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Technical Analysis Division
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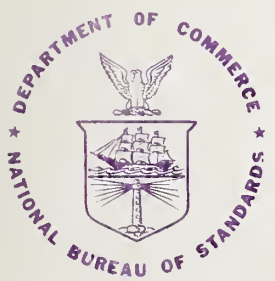

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NATIONAL BUREAU OF STANDARDS, Richard W. Roberts, Director

PREFACE

In July 1972 the National Institute of Law Enforcement and Criminal Justice, the research arm of the Law Enforcement Assistance Administration, approved and funded a project submitted by the Law Enforcement Standards Laboratory, National Bureau of Standards (NBS), to conduct a life-cycle cost analysis of police patrol car acquisition, maintenance and disposal practices. The Law Enforcement Standards Laboratory contracted with the NBS Technical Analysis Division to conduct this study and to prepare a report of its findings for distribution to State and local law enforcement agencies. The full report entitled "Life Cycle Costing of Police Patrol Cars: Efficiency in Vehicle Acquisition, Operation and Disposition", is forthcoming as a publication of the National Institute of Law Enforcement and Criminal Justice.

This summary report is intended as a convenient means of acquainting fleet managers with the research effort, as a basis for discussion of the work prior to the publication of the full report, and as an easy reference to the findings. The full report contains a large amount of descriptive information on fleet practices, life cycle costing methodology, many statistical and informational exhibits and charts, and tables of empirical data which are not included in this summary report.

The fact that the National Institute of Law Enforcement and Criminal Justice furnished financial support to the activity resulting in this publication does not necessarily indicate the concurrence of the Institute in the statements of conclusions contained herein.

ACKNOWLEDGMENT

The Technical Analysis Division extends appreciation to each of those persons and organizations who assisted in providing information to the study. Special assistance was provided by many persons in the following State and local governmental agencies: Arizona Department of Public Safety; Los Angeles Police Department; Arlington County Virginia Equipment Division; Prince Georges County Maryland Police Department; City of Jacksonville Florida, Motor Pool Division; City of Pasadena California; St. Paul Minnesota Police Department; Washington, D. C. Police Department; City of Philadelphia; Bay City Michigan Police Department; Virginia State Police; Maryland State Police; California State Highway Patrol; Mt. Ranier Maryland Police Department; City of Seattle; Alabama Highway Patrol; Honolulu Hawaii Police Department; South Carolina State Highway Department; State of New York; Illinois State Police; and by the following commercial enterprises: Mainstem, Inc., Princeton, N. J.; Peterson, Howell, and Heather, Baltimore, Maryland; Municipal Leasing Systems, Inc., Bethlehem, Pa.; Indiana Auto Auction, Inc.; Midwest Auto Sales, Inc., Dayton, Ohio; Pan-American Auto Wholesaler, Brooklyn, N. Y.; Hill and Sanders Ford, Wheaton, Md.; Rosenthal Chevrolet, Arlington, Va.; Leaseplans Development Corp.; and Arrow Leasing Co.

Thanks are due to members of the Technical Analysis Division, especially to Ms. Linda Cummings, Mr. Don Corrigan, and particularly Ms. Margery King for help in gathering information for the study; to Messrs. William Murphey and William O'Neal for assistance in data handling; and to Dr. Vartkes Broussalian and Mr. Walter Leight who reviewed the draft report and offered valuable comments. Grateful acknowledgement is also made to Mr. Jared Collard, Acting Manager of the Police Vehicle Program, Law Enforcement Standards Laboratory, who provided assistance throughout the study.

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1.0 INTRODUCTION

There are many different choices to be made with respect to police vehicle acquisition, utilization, maintenance, and disposition. Cost comparison among the different alternatives are an important element in the choices to be made. To make valid cost comparisons, it is necessary to employ the techniques of life cycle costing. This means the inclusion of all relevant costs and the conversion of costs to an equivalent basis to take into account differences in the timing of expenditures.

This report briefly summarizes the results of a larger study which investigates the life cycle costs of some of the alternatives associated with police fleet management.[1] Specific decision questions addressed by the larger study and summarized here are the following:

(1) What are the cost effects of purchasing different sizes of patrol cars and different optional equipment?

(2) What are the advantages and disadvantages of direct ownership of vehicles as compared with leasing vehicles?

(3) How do the costs of contracting out maintenance compare with costs of an in-house shop?

(4) What are the effects of alternative utilization practices on fleet costs?

(5) How often should vehicles be replaced?

(6) What method of vehicle disposition is most efficient?

The focus of the study is on police patrol cars, by far the predominant kind of vehicle in most fleets. The methods and techniques are, however, applicable to other types of vehicles.

Information for the study was obtained through interviews and correspondence with State, city, and county police fleet supervisors; interviews and correspondence with management of commercial fleet enterprises, automobile manufacturers, dealers, leasing businesses, and auto auction specialists; review and analysis of internal records, manuals, reports, data banks and surveys of police departments and other organizations; review of published literature, and attendance at meetings dealing with fleet management.

Each topic is presented approximately in the order taken in the full report. Although some cost data are included here, the extensive statistical tables and details of the cost analyses contained in the full report are not included. Also not summarized here is the extensive overview of existing fleet practices which is provided in an appendix to the full report. Current practices that are described in the full report are fleet composition, patrol car selection and accessorization, car acquisition, fleet size, car utilization practices, maintenance, and replacement policy.

2.0 LIFE CYCLE COSTING AND POLICE FLEET MANAGEMENT

The full report contains a chapter on life cycle costing methodology for the purpose of providing an understanding of the techniques used to compare costs of alternative systems. A life cycle costing (LCC) approach to fleet management examines efficiency over the life of the police transportation system, rather than focusing on only one area of cost, such as initial expenditure for one point in time. The study discusses the following procedures which are essential to performing life cycle costing:

(1) Specification of the desired objective or goal; e.g., the objective might be to secure police warning light systems with certain performance characteristics.

(2) Identification of the alternative means or systems by which the objective may be accomplished; e.g., to lease model A lights on a five year full-maintenance lease or to buy model A or model B lights.

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[1] As explained in the Preface, this report is a summary of a more extensive report entitled Life Cycle Costing: Efficiency in Vehicle Acquisition, Operation and Disposition.

(3) Calculation of all relevant cash flows, and their expected timing, associated with each alternative.

(4) Conversion of the cash flow for each alternative to an equivalent base by means of a discount factor, to reflect the opportunity cost of money.

(5) Summation of discounted costs for each alternative.

(6) Comparison of life cycle costs of alternatives, and selection of the alternative with the least life cycle costs.

Because costs of alternative systems may differ both in amount and in time of occurrence, a comparison of discounted costs over the lives of systems may differ markedly from the comparison of the undiscounted sums of present and future expenditures. For example, a comparison of the cost of two warning light systems -- an aluminum bar with 2 rotating lights at each end and a roof-mounted light with four rotating bulbs -- comparable in their level of conspicuity, showed the following. Although the bar light had a higher purchase price, the model costed was less expensive than the bubble light over the lives of the systems. Including the repetitive expenses of removal and re-installation of the systems over their expected lives and taking into account the differences in timing of expenditures resulted in a more valid comparison of costs.

The analyses of police fleet problems performed by the study shows that LCC techniques can be profitably applied to many different kinds of problems which regularly confront the fleet manager. By providing a more complete understanding of the cost effects of alternative decisions LCC can improve efficiency.

Contacts with a number of police departments, however, showed that many do not keep cost records adequate for good management control. In order to assess the effects of alternative fleet decisions, up-to-date cost information is necessary. In developing a good cost accounting system, departments may find helpful the guides, programs, and cost control systems for fleet management which are currently offered by both commercial and public organizations.

In addition to the problem of inadequate cost records, many departments appear to have the problem of faulty accounting systems which cause disincentives to efficient management. Failure to charge or credit appropriate cost centers may cause managers to neglect certain costs in their decisions. For example, it may be more profitable for departments which receive no direct credit from their used vehicles to cannibalize them for parts retrieval, rather than to sell them at the optimal time or transfer them for use by other departments of government, even if the latter means of disposition are more cost effective for the local government at large. A proper charge-back system can provide efficiency incentives.

3.0 COST SAVING PRACTICES IN BUYING AND SELLING

The study investigates managerial practices for reducing vehicle depreciation costs. Specific practices which are considered include procurement; model selection; length of ownership; selection of accessories, color, and equipment; reconditioning; timing of resale; and method of car disposal.

Procurement

A brief examination of specification preparation and bid acceptance by police departments leads to the following conclusions:

(1) Although it is not always economical to accept the lowest bid, many departments continue the practice, believing that they have no alternative or that justification for departing from low bid is too difficult. It was found, however, that procurement regulations are often written to allow exceptions to low bid acceptance. Justification of refusing low bid on the basis of projected higher eventual costs in depreciation, operation and maintenance is usually difficult. Departments appear more successful in rejecting low bid on basis of higher cost of parts, cost of changing inventory, cost of additional maintenance equipment, and cost of retraining mechanics, cost differences which are easier to document than the former.

(2) Cost may be reduced by avoiding unusual and unnecessary features in the specifications, by taking advantage of research and test results and illustrative specifications available from other departments, and possibly, by joining in group buying efforts. Although most of the major car manufacturers no longer offer quantity discounts to fleets, cost reductions in the form of special service delivery priority, or reductions in the dealer's profit margin may be attained by submission of specifications jointly with other departments. Care should be taken, however, to avoid a pitfall common to group buying: the acceptance of an unsuitable vehicle.

Model Selection, Length of Ownership, Accessorizing and Color

Based on representative purchase prices, resale values, and associated patrol car depreciation, the following conclusions are reached regarding practices for reducing depreciation:

(1) Depreciation cost on patrol cars can usually be reduced by choosing less expensive, smaller cars (provided they can be effectively used). As shown in Table 1, typical savings by a medium city department, expressed in terms of uniform annual cost, is about $140 by moving from the standard, top-of-the-line model to the standard, middle-of-the-line model, and about $160 more by moving from the middle to the standard, bottom-of-the-line model. A total savings of $300 in uniform annual cost is therefore possible by moving from the standard, top-of-the-line to the standard, bottom-of-the-line model. The potential savings by moving from standards to intermediates is even larger: a standard, middle-of-the-line car operated for one to two years by a medium size city department was found typically to cost between $500 and $600 more annually in depreciation than intermediate, middle-of-the-line models.

(2) The heavier the utilization (or the poorer the condition of the cars at time of replacement), the greater the savings in depreciation by buying bottom-of-the-line cars. The cost impact of harder utilization and poorer car condition is indicated in the table by the relatively higher depreciation typical of city-owned patrol cars as compared with that typical of State patrol cars of similar model.

(3) Extending the period of ownership reduces average annual depreciation. For example,for a standard, middle-of-the-line patrol car operated by a State highway patrol department, extending the ownership period from one to two years typically decreases annual depreciation by nearly $400, and increasing the period from two to three years, decreases annual depreciation by another $300. (The relationship between depreciation and running costs over time is covered in Section 7.0.)

(4) Purchase of expensive, luxury-model patrol cars generally cannot be justified in terms of costs alone, although they may be justifiable for other reasons, such as performance, officer morale, or appearance. If a luxury model is selected, suitable accessories, good condition, and early replacement are necessary to preserve the car's resale value, but extensive accessorizing and early replacement to preserve resale value nevertheless is not generally cost effective.

(5) Empirical data suggest that depreciation cost may be reduced by selection of "non-patrol-car" colors and color diversification within the fleet. In other words, uniform black and white vehicles have a lower resale or trade-in value than the more popular colors.

(6) Considering cost only, luxury accessories on patrol cars are seldom worthwhile, particularly in the case of bottom-of-the-line cars or those sold after several years' usage with high mileage and/or in poor condition.

(7) If middle or top-of-the-line cars are purchased and early resale is planned, inclusion of luxury accessories and elimination of the austere police car appearance will usually be desirable from the standpoint of cost.

Reconditioning, Timing of Resale, and Method of Disposition

An examination of practices surrounding patrol car disposal results in the following conclusions:

TABLE 1

Comparative Annual Ownership Costs of Standard and Intermediate Size Patrol Cars, by Model-Line, Age, and Department Type

(In dollars)

Department Type	Years Owned[1]	Standard									Intermediate								
		B-O-L			M-O-L			T-O-L			B-O-L			M-O-L			T-O-L		
		PP[2]	Resale V.[3]	AC[4]	PP	RV	AC	PP	RV	AC	PP	RV	AC	PP	RV	AC	PP	RV	AC
State	1	3185	1780	1724	3500	1960	1890	3780	2120	2038	2555	1580	1231	2695	1670	1295	2870	1780	1377
	2	3185	960	1378	3500	1050	1517	3780	1130	1640	2555	920	1034	2695	970	1091	2870	1030	1163
	3	3185	570	1108	3500	630	1217	3780	670	1318	2555	610	788	2695	620	896	2870	690	946
Medium	1	3185	1560	1943	3500	1720	2130	3780	1850	2308	2555	1410	1400	2695	1480	1485	2870	1580	1577
Size	2	3185	510	1592	3500	560	1750	3780	600	1892	2555	560	1206	2695	590	1272	2870	630	1354
City	3	3185	130	1288	3500	140	1365	3780	150	1475	2555	260	949	2695	270	1002	2870	290	1066

[1] It is assumed that cars are driven between 30,000 and 38,000 miles per year.

[2] Purchase price: estimated prices to police departments, including options, as developed in Table 3.3 of the full report.

[3] Resale value: from Table 3.6 of the full report.

[4] Annual Cost of depreciation: calculated from the following annual cost equation: AC = (P-R) (UCR; n, i) + R(i); where AC = Annual Cost, p = purchase price, R = resale value, UCR = Uniform Capital Recovery Factor, n = year, and i = interest rate. For example, annual cost of ownership for an intermediate, bottom-of-line model, owned by a medium size city is calculated as follows: AC = ($2555-260) (.4021) + 260(.10) = $949. The estimates ignore reconditioning expenses.

NOTATION: BOL, Bottom-of-the-line; MOL, Middle-of-the-line; TOL, Top-of-the-line, PP, Purchase Price; RV, Resale Value; AC, Annual Cost.

(1) Selective reconditioning appears to be efficient, with an average expenditure of approximately 10 percent of the estimated value of the car. This percentage may be increased somewhat for cars with greater potential consumer appeal.

(2) Normally it is most efficient to purchase and dispose of cars early in the model year. However, depreciation costs tend to level off between late spring and late summer, rising sharply again thereafter. In consequence, purchase and disposal delayed until spring can be further deferred without significant penalty.

(3) If enough cars in relatively good condition are available for frequent sales, retail methods of disposal -- such as a police auction -- if administratively feasible, will likely be cost effective.

(4) If cars are in poor condition, or if no good local market exists, wholesale disposal (such as consignment to an auto auctio- or sale to used car dealers or wholesalers) is relatively quick and avoids costly storage and built-in depreciation.

(5) Given an equitable cost accountability system, the transfer or sale of cars to other departments may be beneficial to police departments (as well as the local government) by reducing annual depreciation cost.

(6) Although net trade-in prices are usually low, trade-in may appeal to departments without attractive alternatives, possibly providing advantages of preferential service, convenient and timely disposal, and low disposal cost. Care must be taken to determine the true net cost of the new car/trade-in bid, since high quoted trade-in prices often mask high new car prices.

4.0 VEHICLE LEASING AND CONTRACT MAINTENANCE COMPARED WITH OWNERSHIP AND SELF-MAINTENANCE

In connection with vehicle acquisition, the study looks both at ownership and leasing. The types of leases are described and the relative merits of the different types of leases are discussed from the standpoint of police fleets. There are three basic types of leases: (1) The finance lease provides vehicles but makes no provision for maintenance and operating services. The lessee controls and pays for all maintenance and operating costs and reimburses the lessor for any resale loss (or receives any resale gain) when the vehicle is turned back to the lessor for disposition. (2) The net lease, like the finance lease, makes no provision for maintenance or operating expenses, but unlike it, is closed-end, with no financial adjustment for variation in actual depreciation. (3) The maintenance lease includes provision for some maintenance by the lessor, the amount ranging from very limited to comprehensive.

It was found that while the finance lease is the most prevalent form of lease used by private fleets, the maintenance lease is favored by many police departments. Chief reasons for preference for the maintenance lease were that: (1) it offers small and moderate size departments a possible reduction in service costs due to economies of scale achieved by the lessor, and (2) it offers departments of all sizes a possible escape from existing poor maintenance arrangements.

The claim is often made that leasing is not a viable alternative for police fleets. However, the experience of police departments with leasing suggests that such claims are not valid. Examples of actual lease arrangements were found whereby departments avoid or reduce potential problems and achieve considerable control, flexibility, and dependability with leased fleets. No impediments to police fleet leasing were discovered which by nature appear insurmountable.

After lease arrangements and police experience with leasing are considered, the costs of leasing and buying are compared. Two basic questions are addressed: (1) Is it economical to secure use of patrol cars through a lease? (2) Is it economical to secure maintenance through a lease or other contract arrangement with outside parties? The cost comparisons lead to the following general conclusions:

(1) There appears to be no general cost advantage to police departments from leasing vehicles for full-time use on a finance lease, i.e., of securing only the use of the car without provision of service. A cost comparison, shown in Table 2, of finance leasing with buying a car suitable for patrol work indicates a substantially larger cash outlay for leasing than for buying. But, the more relevant comparison of discounted cash flow shows the estimated present value of leasing to be only $164 more than purchase. Special motives,

Acquisition Cost of Purchasing Compared With Finance Leasing

A. Purchase

Initial outlay = $3553[a]

Resale Value After 24 months = 1066[b]

Calculation of Present Worth:

$$P_p = I - (F\ [\frac{1}{(1+i)^N}])$$

where

P_p = the present value of the cost of purchasing.

I = the initial outlay for vehicle purchase.

F = the resale value anticipated at the end of 24 months.

i = monthly interest rate.

N = the number of monthly interest periods.

$$P_p = \$3553 - (\$1066\ [\frac{1}{(1+.01)^{24}}])$$

$$= 3553 - (1066\ [\frac{1}{1.269}])$$

$$= 3553 - 840$$

Present worth of purchase cars = $2713

B. Finance Lease

Monthly Lease Charge for 24 month lease = $118.00[c]

Reimbursement to Lessor at 24th Month = $477.00[d]

Calculation of Present Worth:

$$P_L = A\ [\frac{(1+i)^N-1}{i(1+i)^N}] + F\ [\frac{1}{(1+i)^N}]$$

where

P_L = the present value of the cost of the lease arrangement.

A = the uniform monthly lease payments.

i = monthly interest rate of 1 percent. (For convenience of computation, a 12 percent annual interest rate is assumed here, which is equivalent to a 1 percent monthly rate.)

N = the number of monthly interest periods.

F = the reimbursement payment expected to be due at the end of 24 months.

$$P = \$118\ [\frac{(1+.01)^{24}-1}{.01(1+.01)^{24}}] + 477\ [\frac{1}{(1+.01)^{24}}]$$

$$= 118\ [\frac{0.269}{0.013}] + 477\ [\frac{1}{1.269}]$$

$$= 2501 + 376$$

Present Worth of Lease Cost = $2877

---

[a] Quoted dealer price plus $125 markup + $10 preparation charge for a standard size, middle-of-the-line car with police package.

[b] Based on a 70 percent depreciation rate over two years, the approximate average rate estimated for State Police Departments in Section 3.2.1 of the full report.

[c] Calculated by multiplying the dealer list price ($4383) times the assumed depreciation rate + a rate of dealer profit (2.0 percent + 0.7 percent = 2.7 percent). ($4383) (.027) = $118.34. This "rule-of-thumb" method for calculating monthly lease charges was suggested by Hugh J. Albert, Leasing Manager, Hill and Sanders Ford Dealership, Wheaton, Md., Interview, March 1973.

[d] The difference between the lessee's total payments and depreciation (calculated as the difference between list price and the resale value).

such as the implementation of a more regular and frequent replacement policy or the freeing of funds for alternative purposes having a higher expected rate of return may nevertheless influence some departments to consider financing of vehicle acquisition through leasing.

(2) There is a critical level of utilization, i.e., rate of use per time period, below which short-term rental of a vehicle becomes cheaper than purchase. This critical level of utilization may be approximated by computing the ratio of the annual cost of vehicle ownership to the annual cost of full-time renting. For example, if ownership costs are estimated at $3,000 per year and the rental cost (at short-term rates) for one year at $4,000, then it is cheaper to buy the vehicle if it is to be used more than 75 percent of the time, otherwise, rental is cheaper.

The report compares costs of providing maintenance through an in-house garage with costs of contracting maintenance. Exhibit 1 charts the estimated costs of the maintenance alternatives and shows the breakeven point -- that fleet size/mileage at which the alternatives are equal in cost. Based on the estimated cost data, and assuming a police shop wage rate of $8.00 per hour and outside charge of $12.00 per hour, the breakeven point comes at approximately 95 vehicles/3,325,000 miles, at a cost of about $200,000. With smaller fleets/lower mileage, contract-maintenance appears to be cheaper; with larger fleets, self-maintenance appears cheaper.

To test the sensitivity of the analysis to the specific cost assumptions, the breakeven point is recomputed for alternative wage rate differentials and equipment and building expenditures. For a police labor rate of $5.00 per hour and a private garage rate of $15.00 per hour, the estimated equivalent annual cost of ownership for 95 vehicles becomes approximately $168,000, while the estimated annual contract cost is slightly more than $250,000 for 95 vehicles. Only at fleet sizes as small as 10 to 15 vehicles is contracting-out more economical than self-maintenance. Of course, a relative change in labor rates in the opposite direction can be expected to have an opposite effect, pointing up the need to make comparisons based on actual inputs encountered in a given situation.

The analysis indicates the following:

(1) Even if wage rates in police shops are substantially below labor rates for commercial garages (say, $5.00 per hour compared with $15.00 per hour), contracting maintenance appears the more efficient policy for fleets of fifteen cars or less.

(2) If there is little wage differential between police shops and commercial garages, contracting maintenance appears cheaper than self-maintenance even for fleets as large as 100 cars.

(3) Even for very large fleets, contract maintenance may offer an efficient short-term solution to existing arrangements which provide poor service.

(4) Due to possible reductions in in-house administrative cost, a full-maintenance lease (offering both finance and service) may be an efficient means of contracting out maintenace, even though the finance aspect of the lease by itself offers no particular advantage.

5.0 OPERATING AND MAINTENANCE COSTS

The study discusses operating and maintenance costs for patrol cars, presents empirical data for cars of different sizes and for cars used at different rates and driven in different environments, and discusses means of cost reduction.

Based on a sample of more than one thousand patrol cars operating in twenty-nine cities, the study concludes that selecting smaller cars for patrol work offers savings in fuel costs, but may not offer the savings in maintenance costs usually obtained by use of smaller cars for other purposes. In fact, as shown in Table 3, the sample data showed a small rise in maintenance cost as car size decreased. Nevertheless, overall running cost of smaller-than-standard cars in the sample were less than running cost of standard and larger cars. The findings suggest that standard and larger cars may not cost significantly more to run for patrol purposes than smaller cars, but additional study is needed to validate these comparisons.[1] However, even

[1]Note that the empirical data used in the analysis predate the substantial rise in gasoline prices, which would likely increase the relative cost advantage of the smaller car.

Exhibit 1

In-House Vs. Contracting-Out Maintenance: The Breakeven Point

(Based on a Police Shop Wage Rate of $8.00 per hour and an Outside Charge of $12.00 per hour).

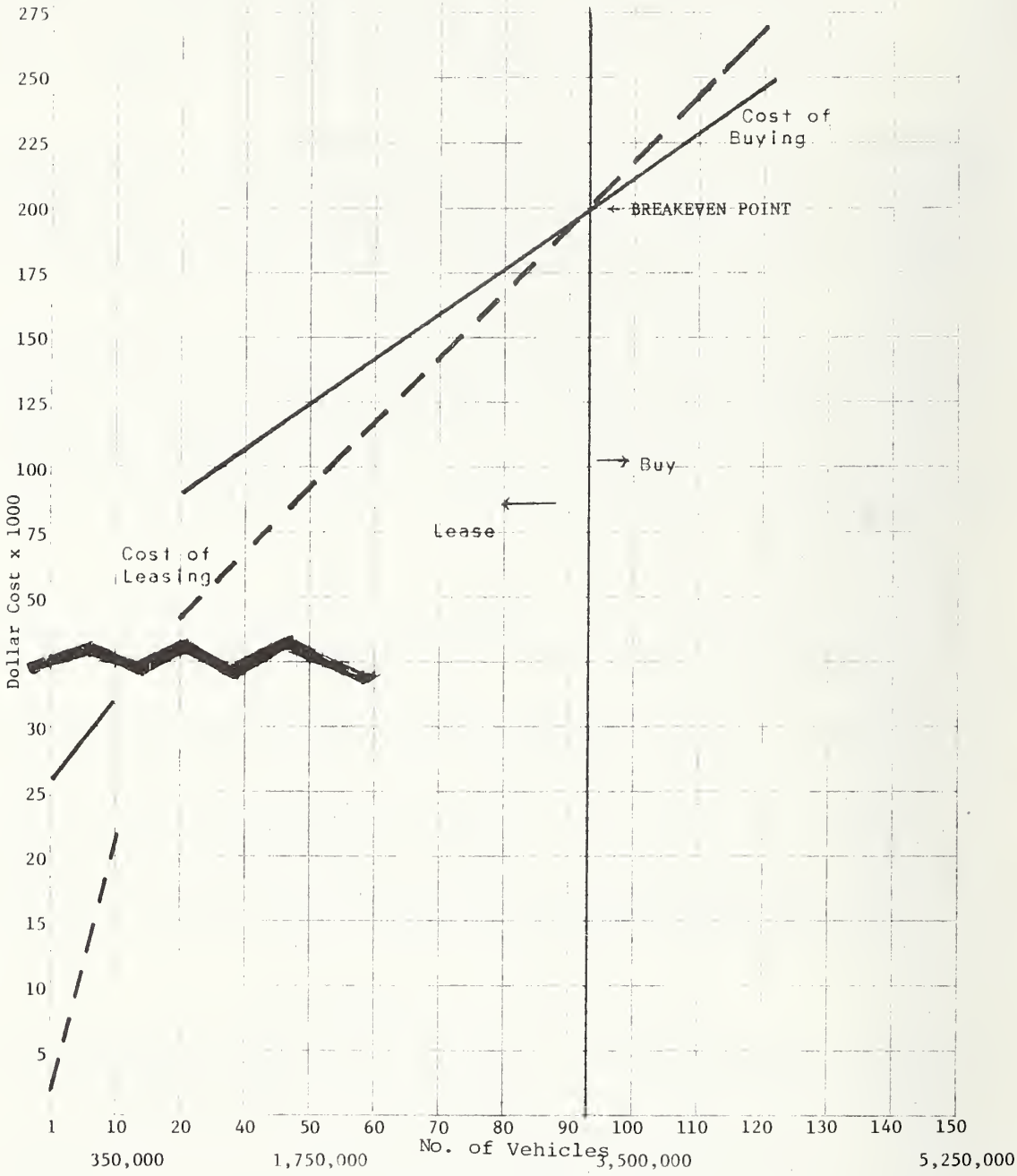


TABLE 3

Operating and Maintenance Cost by Size of Police Patrol Car

Type of Car	Miles per Gallon	Miles per Quarter	Cost per Mile		
			Operating[a]	Maintenance[b]	Total (O+M)
Standard Size (118"-122" wh.b.)	7.9	1144	2.4	3.4	5.9
Intermediate Size (<118" wh.b.)	8.7	2182	1.7	4.0	5.7
Large Size (<122" wh.b.)	7.9	924	2.7	3.2	5.9

[a] Operating cost includes gas and oil.

[b] Maintenance cost includes preventive maintenance, normal repair, and tire expenses.

Source: Data are based on a sample of police cars of various makes and four model years (1970-1973), operated in twenty-nine cities with an approximate average labor rate of $7.75. Computer print-outs of data were previded by Mainstem, Inc.

with little difference in running costs, the savings in depreciation costs of a smaller-than-standard car make it the efficient choice, given that it can be used effectively.

Sample data show that congested traffic conditions lower gasoline mileage significantly, and raise maintenance cost by about $.02 per mile. On this basis, we might estimate the potential savings from decreasing the frequency of stops and starts and reducing the idling of the motor as approaching $.02 per mile.

Life-time operating and maintenance costs for a sample of State highway patrol cars show gasoline and oil costs accountive for a little more than half of the total $3,660 per car in average running costs, and maintenance cost a little less than half the total. Data for a sample of city patrol cars show that maintenance costs exceed gasoline and oil costs.

Table 4 which gives a breakdown of the type and cost of maintenance and the mileage interval of occurrence for sample city patrol cars shows an increase in maintenance cost per mile as mileage accumulates, rising from an average of 2.56¢ per mile for new cars in the sample to 4.60¢ per mile for cars with more than 60,000 miles. The data indicate the expenditures incurred for the various mechanical components, and at what mileage particular kinds of problems arise. For example, during the first 10,000 miles of operation, repairs to the ignition and lighting systems are the largest single cost for mechanical components and by 20,000 miles, brakes begin to account for an important share of cost; at 50,000 miles transmission work becomes large, and at 60,000 miles the power train system is expensive to maintain.

Practices reported by police departments for reducing fuel cost included specification of octane requirements among vehicle types, and elimination of the need for and availability of higher octane gasoline whenever possible.

The study also discusses the organization and location of maintenance facilities, i.e., centralized vs. decentralized facilities, police shop, municipal garage, or private vendor, and presents cost data for samples of departments with different types of facilities, adjusted for differences in average wage rates. On the basis of sample data and a priori reasoning, it was concluded that, other things equal, the possibility of economies of scale and transportation costs to and from the facility, support the municipal garage for small, centrally located fleets, and either a system of decentralized municipal shops or contractual arrangements with scattered private vendors for small dispersed fleets. For larger fleets, the organizational structure of the maintenance facility -- police, municipal, or privately operated -- is probably less important from the standpoint of costs per se.

6.0 COST ANALYSIS OF THE PERSONAL CAR PROGRAM

The report describes the nature and possible benefits of a personal car program whereby each officer is assigned a car to be used for his personal, off-duty use, as well as for his regular duty. Empirical cost data from existing personal car programs are presented and discussed. Capitalization and running expenses of a personal car program are compared to costs of a minimum fleet/multi-shift plan, in which cars are assigned to a vehicle pool.

The primary benefits claimed for the program are reductions in crime and in accidents, increased criminal apprehension, and greater citizen security. Other attributed advantages, such as higher officer moral and safety and improved public image of the police, pertain more to internal department operations. Cost reduction is also sometimes cited as an advantage of the program.

Empirical information provided strong evidence, but not conclusive proof, that running costs of personal cars are less than for multi-shift pool cars, but there is also some evidence to the contrary. Better care of the personal cars, stemming from increased officer accountability, responsibility, and pride in the cars, provides some rationale for the lower running costs of personal cars.

TABLE 4

Maintenance Cost (in cents per mile) for a Sample of City Patrol Cars by Type of Expenditure and Mileage Interval of Occurrence[a]

Type of Service	Mileage Intervals 0 to 10,000	10,000 to 20,000	20,000 to 30,000	30,000 to 40,000	40,000 to 50,000	50,000 to 60,000	60,000 to 999,000
	¢	¢	¢	¢	¢	¢	¢
Inst. Gauge	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Axle, F, ND	0.01	0.01	0.01	0.0-	0.01	0.01	0.02
Axle, R, ND	0.0-	0.0-	0.0-	0.0-	0.0-	0.0-	0.0-
Brakes - Maj.	0.07	0.13	0.29	0.27	0.27	0.29	0.31
Brakes - Min.	0.02	0.04	0.06	0.03	0.05	0.06	0.04
Frame	0.01	0.01	0.01	0.01	0.01	0.02	0.04
Steering	0.05	0.05	0.07	0.09	0.12	0.10	0.19
Suspension	0.07	0.08	0.13	0.12	0.15	0.15	0.16
Wh., Rim, H, B	0.02	0.02	0.03	0.03	0.04	0.04	0.03
Axle Dr., F	----	----	----	----	0.0-	0.0-	0.0-
Axle Dr., R	0.01	0.01	0.02	0.01	0.01	0.01	0.05
Clutch - Maj.	----	0.01	0.0-	0.0-	----	----	----
Clutch - Min.	0.0-	----	0.0-	0.0-	----	0.0-	----
Dr. Shafts	0.0-	0.0-	0.01	0.01	0.01	0.02	0.04
P.T.O.	----	----	0.0-	----	----	0.0-	----
Trans. Maj.	0.06	0.06	0.10	0.13	0.13	0.31	0.34
Trans. Min.	0.02	0.04	0.03	0.07	0.06	0.05	0.08
Trans. Aux.	0.0-	0.0-	0.0-	----	0.0-	0.0-	0.0-
Charge Sys.	0.07	0.11	0.17	0.16	0.16	0.14	0.21
Crnk. & Bat.	0.08	0.10	0.14	0.17	0.18	0.19	0.21
Ignition	0.12	0.20	0.23	0.27	0.30	0.32	0.30
Lighting	0.14	0.09	0.11	0.13	0.12	0.11	0.12
Air Intake	0.0-	0.0-	0.01	0.01	0.01	0.01	0.01
Cooling	0.05	0.05	0.09	0.01	0.15	0.14	0.17
Exhaust	0.06	0.05	0.06	0.08	0.08	0.10	0.09
Fuel	0.03	0.05	0.06	0.09	0.10	0.10	0.11
Power - Maj.	0.03	0.06	0.22	0.22	0.27	0.25	0.41
Power - Min.	0.08	0.13	0.18	0.18	0.16	0.22	0.15
SUB-TOTAL	1.01	1.29	1.99	2.20	2.41	2.71	3.07
Lub.	0.04	0.03	0.03	0.03	0.04	0.04	0.01
PM	0.41	0.37	0.34	0.29	0.32	0.32	0.35
Access & Expen.	0.21	0.10	0.11	0.11	0.12	0.13	0.15
Power Tailgate	----	0.0-	----	----	----	----	0.0-
Radio Equip.	0.04	0.02	0.01	0.02	0.01	0.03	0.04
Winch & VC Sys.	----	----	----	----	----	----	----
AC/Heat/Vent	0.05	0.07	0.08	0.11	0.14	0.15	0.11
Cab/Sheet Metal	0.05	0.08	0.05	0.04	0.05	0.05	0.05
Tires	0.41	0.44	0.51	0.58	0.59	0.55	0.50
Body & Door	0.15	0.18	0.19	0.16	0.30	0.18	0.16
Clean & Paint	0.07	0.07	0.05	0.01	0.01	0.02	0.03
Towing & Other	0.10	0.09	0.08	0.09	0.09	0.11	0.12
Mounted System	0.01	0.01	0.01	0.01	0.01	0.01	0.02
TOTAL	2.56	2.73	3.45	3.66	4.08	4.30	4.60

[a]Cost data are averages for more than 1100 patrol cars operated in twenty-nine cities. There are some problems with the data collection procedure used to generate the new data from which ¢PM figures were computed, that may cause some distortions in the data. The main problem is that maintenance and mileage data are reported for the life of the vehicle in the system, not the current odometer reading. While the magnitude of the problem is probably not great, it may tend to raise the cost of maintenance over the lower mileage intervals.

Source: Computed from data supplied by Mainstem, Inc.

NOTE: Expression of cost items in terms of ¢PM is not meant to imply that cost is in all cases a function of mileage; rather it is used as means to translate costs expressed originally for different numbers of vehicles and mileages to a common denominator for comparison. An effort has been made to separate those cost elements which are more fixed in nature from the variable cost elements, so as to avoid distortion of the ¢PM comparisons which result from spreading fixed cost over different mileages. Therefore, a subtotal is computed for a like group of items for which costs are more clearly variable in nature.

Costs of a personal car program are compared with costs of a multi-shift plan for a hypothetical department with 200 officers and the cash flow patterns shown in Table 5. Table 6, which shows the uniform annual costs of the two plans computed for alternative per mile running costs, off-duty mileage, and depreciation rates, allows us to assess the cost differences between the plans. It appears that (1) the costs of the two plans are about equal if personal cars are used off-duty sparingly, are replaced every three years (as compared with annual replacement for pool cars), maintain their annual resale value about as well as private cars, and incur running cost less than half as much as the pool cars; (2) the personal car program costs much more than a multi-shift plan -- about double in the case examined -- if personal cars are used extensively off-duty, are consequently replaced every two years instead of three, and if they incur about the same per mile operating cost as multi-shift cars; and (3) in all cases a very large reduction in running costs is required to equalize costs of the programs. Given empirical evidence that casts doubt on the likelihood of achieving a large reduction in running costs for personal cars, it is concluded that most personal car programs will probably cost substantially more than multi-shift plans. The program therefore will usually not be justifiable in terms of fleet cost alone. However, the value of benefits from the personal car program may exceed associated costs; hence the program may be justifiable in terms of increased net benefits.

7.0 REPLACEMENT OF PATROL CARS

The investigation of replacement decisions revealed at the outset that, due to substantial variation in costs among vehicles and departments, it is not advisable to think in terms of a uniform economic replacement time for patrol cars. A sounder approach is for individual departments to determine their optimal replacement policy in light of their particular cost experience.

The intention of the study, therefore, is not to define the economic life of patrol cars in general, but rather to describe and to illustrate with police fleet data the techniques for determining optimal replacement. It is, however, possible to express certain of the observed relationships between fleet characteristics and economic life in terms of general guidelines for development of policy within individual departments.

The concept of economic life and development of replacement models is based on the fact that incremental running cost tends to increase with mileage and age, and incremental depreciation cost tends to decline with age of the vehicle, such that there is a point at which combined running expense and depreciation are a minimum per unit of time/mileage. These cost relationships are illustrated in Exhibit 2. Techniques for identifying the replacement time which minimizes the annual cost or present value of long-run fleet costs were found suitable for application to police fleets.

For practicality and efficiency, departments generally need a dual approach to replacement decisions. For the purpose of budgeting and for control, it is useful to predict the average economic lives of the various types of vehicles, based on past costs and resale values. Predicting average life will indicate the approximate number of replacements which will be required over the coming period. A second decision approach is needed for replacing individual vehicles, which may differ substantially in their costs, within the group. Where review on an individual vehicle basis is infeasible, the former approach will allow the manager to set a more informed general replacement rule.

The use of police cost data in a replacement model produces a variety of replacement schedules, ranging from replacement in the first year to no replacement until necessitated by safety, performance and other factors. Results are quite sensitive to the rate of car utilization, the rate of depreciation, and the pattern of maintenance costs. The following generalizations are made on the basis of case examples:

(1) The faster the rate of depreciation, the greater the advantage of retaining vehicles longer.

(2) The lower the rate of utilization, the greater the advantage of retaining vehicles longer.

(3) Maintenance and repair costs must increase fairly sharply with age and mileage for declining depreciation per unit time to be offset.

Table 5

Amount and Timing of Expenditures and Receipts for a Personal Car Program and a Multi-Shift Plan[a]

	PCP	MSP
No. Cars Purchased[b]	200 every 3 yrs.	55 each yr.
Purchase Outlay[c] for New Cars	$600,000 every 3 yrs.	$165,000 each yr.
Receipts from Sale[d] of Used Cars	$228,000 every 3 yrs.	$82,500 each yr.
Purchase Outlay[e] for Car Equipment	$240,000 every 10 yrs.	$66,000 every 10 yrs.
Insurance Premiums	$20,000 each yr.	$5,500 each yr.
Running Cost[f]	4,100,000 (X)	$264,000 each yr.

[a]Only ownership and operating costs are considered here, but in fact, there might be other costs associated with alternative fleet plans, such as cost of parts inventory and garage facilities which would also differ by size of fleet. In addition, there may be costs not easily stated in monetary terms, such as differences in downtime rates, which are not included in this example.

[b]Lower average annual mileage results in a longer replacement cycle for personal cars.

[c]A purchase price of $3,000 is assumed.

[d]Resale value on the pool car, which is replaced annually, is assumed to be $1,500. (Based on typical patrol car depreciation for a standard size car operated by a medium size city department, as developed in the full report). For the personal car, resale value is assumed to be $1,400, or nearly as great as for the pool car, even though personal cars are kept two years longer. Depreciation for the personal cars was based on rates typical of a private car, to reflect the fact that they are normally in good condition.

[e]This assumes an expenditure of $1,200 to equip each car and equipment life of 10 years with no salvage value remaining.

[f]This assumes a cost of 8¢ per mile for pool cars. The comparative per mile running cost for personal cars is the unknown variable in the analysis.

Table 6

Annual Ownership and Operating Costs of a Personal Car Program (PCP) and a Multi-Shift Plan (MSP) Under Alternative Conditions

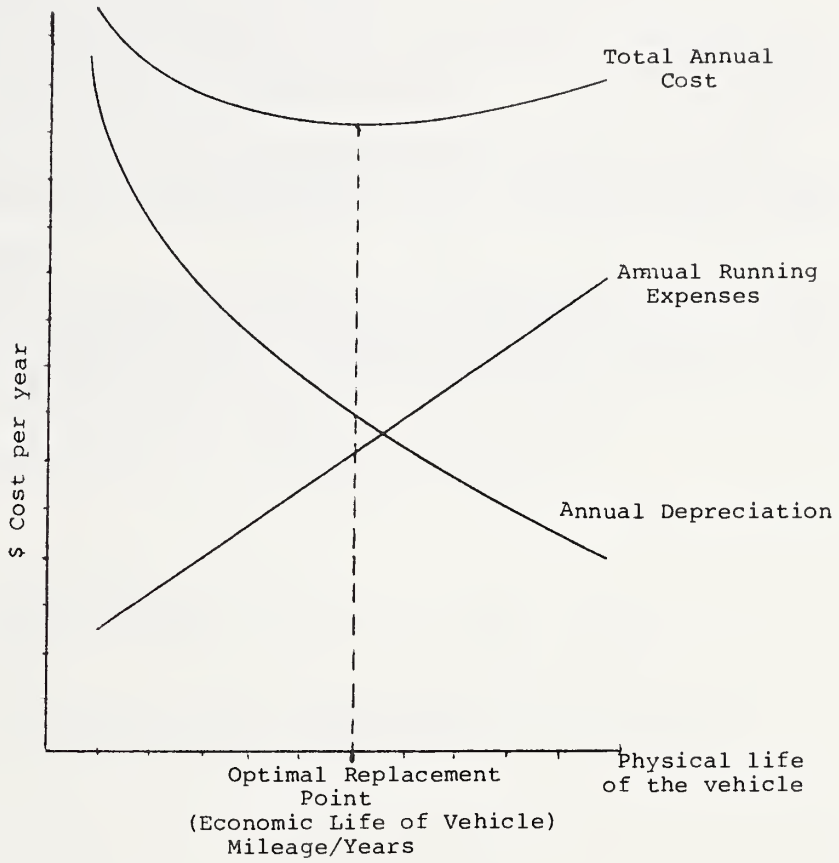
Running Cost Per Mile (¢/mi.)	Uniform Annual Cost (Rounded to the Nearest Ten Thousand Dollars)				
	MSP (1 yr. Replacement Typical Police Car Depreciation Rates)	PCP			
		PCP Fleet Mileage = MSP Fleet Mileage (3 yr. Replacement Private Car Depreciation Rates)	PCP Fleet Mileage = 1.25 MSP Fleet Mileage (3 yr. Replacement Private Car Depre. Rates)	PCP Fleet Mileage = 1.80 MSP Fleet Mileage (2 yrs. Replacement)[a]	
				Private Car Depre. Rates	Typical Police Car Depre. Rates (= MSP Depre. Rates)
(1)	(2)	(3)	(4)	(5)	(6)
1. 8	38	50	56	74	83
2. 6	31	43	49	62	72
3. 4	25	36	40	50	60
4. 2	18	30	31	38	48

[a]Additional off-duty mileage raises total fleet mileage to nearly 6 million miles, or about 30,000 miles per year per car. With a 60,000 mile replacement police, cars would be replaced in 2 years. Using private car depreciation rates, car value would decline by 50% in 2 years; and using typical police car depreciation rates, car value would decline by 84% in 2 years leaving a salvage value of $96,000.

NOTE: Cost calculations are based on cost data presented in Table 6, with exception of variables indicated.

Exhibit 2

Typical Cost Relationships and
Determination of Optimal Replacement Point



NOTE: Optimal Replacement Point does not coincide with the intersection of depreciation with running expense.

(4) Declining performance and reduced reliability are vital factors in determining replacements if cars depreciate rapidly, are used at low rates, or have costs which do not escalate significantly with increased use.

Thus, a very rough rule is to replace relatively early (perhaps in the first year of operation) those vehicles which depreciate slowly (i.e., whose resale values are well maintained), are used moderately to heavily, and whose running cost per mile is rising over time. But for cars which depreciate rapidly, are used at low rates, or whose running cost per mile do not escalate significantly with increased use, costs may be reduced by keeping them as long as safety and performance criteria permit.

8.0 SUMMARY

In summary, the full report defines and investigates alternative approaches to fleet acquisition, operation, maintenance and disposition. It identifies as pertinent to life cycle costing the major cost elements shown in Exhibit 3. It attempts to calculate and compare the costs associated with alternative decisions where possible.

The composition of costs over the life of a typical patrol car as indicated by the study are depicted in Exhibit 4. The present value of the life cycle costs of a typical patrol car kept for two years is estimated to be close to $7000 in direct costs and more than $7500 in total costs.

The great variability among departments makes it inadvisable to think in terms of uniform fleet management rules; individual departments should base management decisions on their specific cost experience. Nevertheless, some of the findings of the study are expressable as general guidelines which may be useful for development of policy within individual departments. These findings are summarized here. Interested readers are directed to the full report for analyses, data and explanation of procedures.

Exhibit 3

Critical Cost Elements to be Considered in a Life Cycle Cost Analysis of Police Patrol Cars

First or Acquisition Costs:

1. Preparation of specifications, testing, and other procurement-related costs.

2. Purchase price of the vehicle, including delivery costs and factory accessories.

3. Add-on equipment cost.

4. Equipping/modification labor cost.

5. Lease or purchase cost of tools, equipment, and facilities which may have to be used in connection with the vehicle acquisition.

Operation Costs:

6. Gas, oil, and tires.
7. Preventive maintenance program - parts and labor.
8. Other repairs - parts and labor.
9. Accident costs not covered by insurance.
10. Cost of maintaining spare-parts inventory.
11. Incidental expenses (parking, storage, washing).
12. Insurance (net of recovery).
13. Down-time costs -- scheduled and unscheduled.
14. Other shop and administrative overhead.

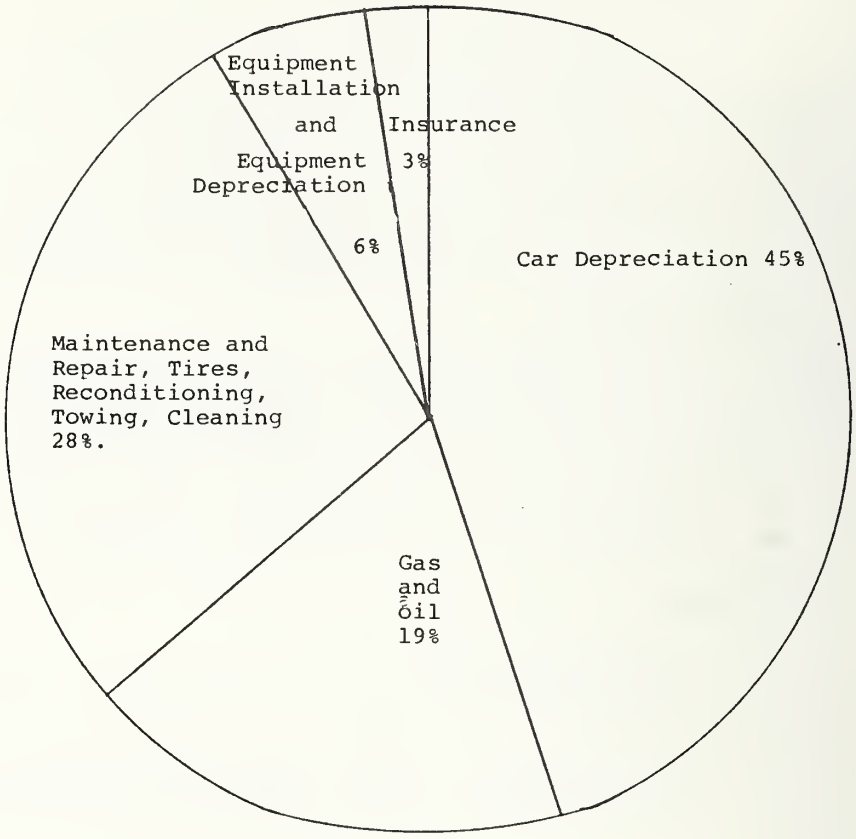
End Costs:

15. Final reconditioning cost.
16. Selling expenses.
17. Resale or salvage value of the vehicle (a negative cost).

(OR, alternatively, monthly lease payments plus other applicable costs (e.g., items 1,3,4,6,9,11,13 and 15).

Exhibit 4

Composition of Patrol Car Costs[a], Direct Cost Only



[a]Based on cost data from Exhibit 3.12 and Table 3.42 of the full report.

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16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

There are many different choices to be made with respect to police vehicle acquisition, utilization, maintenance, and disposition. Cost comparisons among the different alternatives are an important element in the choices to be made. To make valid cost comparisons, it is necessary to employ the techniques of life-cycle costing. This means the inclusion of all relevant costs and the conversion of costs to an equivalent basis to take into account differences in the timing of expenditures.

This report briefly summarizes the results of a larger study which compares the life cycle costs of some of the alternatives associated with police fleet management. The full report from which this report is derived is entitled Life Cycle Costing: Efficiency in Vehicle Acquisition, Operation, and Disposition.

The focus of the study is on police patrol cars, but the methods are applicable to other types of vehicles. Specific topics addressed by the larger study and summarized here are the cost effects of purchasing different sizes of patrol cars and different optional equipment, the advantages and disadvantages of direct ownership of vehicles as compared with leasing, the costs of contracting out maintenance as compared with self-maintenance of vehicles, the cost effects of alternative utilization practices, the optimal timing of vehicle replacement, and the comparative efficiency of different methods of vehicle disposition.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Fleet management; life cycle costing; patrol cars; police fleets; vehicle leasing; vehicle management.

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