chief of police and the other three officers are patrolmen, their salaries can be estimated by multiplying the number of men times the average salary for the service area and type department (Table IX).

In addition to the officers, four radio dispatchers are needed to answer telephone calls and relay these calls to the officers on patrol. Four dispatchers are needed if it is desirable to have one on duty 24 hours a day, seven days a week. By multiplying the number of dispatchers hired times the anticipated annual salary, an estimate of their annual salaries is obtained. If additional personnel hiring is anticipated, their salaries must also be estimated. Form IV (Figure 5) was designed to aid in the estimation procedure.

Estimated total annual salary expenses for this type of system is obtained by summing the annual salaries for all personnel hired by the agency and then adding 15 percent of this total to the salaries for benefits. In this example, annual salary expense is estimated to be \$58,284 (Figure 5--Item A8).

Annual Operating Costs--Vehicle Operation. Estimated costs for vehicle operation is separated into fixed and variable costs. For the estimated fixed costs, the number of cars operated was multiplied by the costs (Table X) in each of the three categories (insurance, tag, and inspection sticker). In this example, operating one patrol car yields an annual fixed cost estimate of \$44.50 (Figure 5--Item B1).

FORM IV--Procedure to estimate operating cost

Service Area Medford

A. Salaries

1. Chief $7,767
2. Assistant Chief (optional) $______
3. Patrolman: (3 no. of patrolmen) x (annual salary $6,305) $18,915
4. Dispatcher(s): (4 no. of dispatchers) x (annual salary $6,000) $24,000
5. Secretary or clerk: (____ no. of persons) x (annual salary ______) $ -
6. Part-time and other $ -

Total $50,682

7. Salaries $50,682 x .15 = benefits $7,602
8. Salaries $50,682 + benefits $7,602 = total salary expense $58,284

B. Vehicle Operation

1. Fixed costs (no. of cars ___ x (cost/car $_____)

   Insurance (no. of cars) 1 x (cost/car $40) = $40.00

   Tag (No. of cars) 1 x (cost/car $2.50) = $ 2.50

   Inspection (No. of cars) 1 x (cost/car $2.00) = $ 2.00

   Subtotal $ 44.50

2. Variable costs

   a. Sheriff's department

      Total annual mileage _____) x (____¢ rate/mile) = (mileage cost $_______)

      Total annual operating cost: Fixed + variable costs = Total annual cost (1 + 2a) $______

   b. Municipal department

      -1- Gas: (estimated mileage 29,184) ÷ (miles per gallon 10) x (price per gallon $.56) = (gas expense) $1,634

Figure 5. User Form Incorporating Annual Operating Cost Estimating Procedure

FORM IV--Cont.

-2- Oil change: (estimated mileage 29,184) ÷ (miles per oil change 2,500) x (cost per oil change $10.00) = oil expense $117

-3- Tune up: (estimated mileage 29,184) ÷ (miles per tune up 5,000) x (cost per tune up $35.00) = tune up cost $204

-4- Tires:

a. (maintenance cost $21 per year) x (1 no. of cars) = maintenance cost $21

b. (replacement: estimated mileage 29,184) ÷ (40,000 miles) x (cost of 4 tires $200)* = replacement cost $146

*(cost per tire $50) x 4 = (cost for 4 tires $200)

-5- Subtotal $2,122

d. Vehicle operating cost = (fixed vehicle cost $44.50) + (variable vehicle cost $2,122) = $2,167

C. Office Overhead $ –

D. Other Costs $200

E. Total Operating Costs $60,651

Figure 5. (Continued)

Four variable cost items are considered. Cost estimates for these items are primarily based upon estimated annual mileage, which was calculated earlier (Figure 3--Item 6a). In addition, an assumption must be made by the decisionmaker as to the frequency of these items and an appropriate cost figure for each. Frequency and costs used in this example are based upon data supplied by police and sheriff's departments in the study area (Table X). Gas mileage for the car was assumed to be 10 miles per gallon with a cost of 56¢ per gallon of gasoline.

Frequency of vehicle maintenance was: oil change every 2,500 miles, tune-up every 5,000 miles, and tire repair once every 60 days. In addition to the tire repair cost, tire replacement cost must also be considered, which requires an assumption concerning the expected mileage for a set of tires. For this example, a set of tires were assumed to be servicable for 40,000 miles. Average cost figures (Table X) were used in conjunction with frequency of vehicle maintenance to arrive at an annual cost estimate. Using these assumptions, total annual variable cost amounted to $2,102 (Figure 5--Item 2). Total annual vehicle operating costs (fixed and variable costs) were estimated to be $2,167 ($44.50 + $2,122).

<u>Total Annual Operating Costs</u>. In addition to the salaries and cost of vehicle operation, office overhead and other costs must be considered. Any charges for utilities, insurance, janitorial service, records keeping, etc. for the police agency must be added to the cost of operation. For this example, it was assumed that no charges would be made for these items. Other costs that must be considered include purchase of ammunition, traffic ticket forms, office supplies, etc. A charge of $200 was

made in this example to cover the cost of these items.

Summing the cost estimates from each of the categories yields an estimate of total annual operating costs. For this example, an estimate of $60,651 was computed.

Blank forms are included in the appendix of this study. Decision-makers can use these when applying the procedure to their area.

Individual Municipality Establishing a Police Department: 8 hours, 7 days/week

Completed Forms III and IV are not displayed for this alternative since they would be completed in a similar manner as the first alternative. Only assumptions and major cost differences are discussed.

Reducing the level of coverage mainly affects patrol car use, equipment, uniforms, and salary expense. From the manpower requirements table (Appendix B, Table XVI), only 1.4 officers are required to provide this level of service. Manpower requirements could be met with one full-time and one part-time officer. With this number of officers annual patrol mileage was estimated to be 19,452 miles. This level of patrol mileage yields a life expectancy of four years. The annual capital costs for the vehicle was estimated to be $1,321. Two complete sets of individual officers items are needed rather than four sets with the higher level of coverage. This lowers the annual cost of firearms to $32. In addition, the annual cost of auxiliary equipment is reduced to $189. These reductions decrease annual capital costs for firearms and auxiliary equipment to $221 ($32 + $189). Uniform costs are also reduced by the amortized cost of 2 uniforms. Uniform costs decrease to $149, since only two sets are needed. The remaining equipment costs stay the same, which results in a total annual capital cost for the reduced level of coverage of $2,608.

The reduced level of coverage affects annual operating costs for salary expenditure and vehicle operation. With only 2 officers and 2 dispatchers, one of each working only half-time, annual salary costs are reduced to $22,908. Vehicle operation costs are $1,466. The reduced level of coverage results in a total annual operating cost of $24,574.

Two Municipalities Jointly Establishing a Department: 16 hours, 7 days/week

In the state of Oklahoma, the Interlocal Cooperation Act of 1965 [42] enables local units of government to cooperate with other entities to provide public services and facilities more efficiently. Any agreements of this nature between two or more entities must be approved by the Attorney General of Oklahoma before taking effect. Cooperative agreements between local entities to provide police services are legally possible under this act and any agreement would be governed by it. Local decisionmakers in Medford, Oklahoma wanted to consider this alternative delivery system.

The town of Pond Creek, Oklahoma, located 11 miles south of Medford, was interested in the possibility of jointly establishing a police department to provide police services to both municipalities. Pond Creek has approximately 908 residents. Decisionmakers considered alternative levels of police coverage of 8 or 16 hours a day, 7 days a week. Cost estimates for these levels of coverage and type of delivery system can be made by completing Form II through IV. For purposes of this study it is easier to determine what changes occur as a result of the expanded service area as compared with the individual municipality system previously completed.

Minimum manpower requirements (Appendix B, Table XVI) for 16 hours of coverage 7 days a week is 2.8. This means that 3 officers and 3 dispatchers would provide sufficient manpower for the desired level of coverage.

An assumption was made that the communications equipment used in our initial example had sufficient range so that purchase of more powerful equipment would not be necessary. It was further assumed that each officer would make one trip to each town on each shift.

Annual capital costs for vehicles was affected by the increased service area. This was mainly due to a reduced life expectancy for the patrol car since additional patrol mileage in Pond Creek as well as round trip distance between Medford and Pond Creek is incurred. Additional patrol mileage can be calculated using the municipal patrol mileage formula (Figure 3). For Pond Creek, which has 0.6 square miles in their city limits, one car, and 3 officers, annual patrol mileage was calculated to be 23,316 miles. Assuming one trip is made to Pond Creek on each officer's shift then a total of 44 miles a day is driven between the two towns (2 trips x 22 round trip miles = 44 miles). If this is done every day, 16,060 miles (44 miles x 365 days = 16,060 miles) are added to annual patrol mileage. Adding the estimated annual patrol mileage for Medford yields total annual mileage for the one car of 64,660 miles (25,284 - Medford patrol + 23,316 - Pond Creek patrol + 16,060 - commuting). At this annual mileage, life expectancy of the patrol car is reduced to 1.24 years (80,000/68,560). Thus, the amortization factor for the vehicle must be appropriate for a one year expected life and a 6 percent interest rate. Using this factor, estimated annual capital costs for the patrol vehicle is $4,852.

With three officers, annual firearms and auxiliary equipment costs were $234 while uniform costs were $224. Other capital cost remain the same as in the individual municipality case. Total annual capital costs for 16 hours a day, 7 days a week police coverage under a cooperative delivery system would be $6,227.

Determining the effect on cost of operation due to expansion of the service area requires consideration of changes in the number of employees and use of the patrol vehicle. It was determined that three officers and three dispatchers needed to be hired. Annual salary expense for these personnel would amount to $44,134.

Changes in the amount of use of patrol vehicle do not affect fixed vehicle costs, but variable operating costs are affected. The increased mileage (patrolling + commuting) changes estimates for all variable costs. Estimated costs for the expanded service area are computed the same way as those in the individual municipality case. Estimated variable vehicle costs under this delivery system and level of service was $4,677. Adding this to estimated fixed costs yields a total vehicle operating cost of $4,722. Total operating costs amounted to $49,056. Total annual costs for this delivery system on level of earnings amounted to $55,283.

Two Municipalities Jointly Establishing a Department: 8 hours, 7 days/week

Annual capital and operating costs for an 8 hour police service, 7 days/week were estimated. Annual vehicle capital costs are affected by the reduced level of coverage. With only one 8 hour shift per day, commuting mileage between the towns decreases 8,939 miles per year. Patrol mileage decreases to 19,452 for Medford and 17,484 for Pond Creek. Total annual mileage is 44,066 miles, which increases patrol car life expectancy to 1.78 years (80,000 miles ÷ 44,966 miles). Rounding life expectancy to 2 years and applying the appropriate amortization factor (Appendix B, Table XVII) to the cost of a patrol car yields an annual vehicle capital cost of $2,497.

Under the cooperative delivery system and a lower level of coverage, the annual firearms and auxiliary equipment costs and uniform costs are changed. A reduction in these costs result from operating a smaller department. Only two officers and two dispatchers are required to deliver this level of coverage. One officer and dispatcher would be employed only part-time. The smaller department would have an annual capital cost of $221 and $149 respectively for firearms and auxiliary equipment, and uniforms.

Other capital costs would remain the same as the higher level of coverage under a cooperative delivery system. Total annual capital costs would amount to $3,784.

Operating costs under this level of service are affected by reductions in the number of personnel in the police agency as well as the annual amount of vehicle mileage from the 16 hour, 7 day/week coverage. With a police chief, one part-time officer, one full-time and one part-time dispatcher, annual salary expense amounts to $22,908. Variable vehicle operating cost was estimated to be $3,259, for the estimated 44,966 annual miles. With no other operating costs changing, total annual operating costs under a cooperative delivery system and 8 hour, 7 days/week coverage, are $26,412. Total annual costs (capital and operating costs) amount to $30,196.

Contracting with the County Sheriff:

80 hours/week

The Interlocal Cooperation Act of 1965 [42], mentioned earlier, would allow local entities in Oklahoma to contract with the county sheriff's department for police services above those already provided by the sheriff.

Decisionmakers in Medford wanted to evaluate the possibility of contracting with the county sheriff's office for one or two full-time officers. The officers would be sheriff's deputies stationed at Medford and performing duties in Medford similar to a municipal department. In order to provide this service, the sheriff must increase his level of operation. It was assumed that the Grant County sheriff would react to Medford's request by hiring additional deputies to provide the desired level of police coverage to Medford. The cost estimating procedure presented in this report can be used to estimate the costs of the sheriff's higher level of operation. This entails a determination of the costs of adding one or two new officers to the sheriff's department.

In the determination of annual capital costs for 2 officers, 80 hours/week it was assumed that sufficient investigation, office and base communications equipment exist so that no additional costs are incurred due to the proposed increased level of operation of the sheriff's department. However, an additional vehicle, mobile radio equipment, firearms, auxiliary equipment and uniforms will be required for the new officers.

Only one vehicle is required for the increased level of service. However, annual mileage will be higher than that estimated for the one municipality case since the officers would perform sheriff's duties in Medford and the open country area surrounding Medford. The amount of additional mileage can be estimated using the procedure for estimating sheriff's department mileage on Form II. Performing the calculations using the estimated service area population of 2,711 (Medford: 1,311 + surrounding Census County Division: 1,400 = 2,711) and summing the estimates for the two activities yields an estimate of 16,443 miles (2,329 + 14,114). Adding this mileage to estimated municipal patrol mileage for Medford yields a total annual mileage of 37,839 (16,443 + 21,396). With this mileage, estimated life expectancy for the vehicle is 2 years. Applying the appropriate amortization factor (2 years and a 6 percent interest rate), to the cost of one vehicle yields an annual vehicle capital cost of $2,497.

Annual costs for vehicle communication equipment were estimated by amortizing the cost of a mobile radio unit, and installation and maintenance for the new vehicle (Table VI). Initial communication equipment costs were estimated to be $1,989, while the annual cost amounted to $270.

Costs of firearms, auxiliary equipment, and uniforms for the additional officers are estimated the same way as in previous examples. Estimated annual capital costs were: firearms and auxiliary equipment $221; uniforms $149. Total estimated annual capital costs under this alternative was computed to be $3,137.

Estimating salary costs for additional officers requires use of annual salaries for sheriff's deputies (Table IX). It was assumed that the sheriff's department already had enough dispatchers to support the additional officers. The estimated annual salary expense was $15,693. Vehicle fixed operation costs are the same as previous examples ($44.50) since only one car is to be insured, licensed and inspected. Variable operating costs are based on estimated mileage, frequency and cost of individual maintenance items. Using the procedures developed previously, variable operation cost for the vehicle under this alternative was $2,790 ($45 + $2,745).

An additional operating cost to the sheriff's department is the administrative overhead cost for the new officers. Seventeen percent of the salary expense for the new officers appeared to be a reasonable charge. For the two new officers, this expense amounts to $2,668 ($15,693 x .17). This charge should not be confused with that for benefits. Total operating costs are estimated to be $21,351.

<u>Contracting with the County Sheriff</u>:

<u>40 hours/week</u>

Annual capital costs for the police vehicle, investigation, communication, and office equipment are the same as in the previous example. Annual vehicle mileage decreases to 33,951, but this is not enough to change the expected life of the vehicle. Only the costs for firearms, auxiliary equipment and uniforms change since only one officer is added to the sheriff's department. Annual capital costs for firearms and auxiliary equipment were estimated to be $204, while annual uniform costs were computed to be $75. Total annual capital costs for one full-time officer was $3,046.

Salary costs, vehicle operating costs, and the administrative overhead costs are affected by having only one full-time officer. Annual salary expense decreases from $15,693 in the previous example to $7,846. As a consequence the overhead charge decreases to $1,334 ($7,846 x .17). Annual vehicle mileage is reduced to 44,951, which reduces operating costs to $2,511. Thus, total annual operating costs under this delivery system and level of service decreases to $11,891.

Comparison of Alternative Police Service Delivery Systems

Costs of alternative police service systems can be compared in two ways. First, estimates of costs of police service under various alternatives provides a basis for comparing different systems. Second, costs of different levels of police coverage under the same type delivery system can be evaluated.

In the previous section, costs for different levels of police coverage under three alternative delivery systems were estimated. Form V (Figure 6) summarizes these cost estimates. Only under the first two alternatives would these costs necessarily represent the cost to Medford. Some cost sharing would occur under the cooperative delivery system and could also be possible under the contracting system.

Several methods could be used to allocate costs of police services under joint delivery systems. Two such methods include equal cost sharing and sharing according to the estimated calls for police service. Either of these methods could be used for the cooperative delivery system, but only cost sharing according to estimated calls for police

FORM V. Procedure used to compare estimated annual costs of alternative law enforcement delivery systems.

Costs		(1)	(2)	(3)	(4)	(5)	(6)
	Delivery system:	Indiv.-Municipality	Indiv.-Municipality	Cooperative	Cooperative	Contract	Contract
	Level of service:	24hr. 7da/wk	8hr. 7da/wk	16hr. 7da/wk	8hr. 7da/wk	80hr./wk.	40hr./wk.
Capital							
Vehicle		$ 1,713	$ 1,321	$ 4,852	$ 2,497	$ 2,497	$ 2,497
Equip. a/		$ 1,171	$ 1,138	$ 1,151	$ 1,138	$ 491	$ 474
Uniforms		$ 298	$ 149	$ 224	$ 149	$ 149	$ 75
Office space		$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
Sub-Total		$3,182	$2,608	$6,227	$3,784	$3,137	$3,046
Operating							
Salaries		$58,284	$22,908	$44,134	$22,908	$15,693	$ 7,846
Vehicle		$ 2,167	$ 1,466	$ 4,722	$ 3,254	$ 2,790	$ 2,511
Office over head		$ 0	$ 0	$ 0	$ 0	$ 2,668	$ 1,334
Other b/		200	200	200	200	200	200
Sub-Total		$60,651	$24,574	$49,056	$26,412	$21,351	$11,891
Total costs		$63,833	$27,182	$55,283	$30,196	$24,488	$14,937

a/ Includes annual costs of investigation, communications, office, fire arms and auxillary equipment.

b/ Includes annual costs of ammunition, traffic ticket forms, etc.

Figure 6. User Form Developed to Record Budget Estimates

service would be appropriate for the contracting alternative.

With equal cost sharing under the cooperative delivery system, Medford and Pond Creek would each bear $27,642 ($55,283 ÷ 2) or $15,098 ($30,196 ÷ 2) of the cost of police service under alternative 3 or 4, respectively. However, decisionmakers in Pond Creek may feel that their share is too high for their size community and that cost sharing according to the estimated calls for police service would be more equitable. In the example, 234 total calls (Medford: 163 + Pond Creek: 71) are estimated annually for the combined service area. Medford would have 69.7 percent of the total calls while Pond Creek would have 30.3 percent. Multiplying these percentages times the total cost of police service would yield cost shares according to calls for police services. Medford's share would be $38,532 ($55,283 x .697) under alternative 3 or $21,047 ($30,196 x .697) under alternative 4. Pond Creek's share would be $16,751 ($55,283 x .303) or $9,149 ($30,196 x .303) under alternative 3 or 4, respectively.

Cost shares based upon estimated calls for police services can be computed in a similar manner under the contract delivery system. For example, decisionmakers in Medford may feel that something less than the total cost under alternatives 5 and 6 (Figure 6) should be paid, since the officer(s) assigned to Medford perform duties outside city limits. In a manner similar to the cooperative delivery system, the total number of calls, percentage of total calls for Medford, and cost shares can be estimated. Applying the estimated procedure (Form I) yields an estimate of 200 annual calls (Medford: 163 + surrounding Census County Division: 37 = 200) for the combined service area. Calculating the percentage of total calls occurring in Medford (163 ÷ 200 = 81.5 percent) and multiplying this percentage times the estimated total annual costs under alternatives 5 and 6 yields Medford's share. Cost estimates of $19,958 ($24,488 x .815) under alternative 5 or $12,174 ($14,937) x .815) under alternative 6 are obtained using this procedure. The remaining cost would have to be borne by the sheriff's department out of the budget approved by the County Commissioners. The sheriff or County Commissioners may be willing to bear this amount since the level of coverage in the open country area would increase due to a larger sheriff's department. Provisions could be made for periodic adjustment of cost share based upon actual experience.

Even though it may appear that lower costs result from the joint provision of police services, other factors must also be considered. Interested municipalities should understand that control over such a delivery system has to be shared, i.e., some local control of the police force is given up. Decisions must be made on such things as number of hours spent in each town, and other operational items. In addition, local codes and laws to be enforced by the police department may need to be standardized to facilitate the police officer's job. These and other considerations need to be evaluated so that the municipality obtains the desired level of police service. Similar considerations are involved in a police service delivery system of contracting for police services with the county sheriff.

Decisionmakers in Medford need to consider not only costs but also whether a delivery system provides the desired quantity and quality of police service. Quantity of police coverage may be increased by adding more manpower or equipment to the police agency. Quality of police service may also be enhanced by expanding the agency. Quality of police service under various alternative delivery systems is difficult to evaluate. A common indicator of quality is the anticipated response time of an officer to a call. Decisionmakers must determine an acceptable response time. In urban areas, a three minute response time for emergency calls and 20 minutes for non-emergency calls is considered acceptable. In rural areas, this standard, particularly for emergency calls may be unrealistic.

Evaluation of costs, quantity and quality of alternative police service delivery systems need to be made by decisionmakers facing this problem. Cost information and other guidelines provided in this report should assist decisionmakers in evaluating various alternatives. In addition, economies of scale issues could be addressed using the budgeting techniques. However, this would require some stringent assumptions and careful application of the budgeting procedure.

Financial Assistance

The Law Enforcement Assistance Administration (LEAA)[2/] is a federal agency which assists state and local governments in strengthening and improving law enforcement and criminal justice. Grants are made to states primarily in lump sum amounts based upon population after approval of a state-wide criminal justice plan [37]. This plan is usually prepared as a result of requests from local governments within the state.

[2/] The Law Enforcement Assistance Administration was established June 19, 1968 by the Omnibus Crime Control and Safe Streets Act of 1968.

In Oklahoma, the Oklahoma Crime Commission (OCC) serves as the State planning and disbursing agency for LEAA grants. Some of the major programs which OCC has initiated are: (1) training for full-time law enforcement officers, (2) state-wide communications systems, and (3) special police units. The special police units program primarily provides funds to qualified local governments to hire additional manpower for an attack on specific crimes or critical areas of law enforcement. Currently, a maximum amount of $50,000 is allocated to these special police units.

In order to qualify for a grant in Oklahoma, the grantee must meet at least two criteria: (1) participate in the Uniform Crime Reporting system and (2) have 15 percent of the local government General Fund committed to law enforcement. Meeting these two standards makes a local government eligible to apply for funds.

In addition to five year funding, one year grants can be made for a specific project. Usually, this type of grant is used to purchase communications equipment, special crime prevention equipment or other special purchases. Eligibility to apply for this type of grant is determined in the same manner as for longer term grants. Interested local governments should work through their planning district office.

Police Officer Training

All full-time police officers in Oklahoma are required to complete a basic police training course within one year of accepting the position. This basic course is established and implemented by the Law Enforcement Training Council. The complete course consists of 160 hours of training in 8 major subject areas.[3/] To complete the instruction, a total of 20 days, 8 hours per day, is required.

The Law Enforcement Training Council maintains a permanent training facility in Oklahoma City, where trainees can attend the 20 day school. In addition, various subject areas are covered in training sessions held at different towns around the state. These sessions are usually scheduled only as the need arises and the council attempts to offer the training in a centrally located town.

Training for full-time police officers is provided by the Council at no extra cost to the officer or his police agency. Transportation, room and board are furnished by the Council. The employing police agency usually continues to pay the officer's salary while he attends the course and the department may hire temporary help while the officer is being trained. The Law Enforcement Training Council has no authority to train any reserve police officers. These officers must obtain what training they can from the full-time officers that they assist.

Auxiliary Police Organizations

Many existing law enforcement agencies in the study area have Auxiliary Police Organizations. Most auxiliary forces are organized under the Civil Defense Auxiliary Program under state statutes [41]. These organizations are made up of local residents who volunteer their time and usually receive no direct compensation. These volunteers are often called upon during emergency situations or to increase manpower

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[3/] Subject areas include Red Cross (2 days), Traffic (2 days), Criminal law (3 days), Crime Scene and Searching (2 days), Firearms (3 days), Arrest (2 days), Patrol (2 days) and General subjects (4 days).

at local athletic events. In most cases, permission from local civil defense directors is needed before these forces can be deployed. Local officials should investigate the legal responsibilities of the entity using these forces, as well as the individuals participating in these organizations. The city or county attorney should be able to provide this information. These organizations usually try to provide themselves with some funds through organizational activities such as raffles.

CHAPTER V

OPTIMUM LOCATIONS OF OFFICERS AND ASSOCIATED COSTS

A county sheriff has the responsibility for law enforcement for an entire county. As a part of this responsibility, members of the sheriff's department must respond to calls for service anywhere in the county. Calls for service may originate from any part of the county, with some areas having a higher frequency of calls than others. This would indicate that the sheriff must make some decision as to the location of his available manpower. In his decision, the spatial distribution of calls for service must be considered as well as costs and quality of service measured in terms of response time, associated with various officer locations.

In an effort to develop decisionmaking aids for decisions on location of manpower, results from a general transportation model were combined with a budget analysis. This combination gives the decision-maker information related to response time from various officer locations as well as the costs of operation associated with a level of service and officer location. Tradeoffs between costs and quality of service can then be evaluated.

Theoretical Model

The model uses two analytical tools: a general transportation model, and a budget analysis. The transportation model is used to derive conditional[1/] optimum location(s) under various objectives. The budget analysis is used to derive cost data for each alternative location combination identified with the transportation model.

The General Transportation Model

The transportation model [22] is a linear programming procedure which seeks to minimize a linear objective function with respect to a specific type of constraint. Definitions for the model are:

m = number of potential locations of police officers,

n = number of locations of police service users,

a_i = police service capacity at the ith police officer location, where $i = 1, \ldots, m$,

b_j = amount of police services demanded by the jth location of police service users, where $j = 1, \ldots, n$,

X_{ij} = amount of police services to be supplied by an officer location i to service users at location j which minimizes, for example, total transportation costs,

C_{ij} = "cost" of supplying one unit of police service from police officer location i to each user location j. Possible units of "cost" measurement include one-way miles or minutes of response time, and

$C_{ij}X_{ij}$ = cost of supplying X_{ij} units of police services from police officer location i to any user at location j.

[1/] The term conditional was used since one officer location was predetermined with the sheriff being located in the county seat.

The transportation problem can be stated in mathematical relationships as follows (see Figure 7):

Minimize:

(1) $$Z = \sum_{i=1}^{m} \sum_{j=1}^{n} C_{ij} X_{ij}$$

Subject to the constraints:

(2) $$\sum_{j=1}^{n} X_{ij} = a_i, \text{ where } i = 1, 2, \ldots, m$$

(3) $$\sum_{i=1}^{m} X_{ij} = b_j, \text{ where } j = 1, 2, \ldots, n$$

(4) $$X_{ij} \geqq 0$$

(5) $$\sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j$$

Given a service capacity for various locations of police officers (a_i), a demand for these services at each consuming center (b_j), and associated costs in terms such as miles, dollars, or response time in minutes (C_{ij}), this procedure can be used to determine the service capacity and the optimum placement of that capacity to serve each consuming center. This procedure was applied to the problem of location of a various number of police officers under a county-wide law enforcement system.

Certain assumptions must be satisfied before the transportation procedure can be used. These assumptions are:

1. Services being provided by each of the various officer locations are homogenous. In other words, availability of services at each origin will equally satisfy the demands in any service user location (equation 2).

2. Service capacities at various origins and demands of various locations of service users are known, and total demand must equal total capacity (equation 5). When discrepancies occur between service capacity and user demand, a dummy service capacity or user demand vector is used to produce equality. This dummy vector is used to signify unused capacities or unsatisfied demands.

Demand for Police Services at User Locations							Service Capacity
i/j	1	2	...	j	...	n	
1	X_{11}	X_{12}	...	X_{ij}	...	X_{1n}	a_1
2	X_{21}	X_{22}		X_{2j}		X_{2n}	a_2
:	.	.	...	.	...	.	.
i	X_{i1}	X_{i2}		X_{ij}		X_{in}	a_i
:	.	.	...	.	...	.	.
m	X_{m1}	X_{m2}	...	X_{mj}	...	X_{mn}	a_m
Service Demand	b_1	b_2	...	b_j	...	b_n	Total

Figure 7. Tableau Format of the Transportation Model

3. Costs of providing services by any one origin to other locations of service users are known, and are independent of the amount of services provided. That is, there is a constant per unit cost of service provided between locations.

4. There is an objective function to be optimized (equation 1).

5. The activities cannot be executed at negative levels (equation 4).

Defining Objectives. Adequately defining objectives for location of emergency services has probably been the major stumbling block to application of quantitative analysis. Since emergency services deal directly with protection of human lives, there is an absence of some overriding objective defining social utility. However, objectives used in this procedure are believed to closely approximate the thought process of service users and decisionmakers.

Two objectives were identified for use in the location analysis. These were:

I. To minimize the maximum response time to reach any user location.

II. To minimize average response time to reach any user location.

These objectives are centered around the idea that both service users and decisionmakers tend to partially identify quality of emergency service with response time (i.e., the lower the response time, the higher the quality of service). "Federal Bureau of Investigation (FBI) studies indicate the clearance rate[2/] of crimes goes up as response time of patrol units is reduced" [32, p. 193]. The two objectives were

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[2/] The clearance rate indicates the proportion of reported crimes for which: (1) an offender has been identified by a law enforcement agency, (2) enough evidence exists to press charges, and (3) suspect is taken into custody. Clearances are also reported when circumstances beyond law enforcement control precludes formal charges.

designed to reflect these ideas and to also allow some quantifiable measure of quality.

Location Procedure. In order to adapt the general transportation procedure for use in this problem, certain modifications were necessary. When objective I was used, each service user location was given a value of 1 (i.e., $b_j = 1$, where $j = 1, \ldots, n$). The officer location(s) which had the smallest solution value (i.e., $\sum_{i=1}^{m} \sum_{j=1}^{n} C_{ij}X_{ij}$) represented the optimum solution and the officer location(s) which minimize the maximum response time. When objective II was considered, each user location was given a value equal to the annual number of calls for police service (i.e., b_j = number of calls, where $j = 1, \ldots, n$). The officer location(s) with the smallest solution value (i.e., $\sum_{i=1}^{m} \sum_{j=1}^{n}$ represents the optimum solution and the location(s) which minimize the average response time. Given that officers are to be placed in $k \leq m$ locations and given each objective, a complete enumeration of all possible combinations of m locations taken k at a time yields the optimum solution. The algorithm [22] provides the necessary data to derive maximum and average distances for each combination of officer locations.

Budget Analysis

Budget analysis for officer location combinations selected from the transportation analysis can be performed using the procedure developed in Chapter IV. This analysis provides estimates of costs of police service for the selected location combinations and levels of coverage.

Application of the Model

Application of this two-step model was made for Grant County, Oklahoma. Characteristics of this Great Plains county were discussed in Chapter III. This model may be applied to other service areas as long as assumptions and data requirements are met.

Location Analysis

In order to carry out the location analysis, three data elements must be determined. First, potential location(s) of police officers must be identified. Second, demand areas must be delineated. Third, the number of calls for police service must be estimated for each demand area. Each of these steps are discussed in detail in the following paragraphs.

Nine incorporated towns in Grant County were considered as potential locations for police officers. These were: Deer Creek, Jefferson, Lamont, Manchester, Medford, Nash, Pond Creek, Renfrow, and Wakita (Figure 8).

Thirty demand areas were delineated along township lines. Demand areas were numbered from the Northwest corner of the county to the Southwest corner and then back toward the North. One-way road mileage was computed from each of the nine potential locations to the center of each of the 30 demand areas. These data constitute the "costs" in miles of responding to calls for service from each officer location.

The number of calls for service were estimated for the open country area and the municipalities within the county. Population estimates [38] were made for the open country area within each of the 30 demand areas. These estimates were used to allocate the total number of open

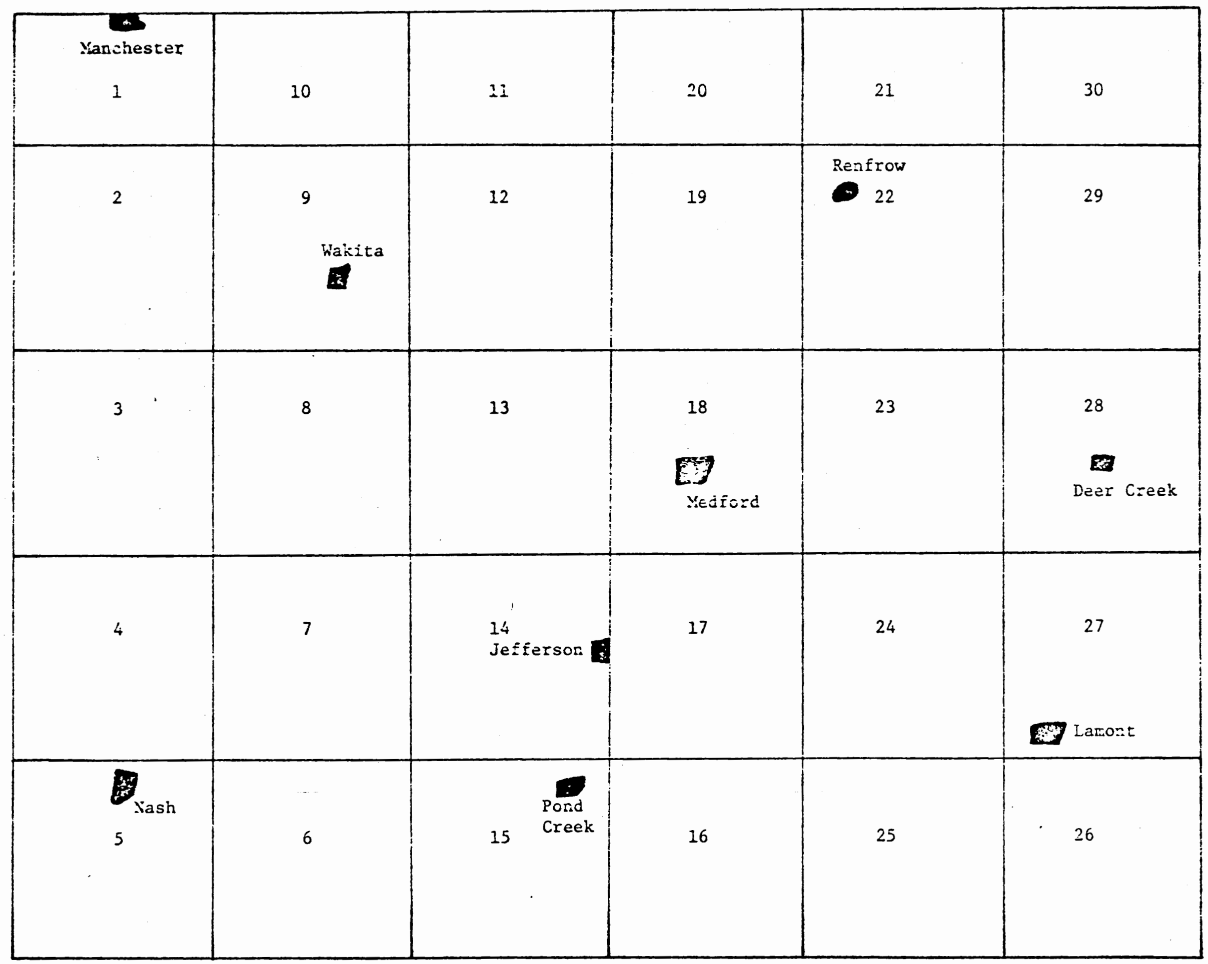


Figure 8. Supply Points and Demand Areas

country calls for service among these demand areas based upon the proportion of the total open country population residing in each demand area. If a demand area contained a municipality, then call for service estimates for that municipality were added to the open country calls for service. For the entire county, the estimated number of calls for service was 425.

To determine the optimum location(s) under each objective, a complete enumeration of all possible combinations of the 9 locations taken 1, 2, ..., 9 at a time must be considered. For example, if two locations are desired, then $\binom{9}{2} = 36$ transportation problems would have to be solved under each objective in order to find the optimum location. However, in the case of a county sheriff, he must maintain an office in the county seat of the county. Thus, one location is already determined. This situation affects the application of the model to Grant County. There are no longer 9 possible locations, but rather only 8 possible locations for officers. The number of transportation problems to be solved is reduced to $\binom{8}{k}$, where k- m, (where m = 8). This modification meant that Medford, the county seat, was included in each location combination. Thus, the best location(s) of officers was obtained, given that at least one officer must be located at Medford. Best locations were obtained for one, two, and three additional officer locations as well as the accompanying quality of service indicator's for the location(s) under each objective.

Location analysis was conducted under two different conditions. One location analysis was performed for a situation where all calls for service occurring in Grant County are handled by the sheriff's department. A second analysis was conducted for a situation where only the calls for service originating from the open country areas and towns without a police agency were considered. Four of the possible locations in Grant County had police departments which would answer calls for service occurring in their municipalities. These were: Lamont, Medford, Pond Creek, and Wakita. Only calls from unprotected towns and open country areas were considered in the second analysis. A total of 149 calls for service were estimated under the second application.

Budget Analysis

Budgets are defined as a plan for the future in which all items of costs and returns are estimated. Following procedures developed in Chapter IV, budgets were developed for locations chosen after application of the transportation model.

The following assumptions were made for the budget analysis:

1. A new, fully equipped patrol car is purchased for each new officer hired. Mileage allowances are not paid to operators of departmental vehicles, but these allowances (15¢/mile) are paid to officers using their own vehicles.

2. Mobile communications equipment, firearms, auxiliary equipment, and uniforms are purchased for new officers.

3. No new investigation or office equipment will be purchased and no additional office space is provided.

4. The sheriff, undersheriff, dispatchers or secretaries will be stationed at Medford, while any deputies are subject to being placed at other locations.

5. Salaries are computed using the average for the study area.

6. No additional dispatchers or secretaries are hired.

Both capital and operating costs were included in the budget analysis.

Results

Optimum location(s) for police officers in Grant County, Oklahoma under the two objective functions are shown in Table XII. Quality of service indicators and costs of operation for these locations are shown in Table XIII and Table XIV, respectively. Results of the location analysis are discussed first, followed by the budget analysis.

Location Analysis. If response time is to be minimized with the location of two officers and county-wide calls are to be answered then the first choice location combination is Medford, Pond Creek and Wakita (Table XII). The second choice is Medford, Lamont and Wakita. With officers at the first choice location combination, maximum distance traveled would be 18 miles while the average would be 5.8 miles (Table XIII). These mileages can be converted to response time in minutes by making an assumption concerning the rate of speed of a police vehicle. If 60 miles per hour (mph) is used, then the mileages can be read as minutes. Thus, the maximum response time for the first choice location combination would be 18 minutes and an average response time of approximately 6 minutes. The second best choice has a higher maximum and average response time than the first choice location combination. As the number of officer locations are increased, maximum and average response times are at least as low or lower as with fewer locations.

Officer location combinations under the first objective were the same if all calls occurring in the county were handled or if only calls from the unprotected areas were considered. Thus, maximum distances are the same, but average distances change because of the different mileages involved. Average distances are higher when only calls from unprotected towns and open country areas are considered.

TABLE XII

BEST LOCATIONS[a] FOR VARIOUS NUMBER OF ADDITIONAL LOCATIONS OF OFFICERS UNDER ALTERNATIVE OBJECTIVES AND SERVICE AREAS, GRANT COUNTY, OKLAHOMA, 1978

Objective and Service Area	Choices: First	Choices: Second
I. Minimize the maximum response time:		
1. one officer	Wakita	Nash
2. two officers	Pond Creek, Wakita	Lamont, Wakita
3. three officers	Deer Creek, Pond Creek, Wakita	Deer Creek, Nash Wakita
II. Minimize the average response time:		
a. County-wide		
1. one officer	Pond Creek	Jefferson
2. two officers	Pond Creek, Wakita	Manchester, Pond Creek
3. three officers	Deer Creek, Pond Creek, Wakita	Deer Creek, Manchester, Pond Creek
b. Rural towns and open country		
1. one officer	Nash	Manchester
2. two officers	Manchester	Deer Creek, Nash
3. three officers	Deer Creek, Manchester, Nash	Deer Creek, Nash Wakita

[a]Medford is included as a location in each combination.

TABLE XIII

RESPONSE TIME IN MILES FOR VARIOUS NUMBER OF ADDITIONAL LOCATIONS OF OFFICERS UNDER ALTERNATIVE OBJECTIVES AND SERVICE AREAS, GRANT COUNTY, OKLAHOMA 1978

Objective and Service Area	Choice			
	First		Second	
	maximum distance	average distance[a]	maximum distance	average distance
I. Minimize the maximum response time:				
a. County-wide				
1. one officer	24.0	8.4	24.0	8.5
2. two officers	18.0	5.8	24.0	7.2
3. three officers	18.0	4.4	19.0	5.7
b. Rural towns and open country areas				
1. one officer	24.0	12.1	24.0	12.2
2. two officers	18.0	10.5	24.0	11.6
3. three officers	18.0	8.5	19.0	7.2
II. Minimize the average response time:				
a. County-wide				
1. one officer	28.0	7.4	28.0	8.3
2. two officers	18.0	5.8	19.0	6.0
3. three officers	18.0	4.4	19.0	4.7
b. Rural towns and open country areas				
1. one officer	24.0	12.2	24.0	12.5
2. two officers	24.0	8.8	23.0	9.1
3. three officers	19.0	6.7	19.0	7.2

[a]Average distances are calculated as $\frac{\sum_{i=1}^{m}\sum_{j=1}^{n} c_{ij}X_{ij}}{\sum_{j=1}^{n} b_j}$ and represent the average distance traveled to handle all calls occurring in the service area.

TABLE XIV

COST OF OPERATION FOR VARIOUS NUMBER OF LOCATIONS OF SHERIFF'S OFFICERS UNDER ALTERNATIVE OBJECTIVES AND SERVICE AREAS, GRANT COUNTY, OKLAHOMA

Objective and Service Area	Choice	
	First	Second
	-dollars-	
I. Minimize maximum response time:		
a. County-wide		
1. one officer	41,473	41,471
2. two officers	49,697	49,972
3. three officers	58,121	58,246
b. Rural towns and open country areas		
1. one officer	40,973	40,897
2. two officers	49,427	49,506
3. three officers	57,845	57,801
II. Minimize average response time:		
a. County-wide		
1. one officer	41,347	41,456
2. two officers	49,697	49,725
3. three officers	58,121	58,146
b. Rural towns and open country areas		
1. one officer	40,897	40,957
2. two officers	49,400	49,409
3. three officers	57,783	57,801

Under the second objective, with all calls being answered, officer location combinations were mainly different from those under the first objective (Table XII). Only the first choice locations for three officers were the same or lower for all officer locations under objective II versus those under objective I.

Officer location combinations, selected when calls for service from the unprotected areas are considered, were not the same as those selected when all calls were handled. These locations had higher average distances traveled than when all calls were considered. The average distances were the same or lower than locations selected under objective I for the same area.

Budget Analysis. Annual costs of operation are associated with each location combination. Capital and operating cost estimates were made for each location combination and total costs are indicated in Table XIV.

For the same number of officer locations the costs of operation varied under each objective and service area. Location combinations selected under objective II had the same or lower costs than those selected under objective I. Slightly higher costs are incurred when all calls county-wide are answered.

Costs of providing police service increased greatly as officer locations are added. New deputies must be hired and equipped in order to reach higher levels of service. For example, under objective II and answering all calls county-wide from the first choice locations of Medford and Pond Creek would cost $41,347. From this location combination, the maximum response distance is 28 miles and the average distance is 7.4 miles. By locating an additional officer at Wakita (i.e., the first choice locations for two officers), the maximum response distance decreases by 10 miles and average distance decreases by 1.6 miles. However, costs of providing the higher level of service increases by $8,350. This indicates the tradeoff that exists between the costs of a level of service and the quality (indicated by changes in response time) of service.

Providing this type of information to decisionmakers should increase their understanding of the implications and tradeoffs involved in various decisions. First, different officer locations should be chosen depending on the objective and calls to be answered. Second, costs of providing police service differ for various locations. Finally, trade-offs exist between the costs of providing police service and quality of service (as measured by response time). Thus, the decisionmaker should be in a better position to evaluate the alternatives confronting him.

CHAPTER VI

EFFICIENT PATROL ROUTES

The routing of officers to patrol a service area is a problem faced by law enforcement decisionmakers. A procedure which designs efficient patrol routes which cover all areas of a service area, yet involve the least road mileage would be very useful. Once an efficient route and the distance traveled is determined, the cost of traveling this distance in terms of time required and vehicle operation expense can be estimated. This information would provide a basis for deciding on the number of patrol tours to make, given budget constraints and other police activities.

The patrol car routing problem is basically a vehicle scheduling problem. Several computer algorithms exist which can be used to develop solutions. The one used in this study is designated ROUTE. First, the vehicle scheduling problem is discussed, followed by a detailed discussion of the ROUTE procedure, and finally ROUTE is applied to Grant County, Oklahoma.

Vehicle Scheduling Problem

A vehicle scheduling problem [19] can be described as follows: a set of customers, each with a known location and a known requirement for some good or service, is to be supplied from a single depot by delivery vehicles of known capacity. The problem is to design the vehicle routes such that total cost of delivery is minimized. This objective is subject to the following constraints:

(a) The requirements of all customers must be met;

(b) Vehicle capacity (i.e., weight, volume, etc., capabilities) is not violated;

(c) The total time or distance for each vehicle to complete its route may not exceed some predetermined value; and

(d) There is an earliest and latest time interval when a customer can accept delivery, and this may not be violated.

Determining a route for a patrol car fits the general description of a vehicle scheduling problem. Any law enforcement service area contains a set of customers or points of known geographical location. Each service area would have at least one officer located in the area (i.e., single depot), but a patrol car would not be limited by weight or volume. Thus, constraint (b) could be ignored. However, constraints (c) and (d) would be realistic constraints for a patrol route. Only a certain number of hours of police service time is available (e.g., 8 hours per day), and due to special circumstances, decisionmakers may want an officer in a particular location at a particular time during a patrol tour. This could occur due to some contractual arrangement or history of calls for service for a particular area.

ROUTE Algorithm

The ROUTE algorithm was designed to develop vehicle routing schedules. The computer routine is an operationally and computationally efficient procedure that is generalizable to many different types of vehicle scheduling problems. This computer routine was developed by

Hallberg and Kriebel at Pennsylvania State University [21] (Figure 9).

The algorithm incorporates a procedure for vehicle scheduling suggested by Clarke and Wright [11]. Initially it is assumed that there are sufficient vehicles available so that a single customer is served on each route (i.e., the number of routes equals the number of customers). This initial solution to the scheduling problem can be characterized as the worst of all possible solutions, unless it is the only solution. A decision rule is then used in an attempt to find a better solution, if one exists. There are N (N-1)/2, (where N = number of customers) possible choices of customer pairs to be linked on the same route (assuming no constraints are violated). A good decision rule would be to pair two customers on one route so that the cost saved would be the greatest from all choices available. This cost saving is determined from one of the following relationships:

$$S_{ij} = C_{oi} + C_{jo} - C_{ij} \quad \text{(symmetrical cost matrix)}$$

or

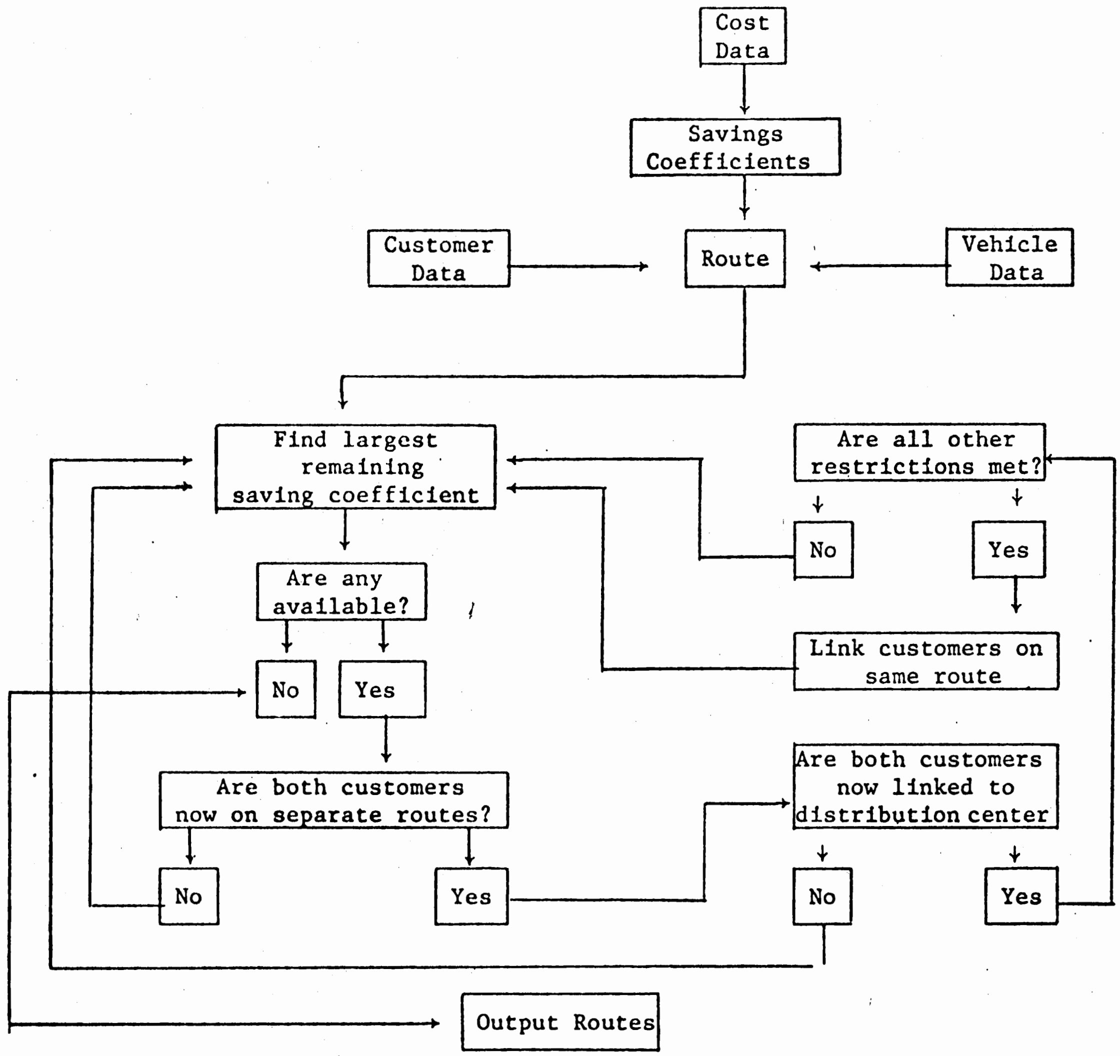
$$S_{ij} = C_{io} + C_{oj} - C_{ij} \quad \text{(asymmetrical cost matrix)}$$

where:

S_{ij} = savings coefficient associated with linking customers i and j on the same route,

C_{oi} = the least cost (in distance, time, or dollars) from the distribution center, (Ø) to customer i, (where i = 1, 2, ..., N),

C_{ij} = the least cost (in distance, time or dollars) involved in traveling from customer i to customer j (where i, j = 1, 2, N, $i \neq j$).



Source: Hallberg, Milton C. and W. R. Kriebel. Designing Efficient Pickup and Delivery Route Systems by Computer. Dept. of Agricultural Economics and Rural Sociology, Pennsylvania State University, Ag. Exp. Sta. Bul. 782, June 1972, p. 14.

Figure 9. Structure of Computer Program

For the initial state of the system (i.e., when one customer is on each route), the cost involved in serving customer i is $C_{oi} + C_{io}$ (asymmetrical cost matrix) or $2C_{io}$ (symmetrical cost matrix). Thus, by linking customers i and j on the same route, the amount saved is represented by C_{io} and C_{jo} while cost C_{ij} is incurred [19]. The total savings can be represented by one of the equations shown previously.

The algorithm calculates savings coefficients (S_{ij}) for each pair of customers for which cost data are provided. These savings coefficients are ordered from highest to lowest. The procedure begins combining pairs of customers onto the same route based upon the linking which would result in the largest savings, assuming no restrictions are violated. The routine continues linking two or more customers onto a single route until a final solution is reached at the end of N (N-1)/2 stages although not all stages result in a linking of customers.

When several customers are already linked by one or more existing routes, another decision rule is used to determine which routes to combine. The basic rule of selecting links based upon the largest saving coefficient still applies, but with the additional condition that breaking up an existing route is prohibited at any stage of the procedure. Thus, a link is selected by choosing that link with the largest saving coefficient among the possible links that exist at the current stage in the procedure.

The procedure used by ROUTE generates a heuristic solution (i.e., an optimal solution is not guaranteed). Finding the optimal solution to even a small problem of this nature is very expensive with known optimizing algorithms. This is due to the large number of possible solutions to be considered. For example, a vehicle routing problem with only 6 stops has 2,076 possible solutions. Thus, what appears as a small problem turns out to be a very large problem which is very expensive to solve with known algorithms.

Application of ROUTE

Various municipalities within Grant County were selected as officer locations based upon the results of the location analysis conducted in Chapter V. The location analysis not only provided the officer location but also indicated which demand areas or points (Figure 8, Chapter V) are served by each officer location. Patrol areas for each officer location were designed by grouping these demand areas as indicated in the location analysis. These patrol areas were designed such that all areas of the county were included. A patrol route was determined for officer location combinations selected as first choice locations in Chapter V. The number of miles incurred on each route was determined as well as time required, vehicle cost and salary expense.

There were 30 demand areas or points in the open country areas, as well as nine towns which were either officer locations or demand points. Thus, the maximum number of demand points for which a route has to be determined was 38 (assuming one of the towns was the distribution center). As more officer locations were considered, the number of demand points in each routing problem decreased.

ROUTE is capable of handling a large number of geographical locations to be served, however, only one distribution center can be specified for any one vehicle scheduling problem. In order to determine a county-wide patrol pattern, each officer location (i.e., distribution center) and its accompanying patrol area must be formulated as a separate problem. The routes for each officer location determine patrol routes covering the entire county. For instance, if two officer locations and their respective patrol areas are known, a vehicle scheduling problem would be formulated and a solution derived for each of the officer locations. Together, the two patrol routes cover the entire county. For Grant County, 20 unique vehicle scheduling problems were solved which reflected either different officer locations or patrol area configurations. These were arranged to form nine alternative county-wide patrol patterns. Each patrol route was designed to pass each demand point at least once during the tour. Vehicle routing problems for one to four officer locations were solved. As a bench mark route, a vehicle scheduling problem was formulated with Medford as a location which would serve all 38 demand points.

Results

The patrol route, miles traveled, time involved and estimated costs for the selected combinations are presented in Table XV.

As an example, with Medford (patrol pattern A) as the distribution center serving the other 38 demand points, a patrol route was developed which required approximately 7 hours to complete and resulted in 209 miles being traveled (Table XV). The time required to complete the tour is based upon a 30 miles per hour average travel speed. Vehicle operating costs amounted to approximately \$31.00. This amount is based upon a 15¢ per mile charge which should cover both variable and fixed operating costs. For this number of hours of patrol, officer's salary expense would be \$25.28. Total costs for one patrol tour would be

TABLE XV

PATROL ROUTES AND ASSOCIATED COSTS FOR VARIOUS OFFICER LOCATIONS AND PATROL AREA, GRANT COUNTY, OKLAHOMA

Officer location(s)	Patrol route	Miles traveled	Time required[a]	Vehicle operating cost[b]	Officer's salary[c]	Total route cost
			hrs.	dol.	dol.	dol.
One Location:						
Patrol Pattern A						
Medford	18, 19, 38, 22, 23, 24, 17, 32, 14, 37, 15, 16, 25, 26, 33, 27, 31, 28, 29, 30, 21, 20, 11, 12, 39, 9, 10, 34, 1, 2, 3, 4, 36, 5, 6, 7, 8, 13	209	6.97	31.35	26.28	57.63
Two Locations:						
Patrol Pattern B						
Medford	13, 32, 14, 37, 15, 16, 25, 26, 33, 27, 24, 17, 18, 19, 22, 38, 20, 21, 30, 29, 28, 31, 23	134	4.47	20.10	16.85	36.95
Wakita	12, 11, 10, 34, 1, 2, 3, 4, 36, 5, 6, 7, 8, 9	86	2.87	12.90	10.82	23.72
Total		220	7.34	33.00	27.67	60.67

TABLE XV (Continued)

Officer location(s)	Patrol route	Miles traveled	Time required[a]	Vehicle operating cost[b]	Officer's salary[c]	Total route cost
			hrs.	dol.	dol.	dol.
Two Locations (cont.)						
Patrol Pattern C						
Medford	17, 24, 33, 27, 31, 28, 29, 30, 21, 20, 11, 12, 39, 9, 10 34, 1, 2, 3, 8, 13, 18, 23, 22, 38, 19	149	4.97	22.35	18.72	41.07
Pond Creek	32, 14, 7, 4, 36, 5, 6, 15, 16, 25, 26	79	2.63	11.85	9.93	21.78
Total		228	7.60	34.20	28.65	62.85
Patrol Pattern D						
Medford	13, 12, 11, 10, 9, 39, 8, 14, 32, 17, 16, 25, 26, 33, 24, 27, 28, 29, 30, 21, 20, 19, 38, 22, 23, 18	159	5.30	23.85	19.98	43.83
Nash	5, 6, 15, 37, 7, 34, 1, 2, 3, 4	86	2.87	12.90	10.81	23.71
Total		245	8.17	36.75	30.79	67.54
Three Locations						
Patrol Pattern E						
Medford	13, 19, 22, 38, 20, 21, 30, 29, 31, 28, 27, 33, 18, 24, 17, 23	100	3.33	15.00	12.57	27.57

TABLE XV (Continued)

Officer location(s)	Patrol route	Miles traveled	Time required[a]	Vehicle operating cost[b]	Officer's salary[c]	Total route cost
			hrs.	dol.	dol.	dol.
<u>Three Locations</u> (cont.)						
Patrol Pattern E (cont.)						
Pond Creed	32, 14, 7, 36, 5, 6, 15, 16, 25, 26,	79	2.63	11.85	9.92	21.77
Wakita	8, 4, 3, 2, 1, 34, 10, 11, 12, 9	69	2.30	10.35	8.67	19.02
Total		248	8.26	37.20	31.16	68.36
Patrol Pattern F						
Medford	3, 8, 13, 18, 17, 24, 33, 27, 31, 28, 23	77	2.57	11.55	9.69	21.24
Pond Creek	32, 14, 7, 36, 4, 5, 6, 14, 16, 25, 26	79	2.63	11.85	9.92	21.77
Wakita	12, 19, 22, 29, 30, 21, 38, 20, 11, 10, 34, 1, 2, 9	84	2.80	12.60	10.56	23.16
Total		240	8.00	36.00	30.17	66.17
Patrol Pattern F						
Manchester	1, 2, 9, 39, 11, 10	41	1.37	6.15	5.15	11.30
Medford	17, 32, 14, 16, 25, 26, 33, 27, 24, 28, 31, 29, 30, 21, 20, 19, 12, 8, 13, 18, 23, 22, 38	160	5.00	22.50	18.85	41.35

TABLE XV (Continued)

Officer location(s)	Patrol route	Miles traveled	Time required[a]	Vehicle operating cost[b]	Officer's salary[c]	Total route cost
			hrs.	dol.	dol.	dol.
Three Locations (cont.)						
Patrol Pattern F (cont.)						
Nash	5, 6, 15, 37, 7, 3, 4	56	1.87	8.40	7.04	15.44
Total		247	8.24	37.05	31.04	68.09
Four Locations						
Patrol Pattern G						
Deer Creek	30, 29, 23, 24, 33, 26, 27, 28	67	2.23	10.05	8.42	18.47
Medford	22, 38, 21, 20, 19, 18, 13, 17	59	1.97	8.85	7.43	16.28
Pond Creek	32, 14, 7, 36, 5, 6, 15, 16, 25	67	2.23	10.05	8.42	18.47
Wakita	8, 4, 3, 2, 1, 34, 10, 11, 12, 9	69	2.30	10.35	8.67	19.02
Total		262	8.73	39.30	32.94	72.24
Patrol Pattern H						
Deer Creek	23, 24, 25, 26, 33, 27, 28, 29, 30	67	2.23	10.05	8.41	18.46
Manchester	1, 2, 9, 39, 11, 10	41	1.37	6.15	5.15	11.30

TABLE XV (Continued)

Officer location(s)	Patrol route	Miles traveled	Time required[a]	Vehicle operating cost[b]	Officer's salary[c]	Total route cost
			hrs.	dol.	dol.	dol.
Four Locations (cont.)						
Patrol Pattern H (cont.)						
Medford	18, 19, 22, 38 21, 20, 12, 8, 13, 14, 32, 16, 17	97	3.23	14.55	12.19	26.74
Nash	5, 6, 15, 37, 7, 3, 4	56	1.87	8.40	7.04	15.44
Total		261	8.70	39.15	32.79	71.94

[a]Time required based upon 30 mph average travel speed.

[b]Vehicle operating cost based upon 15¢/mile.

[c]Officer's salary based upon hourly wage rate required to meet annual salary for deputies in the study area. The hourly rate includes the base salary plus benefits, (i.e., $6,823 + $1,023 = $7,846 ÷ 2080 hr. = $3.77/hr.).

approximately $58.00. The order in which each demand point is to be served as well as the costs associated with a route are also indicated in Table XV.

As another example, consider patrol pattern E (Table XV) developed for officers located at Medford (35), Pond Creek (37) and Wakita (39) (Figure 10). Each of these officer locations had a patrol area associated with it. Separate vehicle scheduling problems were solved for each of these three locations and their respective patrol areas. The order in which each of the demand points are to be patrolled is given in Table XV. An officer located at Medford would patrol his area in the order shown and it would require three and one-half hours to complete the tour (assuming no stops are made). The officer would drive 100 miles during his patrol route at a vehicle cost of $15.00. The cost of the officer's time amounts to $12.57, which when added to vehicle cost yields a patrol route cost of $27.57. Data for the other two officers and routes are interpreted in the same manner. For the whole county, patrol costs with these officer locations and patrol areas are represented by the sum of the time and cost data for each route. Thus, for the entire county, these patrol routes would require 8.26 hours of travel time and a total cost of $68.36 each time these complete routes are made.

The same interpretation can be given for the other combinations of officer locations and patrol areas. Decisionmakers should find this information useful in deciding how much patrol service to provide, given budget constraints and hours of law enforcement manpower available.

The fewer the number of routes the less mileage is incurred on a

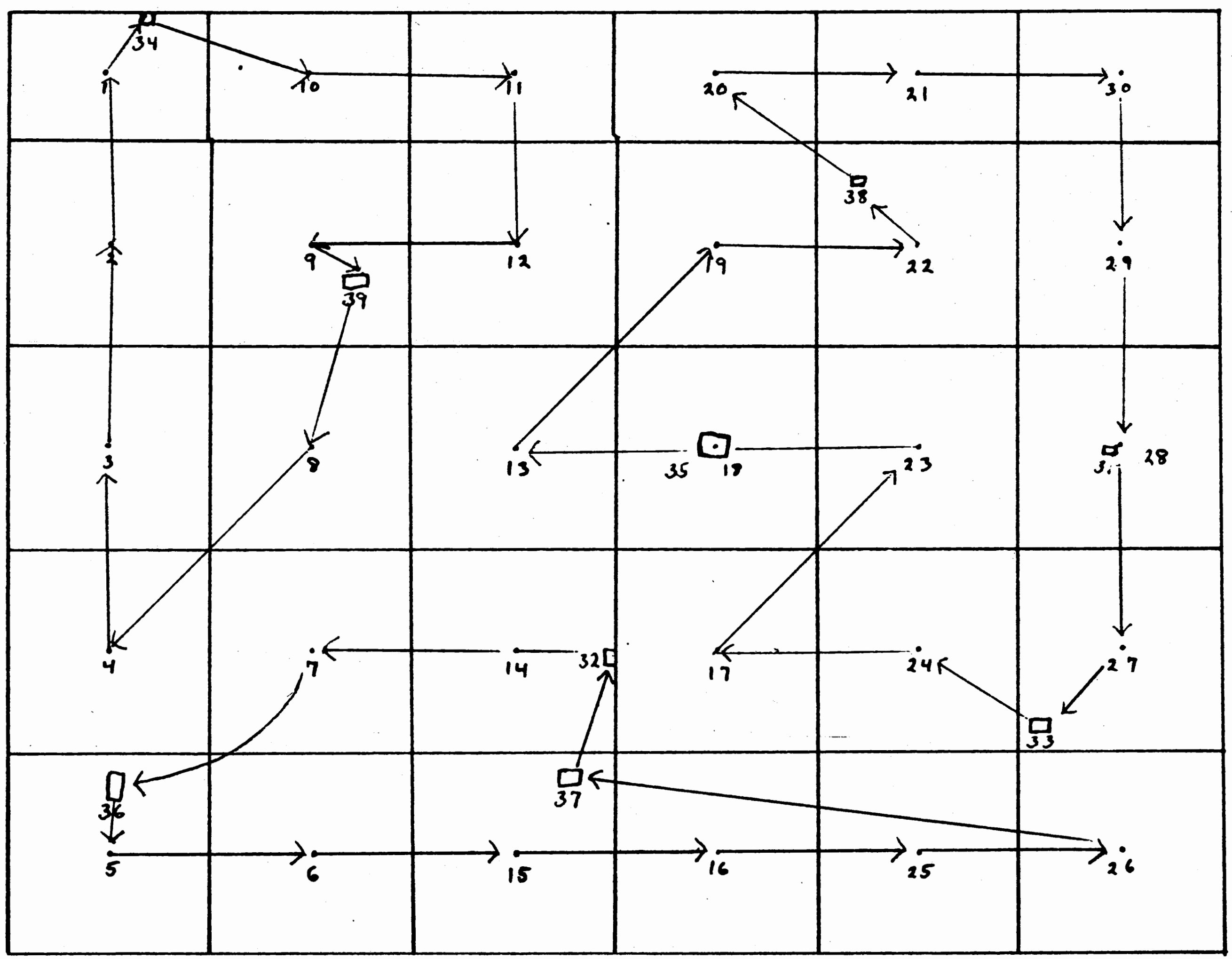


Figure 10. Example Patrol Routes Designed by the ROUTE Algorithm

county-wide basis. Patrol area configuration has some impact on miles traveled. It would appear that when smaller patrol areas within a larger area are designated, some efficiency in terms of miles traveled, and therefore cost, is lost. Thus, some efficiencies exist in patrolling one large area with a single route from a central location versus breaking the area up into smaller patrol areas, with each served by a different officer location. This loss appears to be small since the largest difference in miles traveled when one officer location is used and four locations are used in only 53 miles.

The loss in efficiency may be compensated for by other gains. Considering the type of service and ignoring the costs per tour, it may be more desirable from the service user's standpoint for the police service to have the capability to perform the patrol route more frequently. For instance, with one patrol route for the whole county, an officer spends almost his entire eight hour shift on patrol. However, with smaller patrol areas and more officer locations, an officer can make more than one patrol tour on one eight hour shift. Frequency of passing a particular point can be increased, which may be desirable as long as decisionmakers are willing to pay the additional costs of multiple tours. Also, given the analysis in Chapter V, response time is reduced when the number of officer locations are increased.

Along with some loss in route efficiency in increasing the number of officer locations, there are also some variations in the miles traveled for the same number of officer locations. Again, this is primarily due to patrol area configurations. Law enforcement decisionmakers may want to select the configuration which has the lowest number of miles traveled for the same number of officer locations. However, quality of service indicators (Chapter V) for these locations should also be considered.

CHAPTER VII

SUMMARY, CONCLUSIONS AND IMPLICATIONS

Analysis conducted in this study was designed to develop and illustrate various procedures which decisionmakers in rural areas could use in their evaluation of alternative law enforcement delivery systems, officer locations, and patrolling patterns. Forms usable by local decisionmakers were developed which permit them to estimate the number of calls for police service and evaluate organizational arrangements for the provision of police service. The location analysis provides costs and quality of service indicators for various officer locations. Procedures were developed whereby efficient patrol routes can be determined.

Estimating Annual Calls for Police Service

Regression analysis was used to develop predictive models for the annual number of calls for police service for a given service area using service area characteristics. These characteristics include service area population and the percent of that population between the ages of 15 and 35. Predictive models were developed for Part I crimes (i.e., violent and property crimes), Part II offenses, traffice related incidents (i.e., tickets and accidents), and public service items. Separate estimating procedures were developed for an open country area and municipalities. Differences in types of calls handled in these areas and institutional factors warranted the development of separate procedures. The open country procedure includes estimates of Part I crimes, Part II offenses and public service items. The municipal procedure includes estimates for these same types of calls, plus traffic related incidents.

A user form was developed which incorporates the call for service estimating procedure for each service area. This form should enhance application of the procedure by local decisionmakers. Estimates of calls for police service can be used to evaluate the capability of police manpower and equipment to handle the level of calls. In addition, a municipality considering establishing a police department can estimate the annual number of calls for service and evaluate their need for a police department. Call for service estimates may be used to calculate cost shares for governmental entities jointly producing or contracting for police service. Example applications were made for the open country area and municipalities in Grant County, Oklahoma.

Costs of Police Service Under Alternative Systems

Budgeting techniques were used to develop a procedure to estimate annual capital and operating costs of police service under alternative service delivery systems and levels of coverage. The budget procedure can be used to estimate costs of various levels of coverage under three alternative delivery systems. These were: (1) individual municipality expanding or establishing its own police department, (2) two or more closely located communities cooperating to jointly produce police services, and (3) contracting with another governmental entity (e.g., county sheriff) for police services.

With no functional standard for an adequate police agency, suggestions of knowledgeable people in the law enforcement field were used to identify items to be included in the budget. Departmental capital items included a patrol car and related equipment, investigation, office and communications equipment, uniforms, and weapons. Operating items include salaries, vehicle operation, and office overhead. Costs for these items were determined from study area data and various equipment dealers.

User forms were developed to assist in the application of the budgeting procedure. Separate forms were designed for capital and operating costs. A decisionmaker can use these forms to estimate annual costs under alternative delivery systems and levels of coverage. Another form was designed to summarize the information for alternatives considered in order to facilitate comparisons. In addition, a procedure is described whereby cost shares may be determined under cooperative or contract delivery systems. Use of the budgeting procedure is illustrated by an application to alternative organizations facing Medford, Oklahoma.

Location of Officers

The geographical location of an emergency service can affect the quality and cost of providing the service. Potential locations of police officers need to be evaluated in terms of quality and cost of service. A general transportation model in conjunction with the budgeting procedure was used to develop quality of service indicators and costs of operation for potential officer locations. This model was applied to Grant County, Oklahoma.

Given the sheriff's responsibility for county-wide law enforcement, eight potential officer locations were evaluated for locating one officer in each of one to three towns in addition to Medford, under alternative objectives. These objectives were: (1) locations which minimize the maximum response time and (2) locations which minimize average response time. Associated with the location combinations selected is an average and maximum distance to travel to respond to a call for service. These distances can be converted to minutes of response time and used as indicators of quality of service.

In addition to the quality of service information for officer location combinations, the budget procedure was used to develop annual cost estimates associated with these location combinations. Thus, decisionmakers can evaluate tradeoffs that exist for various number of locations, between the associated quality and cost of service. Application of this decisionmaking aid would require some technical assistance as well as computer facilities.

Patrolling Patterns

Once optimum officer location(s) and patrol areas have been identified, an efficient patrol route can be determined through the use of an algorithm designated as ROUTE. This algorithm was designed to find efficient solutions to vehicle scheduling problems, but it was adapted for use in this study. Not only does the algorithm determine the order in which various geographical points are visited, but it also estimates the miles traveled, time required, and vehicle and officer salary costs for a complete tour of an officer's patrol area.

The ROUTE algorithm was applied to the officer location combinations designated in the application of the general transportation model for

Grant County, Oklahoma. Efficient patrol routes were determined for various number of officer locations and patrol area configurations. Miles traveled, time required, and vehicle and officer salary costs were also calculated for each route. Given this information, a decisionmaker can decide on the frequency of patrol tours in light of budget constraints and available manpower. Similar to the general transportation model, application of the ROUTE algorithm requires technical assistance and computer facilities.

Procedures developed in this study should provide decisionmakers with techniques necessary to develop a basic set of data relevant to decisions that must be made concerning the provision of law enforcement services. Some of the procedures can be conducted by the user with little or no assistance. Procedures for evaluating officer locations and determining patrol routes require some technical assistance and computer facilities. Extension personnel can provide any needed assistance.

Implications

The findings of this study have rural development implications. The predictive procedure developed for calls for service indicates a positive relationship between number of calls and population. Assuming that calls for police service can be used as a proxy for demands for police service, then population growth resulting from rural development efforts would lead to higher demands for police service. This could result in higher expenditures by local governments for police services. Local decisionmakers need to be made aware of these effects. Planning activities for police and other services provided by the public sector need to incorporate the effects of population growth.

Improving law enforcement services in rural areas may affect other components of the criminal justice system. With higher levels of police service, more arrests and court cases may occur. These additional burdens must be considered by decisionmakers, since increases in costs could result for other elements of the criminal justice system.

Decisionmaking aids developed in this study were mainly the result of applying existing techniques to new problems. Techniques designed for other problems were adapted and applied to some very difficult, yet basic problems facing decisionmakers in rural areas. A very fertile area exists for further use of these and other techniques to provide useful information on problems related to community services.

Limitations and Further Research Needs

The limitations of this study mainly center around data and the nature of the service analyzed. Data limitations includes both scarcity of data and lack of data on some items. Much of the data on police activities had to be gathered from primary sources. This was an expensive and time consuming process. More data on these activities could have helped increase the accuracy of some of the predictive models.

This study was conducted for areas exhibiting Great Plains conditions. Thus, parameter estimates and other information is most applicable to areas with similar characteristics. However, techniques used in this study could be applied to data for other areas to develop the same type of decisionmaking aids more suitable for other areas. These techniques also have potential for application to other community services.

The patrol routes designed in Chapter VI should not be used repeatedly. Variation of starting time and direction of travel for patrol activities would help retain randomness in patrol.

Further research efforts should be directed toward determination of measures of effectiveness of additional police manpower and equipment. This information would assist decisionmakers in their determination of resource allocations among public services provided.

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APPENDIXES

APPENDIX A

BLANK FORMS

FORM I--Estimate of the number of annual calls for police service from specified service area

A. Open Country Service Area

1. Part I Offenses:

a. Estimated number of violent crimes: [(violent crime population factor) 0.0011 x (population in service area) ______] + [(violent crime age group factor) 1.8567 x (percent males aged 15-35 in service area) ______] - [(constant) 18.7720] = ______

b. Estimated number of property crimes: [(property crime population factor) 0.0136 x (population in service area) ______ + [(constant) 9.8661] = ______

2. Estimated number of Part II offenses: [(Part II population factor) 0.0024 x (population in service area) ______] + [(constant) 3.3994] = ______

3. Estimated number of other calls: [(other calls population factor 0.0052 x (population in service area) ______ + [(constant) 1.5677] = ______

4. Total Open Country Calls (1a + 1b + 2 + 3) ______

B. Municipal Service Area

1. Part I Offenses:

a. Estimated number of violent crimes: [(violent crime population factor) 0.0013 x (population in town) ______] + [(constant) 1.1778] = ______

b. Estimated number of property crimes: [(property crime population factor) 0.0141 x (population in town) ______] + [(constant) 2.9087] = ______

FORM I--Cont.

2. Estimated number of Part II calls:

   [(Part II population factor) 0.0024 x (town population) ______] + (constant) 3.3994] = ______

3. Traffic related calls:

   a. Estimated number of tickets: [(tickets population factor) 0.1775 x (town population ______] - [(constant) 131.8007] = ______

   b. Estimated number of accidents: [(accidents population factor) 0.0267 x (town population) ______] - [(constant) 12.2107] = ______

4. Estimated number of public service calls:

   [(Public service calls population factor) 0.0052 x (town population) ______] + [(constant) 1.5677] = ______

5. Total Municipal Calls (1a + 1b + 2 + 3a + 3b + 4) ______

C. Combined Service Area

[Total open country calls ______] + [Total municipal calls (i.e., all municipalities included) _____] = ______

FORM II--Service area data and decision sheet

1. Service area and population ____________________

2. Level of desired police service:

   __a. 24 hours/day - 7 days/week   ____d. 40 hours/week

   __b. 16 hours/day - 7 days/week   ____e. 20 hours/week

   __c. 8 hours/day - 7 days/week

3. Number of officers/shift ____.

4. Number of officers required for desired level of service (see Appendix B, Table XVI for manpower guidelines) _____.

5. Number of cars required: (allow one car for each single or double patrol unit on heaviest manned shift). _____

6. Mileage

   a. Estimated municipal patrol mileage:

      1. Monthly mileage = [Sq. miles factor 549.23) x (Sq. miles in city limits ____)] + [No. of police cars factor 2381.38) x (No. of police cars ___)] + [(No. of patrol officers factor (324.17) x (No. of patrol officers ____)] - [constant factor 1740.64] = ______

      2. Annual mileage = [Monthly mileage _____) x (12 months)] = __________

   b. Estimated mileage for Sheriff's duties:

      1. Civil activities mileage = [(Average rate of civil activities 20.22) x (population 42.82 ÷ 1,000)] x [Average miles per activity _____] = _________

      2. Criminal activities mileage = [(Average rate of criminal activities 102.76) x (population _______ ÷ 1,000)] x [Average miles per activity 51.06] = _______

FORM II--Cont.

3. Total annual mileage = [Civil activities mileage ______] + [Criminal activities mileage ______] = ________

7. Life expectancy of police vehicles: [80,000 miles] ÷ [annual patrol mileage ______] = [life expectancy of police vehicles _______]

FORM III--Procedure to estimate annual capital costs

Service Area ______________

1. Vehicle(s):

   a. (No. of vehicle(s) ___) x (cost/vehicle __________) = (initial vehicle(s) cost ___________)

   b. (Initial vehicle(s) cost ________) x (amortization factor* _________) = annual vehicle capital costs ______

   *Appropriate amortization factor for life expectancy (__ years) and an assumed rate of interest (__ percent); see Appendix B, Table XVII.

2. Investigation equipment: (cost of equipment ________) x (_________ amortization rate corresponding to assumed interest rate and 10 year repayment period) = ______

3. Communications equipment:

   a. (Cost of tower ____) + (Cost of control station ________) = (Total base unit cost ________)

   b. (Cost of mobile radio unit _______) x (No. of patrol cars ____) = (Total cost of mobile units _______)

   c. [(Total base unit cost _______) + (Total cost of mobile units _______)] x .17 = (Installation and maintenance cost ______)

   d. Sum of 3a + 3b + 3c = Initial communications equipment cost __________

   e. (Initial communications equipment cost _______) x (amortization factor __________ for assumed life expectancy* and interest rate) = annual communications equipment costs

   *A reasonable life expectancy for this equipment is 10 years.

FORM III--Cont.

4. Office equipment: (cost of equipment ______) x (_______ amortization rate corresponding to assumed interest rate and 10 year repayment period) ______

Firearms and auxiliary equipment:

a. Items needed by each officer
   Firearms: individual officer (No. of officers ____) x (cost/handgun ______) = (total cost for handguns ____)
   Auxiliary equipment: (No. of officers ____) x (cost/night stick + handcuffs + flashlight _______) = total cost for individual officers items _______
b. Items available to officer(s)
   Firearms: (No. of officers)/shift _____) x (cost/shotgun or rifle _____) = (additional weapons cost _____)
   Auxiliary equipment: (No. of vehicles/shift ____) x (cost/gunlock _____) = (total gunlock cost ______). (Cost of radar unit _________). (Total gunlock cost _______) + (cost of radar unit _______) = (Total additional items _______)
c. Total
   Firearms: (Total cost of handguns _____) + (total cost of additional weapon(s) ______) x (amortization factor for assumed rate of interest and 20 year life expectancy ___________) = (annual capital costs for firearms _____)
   Auxiliary equipment: (total cost for individual officer items _____) + (total cost for additional items ________) x (amortization factor for assumed rate of interest and 8 year life expectancy ________) = (annual capital cost for auxiliary equipment ______)
d. (Annual capital cost for firearms ____) + (annual capital cost for auxiliary equipment ______) = (annual capital costs for firearms and auxiliary equipment) ______

FORM III--Cont.

6. Uniforms: (No. of officers ____) x (cost/uniform/officer ________) x (amortization factor corresponding to an assumed rate of interest and 3 year life expectancy ________) = (annual capital costs of uniforms) ________

7. Office space: (cost of building _____) x (_______ amortization rate corresponding to assumed interest rate and 40 year repayment period)

8. Annual capital cost summary:

   a. Vehicle $______

   b. Equipment

      1. Investigation equipment $______
      2. Communications equipment $______
      3. Office equipment $______
      4. Firearms and auxiliary equipment $______
      5. Total equipment costs $______

   c. Uniforms $______

   d. Office space $______

   e. Total annual capital costs $________

FORM IV--Procedure to estimate operating cost

Service Area ____________

A. Salaries

1. Chief $______
2. Assistant Chief (optional) $______
3. Patrolman: (___ no. of patrolmen) x (annual salary ______) $______
4. Dispatcher(s): (_____ no. of dispatchers) x (annual salary ______) $______
5. Secretary or clerk: (_____ no. of persons) x (annual salary ______) $______
6. Part-time and other $______

Total $______

7. Salaries $_________ x .15 = benefits $__________
8. Salaries $_________ + benefits $_________ = total salary expense $___________

B. Vehicle Operation

1. Fixed costs (no. of cars ____ x (cost/car $_____)
   Insurance (no. of cars) __ x (cost/car $___) = $______
   Tag (no. of cars) __ x (cost/car $_____) = $______
   Inspection (No. of cars) __ x (cost/car $___)= $______

   Subtotal $______

2. Variable costs
   a. Sheriff's department
      Total annual mileage _____) x (____¢ rate/ mile) = (mileage cost $_____)
      Total annual operating cost: Fixed + variable costs = Total annual cost (1 + 2a) $______
   b. Municipal department
      -1- Gas: (estimated mileage _______) ÷ (miles per gallon ___) x (price per gallon ______) = (gas expense) $______

FORM IV--Cont.

-2- Oil change: (estimated mileage ______) ÷ (miles per oil change ______) x (cost per oil change $______) = oil expense $______

-3- Tune up: (estimated mileage ______) ÷ (miles per tune up _____) x (cost per tune up $_____) = tune up cost $______

-4- Tires:

a. (maintenance cost $___ per year) x (__ no. of cars) = maintenance cost $______

b. (replacement: estimated mileage _______) , (40, 000 miles) x (cost of 4 tires $____)* = replacement cost $______

*(cost per tire $___) x 4 = (cost for 4 tires $______)

-5- Subtotal $______

d. Vehicle operating cost = (fixed vehicle cost $______) + (variable vehicle cost $______) = $_______

C. Office Overhead $_______

D. Other Costs $_______

E. Total Operating Costs $_______

FORM V. Procedure used to compare estimated annual costs of alternative law enforcement delivery systems.

Costs		(1)	(2)	(3)	(4)	(5)	(6)
	Delivery system:						
	Level of service:						
Capital							
Vehicle		$	$	$	$	$	$
Equip. a/		$	$	$	$	$	$
Uniforms		$	$	$	$	$	$
Office space		$	$	$	$	$	$
Sub-Total		$	$	$	$	$	$
Operating							
Salaries		$	$	$	$	$	$
Vehicle		$	$	$	$	$	$
Office over head		$	$	$	$	$	$
Other b/							
Sub-Total		$	$	$	$	$	$
Total costs		$	$	$	$	$	$

a/ Includes annual costs of investigation, communications, office, fire arms and auxillary equipment.

b/ Includes annual costs of ammunition, traffic ticket forms, etc.

APPENDIX B

TABLES

TABLE XVI

STATISTICAL INFORMATION FOR EQUATIONS AND COEFFICIENTS ESTIMATED USING REGRESSION TECHNIQUES, WESTERN OKLAHOMA

Service area and dependent variable	Intercept	Coefficient of independent variable		$\bar{R}^2$ [5]	Calculated F
		POP[1]	PMAGP[2]		
Open Country					
Part I					
Violent crime	-18.7720*	0.0011**	1.8567**	.236	13.222**
	(-2.39)	(3.19)	(3.04)		(.0001)[4]
Property crime	0.8661	0.0136**	--	.560	101.414**
	(0.76)	(10.07)			(.0001)
Municipalities					
Part I					
Violent crime	1.17778	0.00134**	--	.280	51.407**
	(0.081)	(7.17)	--		(.0001)
Property crime	2.90871	0.01413**	--	.664	253.306**
	(0.42)	(15.02)	--		(.0001)
Traffic tickets	-131.80468	0.1775	--	.240	1.947
	(-0.89)	(1.39)	--		(.2977)
Accidents	-12.21068**	0.02672**	--	.965	916.138**
	(-5.80)	(30.27)	--		(.0001)
All areas					
Part II	3.3994**	0.0024**	--	.210	9.76
	(2.73)	(3.12)			(0.0038)

TABLE XVI (Continued)

Service area and dependent variable	Intercept	Coefficient of independent variable POP[1]	PMAGP[2]	$\bar{R}^2$ [5]	Calculated F
All areas (cont.)					
Public Service	3.3994** (1.07)	0.005211 (5.72)	--	.490	32.72 (0.0001)

**Indicates statistical significance at 1% level.

* Indicates statistical significance at 5% level.

[1]POP = independent variable for number of people in service area.

[2]PMAGP = independent variable for percent of population that is male between the ages of 15-35.

[3]Calculated t value for coefficient.

[4]Probability of calculated F exceeding tabular value.

[5]$\bar{R}^2 = 1 - [(1-R^2) \frac{T-1}{T-R}$ where: T = total number of observations and K = total number of explanatory variables, including the intercept. $\bar{R}^2$ provides adjustments to R^2 (where $R^2 = \frac{RSS}{TSS}$) when either a different number of observations or different number of independent variables are used.

TABLE XVII

MINIMUM MANPOWER REQUIREMENTS[a] FOR SINGLE AND DOUBLE PATROL UNITS AT SELECTED LEVELS OF SERVICE

Level of Service	Single patrol units[b]/shift						Double patrol units[c]/shift					
	1	2	3	4	5	6	1	2	3	4	5	6
24 hrs./day-7 days/wk. (168 hours)	4.2[d]	8.4	12.6	16.8	21.0	25.2	8.4	16.8	25.2	33.6	42.0	50.4
16 hrs./day-7 days/wk. (112 hours)	2.8	5.6	8.4	11.2	14.0	16.8	5.6	11.2	16.8	22.4	28.0	33.6
8 hrs./day-7 days/wk. (56 hours)	1.4	2.8	4.2	5.6	7.0	8.4	2.8	5.6	8.4	11.2	14.0	16.8
40 hrs./wk.	1.0	2.0	3.0	4.0	5.0	6.0	2.0	4.0	6.0	8.0	10.0	12.0
20 hrs./wk.	0.5	1.0	1.5	2.0	2.5	3.0	2.0	4.0	6.0	8.0	10.0	12.0

Calculation of manpower requirements:

$$\text{Manpower Requirements} = \frac{\text{No. of hrs. of patrol service desired}}{\text{No. of hrs. one man works/week}} \times \text{No. of patrol units on each shift}$$

[a]Assumes number of units is same for each shift and 40 hrs. per week for each officer

[b]One officer per patrol unit.

[c]Two officers per patrol unit.

[d]Anything other than zero after the decimal point indicates a need for part-time help or the necessity for more than 40 hours to work per week. For example, with a single patrol unit per shift and a level of service of 24 hours/day-7 days/wk. the manpower requirement is 4.2. This means that 4 officers working 40 hours per week could provide this level of coverage with only one 8 hour shift (0.2 x 40 hrs. = 8 hrs.) left unfilled. This 8 hour shift could be filled by a part-time officer or the 4 full-time officers could alternate working 48 hours per week.

TABLE XVIII

AMORTIZATION FACTORS[a] FOR SELECTED LIFE EXPECTANCY AND INTEREST RATES

Life expectancy	Rate of interest				
	5	5.5	6	6.5	7
(years)	(percent)				
1	1.05	1.005	1.06	1.065	1.07
2	.53780	.54162	.54544	.54926	.55309
3	.36721	.37065	.37411	.37758	.38105
4	.28201	.28529	.38859	.29190	.29523
5	.23097	.23418	.23740	.24063	.24389
6	.19701	.20018	.20336	.20657	.20980
7	.17282	.17596	.17913	.18233	.18555
8	.15472	.15786	.16104	.16424	.16747
9	.14069	.14384	.14702	.15024	.15349
10	.12950	.13267	.13587	.13910	.14238
15	.09634	.09963	.10296	.10635	.10979
20	.08024	.08368	.08718	.09076	.09439
25	.07095	.07455	.07823	.08198	.08581
30	.06505	.06880	.07265	.07658	.08059

[a]Computed by the following formula:

$$\text{Amortization factor} = \frac{i}{1-\frac{1}{(1+i)^n}}$$

Where i = the interest rate and,

n = the number of years.

VITA 2

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