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The Police Patrol Car: Economic Efficiency in Acquisition, Operation, and Disposition

Law Enforcement Equipment Technology

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The Police Patrol Car: Economic Efficiency in Acquisition, Operation, and Disposition

by
Rosalie T. Ruegg
Applied Economics Program
National Engineering Laboratory
National Bureau of Standards
Washington, D.C. 20234

prepared by
Law Enforcement Standards Laboratory
Center for Consumer Product Technology
National Bureau of Standards
Washington, D.C. 20234

prepared for
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and Criminal Justice
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FOREWORD

The Law Enforcement Standards Laboratory (LESL) of the National Bureau of Standards (NBS) furnishes technical support to the National Institute of Law Enforcement and Criminal Justice (NILECJ) program to strengthen law enforcement and criminal justice in the United States. LESL's function is to conduct research that will assist law enforcement and criminal justice agencies in the selection and procurement of quality equipment.

LESL is: (1) Subjecting existing equipment to laboratory testing and evaluation and (2) conducting research leading to the development of several series of documents, including national voluntary equipment standards, user guidelines, state-of-the-art surveys and other reports.

This document is a law enforcement equipment report developed by LESL under the sponsorship of NILECJ. Additional reports as well as other documents are being issued under the LESL program in the areas of protective equipment, communications equipment, security systems, weapons, emergency equipment, investigative aids, vehicles and clothing.

Technical comments and suggestions concerning the subject matter of this report are invited from all interested parties. Comments should be addressed to the Law Enforcement Standards Laboratory, National Bureau of Standards, Washington, D.C.

Jacob J. Diamond, *Chief*
Law Enforcement Standards Laboratory

PREFACE

Expenditures for police patrol vehicles exceed those for any other item of equipment purchased by law enforcement agencies. With growing sizes of fleets, increasing diversity of vehicles for specialist jobs, and an increasing number of options available for acquiring, maintaining, and disposing of vehicles, the management of police fleets is becoming increasingly complex.

The police fleet manager, in his efforts to provide suitable transportation to meet department requirements, has a multiplicity of objectives: to provide a fleet of the composition and size necessary to perform department duties; to provide vehicles which have adequate performance capabilities, meet safety requirements, satisfy officer morale and comfort criteria, and contribute to the desired public image; and to provide the vehicles at lowest possible cost.

In turn, the manager is confronted with a number of decisions regarding provision of the fleet. He must, for example, decide what types of vehicles and how many to buy; what optional equipment is required; what utilization practices to follow; how to secure the vehicles; what type of maintenance and repair facilities to have; how much preventive maintenance to schedule; when to replace a vehicle; and how to dispose of used vehicles.

The alternative courses of action are likely to have unequal efficiencies in terms of resulting costs, but the "best" decision is not always apparent. Information and techniques are needed which will help the police fleet manager secure an effective fleet in the most economical way. In the words of one such administrator, "the need for information in this field is great. A study of existing practices and the success of the various types of operation should be documented so that the police administrator may make intelligent decisions." Elimination of inefficiencies in police fleet management can significantly reduce the cost of police services and result in substantial savings of public funds.

A brief summary of this report, entitled *Life Cycle Costing of Police Patrol Cars: Summary Report*, was published as National Bureau of Standards Interagency Report NBSIR 74-471, in March 1974.

Jacob J. Diamond, *Chief*
Law Enforcement Standards
Laboratory

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EXECUTIVE SUMMARY[1]

There are many different choices to be made with respect to police vehicle acquisition, utilization,, maintenance, and disposition. Cost comparison among the different alternatives is 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 first and end costs, and operation and maintenance costs, as well as the conversion of costs to an equivalent basis to take into account differences in the timing of expenditures.

This report uses life cycle costing techniques to examine the costs of some of the alternative approaches to patrol car acquisition, operation, maintenance, and disposition. Although the great variability among departments makes it inadvisable to think in terms of uniform fleet management rules, the findings of this study are expressed as general guidelines where appropriate. The analytical methods used in the cost comparisons are described, illustrated, and recommended as useful decision tools for fleet managers. In addition, a descriptive overview of existing police fleet practices is provided in a number of tables on fleet composition, patrol car selection and accessorization, car utilization practices, maintenance, and replacement policy.

Specific questions addressed by the study 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 the 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 patrol cars, by far the predominant kind of vehicle in most police 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 managers of commercial fleets, 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.

Following is a brief summary of the major topics treated in the report, together with the principal findings:

LIFE CYCLE COSTING METHODOLOGY AND POLICE FLEET MANAGEMENT

A chapter on life cycle costing methodology explains the techniques used to compare the costs of alternative systems. A life cycle costing (LCC) approach to fleet management examines efficiency over the life of the police transportation system, rather

[1] Supersedes *Life Cycle Costing of Police Patrol Cars: Summary Report*, Rosalie T. Ruegg, National Bureau of Standards Interagency Report, NBSIR 74-471, March 1974.

than focusing on only one area of cost, such as initial expenditure. 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 5-year full-maintenance lease or to buy model A or model B lights.

(3) Identification 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 discount factors, 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 cost.

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 two 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 examined was less expensive than the bubble light over the lives of the systems.

The analyses of police fleet problems performed in the study show 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 showed, however, 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 accounting systems which result in 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.

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 for refusing low bids on the basis of projected higher eventual costs in depreciation, operation, and maintenance is usually difficult. Departments appear more successful in rejecting low bids on the 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, special services, delivery priority, or reduction 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). Typical annual cost savings[2] of about $140 can be achieved by a medium-size city department, by moving from the standard, top-of-the-line model to the standard, middle-of-the-line model, and about $160 more can be saved by moving from the middle to the standard, bottom-of-the-line model. A total annual cost reduction in depreciation of $300 is therefore possible by moving from the standard, top-of-the-line to the standard, bottom-of-the-line model. The potential savings in depreciation is even larger by moving from standard to intermediate automobiles: A standard, middle-of-the-line car operated for 1 to 2 years by a medium-size city department was found to cost from $500 to $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 may be seen by comparing the relatively higher depreciation typical of city-owned patrol cars 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 1 to 2 years typically decreases annual depreciation by nearly $400. Increasing the period from 2 to 3 years decreases annual depreciation by another $300. (The relationship between depreciation and running costs over time is discussed below under **Replacement of Patrol Cars.**)

(4) Purchase of expensive, luxury-model patrol cars generally cannot be justified in terms of costs alone, although it 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 are not generally cost effective.

(5) Empirical data suggest that depreciation cost may be reduced by the selection of "non-patrol car" colors and color diversification within the fleet. In other words,

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[2] These figures are based on 1972-1973 model year prices.

standard 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:

(1) Selective reconditioning appears to be efficient, with an average expenditure of approximately 10 percent of the estimated value of the car as a reasonable rule-of-thumb. 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 a good local market does not exist, wholesale disposal (such as consignment to an auto auction, 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 of government where there is less need for high performance vehicles 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 trade-in allowances often mask high new car prices.

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 lease agreements:

1. the finance lease,
2. the net lease,
3. the maintenance lease.

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. 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. 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 consideration of lease arrangements and police experience with leasing, the costs of leasing and buying are compared. Two basic questions are addressed: Is it economical to secure use of patrol cars through a lease and, 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) Without the tax advantage that private firms enjoy, 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 maintenance. A cost comparison 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 that the estimated present value of leasing is not considerably more than purchase. Special motives, 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 is indicated by the ratio of the annual cost of vehicle ownership to the annual cost of full-time renting (at short-term rates). For example, if ownership costs are estimated at $3,000 per year and the rental cost (at short-term rates) for 1 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 police garage with costs of contracting maintenance to private garages, and estimates 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 per hour and an outside charge of $12 per hour, the breakeven point comes at approximately 90 vehicles/3,150,000 fleet miles (5.1 million km), at a cost of about $200,000. With smaller fleets/lower mileage, contracting 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 per hour and a private garage rate of $15 per hour, only at fleet sizes as small as about 10 or fewer 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 per hour compared with $15 per hour), contracting maintenance appears the more efficient policy for fleets of 15 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 about 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 maintenance, even though the finance aspect of the lease by itself offers no particular advantage.

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 ways of cost reduction.

Based on a sample of more than 1,000 patrol cars operating in 29 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, the sample data showed a small rise in maintenance cost as car size decreased. Nevertheless, overall running costs of smaller-than-standard cars in the sample were less than running costs 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.[3] However, even with little difference in running costs, the savings in depreciation costs of a smaller-than-standard car typically 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 2.0¢ per mile (1.2¢/km) (see table 28). On this basis, we would estimate significant potential savings from decreasing the frequency of stops and starts and reducing the idling of the motor.

Life-time operating and maintenance costs for a sample of State highway patrol cars show gasoline and oil costs accounting 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.[4] Data for a sample of city patrol cars show that maintenance costs exceed gasoline and oil costs.

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 2.5¢ per mile for new cars in the sample to 4.6¢ per mile (1.5¢/km) for cars with more than 60,000 miles (96,000 km). 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 (16,000 km) of operation, repairs to the ignition and lighting systems are the largest single cost for mechanical components and by 20,000 miles (32,000 km), brakes begin to account for an important share of cost; at 50,000 miles (80,000 km) transmission work becomes large, and at 60,000 miles (96,000 km) the power train system is expensive to maintain.

[3] 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.

[4] Again, the reader is reminded that the data do not reflect the recent large rise in gasoline prices.

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 being equal, the possibility of economies of scale and consideration of 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 alone.

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 or her personal, off-duty use, as well as for regular duty. Empirical cost data from existing personal car programs are presented and discussed. Capitalization and running expenses of a full personal car program are compared to costs of a minimum fleet/multishift 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 morale, safety, and improved public image of the police, pertain 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 multishift pool cars, but there is also some evidence that the costs are not substantially different. Better care of the personal cars, stemming from increased officer accountability, responsibility, and pride in the cars, provides some rationale for possibly lower running costs of personal cars.

Costs of a personal car program are compared with costs of a multishift plan for a hypothetical department with 200 officers. Given the particular assumptions regarding cash flow patterns, per-mile running costs, off-duty mileage, and depreciation rates, the following observations were made:

(1) The costs of the two plans are about equal if personal cars are used off-duty sparingly, are replaced every 3 years (as compared with annual replacement for pool cars), maintain their annual resale value about as well as private cars, and incur running costs less than half as much as the pool cars.

(2) The personal car program costs much more than a multishift plan—about double in the case examined—if personal cars are used extensively off-duty, are consequently replaced every 2 years instead of 3, and if they incur about the same per mile operation cost as multishift cars.

(3) Under each set of assumptions a very large reduction in running costs is required to equalize costs of the programs.

Empirical evidence that casts doubt on a large reduction in running costs for personal cars, suggests that most personal car programs will probably cost substantially more than multishift 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.

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 purpose 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. Certain of the observed relationships between fleet characteristics and economic life can, however, be expressed as general guidelines for the development of policy within individual departments.

The concept of economic life and the 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. Techniques for identifying the replacement time which minimizes the uniform 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 their 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 at the outset, 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.

(4) Declining performance and reduced reliability are vital factors in determining replacements if cars depreciate rapidly at the outset 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 costs per mile are rising over time. But for cars which depreciate rapidly, are used at low rates, or whose running costs per mile do not escalate significantly with increased use, costs may be reduced by keeping them as long as safety and performance criteria permit.

TYPICAL COSTS

An examination of sample data shows that the cost in 1972-73 of owning and operating a standard size, middle-of-the-line patrol car might typically exceed $4,000 on a uniform annual cost basis. Depreciation appears the largest single part of total direct costs, with maintenance, repair, tires, gas, and oil together accounting for a comparable part.

In closing, the report reminds the reader that there are considerable opportunities for cost reductions in police fleet management, many of which are examined in the report.

THE POLICE PATROL CAR: ECONOMIC EFFICIENCY IN VEHICLE ACQUISITION, OPERATION AND DISPOSITION

Rosalie T. Ruegg

Institute for Applied Technology, National Bureau of Standards, Washington, D.C. 20234

This study uses the techniques of life cycle costing to analyze some of the decision problems of police fleet management. It addresses the following questions: (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 techniques used to compare costs of alternative systems are described in a chapter on life cycle costing methodology. Cost estimates and empirical data are presented in the many tables, exhibits, and charts which support the study. Existing fleet practices are described. Findings of the study are expressed as general guidelines for fleet management. The focus of the study is on police patrol cars, but the methods are applicable to other kinds of vehicles.

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

1. INTRODUCTION

The purpose of this report is to compare the costs of some alternative approaches to fleet acquisition, operation, maintenance, and disposition, using life cycle costing techniques to make the comparisons. Where appropriate, the findings of the cost comparisons are expressed as general guidelines for fleet management. In addition, the report describes and illustrates methods that can be used to treat a host of other decision problems related to provision of police transportation. It also provides an overview of existing fleet practices. The broad objective of the report is to provide the police fleet manager with information which will assist him in efficiently managing the fleet.

The focus of the study is on the patrol car, by far the predominant kind of vehicle in most police fleets. Since a number of models and makes of different size and performance capability are, in fact, used for patrol purposes, the study implicitly deals with several categories of patrol cars, rather than a single type of car. In addition, the empirical sections contain some cost data related to other types of vehicles, such as administrative and undercover cars, motorcycles and scooters, and vans and wagons. The methods and techniques which are applied in the study to the patrol car, are also applicable to the other types of vehicles.

A life cycle costing approach is taken because it looks for efficiency over the life of the police transportation system. This approach avoids the common decision-making pitfall of preoccupation with initial cost, to the relative neglect of the stream of operating, maintenance, and repair costs and the eventual return from resale. A life cycle costing approach also facilitates analysis of the cost effects achieved by altering elements in the system, such as the size of the vehicle or the length of operational life. With a short-sighted approach to fleet management, attempts to reduce expenses in one phase of fleet provision may lead to cost increases in other areas. For example, a vehicle with a lower initial purchase price may experience a larger net depreciation than a vehicle with a higher purchase price. Keeping vehicles longer may reduce average annual depreciation, but this reduction may be more than offset by rising annual maintenance and repair cost and disruption of police service resulting from increased breakdown. All costs are important from the standpoint of efficiency.

The emphasis is on costs, rather than other attributes of alternative fleet systems and practices. Although noncost advantages and disadvantages are assessed for some of the alternatives, no full attempt is made to measure and compare benefits of the alternatives. Since alternative systems and practices will likely yield unequal benefits, differences in their total costs do not conclusively demonstrate relative merit. It is left to the decision maker to evaluate the costs of alternatives in light of performance, safety, comfort, appearance, and other criteria, and to base his choice on his own priority of objectives. For instance, a finding that one size of car is "X" dollars cheaper over its life than another by no means implies that all police departments should have that car. Rather, it provides the fleet manager with information regarding the cost effects of the decision. He must decide whether other considerations outweigh costs.

The difficulty of empirically isolating and evaluating cost effects of alternative fleet systems is the chief limitation and shortcoming of this report. The diversity of accounting procedures and data banks—or lack thereof—hampered construction of compatible data samples for test purposes, but even more of a problem were the multiple variables affecting the data.

Police departments operate in diverse environmental and operating conditions, hence it was sometimes difficult to know what dollar cost to assign to a given alternative. For example, large metropolitan departments have considerable in-city driving, operate in a relatively small area, and may face stringent budgetary constraints; State Highway Police have a high proportion of high-speed nonstop driving, and are likely to have greater financial leeway; small, rural departments may operate few cars and have little opportunity to utilize sophisticated management techniques. Furthermore, a department may not have control over its fleet decisions, perhaps due to past commitments or preemption by higher bodies of government. Rules applicable to one department may not be suitable for all. Each cost comparison could have been a lengthy study unto itself. For these reasons, guidelines have been couched in terms of particular fleet circumstances or characteristics.

In addition to those problems addressed herein, there remain a host of other decision problems in fleet management. Specifically excluded from the scope of this research at the outset were two problems which are crucial from the standpoint of fleet effectiveness, namely (1) determination of the optimal mix of vehicles, and (2) deployment of the vehicles in the most effective way. The effectiveness of a police transportation system depends upon successful resolution of these problems, just as the efficiency of the operation depends upon correct decisions regarding purchase, maintenance, and disposition. These problem areas have been researched elsewhere, but remain fertile ground for additional analysis.[1]

Another area requiring more extensive investigation is the subject of preventive maintenance. Additional research and experimentation is needed to develop cause-effect relationships between vehicle breakdown and resulting downtime, and various police car preventive maintenance schedules.

In addition, broader data bases are needed to establish more firmly the relationship between rates and types of utilization and corresponding maintenance and repair costs. In fact, as automotive technology and design change, continual update is necessary to detect changes in the relationship.

It would also be desirable to explore further the personal car program, to assess its benefits. The emphasis here is on cost effects.

[1] See for example, Jan M. Chaiken & Richard C. Larson, *Methods for Allocating Urban Emergency Units*, NTIS Report No. PB-208549, New York City: The Rand Institute, May 1971.

Several efforts related to this one are presently underway to extend the state-of-the-art of fleet management. The American Public Works Association, Research Foundation, is conducting a comprehensive 2-year program to improve fleet operations of local, State, and provincial governments. Agencies accepted as participants in the program are offered advisory service, an optional cost management system, newsletters and special reports. Four manuals, dealing with maintenance reporting, equipment acquisition, utilization, and replacement, preventive maintenance scheduling, and parts inventory and warehouse control, are to be forthcoming from this program.[2] The California State Highway Patrol is currently engaged in a study of the relationship between patrol car mileage and operating, maintenance, repair cost and depreciation. The resultant report should shed further light on optimal replacement policy.[3] Interested readers should be alert for these and other related studies in fleet management.

For background, exhibits 1 and 2 illustrate the major decisions in police fleet management. Exhibit 1 lists the factors which determine the demand for transportation

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[2] The American Public Works Association, Research Foundation, 1313 East 60th Street, Chicago, Ill. 60637.

[3] Bob Rutherford, Manager, Fleet Information System, California State Highway Patrol, 2812 Meadowview Road, Sacramento, Calif. 95832, telephone interview, June 1973.

Exhibit 1. *Factors influencing fleet requirements and major decisions in fleet management*

Objective of Fleet Management

Provision of transportation service to meet department requirements at least cost.

Demand Factors

Police functions
Department size
Size and environmental characteristics of the area served
Budget and other constraints
Fleet deployment policy
Target fleet performance levels
- Safety
- Morale (vehicle appearance and comfort)
- Reliability and availability
- Functional performance (size, speed, handling)

Fleet Decisions

Vehicle management program
- Delegation of responsibilities
- Methods of systems control

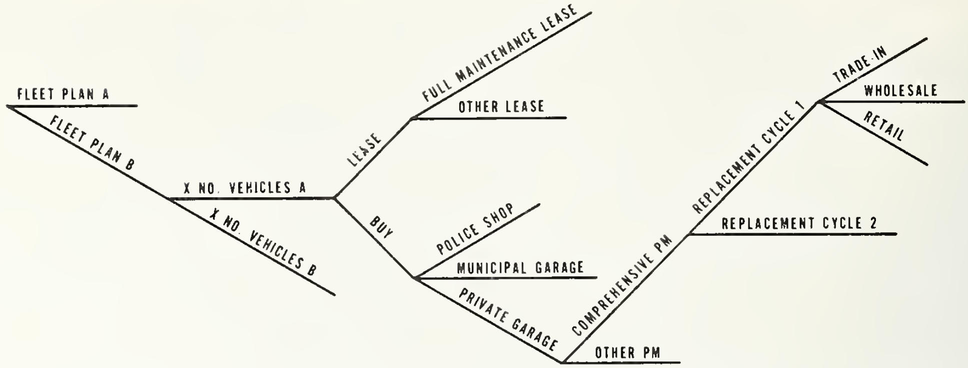
Vehicle selection
- Type vehicle
- Make
- Model
- Color
- Accessorizing

Vehicle utilization factors
- Number of shifts (or mileage)
- Per day driver assignment

Number of vehicles
- For regular use
- For backup pool

To buy or lease vehicles and related equipment
Maintenance program
- Nature of facility
- Preventive maintenance schedule

Replacement cycle
Method of vehicle disposal



*The use of a modified decision tree format does not imply consideration of risk in the analysis. To avoid repetition, only one branch at each decision point is developed when the branches would have been duplicates.

service by a police department (i.e., *what*), and then the major decisions which must be made to provide the transportation service (i.e., *how*). (There is no attempt here to show the sequence of decisions nor their interrelationships.)

The broad objective of all police fleet managers is largely the same; to provide transportation service to meet the department's requirements, in light of budgetary and other constraints, such as traditional practices, environmental conditions, personalities, and other factors dependent on local conditions. This broad objective might be amended to specify that fleet provision be cost-effective. Variations among departments are then revealed not so much in aim, but in method, that is, how the service is provided.

Making fleet decisions involves choices among alternatives for a number of subordinate operations or fleet subsystems. Many configurations of these subsystems are possible: Exhibit 2 depicts a modified decision tree to illustrate some of the alternative ways to operate a fleet.[4] A department might, for example, adopt utilization policy "C," calling for the use of the cars on a 3 shift/day basis, car rotation among officers, and a 10 percent backup pool. After determining the number of vehicles needed, the department may choose to purchase them, rather than leasing under one of the several alternative plans available. It may then decide to maintain and repair its vehicles in a police shop, rather than to utilize a central garage or private garage; it may carry out a comprehensive preventive maintenance (PM) program, rather than wait for failures to occur, it may replace cars at 60,000 miles (96,000 km), instead of 40,000 or 80,000 (64,000 or 129,000 km), or any other possible replacement time. Lastly, the department may sell used cars at retail auction, rather than trade them in, or wholesale them to used car dealers.

The order of decisions shown in exhibit 2 has the semblance of sequential order, but the decision process is interwoven and much more complex than illustrated. The problem of determining the economically optimal fleet arrangement requires, in theory, a simultaneous solution. We can see the joint nature of decisions from the following illustrative interrelationships. A higher utilization rate implies the need for a smaller total number of cars, but a larger backup fleet relative to the number of cars in regular use. Decisions regarding the utilization and maintenance of vehicles will influence the optimal time of replacement. Reliability and availability goals can be achieved in any of a number of ways: By increasing the size of the fleet to provide more backup vehicles or lower utilization rates; by instituting a more effective preventive maintenance program to replace unscheduled maintenance with scheduled; by selecting vehicles less subject to breakdown; or by reducing the length of the replacement cycle to keep the fleet

[4] The reader is reminded that this study is not intended as a comprehensive investigation into all possible decisions which confront the fleet manager. Exhibits 1 and 2 show major decisions which are addressed by this study.

newer. The kind of vehicle, its accessories and condition (which reflects utilization rates, driver assignment, maintenance program, and replacement cycle), will influence the optimal method of disposing of the vehicle.

It is the purpose of this study to investigate the cost effects of making the choices in police fleet operation which have been set forth. However, in order to perform the cost analysis, it has been necessary to simplify, thereby not fully accounting for the above interactions.

2. METHODOLOGY OF LIFE CYCLE COSTING

Analytical methods can be applied to the host of problems of choice which confront the fleet manager. A brief description of methods follows, for the purpose of providing further explanation of the methodology used in this study and additional information to the interested police fleet manager who may wish to apply these methods to problems not dealt with directly in this study.

The reader is reminded that this chapter may be passed over without loss of continuity and understanding of succeeding chapters, although attention to the methodology is probably worthwhile. The material is not exceedingly technical, is presented in simplified form, and should cause little difficulty for the reader unfamiliar with these methods.

2.1. Life Cycle Costing

Life cycle costing (LCC) is one of a number of analytic approaches to problems of choice.[5] It is a tool useful in choosing among alternative systems of durable capital goods.[6] In short, the approach calls for identification and calculation of all relevant costs associated with each alternative system over its entire operational life, conversion of costs to equivalency, and summing for purposes of comparison. In the case of vehicle fleet management, life cycle costing of alternative systems of vehicle operation should take into account cost of acquisition, maintenance, operation, depreciation, and disposition, as well as managerial and other relevant costs. A more in-depth discussion of the concept as applied to law enforcement fleet management follows.

Life Cycle Costing (LCC) analysis includes the following steps:

(1) Specification of the objective to be achieved and any constraints.

(2) Identification of the possible alternative systems which can accomplish the desired objective, given the constraints.

(3) Determination of all relevant cash flows and the expected timing of the cash flows for each alternative, at current prices; where quantification of costs is not feasible, notation of the qualitative effects.

(4) Conversion of the cash flow for each system to an equivalent base (discounting of costs).

(5) Summation of all discounted costs.

(6) Comparison of quantitative and qualitative costs of alternatives in light of constraints, and selection of the preferred system.

Let us now consider in greater detail each of these tasks in the context of LCC of police vehicles:

Specification of Objective and Constraints

There are any number of specific objectives, in addition to the broad objective of providing transportation service to a law enforcement group. For example, an objective

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[5] Cost-benefit analysis, cost-effectiveness analysis, and various forms of cost models are all examples of methods for making systematic comparisons in quantitative terms. They differ in emphasis and context, but are similar in purpose and general principle.

[6] There appears to be an increasing trend in government to use the concept of LCC in the contract definition phase of contracts in order to promote overall efficiency of projects.

in car selection may be to choose the vehicle with the lowest life cycle costs, with the constraint that the vehicle meets minimum performance criteria. Similarly, the objective of the maintenance supervisor may be to maintain vehicles at the lowest possible cost, while achieving a target availability and reliability rate. By showing cost differences among alternative ways of meeting those objectives, LCC assists the decision maker in the efficient allocation of tax dollars.

Identification of Alternatives

We see in exhibit 2 some of the major decision steps in fleet operations. As was explained, however, each step may be accomplished in a number of ways. The fleet manager should aim for flexibility, resourcefulness and creativity in identifying possible solutions to his problems.

Determination of Costs

A thorough LCC analysis should include identification and inclusion of all relevant costs, from the costs related to acquisition through costs involved in final disposal. Exhibit 3 summarizes the fleet cost elements identified in this study. In order to avoid excessive expense in making the cost calculations, it is desirable to utilize any available shortcuts in the estimating procedure. As pointed out elsewhere in the report, this may result in a loss of accuracy, but a "ballpark" estimate will often suffice.

Some costs may not be practicably expressible in dollars, e.g., cost of additional downtime or decline in driver safety or morale. It may be preferable to express these costs in nondollar terms rather than to use highly arbitrary or questionable dollar estimates. In any case, these cost elements should be taken into consideration.

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)

Worth and Annual Cost Models in LCC Analysis

After the analyst has identified the alternative ways of achieving a given objective and has determined all cash flows (positive and negative) associated with each alternative, he must then determine the time at which they occur. A convenient procedure is to set up a cost model in which negative values are shown as costs and positive values as negative costs. The costs and their timing for each alternative under consideration can be illustrated by constructing a cash flow diagram, such as that shown later in the paper in exhibit 14. Since money has a time value,[7] and since the costs of alternative systems may differ both in amount and in time of occurrence, it is necessary to make the expenditures for each system equivalent in order to compare them. Thus, the analysis of alternative plans with different expenditures over time requires more than a simple summing of present and future expenditures. The analyst has two options: He can, using the appropriate interest rate, compute either (1) the present value of the alternative systems for an equivalent period of time, or (2) the annual cost of each system.[8]

There are six basic discounting formulas which are used to move values in time so that they may be compared on an equivalent basis. These formulas are shown in table 1 together with their standard nomenclature and standard shorthand notation.[9]

[7] The fact that there is an opportunity for investment which will yield a return causes a dollar spent today to be valued more highly than a dollar to be spent later, apart from any consideration of inflation.

[8] There are other closely related techniques for comparing alternatives such as cnmputatinn of the rate of return on investment. The conversion of costs to an equivalent annual basis was the method favored in this study. A fuller account of techniques for comparing alternatives can be found in most text books on engineering economy, such as Eugene L. Grant and W. Grant Ireson, *Principles of Engineering Economy*, New York: Ronald Press Co., and books on Cost Analysis, such as A. J. Merrett and Allan Sykes, *The Finance and Analysis of Capital Projects*, London: Longman, 1971. The author relied extensively upon B. J. Keely and J. W. Griffith, *Resource Optimization Using Cost-Benefit Analysis*, K-G Associates Training Manual, K-G Associates, Dallas, Tex.

[9] The interest formulas shown were not all used for cost comparisons in this study; mainly equations 2 and 5 were used. All six are described for completeness.

Table 1. *Discounting Formulas*

Equation no.	Use when	Standard nomenclature	Standard notation	Algebraic form
1	Given P; to find F	Single Compound Amount Factor	(SCA, i%, N)	$F=P\,(1+i)^N$
2	Given F; to find P	Single Present Worth Factor	(SPW, i%, N)	$P=F\left[\frac{1}{(1+i)^N}\right]$
3	Given A; to find F	Uniform Compound Amount Factor	(UCA, i%, N)	$F=A\left[\frac{(1+i)^N-1}{i}\right]$
4	Given F; to find A	Uniform Sinking Fund Factor	(USF, i%, N)	$A=F\left[\frac{1}{(1+i)^N-1}\right]$
5	Given P; to find A	Uniform Capital Recovery Factor	(UCR, i%, N)	$A=P\left[\frac{i(1+i)^N}{(1+i)^N-1}\right]$
6	Given A; to find P	Uniform Present Worth Factor	(UPW, i%, N)	$P=A\left[\frac{(1+i)^N-1}{i(1+i)^N}\right]$

Where:

P = a present sum of money.
F = a future sum of money.
i = a discount rate.
N = number of interest periods.
A = an end-of-period payment (or receipt) in a uniform series of payments (or receipts) over N periods at i discount rate, usually annually.

Source: Committee on Standardization of Engineering Economy Notation, *Manual of Standard Notation for Engineering Economy Parameters and Interest Factors*, Engineering Economy Division, American Society for Engineering Education.

Formula 1, the Single Compound Amount formula (SCA), is used to determine the future value, F, of the present sum, P, N years hence, discounted at a rate of i.

Formula 2, the Single Present Worth formula (SPW), is used to determine the present value, P, of a future sum of money, F, to be received or spent N years in the future, when the discount rate is i.

Formula 3, the Uniform Compound Amount formula (UCA), is used to determine the future value, F, of an annual payment, A, over N years with a discount value of i.

Formula 4, the Uniform Sinking Fund formula (USF), is used to determine the size of an annual payment, A, necessary to produce a given future sum of money, F, in N years with a discount rate of i.

Formula 5, the Uniform Capital Recovery formula (UCR), is used to determine the amount of the annual payment, A, necessary to recover a present sum of money, P, over a period of N years with a discount rate of i.

Formula 6, the Uniform Present Worth formula (UPW) is used to determine the present value, P, of a series of payments, A, over N years at a discount rate of i.

All values should be expressed in constant dollars; i.e., in terms of the general purchasing power of the dollar at the time the comparison is being made. Where there is a reasonable basis for estimating real changes in the cost components (other than general price inflation), estimates may be adjusted to reflect such changes.

Most engineering economic textbooks contain calculations of these different formulas for various values of the parameters i and N, and $1. Tables 2, 3, and 4 are examples of these discount factors and are reprinted here for the convenience of the reader.

As an example of how the tables can be used, assume that it is desired to find the present value of a future cost, such as the present value of a $5,000 cost expected to be incurred 3 years from now, given a discount rate of 10 percent.[10] The appropriate algebraic formula is No. 2,

$$P = F \left[\frac{1}{(1+i)^N}\right], \text{ or } P = \$5{,}000 \left[\frac{1}{(1+.10)^3}\right].$$

Instead of performing the indicated computations, one could refer to the single present worth column, SPW, of Table 3 at the row for year 3, finding the factor 0.7513 for F = $1. Multiplying this factor by the specified future cost yields P = $3,757, the present value of a $5,000 cost expected in 3 years.

With a discount rate of 2 percent, use of table 2 would lead to a calculation of P = $5,000 (0.9423) = $4,712; at i = 15 percent (table 4), P = $3,288.

A similar calculation for an expected expenditure farther in the future (say 8 years, with i = 10%) indicates a present value of the $5,000 equal to $2,333.

These simple calculations illustrate the point made earlier that proper assessment and comparison of costs must take into account when each cost is to be incurred. In the above example it may be noted that: (1) The higher the discount rate used, the less the present value of an expected future expenditure; and (2) the longer the wait until the future cost is incurred, the less the present value of the future cost. Thus, a fleet decision which requires a large initial outlay is actually more costly than an alternative decision calling for the same amount spread out over some future period. Similarly, benefits to be received in the future are worth less the longer they are deferred and the higher the discount rate.

(For examples of the use of the discounting formulas to reduce costs of alternative systems to equivalency, see tables 12, 15, 17, 18, 19, and 32.)

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[10] The minimum discount rate which agencies of the Federal Government have been directed to use is 10 percent. Ten percent represents an estimate of the average rate of return on private investment, before taxes and after inflation.

Table 2. *Discount factors*
(2% Discount Rate)

Year N	SCA P-F	SPW F-P	UCA A-F	USF F-A	UCR P-A	UPW A-P
1	1.020	.9804	1.000	1.000	1.020	0.980
2	1.040	.9612	2.020	.4951	.5151	1.942
3	1.061	.9423	3.060	.3268	.3468	2.884
4	1.082	.9238	4.122	.2426	.2626	3.808
5	1.104	.9057	5.204	.1922	.2122	4.713
6	1.126	.8880	6.308	.1585	.1785	5.601
7	1.149	.8706	7.434	.1345	.1545	6.472
8	1.172	.8535	8.583	.1165	.1365	7.325
9	1.195	.8368	9.755	.1025	.1225	8.162
10	1.219	.8203	10.95	.0913	.1113	8.983
11	1.243	.8043	12.17	.0822	.1022	9.787
12	1.268	.7885	13.41	.0746	.0946	10.58
13	1.294	.7730	14.68	.0681	.0881	11.35
14	1.319	.7579	15.97	.0626	.0826	12.11
15	1.346	.7430	17.29	.0578	.0778	12.85
16	1.373	.7284	18.64	.0537	.0737	13.58
17	1.400	.7142	20.01	.0500	.0700	14.29
18	1.428	.7002	21.41	.0467	.0667	14.99
19	1.457	.6864	22.84	.0438	.0638	15.68
20	1.486	.6730	24.30	.0412	.0612	16.35
21	1.516	.6600	25.78	.0388	.0588	17.01
22	1.546	.6468	27.30	.0366	.0566	17.66
23	1.577	.6342	28.85	.0347	.0547	18.29
24	1.608	.6217	30.42	.0329	.0529	18.91
25	1.641	.6100	32.03	.0312	.0512	19.52
30	1.811	.5521	40.57	.0247	.0447	22.40
35	2.000	.5000	49.99	.0200	.0400	25.00
40	2.208	.4529	60.40	.0166	.0366	27.36
45	2.438	.4102	71.89	.0139	.0339	29.49
50	2.692	.3715	84.58	.0118	.0318	31.42
60	3.281	.3048	114.1	.0088	.0288	34.76
70	4.000	.2500	150.0	.0067	.0267	37.50
80	4.875	.2051	193.8	.0052	.0252	39.75
90	5.943	.1683	247.2	.0041	.0241	41.59
1000	7.245	.1380	312.2	.0032	.0232	43.10

Notation: SCA, Single Compound Amount; SPW, Single Present Worth; UCA, Uniform Compound Amount; USF, Uniform Sinking Fund; UCR, Uniform Capital Recovery; UPW, Uniform Present Worth; P-F would read Given P, to find F; F-P would read Given F, to find P, etc.

TABLE 3. *Discount Factors*
(10% Discount Rate)

Year N	SCA P-F	SPW F-P	UCA A-F	USF F-A	UCR P-A	UPW A-P
1	1.100	.9091	1.000	1.000	1.100	0.909
2	1.210	.8264	2.100	.4762	.5762	1.736
3	1.331	.7513	3.310	.3021	.4021	2.487
4	1.464	.6830	4.641	.2155	.3155	3.170
5	1.611	.6209	6.105	.1638	.2638	3.791
6	1.772	.5645	7.716	.1296	.2296	4.355
7	1.949	.5132	9.487	.1054	.2054	4.868
8	2.144	.4665	11.44	.0874	.1874	5.335
9	2.358	.4241	13.58	.0736	.1736	5.759
10	2.594	.3855	15.94	.0628	.1628	6.144
11	2.853	.3505	18.53	.0540	.1540	6.500
12	3.138	.3186	21.38	.0468	.1468	6.814
13	3.452	.2897	24.52	.0408	.1408	7.103
14	3.797	.2633	27.98	.0358	.1358	7.367
15	4.177	.2394	31.77	.0315	.1315	7.606
16	4.595	.2176	35.95	.0278	.1278	7.824
17	5.054	.1978	40.54	.0247	.1247	8.022
18	5.560	.1799	45.60	.0219	.1219	8.201
19	6.116	.1635	51.16	.0196	.1196	8.365
20	6.727	.1486	57.28	.0175	.1175	8.514
21	7.400	.1351	64.00	.0156	.1156	8.649
22	8.140	.1228	71.40	.0140	.1140	8.772
23	8.954	.1117	79.54	.0126	.1126	8.883
24	9.850	.1015	88.50	.0113	.1113	8.985
25	10.84	.0923	98.35	.0102	.1102	9.007
30	17.50	.0573	164.5	.0061	.1061	9.427
35	28.10	.0356	271.0	.0037	.1037	9.644
40	45.26	.0221	442.6	.0023	.1023	9.779
45	72.89	.0137	718.9	.0014	.1014	9.863
50	117.4	.0085	1164.	.0009	.1009	9.915
60	304.5	.0033	3035.	.0003	.1003	9.967
70	789.7	.0013	7887.	.0001	.1001	9.987
80	2048.	.0005	2047.	.0001	.1001	9.995
90	5313.	.0002	5312.	.0000	.1000	9.999

Table 4. *Discount Factors*
(15% Discount Rate)

Year N	SCA P-F	SPW F-P	UCA A-F	USF F-A	UCR P-A	UPW A-P
1	1.150	.8696	1.000	1.000	1.150	0.870
2	1.322	.7561	2.150	.4651	.6151	1.626
3	1.521	.6575	3.472	.2880	.4380	2.283
4	1.749	.5718	4.993	.2003	.3503	2.855
5	2.011	.4972	6.742	.1483	.2983	3.352
6	2.313	.4323	8.754	.1142	.2642	3.784
7	2.660	.3759	11.07	.0904	.2404	4.160
8	3.059	.3269	13.73	.0729	.2229	4.487
9	3.518	.2843	16.79	.0596	.2096	4.772
10	4.046	.2472	20.30	.0493	.1993	5.019
11	4.652	.2149	24.35	.0411	.1911	5.234
12	5.350	.1869	29.00	.0345	.1845	5.421
13	6.153	.1625	34.35	.0291	.1791	5.583
14	7.076	.1413	40.51	.0247	.1747	5.724
15	8.137	.1229	47.58	.0210	.1710	5.847
16	9.358	.1069	55.72	.0180	.1680	5.954
17	10.76	.0929	65.08	.0154	.1654	6.047
18	12.38	.0808	75.84	.0132	.1632	6.128
19	14.23	.0703	88.21	.0113	.1613	6.198
20	16.37	.0611	102.4	.0098	.1598	6.259
21	18.82	.0531	118.8	.0084	.1584	6.312
22	21.65	.0462	137.6	.0073	.1573	6.359
23	24.89	.0402	159.3	.0063	.1563	6.399
24	28.63	.0349	184.2	.0054	.1554	6.434
25	32.92	.0304	212.8	.0047	.1547	6.464
30	66.21	.0151	434.7	.0023	.1523	6.566
35	133.2	.0075	881.2	.0011	.1511	6.617
40	267.9	.0037	1779.	.0006	.1506	6.642
45	538.8	.0019	3585.	.0003	.1503	6.654
50	1083.	.0009	7218.	.0001	.1501	6.661
60	4384.	.0002	2922.	.0000	.1500	6.665

Summation of Costs

This step represents the actual derivation of the total cost of an alternative over its life cycle—the sum of initial costs, operating costs, maintenance costs, and net disposal costs. As a simple and straightforward example, table 16 compares a "bar-light" system with an alternative "bubble light." Although the initial acquisition cost of the bar-light system is substantially higher than that of the other, its annual cost, after appropriate discounting and totalling, is significantly lower. (Table 16 will be discussed in greater detail later in the report.) Life cycle costing thus provides a clearer picture of the probable costs associated with alternative decisions.

Comparison of Alternatives and Selection

While this step is self-explanatory, it may be well to reiterate the point made earlier: It is unlikely that quantifiable life cycle costs will be the sole standard for decision-making. However, a more complete understanding of the cost effects of alternative decisions cannot but contribute towards more efficient fleet management.[11]

2.2. Break-Even Models

Break-even models are used in cost analysis to determine that value of a preselected variable which will make alternative programs or decisions equal in costs. The break-even point is then the value of the selected variable which will make us indifferent from a cost standpoint between the alternatives. To construct a break-even equation, a present value or annual cost equation is developed for each alternative, and then the equations are set equal to one another, and the value of the break-even variable is determined. For values of the variable greater than the break-even point one alternative becomes more economical; for lower values, the other alternative is cheaper.

Break-even analysis is useful in determining the fleet size which would justify selected expenditures. For example, the fleet manager might wish to know what fleet size would make an in-house garage as efficient as contracting out maintenance; or what number of radios would justify a radio specialist shop. (This form of analysis is used in sec. 3.4 to assess relative costs of the personal car program.)

3. COST ANALYSIS OF POLICE PATROL VEHICLES

In this part of the report the principles of life cycle costing are applied to some problems of police vehicle management. First, the critical cost elements are identified; then (in sec. 3.2 through 3.5) different decision problems are analyzed using appropriate techniques. In section 3.6, the cost elements developed in the previous sections are brought together to show life cycle costs of a typical police car.

3.1. Critical Cost Elements

Exhibit 3 lists, in the approximate order incurred, the major cost elements which are pertinent to life cycle costing of police vehicles. For purposes of analysis, costs may also be grouped according to their characteristics. Exhibit 4 shows two main categories of costs—fixed costs and variable costs. As noted in the exhibit, fixed costs are those that do not vary with mileage or age of the vehicle, and variable costs are those which do. However, a clear-cut categorization of costs is difficult. For example, reconditioning costs are to some extent variable with mileage, inasmuch as more reconditioning is generally needed with greater wear. However, a major part of the reconditioning process is the transformation of a vehicle which looks like a police car into one suitable for private purposes. Since this component is fixed, reconditioning cost is classified as

[11] For reference to the literature of life cycle costing, see entries under Cost Analysis in the list of references.

Exhibit 4. *Fixed and variable vehicle costs*

Fixed Costs

(Those that do *not* vary with the mileage or age of the vehicle)

1. Overhead
   Including costs of procurement, inventory control, cost accounting systems, depreciation of facilities and equipment, selling expenses, supporting systems, and general management.
2. Insurance
3. Equipping, modification, and reconditioning costs
4. Incidental expenses
   Parking
   Storage
   Washing

Variable Costs

(Those that *do* vary with the mileage or age of the vehicle)

1. Depreciation
2. Running expenses
   (a) Those costs which accrue directly with mileage:
       gas
       oil
       tires
       scheduled maintenance
   (b) Those costs whose probability of occurence increases with mileage
       (1) Repair cost due to failure of vehicle components. (Although not exactly predictable, studies suggest a higher failure rate initially, due to manufacturing defects; a lower rate during the "middle life," and a rising rate at higher mileage as the car begins to wear out.)
       (2) Accident repair cost

fixed. By like token, depreciation might be regarded as fixed since it is to a large extent unavoidable regardless of vehicle use. However, this characteristic might more appropriately be designated as "noncontrollable," rather than as fixed, since depreciation does vary with both age and mileage. There may be similar questions regarding classification of accident repair costs. Accidents are random events, but exposure to accident increases with vehicle use. For this reason accident costs may be considered a function of mileage, and classified as variable costs.

Though not shown in exhibit 4, leasing charges may comprise both a predetermined and a variable element. The predetermined part, which reflects finance charges, normal depreciation, overhead and profit, are fixed to the lessee. The lease charge may contain an additional variable part which reflects mileage-related maintenance and repair cost and additional depreciation.

In vehicle management, greater attention is frequently given to the variable costs—particularly running expenses, which are a direct function of mileage—because these generally appear more controllable; indeed, they likely are in the short run. Each category of cost is equally important, however, and in the long run, all can to some degree be controlled.

Due to their different natures, the several categories of costs shown in exhibit 4 require different interpretations for accurate analysis and managerial action. For example, stating fixed costs in terms of cost per mile will, by spreading costs over more miles, give the impression that a highly utilized vehicle is more efficient than a less used vehicle, in terms of the fixed cost element in question. However, it would be incorrect to conclude that the vehicle with the lower cost per mile is more efficient and preferable to the other; they might appear equally efficient if operated over the same mileage.

3.2. Cost of Vehicle Acquisition

This section looks first at costs associated with buying and selling police cars, and then compares buying with leasing.

3.2.1. Purchase Price, Resale Value, and Depreciation Cost

Itemized costs associated with purchase, resale, and depreciation for representative patrol cars and their equipment are first presented. The bases for deriving cost estimates for patrol cars of different size and age and operated by different types of departments are then explained.

Purchase Prices

Table 5 shows a typical price quotation (in 1972-73 prices) for a 4-door standard-size patrol car, representative of the popular model most widely used for patrol purposes today and within the most prevalent price range reported. The price of the optional equipment (approximately $660) appears about average for this size car at the time shown.

Table 6 shows the average base prices of several car models. The second column shows Factory Advertised Delivered (FAD) prices for 1973 models; the third shows the approximate cost to the dealer of the basic, unaccessorized car. The price quotation shown in table 5, of $3,500, is assumed to be representative of the price police paid for the middle-of-the-line, standard-size car in 1973.

TABLE 5. *Typical 1972-1973 price quotation for a 4-door standard size, popular model patrol car*

Factory cost[1]	$2,600
Optional equipment	
Police package[2]	100
400 CID engine—2BB1	67
Radio suppression package	4
Spotlight 6 in. MTD left pillar	26
Universal single keys	4
Release—deck lid power	12
Tinted glass and windows	37
Remote control mirror-left	10
Defogger—rear window	23
Trunk light	4
Tires, police special	60
Air conditioning	303
	660
Freight	100
Dealer preparation and handling	50
Dealer markup	100
Total price	$3,500

[1] Includes power steering, power disc brakes, and transmission.
[2] Includes heavy-duty alternator, battery, seats, and other heavy-duty features.

NOTE: Based on average dealer base costs of four popular models, and actual low bid prices reported by several departments on 1972 and 1973 models.

Table 6. *Average 1973 base prices of Ford, Chevrolet, Plymouth, Dodge, and American Motors' cars by model*

	FAD base price[1]	Approximate base dealer cost[2]
Standard size (120-122 in. Wheelbase)		
Bottom-of-Line (Average for Ford Custom 500, Chevrolet Malibu and Laguna, Plymouth Fury I and Dodge Polara)	$3,341	$2,573
Middle-of-Line (Averages for Ford Galaxie, Chevrolet Bel Air, Plymouth Fury II, and Dodge Polara Custom)	3,678	2,832
Top-of-Line (Averages of Ford LTD, Chevrolet Impala, Plymouth Fury III, Dodge Monaco, AMC Ambassador)	3,984	3,068
Intermediate size (111-118 in. wheelbase)		
Bottom-of-Line (6 cylinders) (Averages of Ford Torino, Chevrolet Nova, Plymouth Satelite Dodge Coronet, and AMC Matador)	2,672	2,057
Middle-of-Line (V-8) (Averages of Ford Torino, Nova Custom, Satelite Custom, Dodge Coronet, and AMC Matador)	2,829	2,178
Top-of-Line (Averages of Ford Grand Torino, Chevelle Deluxe and Coronet Custom)	3,023	2,328

[1] Suggested factory advertised delivered base retail prices for 1973 models as reported in *National Automobile Dealers (NADA), Official Used Car Guide*, Eastern Edition, December 1972. These are base prices and do not include options, or dealer preparation.
[2] These rough approximations derived by multiplying the sticker price by .77 are recommended in "Dealing with the Dealer," *Consumer Reports*, April 1973, p. 232. Compared with a sample of dealer prices as reported in the United Buyers New Car Catalog, these estimates are sometimes high and sometimes low, but appear generally to be within 1 percent of the actual price.

NOTE: This list is intended to provide an approximation of prices, not to show exact prices among currently competing manufacturers.

In order to estimate prices of different models accessorized for patrol work, it is assumed that the prices of fully equipped patrol cars are in the same proportions to one another as are their basic FAD prices. This assumption appears reasonable, given two facts: (1) The factors which dictate using a relatively large, high performance car will likely also require more accessories, such as higher powered engine and heavier duty alternator; and, (2) there is a general rule that higher base priced cars are equipped with more options than cheaper ones in order to realize full resale potential.

Estimates of prices of cars accessorized for patrol work, by model, are derived from tables 5 and 6, by multiplying $3,500 (the estimated police price of the middle-of-the-line, standard car) by the ratio of FAD base price of each model type to the FAD base price of the standard, middle-of-the-line model. The resultant estimated average prices shown in table 7 are used wherever the cost analysis calls for initial car prices.

Car Depreciation[12]

Depreciation (measured in dollars) is the difference between the purchase price and the amount recovered at resale; it is, in other words, the used-up value of the vehicle. Table 8 shows average resale prices recently received for used patrol cars, all

[12] This section treats factors influencing depreciation and estimates of depreciation costs. It does not evaluate the most economical depreciation period; that analysis is presented in section 3.5.2.

Table 7. *Estimated 1972-1973 prices of different models of police-accessorized patrol cars*

	Factory advertised delivered (FAD) price as a percent of average FAD price of standard middle-of-line models[1] %	Estimated price to police departments, including options[2] $
Standard size		
Bottom-of-the-line	91	3,185
Middle-of-the-line	100	3,500[3]
Top-of-the-line	108	3,780
Intermediate size		
Bottom-of-the-line	73	2,555
Middle-of-the-line	77	2,695
Top-of-the-line	82	2,870

[1] Percentages calculated from costs shown in column 2 of table 6.
[2] Estimated prices are derived by multiplying $3,500 by the percentages in column 2. As explained in the text, it is assumed that the prices of accessorized vehicles are in the same proportions as the prices of the basic cars.
[3] Assumed price of accessorized, middle-of-the-line, standard-size car. Based on total cost shown in table 5.

Table 8. *Estimated resale values and depreciation costs for 2-year old patrol cars sold in 1973 by a few police departments*

Department type	Average resale value	Two-year depreciation cost expressed as a percentage of original price of police cars[1]
State highway patrol	$936	70 (55-79)[2]
County	590	82 (74-89)
Medium-size city	533	84 (74-89)
Large city	262	87[3]

[1] In comparison, private cars depreciate on the average 50 percent over a 2-year period, not adjusted for high mileage, and 70 percent, when adjusted for high mileage.
[2] The first figure is the group average; the range among departments within the group is shown in parentheses.
[3] No range is given in this area, because resale values were from a single large city department.

NOTE: These data should be regarded only as a rough approximation of depreciation experienced in general by department types. The sample of departments upon which the table is based is small. The cars differed in make, model, and condition, but all were approximately 2 years old and had been driven between 60,000 and 75,000 miles (96,000 and 120,000 km). The data were gathered by interview and correspondence.

of comparable age and mileage, by a small sample of state, city, and county police departments. The cars sold differed in make, model, and condition, but all were approximately 2 years old and driven 60,000 to 75,000 miles (97,000 to 121,000 km).

Depreciation over the 2 years, which may also be measured as a percentage of original car price, was significantly higher for city departments than for state departments. This is not surprising considering the additional wear-and-tear resulting from urban and suburban driving conditions, the differences in utilization practices and, possibly, greater attention to resale which may be given by fleet administrators in state police departments. In table 8, it appears that all of the police cars sold for much less than comparable cars in private use. However, when the higher mileage driven is taken into account, the difference, on the average, vanishes for state highway patrol cars.

The data in table 8 can be used to estimate depreciation rates for patrol cars as well as resale values as a function of purchase price, age, and type of police department. Estimated depreciation rates for patrol cars are derived by department type in table 9. Departments may be able to do better or worse in terms of resale than shown by the estimates in table 9, but these rates may be indicative of average performance.

Table 9. *Derivation of annual depreciation rates for patrol cars owned by different types of police departments*

	Cumulative depreciation of private car value[1]	Yearly decline in private car value of original purchase price[2]	Excess of depreciation rate for patrol cars over private cars over 2 years[3]				Estimated annual percentage decline in value of patrol cars by department type[4]			
Year	% (1)	% (2)	State (3)	County (4)	Medium size city (5)	Large city (6)	State (7)	County (8)	Medium size city (9)	Large city (10)
1	34	34					44%	50%	51	53
2	50	16	+20%	+32%	+34%	+37%	26	32	33	34
3	62	12					12	12	12	12
4	71	9					9	6	4	1
Totals		71					91	100	100	100

[1] Annual percentage depreciation averaged for five car models, Herman S. Botzow, *Auto Fleet Management*, (New York: John Wiley & Son, 1968), p. 31.
[2] Incremental changes of column 1.
[3] Derived from table 8 and column 1 of table 9.
[4] The excess percentage depreciation of patrol cars over private cars during the first 2 years is divided evenly between the first and second years, and added to the rates of depreciation of private cars (column 2). Depreciation for the third year is assumed the same as for private cars, and depreciation in the fourth year is either assumed the same as for private cars or just sufficient to bring total depreciation to 100 percent.

The depreciation rates of table 9 are applied to the estimated purchase prices of table 7 in order to estimate typical resale values by patrol car model and by department type, as displayed in table 10. The depreciation factors for intermediate models have been reduced by 6 percentage points from the rates shown in table 9 to reflect lower average percentage depreciation incurred by intermediates as compared with standard-size models.[13] There is also some evidence to suggest that higher line models may retain their value better than lower line models, but in absence of documentation, depreciation rates have not been adjusted to differentiate between bottom, middle, and top-of-the-line models.[14]

Clearly, depreciation is influenced by many factors in addition to model, age, and mileage, such as make, accessories, color, and condition. The effect of these other factors account in large part for the differences in the estimates of resale value for cars in the various types of police departments as shown in table 10. The impact of car condition, which—aside from age—reflects both different utilization practices and different driving conditions, shows up in the variations in the estimates among department types. For purposes of most of the cost comparisons described later, these estimated resale values are adequate; only for the costing of very low utilization rates does it appear necessary to adjust these estimates.

The background research for this report was completed too early to determine the effect of the Federal Odometer Law of 1973, on car resale values. Used car price guides show significant deductions for higher mileage cars, and many dealers appear concerned about used cars with mileage over 40,000 (64,000 km). However, the patrol car may be in a unique position with respect to this law. In effect, the antirollback laws require truthfulness on the part of the seller, thereby increasing the buyer's knowledge of the car's condition. Used patrol cars are often identified as such despite reconditioning, and are generally expected to have high mileage regardless of the odometer reading. The odometer laws may, therefore, tend to reduce the disadvantage of the used patrol car relative to other high mileage, used cars.

On the other hand, the odometer laws are likely to have a negative impact on prices of patrol cars which are not otherwise identifiable as such. Prices offered for patrol cars by used car dealers and wholesalers who in turn do not identify them as used police cars at time of resale, may fall sharply from previous levels. According to a large midwestern dealer who specializes in sales of used police cars, the odometer law is causing a decline in police car resale values.[15]

Equipment Cost

The purchase, installation, repair, and removal expenses of reusable patrol car equipment is a significant part of total vehicle costs. A list of representative equipment for a standard size patrol car is shown in table 11. The prices shown were recently paid by a police department, but would not necessarily be those available to all buyers. The original purchase price of the full equipment package shown is nearly $1,200.

Since most of the equipment can be sold or reused on replacement cars, the full cost is not incurred at once. Using a 10 percent discount rate, the initial cost of the equipment can be converted to an annual cost, in constant dollar terms, based on the assumed life of the equipment. As shown in table 12, the annual equipment cost is nearly $700 if the equipment is used only 2 years and no resale or trade-in value is received, but can be reduced to about $200 if used for 8 to 10 years.

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[13] The percentage differential was suggested by John A Rowley, "Fleet Car Selection," (paper presented at the NAFA Conference) March 25, 1973, p. 15.

[14] *Ibid*., p. 21.

[15] David Copser, Midwest Auto Sales, Inc., Dayton, Ohio, telephone interview, March 20, 1973.

TABLE 10. *Estimated resale values at the end of each year for patrol cars, by model and type of department, over a 4-year period*[1]

Model	Estimated original purchase price[2]	State				County				Medium-size city				Large city			
		Year				Year				Year				Year			
		1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
Standard-size																	
Bottom-of-line	3185	1780	960	570	290	1590	570	190	0	1560	510	130	0	1500	410	30	0
Middle-of-line	3500	1960	1050	630	320	1750	630	210	0	1720	560	140	0	1650	460	40	0
Top-of-line	3780	2120	1130	670	340	1890	680	230	0	1850	600	150	0	1780	490	380	0
Intermediate																	
Bottom-of-line	2555	1580	920	610	530	1430	610	310	0	1410	560	260	150	1350	490	180	150
Middle-of-line	2695	1670	970	620	380	1510	650	320	160	1480	590	270	160	1430	510	190	160
Top-of-line	2870	1780	1030	690	430	1610	690	340	170	1580	630	290	170	1520	550	200	170

[1] Derived by applying the depreciation rates estimated in table 9 to the estimated initial purchase prices, derived in table 7. The rates applied to prices of standard size models are as shown in table 9; the rates applied to prices of intermediate size models have been reduced by 6 percentage points to reflect lower depreciation generally experienced by intermediates. (Rowley, "Car Selection," p. 15.)

[2] Derived in table 7.

NOTE: Resale values are based on annual mileage accumulation of between 30,000 and 38,000 miles (48,000 and 61,000 km) per car.

Table 11. *Typical 1973 prices of a representative selection of add-on equipment for patrol cars*

Top lights[1]		$ 95.50
Electronic siren/public address system		185.50
Wig-wag head lights		4.50
Two amber lights rear window		13.50
Two red grill lights		13.50
Shot gun scabbard		10.00
Fire extinguisher		7.20
Push bumper		35.00
Decals		12.00
Metal trunk box		17.00
		393.70
Radio (a wide price range exists, ranging from about $600 to $1500 for a standard model mobile radio)		800.00
Total equipment costs	$1,193.70 rounded to	$1,200.00

[1] For a cost comparison of two models of top lights, see table 16.

NOTE: This is not intended as a comprehensive listing of equipment nor as an official price list. Items are those actually included on the patrol cars of a particular state highway patrol department, and prices are those paid in 1973, by that department.

Table 12. *Annual cost of patrol car equipment*[1]

Assumed Life of the equipment (Years)	First cost ($)	UCR factor	Discount rate	Annual cost of equipment
2	1,200	.5762	10%	$691
4	"	.3155	"	379
6	"	.2296	"	276
8	"	.1874	"	225
10	"	.1628	"	195

[1] Assuming various life-periods for the equipment, no salvage value, and a discount rate of 10 percent, the initial cost of the equipment can be converted to an annual cost basis by multiplying the first cost by the Uniform Capital Recovery Factor (UCR) for the selected time period. For example, for a life of 6 years, annual cost of equipment = $1,200 × (.2296) = $276.

It is estimated that about 3 labor hours would be needed to install the radio, and about 6 labor hours to install the other equipment.[16] Depending on labor costs (which might range from $5 to $15 an hour), installation would cost from $45 to $135.

3.2.2. Cost Saving Practices in Buying and Selling

An expert in transportation management has estimated that a fleet manager often can save at least 15 percent of total fleet costs and possibly as much as 40 to 50 percent by applying efficient management practices.[17] Significant reductions are often possible in each area of costs. This section explores some of the methods for lowering the purchase price or raising the resale value to reduce depreciation costs.

[16] Estimates of 6 hours to install equipment other than the radio, and 3 hours to install the radio were provided by the Arizona Department of Public Safety, Phoenix, Ariz., May 1973.

[17] Herman S. Botzow, Auto Fleet Management, (New York: John Wiley & Son, 1968), pp. 4, 129.

Model Selection

As was shown in tables 6 and 7 it is possible to reduce the purchase price by moving down the model line from one make or model to the next. The difference between the price of a bottom-of-the-line intermediate and a top-of-the-line standard-size car averaged more than $1,000, based on 1972-1973 prices (see col. 3, table 7).

The cost effect of "moving down the line" is, of course, not this simple. What is important is the combined effect of the lower purchase price, the corresponding change in resale value, and the impact of the change on operating cost.

Table 13 compares representative ownership cost for several car models kept for 1, 2, or 3 years by 2 different types of police departments. Consider for the time being only the effect of model difference, and not age or department type. In row 5 we can compare the costs of 6 different models, all owned by a medium-size city department and kept for 2 years. Based on the data developed here, the standard, top-of-the-line model costs $142 more in annual depreciation than the middle-of-the-line model, which, in turn, costs $158 more annually than the standard, bottom-of-the-line. Potential savings in annual cost is $300 per car by moving from the top-of-the-line to the bottom. A middle-of-the-line standard car operated for 1 year by a State highway patrol costs nearly $600 more annually in depreciation than a middle-of-the-line intermediate kept 1 year.[18]

These data suggest that depreciation costs can be reduced by choosing less-expensive, smaller cars (provided these cars can be *effectively* used). This reasoning may not apply if, for instance, a department has access to an exceptional or specialty resale market for a particular model of used car where the depreciation rates among models are significantly different from those normally incurred. However, it should again be stressed that a substantial difference in depreciation rates is necessary to equalize the depreciation costs of higher and lower priced cars. Since more expensive cars generally have to be in good condition in order to realize full resale potential, the rule of selecting less-expensive models whenever possible undoubtedly is appropriate for departments whose cars at the time of disposition are usually in poor condition.[19]

Length of Ownership

The effect on depreciation cost of keeping cars longer can also be seen in table 13. Examine in the top three rows the depreciation costs of a middle-of-the-line, standard car owned for 1, 2, or 3 years. In this case, extending the period of ownership from 1 to 2 years decreased annual depreciation by $373, and from 2 to 3 years, by an additional $300.

The impact of harder utilization and poorer car condition on annual depreciation is suggested by the comparison of a standard, middle-of-the-line car owned for 2 years by a state highway patrol with the same type of car owned for the same period of time by a city department. Annual depreciation costs incurred by the city's car exceed the state's by a substantial amount; in actual practice, examples of much larger differences may be found.

The combined effects of both model and age on annual depreciation can be seen in the extreme case in the comparison of costs to a State police department of a top-of-the-line standard car owned for 1 year with cost of a bottom-of-the line intermediate car

[18] These estimates rest on the assumptions of equal depreciation rates for bottom, top, and middle-of-the-line models within each size category, and 6 percentage points lower depreciation rates for intermediates as compared with standards. Although it has been suggested that rates of depreciation may decline as car price increases within a particular size group, no conclusive evidence was found. It is apparent from the cost estimates that a fairly sizable difference in depreciation rates would be required to eliminate or reverse the effect shown. A check of first year depreciation on bottom, middle, and top-of-the-line standard-size cars, in private usage, showed little difference in depreciation rates, but to the extent there was a difference, depreciation rates for higher line models were greater than for the bottom-of-the-line model. (*NADA Used Car Guide.*) It has also been said that certain makes of vehicles depreciate less than others. Any differences which may exist between makes are not taken into account.

[19] This finding is compatible with the recommendation fleet managers to "trend towards low-line models for high mileage—hard usage," given by Rowley, "Car Selection," p. 11.

TABLE 13. *Comparative annual ownership costs of standard and intermediate-size patrol cars, by model-line, age, and department type (in constant 1973 dollars)*

Department type		years owned[1]	Standard-size									Intermediate-size								
			B-O-L			M-O-L			T-O-L			B-O-L			M-O-L			T-O-L		
			PP[2]	RV[3]	AC[4]	PP	RV	AC	PP	RV	AC	PP	RV	AC	PP	RV	AC	PP	RV	AC
	(1)	1	3,185	1,780	1,724	3,500	1,960	1,890	3,780	2,120	2,038	2,555	1,580	1,231	2,695	1,670	1,295	2,870	1,780	1,377
State	(2)	2	3,185	960	1,378	3,500	1,050	1,517	3,780	1,130	1,640	2,555	920	1,034	2,695	970	1,091	2,870	1,030	1,163
	(3)	3	3,185	570	1,108	3,500	630	1,217	3,780	670	1,318	2,555	610	788	2,695	620	896	2,870	690	946
Medium	(4)	1	3,185	1,560	1,943	3,500	1,720	2,130	3,780	1,850	2,308	2,555	1,410	1,400	2,695	1,480	1,485	2,870	1,580	1,577
Size	(5)	2	3,185	510	1,592	3,500	560	1,750	3,780	600	1,892	2,555	560	1,206	2,695	590	1,272	2,870	630	1,354
City	(6)	3	3,185	130	1,288	3,500	140	1,365	3,780	150	1,475	2,555	260	949	2,695	270	1,002	2,870	290	1,066

[1] It is assumed that cars are driven between 30,000 and 38,000 miles (48,000 and 61,000 km) per year.

[2] Purchase price: estimated prices to police departments, including options, as developed in table 7.

[3] Resale value: from table 10.

[4] Annual cost of depreciation: calculated from the following annual cost equation: AC=(PP-RV)(UCR; n, i)+RV(i); where AC=annual cost, PP=purchase price, R=resale value, UCR=uniform capital recovery factor, n=year, and i=discount rate. For example, with a 10 percent discount rate, annual cost of ownership for an intermediate, bottom-of-the-line model owned by a medium size city for 3 years is calculated as follows: AC=($2,555-260)(.4021)+260 (.10)=$949. The estimates ignore reconditioning expenses.

NOTATION: B-O-L, Bottom-of-the-line; M-O-L, Middle-of-the-line; T-O-L, Top-of-the-line; PP, Purchase Price; RV, Resale Value; AC, Annual Cost.

owned 3 years. The estimated annual costs in constant 1973 dollars, are $2,038 and $788, respectively—a difference of $1,250.

For a car in ordinary use, depreciation increases, but at a declining rate, until about the sixth or seventh year. After this time depreciation remains about constant at a low level or goes to zero. A patrol car, with its high mileage and sometimes rough use, usually depreciates out much more quickly. As was estimated in table 10, a patrol car driven in a city will, on the average, have lost most of its value between the third and fourth years of use.

Accessories, Color and Equipment

From a cost standpoint alone, most accessories would be ordered by most departments expressly to meet functional police requirements.[20] It will seldom pay to add extensively to the list of optional accessories solely for the purpose of increasing resale value. This is especially true: (1) When bottom-of-the-line cars are selected; and (2) when cars are sold after several years with high mileage and in poor condition. Equipment added in such cases will have little influence on resale values.

In other circumstances, however, careful and selective use of equipment and color may be used to decrease depreciation.[21] This may be done in two ways: (1) By giving attention to selection of those features which are standard with the car (i.e., their costs are included in the base price) and (2) by adding only those accessories which hold their value well and add to the general appeal of the car.

With respect to standard features, some departments have reported the benefits of specifying that the department will have choice of a variety of interior and exterior colors without additional charge.[22] A diversity of color choice appears to improve demand for the used cars; prospective buyers facing 400 identical cars, for instance, are not likely to feel very competitive. From the standpoint of resale alone, the more distinctive the car, the higher the price. Light, pastel colors appear to be good choices for exterior colors. Light-to-medium metallic colors seem preferable to darker metallics.[23]

Although the cost savings possible through the color selection cannot be definitively measured, some effects were observed in the following several special cases:

(1) Of cars disposed of by a large city department in 1971-72, unmarked colored cars sold at an average price of about $340, compared with an average of only $260 for black and white cars which had been marked. The colored cars averaged several years older than the black and white cars, but the average mileages were similar. The greater age of the colored cars would to some extent offset their advantages of better condition and fewer police features, hence color may well have accounted for the better sale prices of that group.

(2) In a recent sale of State police cars, white patrol cars which had been marked sold for about $60 less than colored patrol cars which also had been marked. All of the cars were of comparable model, with similar accessories and of similar condition.

(3) During 1970, in a southwestern state, resale prices of similar white and colored state patrol cars, while nearly identical to one another, were substantially higher than those received in other states not having a patrol fleet mixed in color. The

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[20] There are, of course, other considerations in selection of accessories and options besides functional requirements and cost, including officer safety, morale, comfort, and officer and vehicle appearance.

[21] Perhaps attention should be called to the words "decrease depreciation." There is no question that optional equipment can raise resale value, but this does not necessarily mean it decreases depreciation, a point often neglected.

[22] This obviously does not apply to departments which are not free to have a mixed color fleet (due to restrictive codes), or which choose not to, or to vehicles whose use requires a uniform distinctive color and markings so as to be readily identifiable.

[23] Discussion of fleet car selection, Annual Conference, National Association of Fleet Administrators, Inc., Detroit, Mich., March 25-28, 1973.

manager of car disposition explained that white cars sold as well as colored ones due to the strong demand for white cars in the hot climate, but the mixture of white and colored cars helped raise the average resale price of all their cars by stimulating interest in the whole fleet.

(4) Of a group of state toll-way cars sold in 1972 to an auto auction house which, in turn, reconditioned and resold them, the following observations were made:

a. White cars were bought at a lower average price from the state police department than were colored cars, and

b. a lower price was received by the auction house for the reconditioned white cars than for the reconditioned colored cars.[24]

It may also be noted that some departments diversify their fleets even further for resale purposes by varying models and makes, as well as colors.[25]

As to the cost effects of various optional accessories, the particular combination of car and equipment seems to be very important. Generalizations regarding the cost effects of individual accessories are meaningful only as they relate to particular models, other accessories, car condition, and method of disposition.

Table 14 presents examples of the "holding cost" for selected accessories. These data suggest that the V-8 engine, automatic transmission, and power steering may cost little, or even reduce overall depreciation cost. On the other hand, the air-conditioning system appears to lose nearly a third of its value in 1 year, about comparable to the rate of overall car depreciation in the first year. However, air-conditioning in top-of-the-line models in good condition has become almost necessary in order to retain their full resale appeal. Also, air-conditioning and power features have become increasingly regarded as expected concessions to driver comfort, just as air-conditioned environments are expected by office workers.

There are disadvantages to locally-installed air-conditioning units such as interference with the installation of other police equipment. However, departments whose cars are heavily depreciated at time of resale may find the ability to rotate units an efficient way to have air-conditioning.

Following are some general guidelines suggested for accessorizing fleet cars, which may be adaptable to patrol cars:[26]

For Lower Priced Makes (i.e., Chevrolet, Ford, Plymouth and Ambassador)

B-O-L—Keep equipment to minimum—automatic transmission, radio, and power steering with V-8 engine.

M-O-L—Automatic transmission, radio, V-8 engine, and power steering and power brakes a must. Air-conditioning rapidly becoming mandatory for good resale.

T-O-L—These cars must be well equipped—add miscellaneous items of equipment such as light groups, wheel covers, white sidewall tires.

For Medium Priced Makes (e.g., Mercury, Buick, Pontiac, and Oldsmobile).

B-O-L—Should be equipped with automatic transmission, power steering, power brakes, radio, white sidewalls.

When a more expensive car is selected, air conditioning, power steering and other luxury features should probably be added and efforts should be made to eliminate the austere appearance often typical of police cars, in order to reduce depreciation. A sales manager of a large auto auction has expressed it this way: "Even though they (middle and top-of-the-line cars) may have both air-conditioning and power features, 'Police Specials' with taxi cab interiors and rubber floor mats cannot successfully be converted

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[24] The auction house made the larger profit margin on the white cars. The advantage of the lower price paid for them more than offset the higher reconditioning costs and lower price received. The conclusion we can perhaps draw from this is that, given the apparent profit potential, police departments may tend to sell their unattractive patrol cars to wholesale dealers more cheaply than they could.

[25] In the cases found, maintenance was contracted out to private dealers and garages. The problems and additional costs which might otherwise result from need for larger parts inventories, more equipment, and loss in efficiencies of specialization by mechanics were thereby avoided.

[26] Taken from Rowley, "Car Selection," p. 28. Notation: B-O-L, M-O-L, T-O-L indicates bottom-of-the-line, middle, and top.

TABLE 14. *"Holding costs" for selected items of car accessories*[1]

Accessories on intermediate model	Average value of 1971 model equipment sold in 1972 ($)	Typical 1973 cost ($)	Holding cost ($)
Power steering	101	88	(13)[2]
Automatic transmission	203	177	(26)
Air conditioning		310	
North value	213		97
South value	225		85
Vinyl top	53	76	23
V-8 engine	116	91	(25)

[1]Cost data were obtained by averaging values from three used car guides. In the examples, holding cost is defined as the difference between the price of the equipment on a 1973 intermediate model, and the used value for the same type of equipment installed on a 1971 model and sold in 1972. Clearly this is a dubious measure and actual experience might produce much different experience.

[2]Parentheses indicate a negative holding cost.

Source: Rowley, "Car Selection," p. 24.

to desirable used cars, at least not from a cost standpoint." [27] To this end, some departments order patrol cars with carpeting and protect it with rubber throw mats; put on attractive tires (such as whitewall recaps), and add other touches to help remove the patrol car look at resale time. These steps will be effective, however, only if the car is sold while it is still in good condition. If the car is kept until it is in poor condition, the remnants of luxury features will have little impact on resale and will merely add to purchase price, hence to depreciation cost.

Some departments select cars for resale appeal, equip them well, maintain them in top condition, and keep them for a relatively short time—in some cases for 40,000 miles (64,000 km), or less. Such practice may yield resale values quite close to those received for similar cars in private use.[28] The improvement in resale value, however, is contingent on luxury accessories, a shorter period of use, good maintenance, top condition at resale, and an effective selling program—all of which may add to ownership costs.

Table 15 shows estimated annual depreciation costs for two cases: (1) The same expensive model, but equipped with options added exclusively for resale purposes, and sold in top condition after 1 year of use with relatively low mileage; and (2) the same expensive model, but with somewhat fewer accessories, and sold in "average" condition after 3 years of use. It appears that, by keeping the car longer, annual depreciation can be reduced by about $300 to $600, even though resale value is lowered. Thus, even if a higher-line, more expensive car is used, depreciation costs may be lowered by extending the service life.

It may be argued, however, that the purpose of moving up the model line is to improve officer morale, car appearance and car performance, and that increasing the age of the vehicle negates the advantages of the higher model line. Alternatively, it might be claimed that reducing vehicle age is intended to lower maintenance costs and downtime. [The cost relationships between maintenance and repair cost and age (mileage) are examined in section 3.3.] From the information presented here we can conclude that decisions to buy higher-priced cars with luxury accessories and to keep them for short periods of time generally do not appear to be justifiable in terms of reducing depreciation cost—although they may well be justifiable on other grounds.

[27]R. W. Edmonds, General Sales Manager, Indiana Auto Auction, Inc., Fort Wayne, Ind., Letter of April 16, 1973.

[28]The similarity in resale values were determined by comparing used patrol car prices of a department with used car values as reported in the *National Used Car Market Report*, *Blue Book* and *Automotive Market Report*.

TABLE 15. *Comparison of annual depreciation costs associated with two approaches to ownership of a more expensive patrol car*[1]
(In constant 1973 dollars)

Approach 1:	Luxury Equipment, Top Condition, 1 Year Old—Low Mileage	
	Purchase Price	\$3,880[2]
	Resale Value	\$2,561 to 2,910[3]
	Reconditioning Expense	\$250
	Annual Depreciation Cost[4]	[\$3,880—(\$2,561 to 2,910)] (1.1) + (\$2,561 to 2,910) (.10) +250 (1.0)[5]
		= \$1,957 to 1,608
Approach 2:	\$100 Less Equipment, "Average" Resale Condition, 3 Years Old—High Mileage	
	Purchase Price	\$3,780
	Resale Value	670
	Reconditioning Expense	67
	Annual Cost	= (\$3,780-670)(.4021) + (670)(.10) + (67)(.3021)
		= \$1,338

[1] The costs of maintaining a 1-year old car in "top" condition as compared with maintaining a 1 to 3-year old car in "average" condition is difficult to estimate. This cost difference is ignored here, except as reflected in the assumption of higher and lower reconditioning expenses, respectively.
[2] The purchase price of \$3,880 is the sum of \$3,790, the estimated price of an equipped top-of-the-line patrol car (table 7), and \$100, the estimated cost of additional equipment chosen for resale appeal.
[3] The low end of the range is based on a depreciation rate of 34 percent, the rate assumed average for ordinary passenger cars during the first year, with no increase added to reflect police use. The high end of the range is based on a depreciation rate of 25 percent, to compare the two approaches when a substantial depreciation advantage is assumed for the first approach.
[4] As shown in table 10 and based on estimated patrol car depreciation rates developed in table 9.
[5] Uniform Sinking Fund (USF) factor.

Cost savings are also possible in equipping the vehicles, both by eliminating any unnecessary items and by choosing wisely among alternative model designs. Although it is not possible within the scope of this study to make cost comparisons among all alternative equipment systems—and there are many—a brief cost comparison is made of two suitable warning light systems, for illustrative purposes.

The two systems costed are: (1) An aluminum mounting bar, having at each end a light with two rotating light bulbs, and; (2) a roof mounted light with four rotating bulbs. An electronic siren/PA system is required with each light system but need not be costed since there is little difference in price. (With the bar light, the speaker can be mounted in the center of the bar and the electronics housed within the car; with the bubble light, essentially the same speaker, with a flat horn design, can be mounted under the light unit with the electronics unit in the car.) For the purpose of comparison, the light units are the relevant items.

Although the two systems may differ slightly in terms of performance (e.g., the bar light appears to be more visible, but may also be subject to theft and cause greater wind resistance and wind noise than the bubble light), they seem to be roughly equivalent. Their comparative costs, including purchase price (less salvage value), installation cost, cost of vehicle modification necessary to mount the systems, maintenance costs, removal costs, and cost of repairing damage resulting to the vehicle—would, therefore be a prime criterion for selection.

Part A of table 16 lists the relevant costs for each system. The bubble light is seen to have a lower purchase price than the bar light. This comparison is often cited as justification for buying the bubble light. However, a much more valid comparison of costs is provided in Part B, where the alternative costs are converted to the same annualized cost basis. This shows that the bubble light is actually more costly than the bar light because of the repetitive expenses of removal and reinstallation.

TABLE 16. *Cost comparison of visi-bar light system with bubble light*
(In constant 1973 dollars)

	Bar-light system	Bubble light
A. Costs of the Two Systems[1]		
Purchase price	$161.50	$115.75
Installation cost[2]	5.00	17.50
Removal cost[3]	1.00	5.00
Repair of vehicle[4]	0	25.00
Expected life	8 years	8 years

B. Comparison of Annualized Costs

Starting with new equipment, using a 10 percent discount rate, and assuming equipment is rotated to replacement cars every 2 years, the annual costs of each system can be calculated as follows:

Annual cost of bar light (A_1): A_1 = [$166.50 + $6.00 (SPW, yr. = 2) + $6.00 (SPW, yr. = 4) + $6.00 (SPW, yr. = 6) + $1.00 (SPW, yr. = 8)] [UCR, yr. = 8] = $33.62

Annual cost of bubble light (A_2): A_2 = [$133.25 + $47.50 (SPW, yr. = 2) + $47.50 (SPW, yr. = 4) + $47.50 (SPW, yr. = 6) + $30.00 (SPW, yr. = 8)][UCR, yr. = 8] = $46.05

[1] The systems costed are two popular brand models; prices are 1973 catalog prices. Several items of costs are omitted from the comparison: costs of modifying the vehicle to make it ready for the light installation are omitted because it is estimated that costs of switches and wiring for the two systems would be approximately the same. Costs of subsequently repairing the two units appear likely to differ, but are not included in analysis due to the inability to get good quantitative estimates. In addition, differences in failure rates and repair costs are not included. In addition, differences in failure rates and repair costs are not included. However, it was suggested by several police fleet managers that the bar-light system is less subject to failure than the bubble light. Thus, cost of the bubble light might be increased relative to the bar light if maintenance costs were included. Salvage values (negative costs) also are not included, due to uncertainty regarding appropriate values. One fleet administrator estimated both would be worth about $25 at the end of 8 years. Another estimated no salvage value for either at the end of 8 years. To the extent that salvage values do remain, it would seem likely that the bar light would have a greater salvage value than the bubble light since it might be considered a more modern model and is less likely to corrode or be marred during installation and removal.

[2] Based on an assumed labor rate of $10/hour and estimates of 30 minutes to install the bar light and 1 hour and 45 minutes to install the bubble light. (Estimates provided by the Vehicle Maintenance Section, Prince Georges County Maryland Police Department; Interview, April 1973.)

[3] Based on a $10/hour labor rate and estimates of 5 minutes removal time for the bar light and 30 minutes for the bubble light. Same source as above.

[4] Same source as above.

If the likely higher maintenance cost of the bubble light and its probable lower salvage value were also considered, the cost advantage of the bar-light system would be even greater. (See footnote b to table 16 for an explanation of these other cost items.)

Reconditioning

In practice, reconditioning expenditures vary greatly among departments, and among vehicles. Some departments do not recondition; others invest substantially in upgrading cars for resale. This is not surprising since differently equipped cars incur different reconditioning costs, and not all cars warrant or merit the same amount of reconditioning.

A rule-of-thumb used by some departments is that reconditioning costs be about 10 percent of the estimated resale value of the car. Based on resale values developed earlier, we would therefore expect reconditioning costs to range from $20 to $200 for police cars. In general, more should be spent on newer, more expensive models, and less on less expensive models, and those in poor condition. There are exceptions to these guidelines, depending mainly on the type of car. For example, elaborate reconditioning of a car with an austere interior is unlikely to pay, even for a relatively expensive model in good condition. Its lack of consumer appeal will likely prevent attainment of full resale potential.

On the other hand, minimal reconditioning even if no more than a good cleaning, is almost always worthwhile. Cars in exceptionally poor condition may be worth more through parts recovery than through reconditioning and resale.

Institutional Impediments and Incentives to Efficient Buying and Selling

There may be institutional barriers to efficient fleet management. In the buying and selling of police cars, there may be a lack of direct lines of responsibility, communication, and recognition between those in charge of purchasing, using, and disposing of vehicles. For example, some police departments have insufficient influence on decisions regarding fleet composition, make and model selection, accessorizing, and replacement. This lack of influence may cause morale problems and an inferior job in managing and caring for the vehicles provided.

There is an obvious disincentive to efficient vehicle disposition when the police department staff perceives no direct benefit from achieving cost savings in depreciation. In centralized fleet management, for example, the police department may turn over its vehicles to another governmental division for disposition with the proceeds from resale going into a general fund. This may ultimately benefit the police department, but so indirectly as to occasion comments from police administrators such as, "It makes no difference to the police department whether it surrenders its vehicles in good or poor condition." Departments which receive no direct credit from their retired vehicles may find it profitable to junk cars for parts retrieval, rather than pass the cars along for resale even if more might be recoverable from resale. Such a practice may be perfectly efficient from the standpoint of the police department, but not from that of local government and society.

This undesirable side effect of centralizing the management of fleets of the various units of government (such as the police department, fire department, and sanitation department) is ironic, since one of the main arguments for centralizing fleet operations is efficiency—the possibility of achieving economies of scale and better coordination among subunits.

The problem of incentives to efficient management deserves attention. Sound cost accountability procedures which would shift charges and credits to the cost centers from which they arise are necessary. In this regard, it might be fruitful to examine departments with centralized management, and to look into their respective incentives systems.

Preparation of Specifications, Price Documentation, and Bid Acceptance

Cost savings are often possible in the purchase of vehicles. Careful specifications can reduce costs and improve fleet effectiveness. According to one manufacturer's representative who has considerable contact with law enforcement fleets, "many departments order the wrong kind of vehicle, not really suited for the intended use, such as pursuit cars for in-city use." He further commented that departments often submit "weird" or obsolete specs, calling for features which are not really needed and which add to the cost.

Attention to details can prevent unanticipated ballooning of costs. As an example, one county fleet administrator cited a savings of $30 per car (compared to a nearby police department buying the same car) simply by specifying the inclusion of preparation and handling charges within the bid price.

There are probably advantages in quantity buying, although the largest car manufacturers ceased granting special discounts to fleets in the summer of 1970. In informal conversation, a major company representative stated that special concessions and consideration with respect to such items as warranty coverage and delivery are extended to two types of fleet customer: the most important from the standpoint of volume of business, and those who "scream the loudest." Police fleet managers who were interviewed attest to this statement. Departments with small fleets might therefore find it advantageous to join in group buying. Joint efforts and larger orders may result in a somewhat better price or better service, in that the dealer may be willing to accept a lower profit margin or provide additional service on larger volume orders. "Piggy-backing" on other departments' orders or group buying can further reduce the total cost of preparing bid proposals, advertising, receiving and analyzing bids, awarding contracts, and other managerial expenses.

Cooperative buying may present considerable difficulty in interpersonal and intergovernment relationships. It is not easy to exercise efficient, large-scale and centralized buying techniques without abridgement of local department prerogatives, responsibilities and vehicle requirements. Cooperative buying also can be inefficient if smaller departments purchase more expensive vehicles or more optional equipment than they actually need. However, some departments and local governments presently claim savings through group purchasing.[29]

Departments can also save on costs of preparing specifications by drawing on the experience and information available from other departments, including research, test results, and illustrative specifications. Some large departments—most notably the Los Angeles Police Department—test vehicles and equipment and share information with inquiring departments. The National Association of Fleet Administrators maintains a file of sample specifications, available to member departments. The exchange of police vehicle procurement information is also a by-product of intergovernmental cooperative purchasing.

Information exchange might be further and profitably widened through establishment of a national clearinghouse or reference service. Perhaps an existing organization already active in the area (such as the National Institute of Governmental Purchasing or the Law Enforcement Group of the National Association of Fleet Administrators) could broaden its dissemination of relevant procurement data.

Several police fleet administrators who were interviewed suggested that procurement savings might be possible through direct participation by state, county and city police departments in Federal supply contracts administered by the U.S. General Services Administration, but this does not appear to be possible under existing Federal law. However, establishment of a national procurement data exchange does seem possible under Title III of the Intergovernmental Cooperation Act of 1968 (P.L. 90-577): *Permitting Federal Departments and Agencies to Provide Special or Technical Services to States and Local Units of Governments*.[30]

A source of current car price data for the different car makes is useful to estimate expected costs of vehicles and parts, and to evaluate bids. Examples are: (1) The *AIS New Car Cost Guide*, distributed by the Automotive Invoice Service Company; and, (2) the *Unicomp Directory of Used Cars*. Some police departments secure price lists from dealers or from the manufacturers. The manufacturers also make available annual vehicle specifications describing available options and features, but generally not prices.

Advance notice of planned design changes is useful for efficient planning and coordination of vehicle and equipment purchases. Changes in interior configuration may mean that equipment purchased earlier will not fit later models and will, therefore, become quickly obsolete. Close contact with manufacturers' representatives may help to avoid this problem.

Conventional procurement practice is to accept bids from local dealers. Many departments accept strictly the low bid, resulting in the lowest purchase price. However, departments increasingly have come to realize that the lowest purchase price may not mean the lowest life cost. One department, through low bid acceptance, changed to a model which was bid 40 cents below the department's existing vehicle model, but which necessitated considerable expenditure for new equipment, new parts inventory, and retraining of mechanics to make the transition.

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[29] See, for example, Robert N. Belmonte, County of Bergen, N.J., "Another Look at Large-Scale Intergovernmental Cooperative Purchasing," *Journal of Purchasing*, February, 1972, pp. 34-49.

[30] *Ibid.*, pp. 47-48.

Some departments believe that low bid acceptance is legally mandatory, regardless of the overall cost effects, and in some cases this is true. Typically, however, procurement regulations are written to allow exceptions when low bid acceptance would be inefficient.

A parallel may be drawn between state and local procurement practices and Federal practices. Section 2305(c), Title 10, U.S. Code states, "Award shall be made...to the responsible bidder whose bid...will be most advantageous to the United States, price and other factors considered." In past practice, the word price has been the chief or only consideration in awarding advertised contracts. This avoids related protests and complaints, as well as the need to justify exceptions. With more attention being given to life cycle costs, the Federal Government appears to be moving away from this practice.

Timing of Purchase and Resale

The time at which cars are bought and sold affects costs, but the existing views and practices concerning timing are mixed. For purchase, many departments prefer to wait until late in the model year (e.g., late spring or early summer), believing that they can get better prices when the changeover to new models is imminent, and that the factory delivered condition of the car is better due to correction of earlier assembly line problems. Other possible reasons for delaying purchase are the low priority given fleet sales by some dealers, and departmental indifference to depreciation due either to a poor incentive structure or to planned use of the vehicle until little resale value remains.

Depreciation costs under normal conditions do not justify delaying purchase. Cars depreciate primarily in terms of model years: a car bought at the end of the model year is assigned a full year's depreciation cost at the time of model change-over. This depreciation is essentially "unused" and raises annual average cost. Therefore, a department which practices relatively quick turnover of its fleet and emphasizes reduction of depreciation cost should, if possible, buy vehicles early in the model year. Any purchase price differential in early and late buying is likely to be small—particularly since price increases often occur during the model year.

Three main forces in the resale market affect optimal timing of disposition—trend, cycle, and seasonal variation. The general direction, or trend, of resale values for a given model is, of course, normally downward. This is shown in exhibit 5, which charts the resale values of a low-price, standard-size car (not a patrol car) from the time of first introduction in the fall of 1969 to late spring of 1973. The car was priced new at $2,930, sold used for $2,275 at the end of 1970, for $1,875 at the end of 1971, and for $1,425 at the end of 1972.[31] The inset of the figure stacks the model years vertically to accentuate the seasonal pattern. Values appear to decline most sharply from about November through March each year, but remain fairly constant from April through the summer months.

Exhibit 6 shows recent cyclical fluctuations in the used car market, which appeared generally strong from early 1970 until the third quarter of 1971, but then was depressed in the fourth quarter of 1971 and early in 1972. Buoyant or depressed markets could alter the resale value normally expected.

Except for unusually strong aberrations in the used car market, it appears generally most efficient to purchase new cars and to dispose of old cars as early in the model year as possible. If delayed until late spring, however, purchase and disposition can usually be further delayed until late summer with little additional depreciation cost. Any further delay tends to result in a large rise in depreciation cost.

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[31] *NADA Used Car Guide*, Eastern Editions, 1970 Plymouth Fury I.

Exhibit 5. *The pattern of resale values for a bottom-of-the-line, standard size car in private use.*

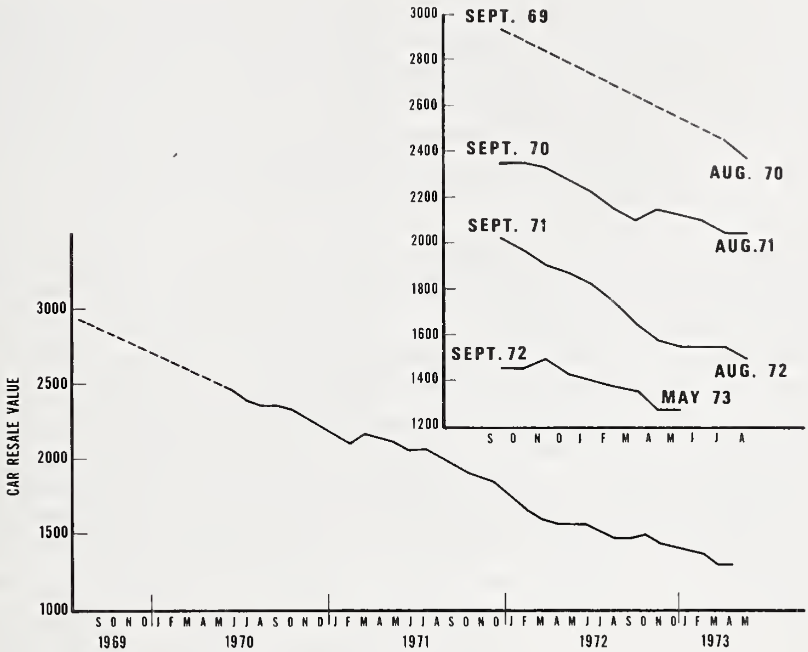
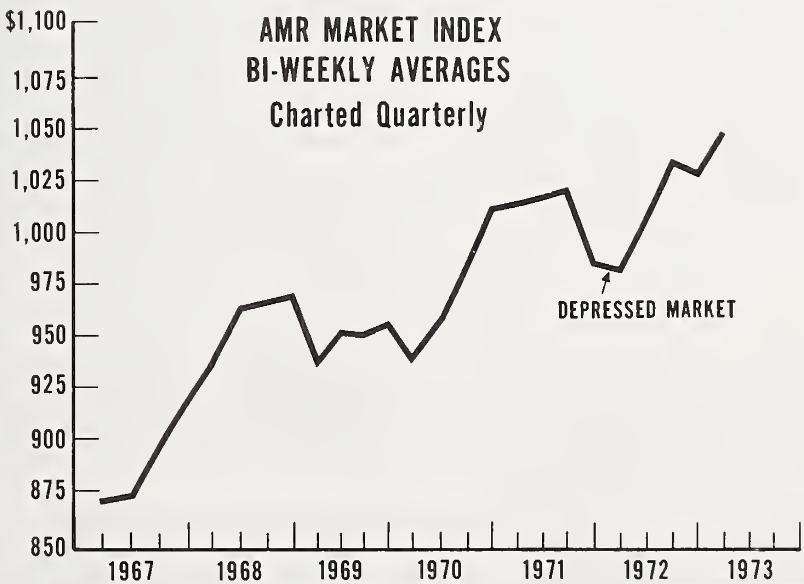


Exhibit 6. *Overall level of used car prices, seasonally adjusted, 1967 to 1973.*



SOURCE: Rowley, "Car Selection," p. 19.

Source: Resale values were taken from the 1969–1973 issue of *NADA Used Car Guide*, Eastern Edition. Resale values are for a 1970 Plymouth Fury I, V–8, CID 318, 4-door, automatic transmission, power steering and brakes, but excluding air conditioning.

NOTE: Dotted line indicates estimated resale values not listed in NADA Used Car Guide.

Alternative Methods of Car Disposal

The means of disposing of used vehicles is another factor which influences depreciation costs. There are essentially two methods of disposing of vehicles in the open market—by wholesale or retail. (The variety of wholesale and retail disposal methods are listed below.) In addition, vehicles may be transferred from the police department to other governmental units prior to subsequent resale. The following specific ways of disposing of patrol cars were identified by this study:

(1) Trade-in to new car dealer upon purchase of replacement vehicles.
(2) Sale to a used car dealer.
(3) Consignment to an automobile auction house.
(4) Transfer of vehicles from the police fleet to another department of government.
(5) Periodic public police auctions.
(6) Periodic acceptance of sealed bids from the public.
(7) Prearranged sale to employees or private buyers when vehicles are retired.
(8) In the case of leased cars, disposal handled by a leasing company.

Each method has its advantages, disadvantages, and relative appeal depending in part on the model, age, and condition of the car, and in part on the characteristics of the police department and the availability of alternative methods of disposal. In considering the alternative methods from a cost viewpoint, it should be remembered that it is the net resale value that counts; that is, it is important to take into account the selling costs associated with each method, as well as the price received.

Retail sale methods, which omit the middleman, appear to yield highest prices. Methods 5, 6, and 7 above all may include retail transactions. A comparison of NADA retail and trade-in prices for four makes and eight popular models showed retail prices of cars generally to be between $425 and $475 higher than trade-in prices. The City of Atlanta, Georgia, cites "an excellent return" from the annual public auction of its entire police passenger car lineup; prior experience with trade-in disposition yielded poor results.[32]

The main disadvantages of retail methods are the higher reconditioning and selling costs which are usually involved, and the possible delay in disposal. Since the aim is to sell cars directly to the ultimate buyer, more attention is usually given to detailing or reconditioning the car. Many police departments are not equipped to do this as efficiently as dealers. Methods 5 and 6—police auctions and acceptance of sealed bids—are likely to require storage from time of retirement to time of auction or awarding of the bid, with the attendant storage costs, insurance cost, and unused depreciation. Advertising will probably be necessary to stimulate consumer interest, and administrative and management talent will be needed to successfully conduct or oversee the sale.

Of the retail methods, the police auction offers the advantage of competitive bidding, which may raise prices. If the fleet is of sufficient size to enable scheduling of frequent auctions, the problems of storage costs and unused depreciation may not be serious. Some departments and governmental bodies, such as the Arizona Department of Public Safety and the City of Seattle, hold regularly scheduled auctions of police cars on their own used car lots. This method is most suitable for disposal of cars in relatively good condition with consumer appeal.

Prearranged selling to employees or others appears to be feasible only for small fleets. In contrast, acceptance of sealed bids is a fairly simple method of disposal which is manageable even for large fleets. Its main drawback is the necessity for storage and making vehicles available for public inspection for a period prior to bid awarding.

Wholesaling—selling to used car dealers, to wholesalers and brokers, or consigning to automobile auction houses—offers the advantages of quick sale and low selling costs,

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[32] Al Trager, "Going, Going, Gone'." *Commercial Car Journal*, June 1972, 114-116.

but prices may be lower than attainable through retailing. Wholesale methods are often used by departments interested in quick sale with little or no reconditioning. Utility, service vehicles, and cars in poor condition usually are wholesaled.[33] Some auto wholesalers advertise in trade journals specifically for police vehicles. They buy in quantity, rely on scale economies for low reconditioning cost, and distribute the reconditioned cars to scattered outlets, thus overcoming in part the problem of selling a large number of look-alike cars. They sell to other wholesalers, taxi companies, and private buyers.

Transfer of vehicles from the police fleet to other governmental agencies may be efficient for the overall government unit and may also benefit the police department directly, if charge-backs are used properly to assign costs and credits. Vehicles which no longer meet the reliability requirements for police work may nevertheless be adequate for lesser demands. The Arlington County Virginia Equipment Division, for example, selects suitable retired police cars and reassigns them to other units requiring transportation, such as the Public Health Office.[34] The resulting lower average annual depreciation costs are passed along to the police department in the form of lower monthly rental charges. (This approach is efficient overall only if rising maintenance and repair costs do not more than offset the decline in average depreciation at the time of vehicle transfer. For further explanation, see section 3.5 on replacement policy.) If there is not a good cost accountability system, the police department itself will probably not benefit from intragovernmental transfer of vehicles, even though the parent organization may.

Top disposal prices are usually not obtained through trade-in to dealers. Trade-in may, however, be used to obtain favorable servicing or special consideration in new car delivery. In addition, it eliminates the problem of coordinating disposal and new car delivery and the need for storage, as well as most selling expenses.

Perhaps the most important point to be made with respect to trade-in is that quoted trade-in prices are often deceptive. A high trade-in figure associated with an inflated new car price may mean that the *net* new car cost (or net trade-in value) is actually poor. A more valid approach compares trade-in with other means of disposal by computing the net costs of the two bids received. This can be illustrated with actual data from a police car sale in a west coast city: A new car dealer offered $15,325.00 trade-in allowance for nineteen used cars, but the cars were sold retail at auction for $14,436.30. Deducting the advertising costs of $142.38, the net proceeds of $14,293.92 were $1031.08 less than the dealer's offer, an apparently large loss to the city from selling retail instead of trading-in. A closer and more valid look shows that the city in fact saved $2,400, since the higher trade-in allowance masked a higher bid price on the new replacement vehicles. The effective cost comparison is the following:

Costs Using Trade-in Method of Disposal

Bid on 20 new cars by "X" Motors:	$54,970.25
Less Trade-in Allowance on 19 cars by "X" Motors:	15,325.00
Net Cost:	$39,645.25

Costs Using Auction Method of Disposal

Bid on 20 new cars by "Y" Motors:	$51,529.00
Auction Sale Price:	14,293.92
Net Cost:	$37,235.08

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[33] "Special Report: The Growing Lure of Fleet Leasing," *Business Management*, December 1969, pp. 40-44.

[34] Mr. David Carter, Arlington County Virginia Equipment Division, Arlington, Va., interview, 1973.

Here the bid price on the same cars from another dealer, without trade-in, was over $3,000 less than the new car/trade-in package, with a net savings of $2,410.17 possible by buying the new cars and selling the old ones separately.[35] Findings regarding disposal of used police cars can be summarized as follows:

(1) If cars are in relatively good condition, and enough are available to permit frequent sales, a retail sales method of disposal—preferably an auction if administratively feasible—will likely be cost effective.

(2) If cars are in poor condition, or if there otherwise is no good local market, a wholesale method of disposal, such as consignment to an auto auction or sale to used car dealers or wholesalers, offers a relatively quick method of disposal which avoids costly storage and built-in depreciation.

(3) With an equitable cost accountability system in effect, transfer of cars to other departments may be beneficial to police departments by reducing annual depreciation cost.

(4) Although net trade-in prices usually tend to be relatively low, trade-in may nonetheless appeal to departments without attractive alternatives due to the possible advantages of preferential service, convenient and timely disposal, and low selling cost. But it should be remembered that quoted trade-in prices are often deceptive, and attention should be given to the net cost of the new car/trade-in bid.

3.2.3. Lease Vs. Buy

In recent years in commercial organizations there has been a steady trend away from company-owned and employee-owned[36] fleets towards fleet-leased cars, such that the majority of business fleet cars are now leased. Many articles citing the merits of fleet leasing appear in fleet journals, and leasing is frequently a topic at fleet management seminars and conventions. These developments have not gone unnoticed by police fleet managers, and many of them wonder whether police departments should switch from purchasing to leasing. This section explores the question of leasing versus buying.

Leasing Arrangements

Leasing is a method of legally obtaining possession and use of assets for a period of time (usually a year or more) without assuming ownership, and generally involves a combination of finance and service. There are three basic types of vehicle lease: (1) the finance lease, (2) the net lease, and (3) the maintenance lease.

The finance lease, which is the most popular lease among business organizations, 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. The period of lease is flexible, and the monthly payment is expressed as a percentage of the capitalized value of the new vehicle. The amount of payment declines each year as the lessee continues to use the vehicle.

The net lease, like the finance lease, makes no provision for maintenance or operating expenses. However, the net lease is generally closed-end in terms of the period of lease, with no adjustment for variation in actual depreciation. The lessee is required to return vehicles in a condition showing only "normal" wear. The monthly lease charge is usually a flat dollar amount.

The maintenance lease includes provision for some maintenance by the lessor, the amount ranging from limited to comprehensive. The cost of this type of lease consists of a charge for the vehicle's use, as is made under the finance lease and the net lease,

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[35] Mr. James C. Jones, Equipment Analyst, Transportation Division, City of Pasadena, Calif., memo transmitted in a letter of April 19, 1973.

[36] This is the practice of a few police departments, although the trend is away from this practice.

plus a maintenance charge. Its price is therefore higher than the other types of lease arrangements. The lease may be either closed-end or open-end.[37]

Within these three basic types of leases there are countless possible variations in provisions, as well as alternate names, such as the service lease (same as maintenance lease), the walkaway lease (same as the net lease), the guaranteed lease (net lease), or the cost-plus lease (finance lease under which the lessor administers maintenance control for a separate fee). A procedure called "sale-leaseback" does not designate a fourth type of lease, but is simply one way of putting into effect one of the three basic types of lease listed here. Just what the leasing company contracts to provide to the lessee can be determined only by a careful reading of the contract in each case.

While the finance lease is most prevalent for private enterprise, the maintenance lease appears to be favored by police departments. The discussion of leasing advantages and disadvantages will help to explain the police preference for the maintenance lease.

A copy of an actual maintenance lease agreement between a medium size city police department and a local dealer leasing company is presented in appendix B-l. At a glance, this appears to be an agreement for maintenance only and not a leasing arrangement for use of the car. In fact, it is both. The initial purchase of vehicles by the city from the leasing company and subsequent repurchase by the leasing company from the city, as called for in item 7 of the contract, is merely a formality designed to protect the lessor from ownership liability; no purchase or resale money actually changes hands.

Under this agreement, vehicles are replaced at 60,000 miles (97,000 km) or 3 years, whichever comes first. (For this department, this arrangement has resulted in an annual replacement of most of the marked cars and a replacement every 2 or 3 years for unmarked cars.) The lessor contracts to provide general maintenance at 6,000 miles/60 days (10,000 km/60 days); operating repairs, repair parts, tire maintenance and repair, and washing as required; oil change at every 2,000 miles/60 days (3,000 km/60 days); and lubrication every 4,000 miles/60 days (6,000 km/60 days), all of which is to be performed weekdays between the hours of 8 a.m. and 5:30 p.m. Wrecker service and emergency maintenance for tire repair or replacement and breakdown repairs or parts are provided on a 24-hour basis. Contract provisions specify priority service for police vehicles, service to be provided at a place convenient to the police department, and alternative arrangements to be made by the lessor for contract compliance should a strike cause the lessor to close down. Not covered under the lease are the following: (1) decaling and installation of special equipment, (2) repair necessitated by accident or other casualty, (3) repair made necessary by driver abuse or failure to follow prescribed operating instructions, (4) theft or loss, (5) repair of exempted damage required prior to turning in the vehicle, and (6) gasoline. (The agreement does cover partial reconditioning, including removal of decals and standard preparation.) Insurance costs are borne by the lessee. The monthly lease charge is based on a specified rate per mile for the number of miles driven each month, with a minimum mileage charge quoted.

Additional clauses have been extracted from several other police leasing contracts to indicate further the kinds of arrangements which are made and how certain problems generally associated with police leasing are being handled:

(1) "The lessee shall have the option to lease additional police cars per year up to a specified maximum."

(2) "The lessor will be responsible for maintenance of the leased vehicles, except that gasoline, cleaning and washing, speedometer certifications, and all forms of liability and comprehensive insurance shall be the responsibility of the lessee."

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[37] Clyde W. Phelps, *The Role of Fleet Leasing in Motor Vehicle Fleet Plans of Business Firms*, Studies in Commercial Financing, No. 4, Education Division, Commercial Credit Co., Baltimore, Md., 1969, pp. 1-20.

(3) "The lessor will maintain a specified number of backup cars in service, on call, both marked and unmarked in a proportionate amount sufficient to immediately replace leased vehicles. In addition, the lessor will maintain a specified number of cars in inventory."

(4) "Special police equipment, such as visi-bars, flashing lights, electronic sirens, speakers, and police radios shall be deemed extra equipment...will be provided by the lessor at the lessee's request; at prices to be mutually agreed upon."

(5) "To assure faithful performance of its obligations, the lessor will assign its contract with the lessee to a federally regulated bank. All payments due by the lessee will be made directly to the bank. The lessor will voluntarily restrict its use of any money paid into the bank by the lessee for the full term of the contract. The lessor will agree that it will not withdraw the money paid into the bank by the lessee except for the sums necessary to fulfill its services and maintenance obligations."

(6) "The lessee shall be solely responsible for disposition and retirement of department-owned police vehicles."

(7) [As an alternative to (3) and (6)] "The lessor will purchase from the lessee a quantity of existing patrol cars to be used as replacement (backup) vehicles."

(8) "The lessor will perform maintenance, repairs, and warranty repair in such a way as to keep down-time to an absolute minimum. The repair shop will operate on a 3-shift basis, 24 hours a day, from 8 a.m. Monday through 5 p.m. Saturday. During these hours a specified minimum number of fully qualified mechanics will be on duty."

(9) "A sufficient stock of repair and/or replacement parts will be maintained at the lessor's repair shop to insure an efficient flow of repairs, while maintaining the minimum down-time concept."

(10) A replacement patrol car will be provided when any car is in the shop for service or repairs."

(11) "The lessee (police department) agrees to furnish legal exemption certificates covering Federal excise and other taxes to the lessor."

Contracted replacement mileage ranged from a low of replacement every 30,000 miles (48,000 km) to a high of replacement every 60,000 miles (97,000 km), but in most cases the aim was to replace patrol cars about once a year and other cars about once every 2 to 3 years.

Terms regarding choice of car model and accessories vary, but rates appear generally more favorable if the lessee selects a car which permits easy disposal by the lessor, while still meeting police requirements.

Rates vary among leasing companies and depend greatly on the specific provisions of the contract. Sometimes the lessor follows a flexible policy in which he adjusts the quoted rates upward or downward depending upon the desire of the police department to assume or relinquish maintenance duties. The lessor may charge by the mile, with or without a minimum mileage requirement; there may be a flat monthly rate, or the charge may have two components, a flat monthly rate plus a mileage charge.

Advantages and Disadvantages of Leasing

Some police administrators who were interviewed asserted that leasing must always be more expensive than a well-run, in-house operation, since the lessor's profit is added to the basic cost of operating the fleet. This point of view, however, ignores the possibilities of economies of scale and economies of specialization. A leasing company may supply vehicles to a number of departments, thereby operating a combined group of vehicles very much larger than the fleets of any one client. Through mass purchasing, a large leasing company may be able to overcome one of the disadvantages often cited, i.e., that a private firm cannot buy at the favorable prices extended to state and local government units. Economies of scale may also exist in car disposal. A large leasing company may have access to many and different types of resale outlets and a better view of the resale market, permitting it to obtain higher resale values than some police departments could obtain. Thus, it is quite possible for the depreciation cost included in the monthly lease payment to compare favorably with that which the department would incur through ownership. Similarly, economies of scale might be realized in more efficient utilization of maintenance and repair equipment and specialized personnel, and in use of automated data processing equipment and mass paper handling methods, thereby reducing overhead cost.

It may also be asserted that acquisition of vehicles by lease must be more costly—from the standpoint of the drain on the police department's budget—than department ownership, because the borrowing cost of private firms is normally greater than that of governmental agencies, which may float tax-exempt securities. Apart, however, from consideration of the true social cost of public borrowing, there are limits to the amount of funds which government agencies may raise in this way. In addition, restrictions are sometimes placed on the financing of short-life capital assets by issuing securities. Also, as with a private firm, leasing may improve the working capital position of a public agency, thereby freeing funds to be used for purchasing other resources or undertaking other activities which are expected to yield positive net benefits to society.

Another argument sometimes raised against leasing by government agencies is the absence of special tax advantages which may accrue to private firms which lease. Since government agencies are tax-exempt, it is true that the same tax considerations which apply to private fleet decisions do not apply to police fleets. Furthermore, it may be argued that government agencies which lease forego the advantage of their tax-exempt status, which allows them to purchase at a lower price than leasing companies. However, as we have seen, the government agency may be able to preserve this advantage if it can pass the tax-exemption on to the lessor.[38]

In addition to cost considerations, there are other reasons why police departments might find leasing advantageous. One advantage of leasing was cited by several police departments who leased: the regular streams of contracted payments facilitated budgeting. Less resistance may be encountered from the appropriations body to police department requests for monthly lease payments than for funds to purchase new and/or additional cars. One police fleet manager explained that prior to leasing the department faced a constant, recurrent struggle to obtain funds for purchasing replacement vehicles. The fleet was generally old, and failing cars posed constant problems. After acceptance of a leasing arrangement—with its 1-to-2-year replacement clause—little difficulty was experienced in obtaining annual approval of the monthly rental payments. The average age of the fleet is now much lower and car condition much improved.

Another police department reported an inability to obtain funding for the capital outlay needed to expand its fleet to meet growing requirements for transportation. However, it could get sufficient funding to meet the monthly rental charge for additional vehicles on a leased basis and reported improved vehicle availability under leasing. This same department cited the advantage of greater ease in adjusting the number of vehicles to actual need under leasing.[39] Clauses in the lease contract calling for standby vehicles immediately deliverable from the lessor can achieve this flexibility. A lessor who serves several departments may be able to maintain an adequate backup inventory at a lower cost than each individual department, since the likelihood that all clients will need emergency replacements at the same time is rather small.

Two chief motivating forces were found for the apparent preference of police departments for the maintenance lease: (1) Maintenance leasing offers to small and moderate-size departments a possible reduction in maintenance service costs achievable

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[38] Wayne K. Armstrong, Chief of Police, Rapid City, S. Dakota, "Should Your Department Lease Its Police Cars?" *FBI Law Enforcement Bulletin*, November 1964, p. 12.

[39] *Ibid.*, p. 11.

through economies of scale of the lessor; and (2) maintenance leasing may offer escape from an existing poor maintenance arrangement.

The short-term maintenance lease provides a more flexible, less binding arrangement than is possible through the establishment of an internal maintenance facility. Some claim that this rationale for leasing is a "cop-out"—an admission of failure by the police department to operate its fleet efficiently, and, doubtlessly, it is an indication that the existing system is not functioning satisfactorily. However, the roots of the problem may not lie directly within the police department or within its power of control. If this is the situation, leasing—if leasing is more cost-effective than the existing system—is preferable to continuing a less efficient operation merely for the sake of having a police- or municipal-owned and serviced fleet.

A prevalent objection to leasing is that the police department loses control of its fleet and can no longer assure proper car selection, maintenance, and availability. It is sometimes asserted that a lessor will not provide suitable vehicles, that his maintenance facilities will be inadequate for the unique and specialized police vehicle, that the availability of police transportation (and protection) will be subject to the whims of the lessor, and that police cars damaged in riots or other disturbances after 5 p.m. will become unavailable until the following day. However, actual experience with leasing by police departments suggests that most of these problems are exaggerated. The lease arrangements presented earlier illustrate some of the ways departments avoid, or at least greatly reduce, these potential problems. A considerable degree of control and flexibility with a leased fleet does appear to be possible.

Other objections to leasing and reasons for department ownership which were given by police fleet managers included the following: (1) Tradition: "this is the way it has always been done"; (2) an ample annual capital equipment budget; (3) the cost and trouble of making a change in the system; (4) a small expected cost difference between the alternatives; (5) existing reciprocal community arrangements; and (6) pride of ownership. The first five of these rationales for ownership in themselves make little sense in terms of economic efficiency. Even if a department's budget does allow purchase, this by itself does not warrant purchase. Pride of ownership is a psychological motive whose value is difficult to assess; but this also appears to be a weak argument for ownership.

In summary, this investigation found no impediments to police fleet leasing which by nature appear insurmountable. It found several motives for police leasing aside from possible cost advantage. It appears that leasing could, under certain circumstances, offer cost advantages not only to small police departments, but to departments of any size.

Cost Comparison of Leasing and Buying

Lease costs may cover either the cost of providing use of the vehicle (i.e., financing), the cost of any services under contract, or both of these. A wide variety of services may be provided under a maintenance lease contract; hence, quoted costs of the service part of leases vary greatly. It should also be noted that maintenance and management services may be leased from outside businesses by a department which owns its vehicles, and, conversely, cars may be leased by departments which provide their own maintenance. Two separate cost decisions must therefore be made: (1) Is it cost-effective to secure vehicles through leasing, and (2) Is it cost-effective to secure maintenance and management services from outside sources? (Attractive terms for a combination lease arrangement may, in practice, encourage a joint decision.) The approach taken here is to compare the costs of leasing, without provision of services, with outright purchase, and to compare costs of contracted maintenance with in-house services.

Let us first compare the costs of buying a car outright to obtaining it through a finance lease, which only provides use of the car and not maintenance service. Assume that the lease is open-ended, thereby requiring the lessee at the end of the contract to insure that the lessor has received payments equalling full depreciation. For purpose of comparison, a present worth model is used to convert the costs of each method of acquisition to a single cost today, with a discount rate of 10 percent.

The cost estimates are computed for a standard-size, middle-of-the-line model, listing for $4,383 and available for purchase by the police for $135 over dealer price, or $3,553. In keeping with provisions of the finance type of lease, it is assumed that the police department must make arrangements for and bear the cost of decaling, equipping, operating, maintaining, repairing, and reconditioning, regardless of whether it buys the car or leases it. These costs are therefore identical for both alternatives and can be neglected here. A 2-year replacement cycle is assumed,[40] and the assumed depreciation rate is that estimated earlier for State Police. For simplicity, all costs which would be equal or nearly equal for the alternatives are omitted from the analysis since they would not alter the choice. The cost estimates are presented in table 17.

The comparison shows the estimated present value of the cost of acquiring a car by purchasing to be $164 less than the cost of leasing it. However, the extra cost of leasing is not nearly as great as would be expected by comparing the total monthly lease charges and depreciation reimbursement (undiscounted) with the purchase price less resale value.

The cost estimates shown are, of course, based on a particular set of values; the outcome would vary depending on inputs. However, to change the direction of the difference, the monthly lease charge would have to be reduced or the department's purchase price increased. Contacts with several leasing companies provided estimates of a monthly lease charge for a car of the type and price described quite close to that used in the example.

According to one leasing company representative, quantity discounts on leasing charges are sometimes offered, perhaps $5 per car per month for leasing 10 to 49 cars, and $10 discounts for leasing 50 or more cars.[41] Thus, increasing the number of cars leased might reduce the monthly lease charge from the illustrative $118 to, perhaps, $110 per car.

By like token, the police department might also obtain lower purchase prices with larger orders, so that increasing the size of the fleet might not change the relative cost difference. Similarly, increasing the estimated resale value will reduce the costs of both alternatives by a comparable amount; thus, the analysis does not appear to be very sensitive to assumptions regarding resale value.

An alternative to the full-time lease (treated above) is short-term rental. This may also be compared with ownership. For those vehicles whose workload is irregular, short-term rental offers the possibility of avoiding part of the fixed cost otherwise incurred while the vehicle is not in use, e.g., insurance, depreciation, and storage. For functions requiring incognito vehicles, short-term rental cars avoid the costs of frequent buying and selling or reduce the tie-up of capital otherwise required for a sufficiently diverse undercover fleet. In these cases, the problem is to determine the critical or breakeven level of use, at which the cost of owning each vehicle is equal to the cost of renting.

A simple method for approximating the critical level of utilization for each vehicle is based on the following relationship: The critical level of utilization is equal to the ratio of the annual cost of vehicle ownership to the annual cost of full-time renting.[42] For

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[40] The following leasing periods for different mileage rates were suggested by a leasing company manager: 50,000+ miles/year (80,000+ km/year), 1-year lease; 20,000-49,999 miles/year (32,000-80,000 km/year), 2-year lease; 0-19,000 miles/year (0-32,000 km/year), 3-year lease. Mr. Nathenson, Manager, Leaseplans Development Corp., interview, March 1973.

[41] Leasing manager of a local leasing company, interview, March 1973.

[42] A. A. Britten, *Decision Making in Vehicle Management*, Report No. S.15, Local Government Operational Research Unit (LGORU), Royal Institute of Police Administration, Reading, England, 1971, p. 10.

TABLE 17. *Acquisition cost of purchasing a patrol car as compared with leasing it*

A. Purchase

Initial outlay = \$3,553[1]

Resale value after 24 months = 1,066[2]

Calculation of present worth:

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

where

P_P = the present value of the cost of purchasing.

I = the intial outlay for vehicle purchase.[3]

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

i = monthly interest rate of .01.[4]

N = the number of monthly interest periods.

$$P_P = \$3{,}553 - \left(\$1{,}066\left[\frac{1}{(1+.01)^{24}}\right]\right)$$

$$= 3{,}553 - \left(1{,}066\left[\frac{1}{(1.269)}\right]\right)$$

$$= 3{,}553 - 840$$

Present value of the cost of purchasing the car = \$2,713

B. Finance Lease

Monthly lease charge for 24 month lease = \$118.00[5]

Reimbursement to lessor at 24th month = \$477.00

Calculation of present worth:

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

where

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

A = the uniform monthly lease payments.

i = monthly interest rate of 101.[6]

N = the number of monthly interest periods.

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

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

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

$$= 2{,}501 + 376$$

Present worth of lease cost = \$2,877

[1] Quoted dealer price plus \$135 markup and preparation charge for a standard-size, middle-of-the-line car with police package.

[2] Based on a 70 percent depreciation rate over 2 years, the approximate average rate estimated for state police departments in section 3.2.1.

[3] The acquisition cost of the vehicle may be entered into the cost equation either as an initial outlay or as a stream of monthly payments with an interest charge. The present value of the stream of monthly payments is equivalent to the initial outlay if the discount rate is equal to the interest charge on borrowed money.

[4] For convenience, a 12 percent annual interest rate is assumed here, which is equivalent to a 1 percent monthly rate.

[5] Calculated by multiplying the dealer list price (\$4,383) by the assumed monthly depreciation rate (2.0%) and a monthly rate of dealer profit (0.7%), (\$4,383)(.027) = \$118.34. This "rule-of-thumb" method for calculating monthly lease charges was provided by the leasing manager of a local automobile company, interview, March 1973.

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

example, if ownership costs are estimated to be $3,000 per year and the rental cost for the vehicle for 1 year is $4,000, then it is cheaper to buy if the vehicle is to be used more than 75 percent of the time; otherwise, renting whenever the vehicle is needed is cheaper.

Now let us consider the major item on the service side of leasing—that is, maintenance. Other things equal, how does the cost of providing maintenance through an in-house operation compare with contracting-out maintenance, either through a lease agreement or through separate arrangements with private vendors?[43]

Table 18 provides an estimate of in-house garage staff requirements and related annual labor cost for different fleet sizes. The number of service people and their cost are estimated in a series of five steps:

(1) The number of patrol cars in the fleet is multiplied by the average annual mileage per car [here assumed to be 35,000 miles (56,000 km)] to get total annual fleet mileage.

(2) Fleet mileage is multiplied by estimated labor hours per mile to derive labor hours directly chargeable to vehicle maintenance.

(3) The number of labor hours is divided by 1920, the estimated number of labor hours available per year per garage staff person, to arrive at the number of service people required for vehicle maintenance at 100 percent manpower utilization.

(4) This number is then increased by 20 percent, to take into account labor time not directly chargeable to vehicle repair, such as coffee breaks, and unevenness in the flow of work into the shop. The resulting figures, rounded, are rough estimates of total garage staff requirements.

(5) Annual labor cost is calculated by multiplying the number of garage workers by the average annual salary, which in turn equals the number of labor hours per person per year times the average hourly wage rate. Annual labor costs are shown for three alternative wage rates—$5 per hour, $8 per hour, and $10 per hour.

The estimates of labor hour requirements, on a per mile basis, are based on the average experience of a sample of police departments in 29 cities, whose average was 0.0034 hours per mile (0.002 hours per km). Use of this figure unadjusted for fleet size resulted in reasonable estimates for small-to-moderate-size fleets, but appeared to yield overestimates for large fleets. Informal discussions with police fleet administrators suggested that, due to economies of scale, staff requirements probably increase at a decreasing rate as fleet size increases, rather than linearly. Accordingly, the estimate of average labor hours per mile was adjusted downward at a 10 percent rate for each incremental 100 vehicles after the first 100 vehicles. (See footnote b, table 18, for a fuller explanation.)

Operating conditions reflected by the maintenance and repair experience of the 29 cities from which the average labor hours/mile figure was a mixture of congested in-city driving, suburban driving, and freeway driving. Thus, the estimated labor-hours-per-mile factors should be representative for most small to large cities, but may be somewhat low for very large city departments whose driving conditions are more severe than those in the sample cities, and somewhat high for most state highway patrols which, on the average, incur their mileage with fewer engine hours of use than city departments.

Clearly there are a number of reasons why garage staffing requirements might vary considerably among departments. To test the conclusions for sensitivity to the particular set of assumptions employed in the analysis, the estimated costs of manpower and other factors are varied in the final cost comparisons at the end of this section.

Table 19 shows the procedure used to estimate the cost of equipping a police garage. The requirements for some items of equipment are expressed as a function of total garage staff, while others are expressed as a function of fleet mileage. The size of the garage staff (N) is, however, itself based on mileage (M).

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[43] Appendix B-2 provides an illustration of arrangements for contracting-out maintenance to private garages.

TABLE 18. *Estimation of garage staff requirements and annual labor cost*
(In constant 1973 dollars)

Number vehicles	Total annual fleet mileage[1]	Total directly allocated labor hours[2]	Number of service people required for directly allocated[3] labor (100% manpower utilization)	Number of service people required for total garage staffing[4]	Annual labor cost, Hourly rate[5] $5.00	$8.00	$10.00
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		(col. 2 × est. labor hrs./mi.)	(col. 3 1,920)	(col. 4 × 1.20)	(col. 5 × hr. rate × 1,920 hrs.)		
1	35,000	119	0.1	1	$ 9,600	15,360	19,200
10	350,000	1,190	0.6	1	9,600	15,360	19,200
25	875,000	2,975	1.5	2	19,200	30,720	38,400
50	1,750,000	5,950	3.1	4	38,400	61,440	76,800
100	3,500,000	11,900	6.2	7	67,200	107,520	134,400
200	7,000,000	22,750	11.8	14	134,400	215,040	268,800
500	17,500,000	49,000	25.5	31	297,600	476,160	595,200
1,000	35,000,000	77,700	40.5	49	470,400	752,640	940,800
1,500	52,500,000	95,200	49.6	60	576,000	921,600	1,152,000
2,000	70,000,000	105,350	54.9	66	633,600	1,013,760	1,267,200

[1] On the basis of a sample of State police departments (as shown in app. A, table A-15), an average of 35,000 miles (56,000 km) per vehicle per year is assumed. The total annual mileage for a fleet is found by multiplying the number of vehicles in the fleet by 35,000 miles (56,000 km).

[2] Directly allotted maintenance and repair labor hours were estimated on the basis of relationships between labor hours and mileage, derived from Mainstem Inc. data reports on more than 1,100 standard, 4-door police cars operating in 29 cities. Vehicles are city-owned and maintained predominantly in police shops and partially in private garages. The relationships were not available directly, but were estimated in the following way: labor was found to comprise about 56 percent of total parts and labor costs for work performed in police shops. This percentage was assumed to apply to labor as a component of total maintenance and repair costs, and was applied to the average total cost of monthly maintenance, "normal" repair, accident repair, and vehicle modification to estimate the average cost of labor ($61,736). Dividing this by the labor rate ($7.75) resulted in an estimate of 7,965 labor hours per month for the sample group. Over the same period, mileage averaged 2.36 million miles (3.78 million km) per month. The average number of labor hours per month was divided by average mileage per month to obtain average labor hours per mile, which was .0034 hours per mile.

TABLE 18.—*Continued*

With this average of labor hours per mile applied to total fleet mileage (col. 2), the resulting estimates of total directly allocated labor hours were quite reasonable for small-to-moderate size fleets, but high for large fleets. Informal discussions with police fleet administrators substantiated the opinion that overestimates resulted for large fleets—the reason probably being that economies of scale may be achieved by large departments. (The estimates of .0034 labor hours per mile was based on the cost experience of small to medium size departments.) The view was that staff requirements probably increase at a decreasing rate as fleet size increases. Accordingly, a schedule of the labor hours per mile was estimated, based on .0034 hours per mile for mileage incurred on up to the first 100 vehicles, and declining thereafter at a rate of 10 percent per each additional increment of 100 vehicles. That is, the labor hours per mile for mileage incurred on the 1st through the 100th patrol car is estimated to be .0034 hrs./mi.; on the 101st through the 200th car, the estimate is .0034–.00034 = .00306, rounded to .0031; on the 201st through the 300th car, the estimate is .00306–.000306 = .002754, rounded to .0028. Following is the schedule of estimated direct maintenance and repair requirements in terms of labor hours per mile for fleet sizes up to 2,000 cars: (These figures were computed in each case as described above and then rounded to the fourth decimal place.)

Number of cars in fleet	Estimated labor hours per mile	Number of cars in fleet	Estimated labor hours per mile
0–100	.0034	1,001–1,100	.0012
101–200	.0031	1,101–1,200	.0011
201–300	.0028	1,201–1,300	.0010
301–400	.0025	1,301–1,400	.0009
401–500	.0022	1,401–1,500	.0008
501–600	.0020	1,501–1,600	.0007
601–700	.0018	1,601–1,700	.0006
701–800	.0016	1,701–1,800	.0006
801–900	.0015	1,801–1,900	.0005
901–1,000	.0013	1,901–2,000	.0005

Total directly allocated labor hours (col. 3) are then derived by summing the incremental labor required for each vehicle/mileage level; e.g., for 300 vehicles, direct labor hours are estimated as 3.5 million miles × .0034 + 3.5 million miles × .0031 + 3.5 million × .0028 = 11,900 + 10,850 + 9,850 = 32,550 hours.

[3] The annual hours available per person is estimated to be 1,920 hours. (240 working days per year × 8 hours per day.)

[4] The estimate of column 3 is for directly allocated labor only; the estimate of column 4 therefore assumes 100 percent utilization of manpower. In fact, garage staff may spend a significant share of their time performing jobs for which their time is not directly chargeable to a vehicle. Here, the assumption is made that one fifth of total maintenance and repair labor time is charged to overhead: In actual fact, the amount of labor charged to overhead will depend upon the form of organization and approach taken by the fleet administrator, as well as the efficiency of the operation. It may be significantly less than 20 percent, or much more. Thus, the garage staffing is estimated as directly allocated manpower × 1.20, rounded to the nearest positive whole number. Although it might be possible for a garage to hire qualified people, for part-time positions, this would likely be difficult under normal circumstances. Therefore, it is assumed that another person is hired full time when work amounts to the equivalent or at least 1/2 man year. When it is less than 1/2 man year, the additional work is assumed to be absorbed by existing employees.

[5] Hourly wage rates paid by local government departments appear to average substantially less than rates paid by private garages. Thus the hourly rates used to estimate annual labor cost of an in-house shop are lower than those used in estimating the cost of contracting-out maintenance. The lower rates are to some extent offset by greater fringe benefits and job security, but these associated costs are assumed included here in overhead expenses.

Table 19. *Estimation of equipment cost*

Equipment (E)	Price (P)[1]	Method of estimating no. units (U) required	Equipment requirements and cost for 100 vehicles/3.5 million miles (5.6 million km)/7 garage attendents No. units	Cost
A. Equipment, prices, and quantity estimating procedures[2]				
1. Life-hydraulic	$ 730	$U_1=1.5N$, N even; $1.5N+.5$, N odd	11	$ 8,030
2. Air compressor	890	$U_2=1+\frac{[N-1]}{10}$	1	890
3. Automatic transmission tester	140		2	280
4. Alternator-regulator tester	150		2	300
5. Brake pedal adjustment gate	37	$U_3=1+\frac{[N-1]}{6}$	2	74
6. Headlight aiming kit	109		2	218
7. Hydraulic floor jack	180		2	360
8. Storage cabinets	67		2	134
9. Roll-about vacuum cleaner	115		2	230
10. Exhaust emission analyzer	660		1	660
11. Battery cell analyzer	36		1	36
12. Battery charger	129	$U_4=1+\frac{[N-1]}{12}$	1	129
13. Battery tester	58		1	58
14. Gasoline tanker	265		1	265
15. Basic tool kit	237		7	1,659
16. Tool stand	37		7	259
17. Work bench	40	$U_5=N$	7	280
18. Mechanic's vise	52		7	364
19. Impact wrench	139		3	417
20. Belt tension gage	17	$U_6=1\ \frac{[N-1]}{3}$	3	51
21. Roll-about oil tank	130	$U_7=2+2\ \frac{[N-1]}{12}$	2	260
22. Ceiling reel lub set	1,766	$U_8=N-[N/4]$	6	10,596
23. Drum racks	19	$U_9=4+4\ \frac{[N-1]}{12}$	4	76
24. Oil drain tank	94	$U_{10}=1+\frac{[M-1]}{2,880,000}$	2	188
25. Total performance scope analyzer	2,480	$U_{11}=1+\frac{[M-1]}{6,480,000}$	1	2,480
26. Hi-compression tester	48		1	48
27. Alignment rack	3,760		1	3,760
28. Alignment accessory package	266	$U_{12}=1+\frac{[M-1]}{10,800,000}$	1	226
29. Tire changer	450		1	450
30. Mechanical wheel balancer	692		1	692
31. Brake shoe adjustment guide	10	$U_{13}=1+\frac{[M-1]}{12,960,000}$	1	10
32. Diaphram brake bleeder	84		1	84
Total equipment cost for 100 vehicle garage = $33,564				

[1] Cost of equipment does not include installation cost.

[2] The list of equipment, equipment prices and the general approach to estimating quantity of equipment are based on descriptions in Ludwig, *Study of Police Patrol Vehicle*, March 1970, pp. 161-168. Logical relationship between equipment, fleet mileage, and mechanics, described in Ludwig's study are expressed here in estimating equations.

B. Estimation equation[3]

$$\text{Total equipment cost} = P_1(1.5N, + .5 \text{ if } N \text{ is odd}) + P_2\left(1 + \frac{[N-1]}{10}\right) + \sum_{i=3}^{9} P_i\left(1 + \frac{[N-1]}{6}\right)$$

$$+ \sum_{i=10}^{14} P_i\left(1 + \frac{[N-1]}{12}\right) + \sum_{i=15}^{18} P_i(N) + \sum_{i=19}^{20} P_i\left(1 + \frac{[N-1]}{3}\right) + P_{21}\left(2 + 2\frac{[N-1]}{12}\right)$$

$$+ P_{22}(N-N/4]) + P_{23}\left(4+4\frac{[N-1]}{12}\right) + P_{24}\left(1 + \frac{[M-1]}{2{,}880{,}000}\right) + \sum_{i=25}^{26} P_i\left(1 + \frac{[M-1]}{6{,}480{,}000}\right)$$

$$+ \sum_{i=27}^{30} P_i\left(1 + \frac{[M-1]}{10{,}800{,}000}\right) + \sum_{i=31}^{32}\left(1 + \frac{[M-1]}{12{,}960{,}000}\right)$$

Where

P = equipment price and subscripts indicate the particular items of equipment
N = number of service people
M = number of miles incurred by the fleet in 1 year
[ ] = largest integer not exceeding quantity in brackets.

C. Estimated costs

Number of vehicles	Total annual mileage	Equipment cost	
1	35,000	$ 14,764	$ 2,845[4]
10	350,000	14,764	2,845
25	875,000	17,626	7,113[5]
50	1,750,000	22,470	14,225
100	3,500,000	33,564	
200	7,000,000	61,954	
500	17,500,000	139,666	
1,000	35,000,000	196,014	
1,500	52,500,000	251,638	
2,000	70,000,000	278,688	

[3] N=Number of garage service people, as estimated in table 18, M=patrol car mileage as estimated in table 18, and [] indicates the largest integer not exceeding the quantity in brackets.

[4] The lower cost figure is for a more modest selection of equipment as described below in the text.

[5] For fleets up to 50 cars, the cost of a more modest package of equipment is assumed to be equal to (the number of vehicles ÷10)×$2,845. For fleets exceeding 50 cars, it is assumed that the modest selection of equipment is inadequate and the more extensive package of equipment is required.

The equipment items shown were suggested in a recent study as necessary to perform in-house fleet maintenance.[44] Equipment selection assumes that only routine maintenance and repair is done; extensive repair work is not included. Thus, the equipment cost estimate may be somewhat inconsistent with the estimates for labor cost, which encompasses accident repair, modification, equipping, and reconditioning work, but not seriously so.

The equation at the end of table 19 is used to estimate total equipment cost. The prices of each item of equipment are multiplied by the expression which estimates the number of units of the equipment needed, yielding the equipment cost associated with a given fleet mileage.

Although the list of equipment presented in table 19 excludes highly specialized equipment necessary for some kinds of vehicle repair, the list is perhaps nonetheless extravagant for a small operation. A more modest selection of equipment might suffice for small gaiages. According to one authority, the following items would essentially meet the basic requirements of a small operation.[45]

Lift	$730
Air compressor	890
Tire changer, manual	175
Work bench with vise	100
Mechanics tools	500
Lube equipment, air operated, portable	250
Miscellaneous items, e.g., drop lights, air hose	200
Total cost	$2,845

The total cost of this group, assuming one unit each, and expressed in 1973 prices, is $2,845, compared with a cost of $14,764 for the smallest package of equipment estimated in table 19. Determination of the most efficient type and quantity of equipment depends on trade-offs between labor and equipment and assessment of benefits of various kinds of equipment; e.g., whether a power or a manual tire changer is more efficient, and whether each bay should be equipped with tools rather than sharing tools among bays. In-depth study of optimal equipment/labor combinations was not intended here, hence the estimates shown are approximate and tentative.

The cost of parts needed to maintain and repair vehicles is estimated in table 20, using an approach similar to that for assessing labor hours per mile. The average cost of parts per mile was calculated for the sample of 29 cities operating more than 1,100 patrol cars. For the initial 99 vehicles/3,465,000 miles (5.6 million km), the resulting average cost per mile of $0.0206 was multiplied by total fleet mileage to yield annual cost of parts required for fleet maintenance. To reflect the possibility of achieving price reductions through quantity discounts, the average cost of $0.0206 was reduced at a rate of 10 percent for every additional 500 vehicles in excess of 99, and the resulting estimate of parts cost per mile was applied to total mileage for the particular fleet size.

The estimated cost of parts may appear high at first glance; however, it includes the cost of tires, an item incorporated in the sample cost data which was used to derive the estimates. For instance, if four tires are replaced on an average of every 9,000 miles (14,000 km) at a cost of $78 for the four, (this figure is based on a conservative estimate of police expenditure for tires in 1973) tire cost alone accounts for $234 of the estimated

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44 Herbert G. Ludwig, *Study of the Police Patrol Vehicle*. Report to the Law Enforcement Assistance Administration, Detroit, Mich.: Wayne State University, College of Engineering, March 1970, pp. 164-165.

45 William Cook, Interstate Equipment Company, interview, June 1973.

Table 20. *Estimation of the annual cost of parts*
(In 1973 dollars)

Number of vehicles	Total mileage	Estimated parts and tire cost[1]
(1)	(2)	(3)
1	35,000	721
10	350,000	7,210
25	875,000	18,025
50	1,750,000	36,050
100	3,500,000	64,750
200	7,000,000	129,500
500	17,500,000	292,250
1,000	35,000,000	525,000
1,500	52,500,000	708,750
2,000	70,000,000	854,000

[1] An average parts cost per mile was derived in a manner similar to the method of estimating average labor hours per mile (see table 18, footnote h). Parts cost for the sample of 29 city police departments, operating more than 1,100 patrol cars, was found to average $48,491 per month over an average of 2.36 million miles (3.78 million km), resulting in an average parts cost per mile of $.0206. Because this cost per mile of parts is based on the average experience of relatively modest-size fleets, it was felt that the figure might tend to be higher than would be typical for larger fleets, which might obtain quantity discounts. Hence, to calculate total parts cost the $.0206 per mile average cost was reduced at a rate of 10% for every additional 500 vehicles/17,500,000 miles (28 million km) after the first 99 vehicles/3,465,000 miles (5.54 million km) and the resulting cost per mile was multiplied by total mileage for that fleet size. The following schedule of parts costs per mile was used: for 1 through 99 vehicles, $.0206; for 100 to 499 vehicles, $.0185; for 500 to 999, $.0167; for 1,000 to 1,499, $.0150; for 1,500 to 1,999, $.0135; for 2,000 and over, $.0122. Parts cost for a fleet of up to 99 cars is estimated, for example, as 99 × 35,000 × .0206; cost for a fleet of 1,000 is estimated as 1,000 × 35,000 × .0150.

NOTE: Tire cost and parts for accident repairs are included in the total parts cost. The cost for carrying parts inventory is not included.

$721 (from col. 3, table 20) expenditure over 35,000 miles (56,000 km). Considering that accident repairs are also included in the estimation of parts cost per mile, the parts cost estimate is probably reasonable.

Garage building costs are estimated in table 21. Building area is based on the number of bays or service areas—one bay for each lift—and the number of alignment racks and storage areas required. Square footage cost is based on the national average for a good quality, masonry service center.

In addition to the costs of garage equipment, facilities, and staffing, an in-house operation requires more administrative and clerical personnel than are needed for a contract-out operation. The difference in administrative costs of alternatives will, of course, depend upon the degree to which fleet responsibility is delegated. Under a full-service maintenance lease, there will be very little requirement for in-house administrative personnel. For a small-to-medium-size fleet, one part-time employee can probably handle the fleet duties of the lessee. If cars are purchased and maintenance is arranged with a number of private vendors, there will be somewhat greater need for a fleet administrator and clerical staff to negotiate with vendors, to ensure that the cars receive proper care, to monitor private vendor work, and to keep fleet records. For an in-house operation, the following administrative and clerical personnel have been suggested by one authority:[46]

Number of cars	Fleet manager	Ass't. fleet manager	Clerk	Steno-typist	Total number	Total estimated annual cost
100–299	1	—	1	—	2	$17,000
300–599	1	—	1	1	3	23,000
600–999	1	1	1	1	4	30,000
1000–1999	1	1	1	2	5	36,000
2000–3000	1	1	2	1	5	39,000

[46] Botzow, *Fleet Management*, p. 133.

TABLE 21. *Estimation of garage building cost*
(In 1973 dollars)

Number of vehicles	Total mileage	Number of garage staff[1]	Number of service bays[2]	Number of alignment racks[2]	Number of storage areas[2]	Estimated building area[3] (sq. ft.)	Estimated cost[4]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	35,000	1	2	1	1	1,440	$ 20,909
10	350,000	1	2	1	1	1,440	20,909
25	875,000	2	3	1	1	1,800	26,136
50	1,750,000	4	6	1	1	2,880	41,818
100	3,500,000	7	11	1	2	5,040	71,870
200	7,000,000	14	21	1	3	9,000	112,680
500	17,500,000	31	47	2	7	20,160	243,533
1,000	35,000,000	49	74	4	11	32,040	387,043
1,500	52,500,000	60	90	5	13	38,880	469,670
2,000	70,000,000	66	99	7	14	43,200	521,856

[1] See table 18, column 5.

[2] See table 19. The number of service bays is calculated as 1.5N, N even; 1.5N + .5, N odd, where N = number of garage staff. The number of alignment racks is calculated as

$$1 + \left[\frac{M-1}{10{,}800{,}000}\right]$$

where M = total fleet mileage and [] indicates the largest integer not exceeding the value in the brackets. The number of storage areas is calculated as the number of service bays ÷7, rounded to the next highest integer.

[3] The area of the building required is estimated as follows:

Area = (B + A + S)(12′)(30′)

Where B = number of bays
A = number of alignment racks
S = number of storage areas

and, a bay measures 12′ x 30′.

[4] Building cost estimates are based on the following national average square footage costs for a good quality, masonry automobile service center in 1970: for 4,000 sq. ft., $14.52 sq. ft.; 5,000 sq. ft., $14.26 sq. ft.; 6,000, $14.05; 7,000, $13.52; 8,000, $13.06; 9,000, $12.52; 10,000, $12.08.

Costs per square foot were given only for the range from 4,000 ft.^{2} to 10,000 ft.^{2} For the estimates of costs for square footage below 4,000 ft.^{2}, the square footage cost for 4,000 ft.^{2} was used; for estimates above 10,000 ft.^{2}, the square footage cost for 10,000 ft.^{2} was used.

The square footage cost estimates, as well as local building cost multipliers which can be used to adjust costs to a particular area, appear in *Dodge Building Cost Calculator and Valuation Guide*, New York City: McGraw Hill, 10th Ed., April-June 1973.

NOTE: The general method of calculating required area of the buidling is similar to the method used by Ludwig, *Study of the Police Patrol Vehicle*, pp. 169–172. Land costs are not included.

These suggested costs for administrative personnel are entered into the estimates given in table 22 for in-house maintenance costs. The estimate of administrative personnel given above for a fleet of 100-299 cars is assumed to apply also for as few as 50 cars. For 25-49 cars, the cost estimate is reduced by one-half and for less than 25 cars, it is reduced by two-thirds. (At the reduced levels it is assumed that assigned personnel devote only part-time attention to fleet administration.)

There are additional costs which may be incurred with an in-house operation. These include the costs of office equipment and supplies, data processing equipment and personnel, and parts inventory holding cost, but estimates of these additional cost items are not included in the analysis.

Table 22 consolidates the estimates of cost for providing in-house maintenance and shows the equivalent annualized cost for selected fleet sizes. Notice the very large estimated cost of operating a single vehicle—the costs of building, equipment, parts, and labor are not divisible beyond a certain minimum. Note also that reducing the garage equipment to the minimal package has little effect on the annualized cost.

Table 23 presents a rough estimate of the cost of contracting out maintenance. It is assumed that parts costs are the same as for the in-house operation (including tire cost here, too) and that overhead and profit mark-up are subsumed in the labor charge. A range of $10 to $15 was suggested as typical of rates in private garages. Costs are based on a linear relationship between fleet size and required hours of contract maintenance. The labor charge is in this case, applied only to directly allocated labor hours.

Exhibit 7 charts the estimated costs of self-maintenance and contract-maintenance for fleet sizes of up to 150 vehicles and 5,250,000 miles (8.4 million km). The breakeven point—that fleet size/mileage at which the two alternatives are equal in cost—comes at approximately 90 vehicles/3,150,000 miles (5 million km), at a cost of about $200,000. With smaller fleets/lower mileage, contract-maintenance appears cheaper; with larger fleets, self-maintenance appears cheaper. This outcome, however, is based on the specific assumption of a police shop wage rate of $8 per hour and an outside charge of $12 per hour.[47]

Let us consider the effect if there is a greater differential between wage rates. Assume the police shop labor rate is about $5 per hour, and the private garage rate about $15. Other things as before, the annual cost of ownership is lowered relative to the annual contract cost. Only for fleet sizes comprising about 10 or fewer vehicles is contracting-out now more economical than ownership.

The analysis is not very sensitive to variations in assumptions regarding equipment and building expenditure, since these costs are amortized over a relatively long period of time. It may be seen in row 1 of table 22 that an original expenditure of $14,764 on equipment, shown annualized in column 3 as $2,311, adds less than $2,000 more in annualized cost than does an original equipment expenditure of $2,845, shown annualized in column 4 as $445.

The outcome of the cost comparison might be altered by inclusion of additional cost elements for either alternative. For ownership, the cost of land for the service facility, the cost of holding parts inventory, and expenditure on computer services and other support facilities would increase annual costs. In the case of contract arrangements, the cost of transporting vehicles to the place of servicing, assuming this is greater than what would be incurred in an in-house operation, as well as the cost of an in-house administrative and clerical staff to administer contract arrangements would raise the annual cost.

Another point to remember in comparing costs of lease-versus-buy alternatives is that, typically, not all maintenance and repair work is covered by the lease, so that the

[47] Due to revisions made in tables 22 and 23 and in exhibit 7 after publication of the summary report, there are slight discrepancies between this, the full report, and the earlier summary report.

TABLE 22. *Estimated annual cost of performing maintenance in-house*
(In 1973 dollars)

Number of vehicles	Annual total mileage	Annual equipment cost[1]		Annual building cost[2]	Annual parts and tire cost	Annual garage labor cost ($8.00 hourly rate)[3]	Annual administrative personnel cost[4]	Uniform annual cost of in-house maintenance[5]	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
1	35,000	2,311	445	2,139	721	15,360	5,666	26,197	24,331
10	350,000	2,331	445	2,139	7,210	15,360	5,666	32,686	30,820
25	875,000	2,759	1,113	2,674	18,025	30,720	8,500	62,678	61,032
50	1,750,000	3,517	2,250	4,278	36,050	51,440	17,000	122,285	120,994
100	3,500,000	5,254		7,352	64,750	107,520	17,000	201,876	
200	7,000,000	9,697		11,527	129,500	215,040	17,000	382,764	
500	17,500,000	21,861		24,913	292,250	476,160	23,000	838,184	
1,000	35,000,000	30,680		39,594	525,000	752,640	36,000	1,383,914	
1,500	52,500,000	35,405		48,047	708,750	921,600	36,000	1,749,802	
2,000	70,000,000	43,620		53,386	854,000	1,013,760	39,000	2,003,766	

[1] Derived from table 19. An average 10 year life is assumed for equipment, with a 10 percent salvage value at the end of 10 years. Column 3 shows the annualized cost of the more comprehensive equipment package; column 4 shows the modest package. Annualized equipment cost =

$$(P-S)\left[\frac{i(1+i)^N}{(1+i)^N-1}\right]+S(i),$$

where P = first cost of total equipment; S = salvage value; $\left[\frac{i(1+i)^N}{(1+i)^N-1}\right]$ =uniform capital recovery factor; and a discount rate of 10 percent is used.

[2] Derived from table 21. An average life of 40 years is assumed for the building, with no salvage value at the end of the period. Annualized building cost is calculated using the same formula as shown in footnote 1, above, where P becomes B = first cost of building.

[3] Taken from table 22.

[4] Based on Botzow, *Fleet Management*, p. 133, as shown on p. 63 of the text.

[5] Column 9 is the summation of columns 3, 5, 6, 7, and 8; column 10 is the summation of columns 4, 5, 6, 7, and 8.

TABLE 23. *Estimated annual cost of contracting maintenance work*

Number of vehicles	Total directly allocated labor hours[1]	Annual labor cost[2] $10.00	$12.00	$15.00	Annual parts and tire cost[3]	Total annual cost ($12.00 labor charge)
1	119	$ 1,190	$ 1,428	$ 1,785	$ 721	$ 2,149
10	1,190	11,190	14,280	17,280	7,210	21,490
25	2,975	29,750	35,700	44,625	18,025	53,725
50	5,950	59,500	71,400	89,250	36,050	107,450
100	11,900	119,000	142,800	178,500	64,750	207,550
200	23,800	238,000	285,600	357,000	129,500	415,100
500	59,500	595,000	714,000	892,500	292,250	1,006,250
1,000	119,000	1,190,000	1,428,000	1,785,000	525,000	1,953,000
1,500	178,500	1,875,000	2,142,000	2,677,500	708,750	2,850,750
2,000	238,000	2,380,000	2,856,000	3,570,000	854,000	3,710,000

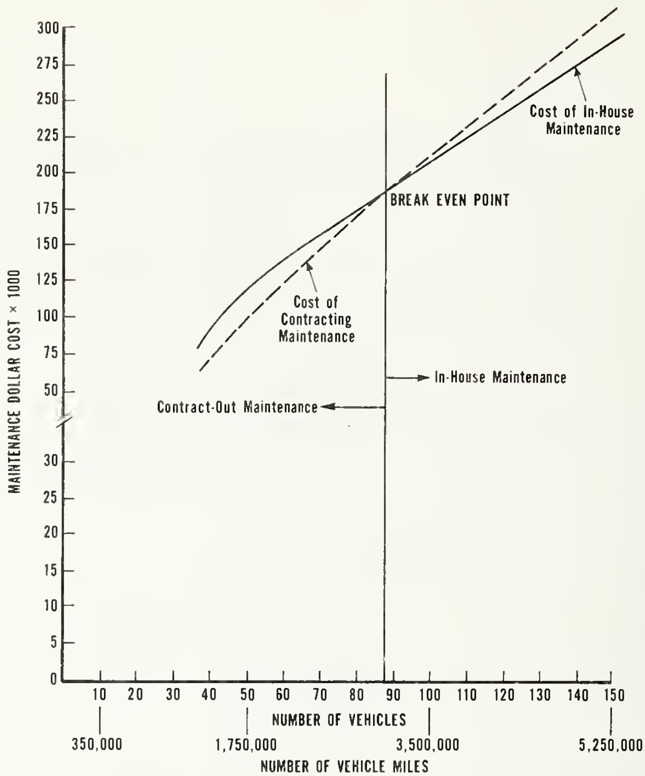
[1] The estimate of contract labor hours required to maintain fleets of various sizes is based on the average labor hours per mile (0.0034) for the sample group of departments, with a linear relationship assumed between labor requirements and fleet size. There appears little rationale for assuming economies of scale in the amount of necessary maintenance work per car as fleet size increases if maintenance is contracted out. To the extent contracting garages were to take into account number of cars services, it would likely be reflected in a reduced labor rate.

[2] According to several police fleet administrators who were contracting out their maintenance in different locations, hourly labor rates in private garages tend to be higher than rates in police or municipal shops. A range of $10.00 to $15.00 was suggested as typical of rates in private garages. It is assumed here that the overhead and profit margins of the private garage are included in the labor charge.

[3] Taken from table 20. Cost of parts are assumed equal for the police department whether they are purchased directly or under contract from private garages. For simplicity, it is assumed that all markup is included in the labor charge.

NOTE: Costs of transporting vehicles to and from the service center are not taken into account for either alternative.

EXHIBIT 7. *In-house vs. contracting-out maintenance: The breakeven point.*



real alternatives to the department are ownership versus a combination of leasing and ownership, rather than the all-or-nothing choices treated above. If the lease requires that part of the maintenance be performed in house, the cost of that in-house maintenance should be added to the cost of the lease in comparing costs of leasing with ownership. Alternatively, all costs which will be borne, regardless of the choice made, can be deducted from both alternatives for purpose of comparison.

As a case in point, a city police department, which now leases 23 cars, was charged 6.9¢ per mile (4.1¢ per km) in 1973 for unair-conditioned cars and 7.6¢ per mile (4.6¢ per km) for air-conditioned cars, with a minimum fleet mileage stipulation of 600,000 miles (970,000 km) per year. Last year the fleet totaled about 652,000 miles (about 1 million km) and paid approximately $45,000 in annual lease payments. This was not the total cost of the fleet, since the lease agreement did not cover equipping and decaling of cars; accident repairs, repairs necessitated by driver abuse, or failure to follow prescribed operating instructions; maintenance and repair of special equipment; theft or loss; final reconditioning; gasoline; or insurance. Additional expenditures over the year totaled $8,100 for gasoline; $10,000 for maintenance and repair covered by neither the lease contract nor insurance; $7,400 for collision insurance (net of insurance awards); and $5,000 for part-time administrative and clerical services. Adding these to the per mile charge raises the total cost of leasing from $45,000 to $75,000, and from 6.9¢ per mile to 11.6¢ per mile (4.1¢ to 7.0¢ per km). In comparing leasing with ownership/self-maintenance, the relevant comparison is between this total expenditure of $75,000 and the estimated total cost of a completely in-house operation.

Finally, a question should be addressed which may otherwise trouble the reader. The lease-buy analysis presented above assumes that the department is starting fresh, with no sunk cost. But, in fact, most police departments now own their fleets and maintain them in police shops, and have already invested heavily in vehicles, equipment and facilities. The kinds of decisions faced by most fleet managers are: (1) Whether to provide new required services by making additions to existing in-house facilities or by contracting out; (2) when to change some portion of existing service arrangement in response to a change in the fleet, (as an example, determining the point at which a growing fleet warrants the addition of an in-house radio repair specialty shop to replace the existing practice of sending radios out for repair); and, in some cases, (3) whether to continue to own and self-maintain vehicles or to change to leasing vehicles and/or contracting out maintenance.

The first kind of decision is a counterpart to the lease-buy question just addressed, but on a smaller scale. The procedure for analyzing it is identical to that used above.

The other two kinds of decisions are also quite similar except they require a comparison of the cost of the existing mode of operation with the cost of the new alternative, rather than a comparison of two new alternatives. The important point is that the cost of the existing operation should include the opportunity cost of keeping existing capital assets. The estimated value of existing assets should be treated as a cost of continuing the existing mode of operation because, to the extent that they have a market value, an opportunity cost is associated with keeping them. If the market value of existing garage and equipment is, say \$40,000, the estimated salvage value in 5 years is \$24,000, and an additional investment of \$5,000 in equipment is needed in order to continue the in-house operation, then the present value (PV) of the relevant building and equipment costs, for 5 more years of operation, may be calculated as follows:

$$\begin{aligned} PV_E &= M + N - S \\ &= \$40{,}000 + \$5{,}000 - \$24{,}000\ (\text{SPW; 5 years; 10\%}) \\ &= \$45{,}000 - \$14{,}902 \\ &= \$30{,}098, \end{aligned}$$

where

PV_E = Present value of the capital costs of continuing the existing maintenance operation for 5 more years,

M = Current market value of the existing garage and equipment,

N = Current cost of additional equipment purchase,

S = Present value of the expected salvage value of the garage and equipment in 5 years; i.e., the expected resale value 5 years hence, discounted to the present at a discount rate of 10 percent.

Thus, the lease-buy analysis presented in the text is relevant to decision makers who are choosing between continuing ownership and leasing, even though the department has existing assets. The cost of continuing ownership simply reflects the market value of existing assets, rather than original purchase price.

The main findings of the two parts of the lease-buy analysis may be summarized and synthesized as follows: Apart from special motives for the financing of vehicle acquisition through leasing—such as to implement a more regular and frequent replacement policy or to free funds for alternative purposes having a higher expected rate of return—there appears to be no general cost advantage to police departments from the finance aspect of leasing vehicles for full-time use. However, there is a potential for savings through short-term rental of vehicles with low utilization. Contracting for maintenance and other services does appear to offer cost savings to very small departments and, dependent on relative wage rates, may offer savings to fleets of as many as 100 vehicles. In face of problems with existing operations, contract-maintenance may be preferable to self-maintenance even for very large fleets. Maintenance and management services can be acquired apart from a vehicle lease, but a combined finance/maintenance lease arrangement may provide a convenient package of finance and service which enables reductions in in-house administrative and record keeping cost. Hence, a maintenance lease may be an efficient means of contracting out maintenance, even though the finance aspect of the lease in itself may offer no particular advantage over ownership.

3.3. Operating and Maintenance Costs

The main components of running costs are gasoline, oil, tires, and maintenance and repair expenses. Most of these expenses occur daily and vary with mileage, and so they often receive predominant attention in fleet expense control programs. This section discusses operating and maintenance costs, presents some empirical data, and attempts to show ways by which these costs may be reduced.

Reported operating and maintenance costs vary significantly among departments, due not only to differences in accounting practices, but also to differences in labor wage rates, driving conditions, and relative efficiencies. Consequently, comparison of costs among departments can be misleading; it is difficult to determine when costs are indicative of an efficient operation. Emphasis in the empirical analysis is therefore placed on comparisons of cost items within individual departments or groups of departments, rather than on comparisons between departments. The data should be regarded only as the reported experience of sample groups, not necessarily representative of all departments, and not necessarily optimal.

3.3.1. Operating and Maintenance Costs for Patrol Cars of Different Sizes

Table 24 shows reported operating and maintenance costs for patrol cars of different sizes averaged for 29 cities. Table 25 shows, for purpose of reference, operating and maintenance costs for private automobiles and fleet cars of different sizes. Both operating and maintenance costs of private and fleet cars increase with car size. A small subcompact-size car in private use is shown to cost about one-half cent per mile less in maintenance cost and slightly over a half-cent per mile less in operating cost than a larger, standard-size car.

TABLE 24. *Operating and maintenance costs by size of police patrol car*

Type of car	Miles per gallon of gasoline	Miles per quart of oil	Operating costs [1] (¢/mile)	Maintenance costs [2] (¢/mile)	Total operating and maintenance cost (¢/mile)
Luxury-Size (>122 wheel-base)	7.9	924	2.7	3.2	5.9
Standard-Size (118″-122″ wheelbase)	7.9	1,144	2.5	3.4	5.9
Intermediate-Size (<118″ wheelbase)	8.7	2,182	1.7	4.0	5.7

[1] Operating costs include gas and oil, and do not reflect the recent large increases in gasoline prices.
[2] Maintenance costs include labor and parts for preventive maintenance and normal repair, as well as tire expenses.

SOURCE: Data are based on a sample of police cars of various makes and 4 model years (1970-1973), operated in 29 cities whose labor rate average $7.75 per hour. Computer print-outs of data were provided by Mainstem, Inc.

TABLE 25. *Operating amd maintenance costs of private and fleet cars, by size of car*

	Cost per mile (in cents)		
	Maintenance, accessories, parts and tires	Gas and oil, excluding taxes	Total
A. Private Cars[1]			
Standard-Size	2.6	2.1	4.7
Compact-size (approximately the same as "Intermediate" in table 24)	2.2	1.8	4.0
Subcompact size (No comparable police class shown in table 24)	2.1	1.4	3.5
	Cost per car per month (in dollars)		
B. Fleet Cars[2]			
Full-size cars		$218.83	
Station wagons		237.73	
Intermediates		199.86	

[1] Costs nf private cars are from "Cost of Operating an Automobile," U.S. Department of Transportation, Washington, D.C., GPO, April 1972.

[2] These data are taken from a cost study of a large commercial fleet. No reference to mileage or time in service nf the cars was given. (Letter Attachment to Rowley, *Car Selection*, from Bill Wise, Vice President/Sales, McCullagh Leasing, Inc., Roseville, Michigan).

NOTE: These data are not strictly comparable with the police car data shown in table 24; however they do indicate how the costs of the different sizes of cars compare in police, private and fleet use.

As shown in table 24, the sample cities reported a similar, though slightly larger, excess in the operating cost of the larger patrol cars over the smaller ones. However, the reported relationship between car size and maintenance cost for patrol cars appears to be just the reverse of that shown for private and fleet cars: There is less maintenance and repair cost per mile for the larger-size patrol car than for the standard-size car, and less for the standard-size than the intermediate. It may be that police work places demands on the patrol vehicle which tend to increase maintenance and repair cost of a smaller car relative to a large car. However, it is impossible to know to what extent the differences reflect reporting errors, biases in the distribution of cars by size among the sample departments, and differences in usage, rather than size alone.

Despite this discrepancy in maintenance costs, intermediate-size cars appear less expensive overall to run than larger cars. The advantage, however, appears substantially less than would be suggested by the experience of private cars.

3.3.2. Operating and Maintenance Costs by Type of Expenditure, and as a Function of Driving Environment, Usage Rate, and Mileage

Table 26 shows life-time operating and maintenance costs for a sample of state highway patrol cars purchased in 1970 and disposed of in 1972. Average expenditure per car for each category of expenses, as well as the cents per mile costs are shown.

Gasoline and oil accounted for just over $2,000, or 55 percent of total operating and maintenance costs. Maintenance accounted for almost $1,650, the remaining 45 percent of total costs. This contrasts with the ratio of operating-to-maintenance cost for the sample group of city departments, shown in table 24 where operating cost accounted for 42 percent of the total, and maintenance cost for 58 percent. Over the life of the average state patrol car in the sample, major engine overhaul or replacement was the highest maintenance expense, initial installation and final removal of equipment ranked next in size, followed by tire expense, and maintenance and repair cost on the battery, cable, alternator, ignition and starter systems. Over the life of these patrol cars, $3,660 was spent on average for the operating costs and repair work performed.

Table 27 furnishes a breakdown of the type of maintenance cost and the mileage interval of occurrence for a sample of city patrol cars. Here we can see an increase in maintenance cost per mile as a car accumulates mileage, rising from an average of 2.56¢ per mile (1.5¢/km) for new cars, to 4.60¢ per mile (2.8¢/km) after 60,000 miles (97,000 km). Cents-per-mile costs are also computed for a subtotal of mechanical components, which appear more clearly variable in nature. This relationship between maintenance

Table 26. *Operating and maintenance costs by type of expenditure, over the life of a sample of State highway patrol cars*[1]

Type of expenditure	Average cost per car over its life	Average cost stated in cents per mile over vehicle life
	($)	(¢/mi.)
Gasoline	2004	3.30
Oil, engine oil change, oil fuel filter, transmission fluid, and other lub.	15	0.02
Fan belt hoses, water pump, radiator, and other engine cooling	38	0.06
Battery or cable, alternator system, ignition system, and starter system	144	0.23
Front-end align and repair, shocks, other rear suspension, ball joints, steering link	40	0.06
New tire and tubes, tire repair and other tire related	230	0.37
Speedometer and calibration	28	0.04
Brake system and fluid, trans-clutch	44	0.07
Air conditioner and heater	50	0.08
Other "normal" repairs (drive belts, exhaust system, hydraulic system)	49	0.08
Engine overhaul or replacement	649	1.07
Install and remove equipment[2]	295	0.48
Fees and towing	32	0.05
Wash[2]	42	0.06
Total, gas and oil	$2019	3.33
Total, tire, wash, and maintenance	$1641	2.70
Total, all	$3660	6.03

[1] The sample was composed of eleven 1970 model Highway Patrol cars, operated an average of 60,630 miles (97,000 km) before replacement.
[2] Expression of these cost items in terms of cents-per-mile is done for convenience and is not meant to indicate variability in terms of mileage.

Table 27. *Maintenance cost for a sample of city patrol cars by type of expenditure and mileage interval of occurrence*[1]

(¢/mile)

Type of service	Mileage interval: 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 and over
Instrument gauge	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Axle, front, nondriven	0.01	0.01	0.01	----	0.01	0.01	0.02
Axle, rear, nondriven	----[3]	----	----	----	----	----	----
Brakes—major repair	0.07	0.13	0.29	0.27	0.27	0.29	0.31
Brakes—minor repair	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
Wheel rims, hubs, bearings	0.02	0.02	0.03	0.03	0.04	0.04	0.03
Axle drive, front	----	----	----	----	----	----	----
Axle drive, rear	0.01	0.01	0.02	0.01	0.01	0.01	0.05
Clutch—major repair	----	0.01	----	----	----	----	----
Clutch—minor repair	----	----	----	----	----	----	----
Drive shafts	----	----	0.01	0.01	0.01	0.02	0.04
Power take off	----	----	----	----	----	----	----
Transmission—major repair	0.06	0.06	0.10	0.13	0.13	0.31	0.34
Transmission—minor repair	0.02	0.04	0.03	0.07	0.06	0.05	0.08
Transmission—auxiliary	----	----	----	----	----	----	----
Charge system	0.07	0.11	0.17	0.16	0.16	0.14	0.21
Cranking and battery system	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	----	----	0.01	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—major repair	0.03	0.06	0.22	0.22	0.27	0.25	0.41
Power—minor repair	0.08	0.13	0.18	0.18	0.16	0.22	0.15
Sub-total[2]	1.01	1.29	1.99	2.20	2.41	2.71	3.07
Lubrication	0.04	0.03	0.03	0.03	0.04	0.04	0.01
Preventive maintenance	0.41	0.37	0.34	0.29	0.32	0.32	0.35
Accessories and expendable items	0.21	0.10	0.11	0.11	0.12	0.13	0.15
Power tailgate	----	----	----	----	----	----	----
Radio equipment	0.04	0.02	0.01	0.02	0.01	0.03	0.04
Winch and vehicle coupling system	----	----	----	----	----	----	----
Air conditioning/heating/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 and door	0.15	0.18	0.19	0.16	0.30	0.18	0.16
Clean and paint	0.07	0.07	0.05	0.01	0.01	0.02	0.03
Towing and other	0.10	0.09	0.08	0.09	0.09	0.11	0.12
Mounted systems	0.01	0.01	0.01	0.01	0.01	0.01	0.02
Total[2]	2.56	2.73	3.45	3.66	4.08	4.30	4.60

[1] Cost data are averages for more than 1,100 patrol cars operated in 29 cities. The data collection procedure which was used to generate the data from which these ¢/mi figures were computed may cause some distortions in the figures. The problem was that maintenance and mileage data were reported for the life of the vehicle in the system, not the current odometer reading. (That is, cars of a department just adopting the cost management system would have their maintenance costs for the first period accumulated under the 0 to 10,000 mileage interval, regardless of their actual mileage. As a department once in the cost system replaced its cars, however, costs would be recorded in the correct mileage interval. While the magnitude of this problem is probably not great, it may tend to raise the cost of maintenance over the lower mileage intervals relative to the costs at the higher mileage intervals.)

[2] Expression of cost items in terms of ¢/mi is not meant to imply that costs are in all cases a function of mileage, rather it is used 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 ¢/mi comparisons which would result from spreading fixed cost over different mileages. Therefore, a subtotal is computed for a group of items for which costs are more clearly variable in nature.

[3] --- indicates negligible or no cost incurred.

SOURCE: Computed from data supplied by Mainstem, Inc.

cost and mileage is employed in section 3.5 to determine time of optimal replacement of patrol cars. Additional quantitative information there further shows the relationship between maintenance cost and mileage.

The data in table 27 are also useful in determining which items account for the largest part of the maintenance cost and at what mileage particular problems arise. For example, during the first 10,000 miles (16,000 km) of operation, repairs to the ignition and lighting systems are the largest single items of costs with respect to mechanical components. During this period, preventive maintenance accounts for by far the largest kind of maintenance expenditure (tires excluded). We can also see that, by 20,000 miles (32,000 km), brakes begin to account for an important share of cost; at 50,000 miles (80,000 km), transmission work becomes significant; and at 60,000 miles (97,000 km) the power system becomes expensive to maintain. There is no particular trend in costs of preventive maintenance, lubrication, or tires as mileage increases. Tire costs average about one-half cent per mile over the life of the vehicle.

Table 28 indicates the effect of driving environments and rate of vehicle usage on operating and maintenance costs of a patrol car. It appears from these sample data that congested traffic conditions lower gasoline mileage significantly, and raise maintenance cost (by about 2.0¢ per mile (1.2¢/km) for the sample cars). This supports the view that running cost per mile for city police department fleets will generally exceed the cost for state police departments.

Additional related information in section 3.4 deals with the cost effects of alternative vehicle-driver assignment plans. There, the impact on maintenance and repair cost of personal car assignment is examined.

Regression analysis was performed to determine whether gasoline mileage changes with car mileage. A significant dependence of operating cost on vehicle mileage would

Table 28. *The effect of different driving environments and vehicle usage rates on operating and maintenance costs of the patrol car*

	Miles per gallon of gasoline	Maintenance cost (labor, parts, tires; ¢ per mile)
A. A large city police department		
Congested traffic district [1]	7.65	4.7
Open driving (suburban) district [2]	8.78	2.6
High car utilization district [3]	8.70	3.7
		Maintenance cost (labor, parts, tires, gas & oil)
B. A State highway patrol department		
Congested traffic district [4]	10.2	6.6
Open driving district [5]	N.A.	4.7

[1] Averages are for 3 samples of 23 vehicles each, driven in 3 congested downtown city areas. Vehicles in these districts accumulate mileage at a slower rate than the department average, but corresponding engine hours are higher than average.

[2] Averages are for 2 samples of 28 vehicles each, driven in 2 suburban districts characterized by relatively low population density and rural driving conditions. Vehicles in these districts accumulate mileage at a higher rate than the department average, but associated engine hours tend lower than average and stop and starts are fewer.

[3] Averages are for a sample of 25 vehicles operated in a high crime community. Driving conditions are not particularly severe, but the need for constant patrol results in higher than average utilization of cars in this district.

[4] Averages are for a sample of six cars driven in a congested district where driving is at slower speeds with many stops and starts.

[5] Averages are for a sample of six cars operated in a district characterized by open driving conditions, where cars are driven at higher and more constant speeds.

SOURCE: Internal data files of a large city police department and a state highway patrol department.

NOTE: The samples were constructed to be as similar as possible with respect to car model and year, among districts within each department. Because of differences in sample composition and in accounting practices between departments, it is not meaningful to make comparisons across department lines.

bear on the timing of vehicle replacement. For the sample data, gasoline mileage appeared to improve slightly with increased mileage, but the relationship was slight [approximately one-half mile per gallon increase for each additional 10,000 miles (16,000 km) driven], and may reflect a bias in the data caused by earlier replacement of inferior cars and later replacement of those having better operating histories.

Although gasoline prices are largely beyond the control of fleet management, there are ways to reduce gasoline cost. One approach is to adopt vehicles which require low octane fuel, to strive for compatibility in octane requirements among vehicles of different types, and to buy gasoline as near as possible to minimum octane requirements. Use of higher octane gasoline is cost effective only if it reduces maintenance cost or increases performance by an amount equivalent to its higher cost.

3.3.3. Selection of Maintenance Facility: Centralized or Decentralized Organization and Location—Police Shop, Municipal Garage, or Private Vendor

The selection of a maintenance facility has already been treated, in part, in connection with leasing, when the cost of contracting out maintenance was compared to the cost of maintaining vehicles in a police shop. However, in establishing a maintenance operation, it is necessary to decide not only between private vendors and an in-house shop, but also to determine the best physical location for service facilities and, given an in-house operation, the optimal degree of administrative and managerial centralization. Thus, centralization may be considered in terms of physical location of shops and administration; (i.e., regional shops versus a central shop, and police, fire, sanitation, etc. garages versus a single municipal garage).

The two main cost considerations in these decisions are: (1) What are the travel costs and downtime costs connected with transporting vehicles to and from a central point for repairs, as compared with a number of decentralized points?;[48] and (2) to what extent will possible economies of scale be lost by dividing facilities into separate units? Intuitively, a municipal garage seems suited to small fleets, with some form of geographically decentralized shops for widely dispersed fleets. For dispersed fleets, the smaller the fleet, the greater the advantage of decentralized municipal shops, or contract arrangements with scattered private vendors.

A primary consideration aside from cost is the expected effectiveness of the different modes of service. Certain problems were mentioned frequently in association with both municipal garages and private shops. This study found the following objections to the municipal garage most often cited: (1) Police vehicles may not receive adequate priority, leading to excessive downtime; and (2) due to the diversity of vehicles and the size of the facility, quality control may not be as stringent as would be attainable in a police shop. Similarly, police fleet administrators often object to contracting maintenance on grounds that control over the quality of work is lost. Examples were also found, however, of departments with successful municipal or private garage maintenance arrangements.

Costs for alternative facilities can, of course, be estimated and compared on a case-by-case basis, but empirical determination of the average efficiency of each type of maintenance facility is difficult or impossible. This is in part due to the paucity of data available for analysis, but mainly because such data as are available reflect many factors other than the type of shop. Despite these drawbacks, average maintenance costs per mile are shown in table 29 for samples of departments using different types of facilities. When the cost data are adjusted for differences in labor rates, table 29 shows maintenance costs in municipal garages to be lowest, on the average.

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[48] Simulation models have been developed in other studies to help local authorities plan optimal location of shops.

TABLE 29. *Comparative maintenance cost per mile for vehicles maintained in a sample of police shops, municipal garages, and a commercial garage* (¢/mi)

Type of maintenance facility[1]	Standard 4-dr. police car		Administrative sedans and wagons		Administrative compacts		Scooters	
	Reported	Adjusted[2] for labor rate	Reported	Adjusted[2] for labor rate	Reported	Adjusted[2] for labor rate	Reported	Adjusted[2] for labor rate
Police Shop	3.2	5.8	3.8	7.0	1.7	3.2	5.8	10.1
Municipal Garage	4.0	4.7	3.3	4.0	1.7	2.2	6.3	8.9
Commercial Garage	4.0	6.3	5.4	7.5	N.A.	N.A.	N.A.	N.A.

[1] The cost data are computed for the following samples: (1) Five cities operating 135 or more police cars each, maintained in a police garage, (2) 24 cities, 8 operating 45 or more police cars each and 16 operating less than 45 police cars each, maintained in a municipal garage, and (3) one city contracting maintenance to a commercial garage.

[2] Labor rates were found to differ among the sample groups. Since the variation in rates appeared more likely attributable to geographical differences than to differences in type of garage, the data are shown adjusted to a common wage rate.

SOURCE: Computer printouts of data were provided by Mainstem, Inc.

3.4. Cost Effects of Alternative Vehicle-Driver Assignment Plans: The Personal Car Program

To achieve fleet economy, emphasis traditionally has been placed on minimizing the total number of cars in the fleet. This has been accomplished primarily by multipurpose use of vehicles, multishift use of cars, and reduction in vehicle requirements of the maximum-use shift.[49]

Until recently, individual officer-car assignment and single shift use of cars were limited chiefly to fleets dispersed over large areas, for which pooling at a central point would be impractical and inefficient. But this practice now appears to be expanding in conjunction with the "personal" or "take home" car program. While primary justification of the personal car program is usually crime prevention and apprehension—rather than fleet economy—there are claims that important cost reductions from the program make it about as cheap as (or even cheaper than) the pool/multishift arrangement.[50]

This section of the study examines the personal car program in terms of cost. The nature of the program is briefly described and the possible benefits listed. For a simplified case, it examines capitalization and running expenses for a single-shift program as compared to a multishift program. It presents some empirical information regarding costs of existing personal car programs, and uses a breakeven model to determine the reduction in running costs necessary to offset the higher capital costs of the program. An overall, in-depth analysis of the program is not provided here; only vehicle costs are considered.

[49] Fleet size is geared to requirements of the highest-use shift, which may be reduced by: (1) Shifting duties to other shifts, where possible, so that there is a more even balance among shifts, thereby reducing the number of vehicles which would be used for only one shift; (2) scheduling maintenance and repair work during slack periods, so that all or most of the fleet is operational during the high-use shift; (surplus vehicles from the maximum-use shift can be used as backup vehicles for other shifts); (3) minimizing shift overlap, or planning officer schedules to avoid double demands for vehicles during overlap periods.

[50] For example, Officers Earl Flowers and James Griswold, in a paper on the Arlington County, Virginia, Police Department's Take Home Program, state, "In Arlington County, Va., projected figures show that the present take home program will save the county in excess of $100,000 in a 1-year period. Although more vehicles and larger initial investments are necessary, lower maintenance and operating costs offset the initial cash outlay. This program is expected to pay for itself in a 3-year period." (Officers Earl Flowers and James Griswold, *Take Home Car Program*, Paper presented to the Northern Virginia Police Academy, April 10, 1972, p. 5.)

3.4.1. Description of the Personal Car Program[51]

In brief, personal car programs assign patrol cars to individual officers on a one-to-one basis, allowing use of the cars for personal activities during off-duty hours. For his part, the officer is required to operate the vehicle in the department's jurisdiction, maintain radio contact, have his gun, and respond to emergencies whenever the car is in use.

The officer is allowed to have his family or other passengers in the car with him during off-duty hours, but must drop civilian passengers before responding to an emergency call. When using the patrol car off-duty, the officer is required to dress conservatively and to avoid conduct or places which might create a bad image for the police department. The participating officer must insure that the car is cleaned, gassed, and serviced as scheduled and as needed, during off-duty hours, if possible. However, he is reimbursed for these costs. The department bears the expense of purchasing and operating the cars for off-duty and on-duty use.

The plan, in effect, gives participating patrolmen a sizable, tax-free benefit in return for intermittent services rendered. Department members other than patrolmen do not receive this benefit.[52] (Take-home provision for non-patrol cars is not considered a part of the personal car concept and is not dealt with here.)

The primary benefits claimed for the program—both from greater patrol car visibility and from quicker officer response—are reductions in crime and in accidents, increased criminal apprehension, and greater citizen security. These benefits are attributed not only to use of cars during off-duty hours, but also to increased time available for on-duty patrol. Due to the larger fleet and individually assigned cars, beat time previously lost to downtime—due to maintenance, gassing, and car exchange between shifts—can be reduced, thereby increasing effective patrol time. In addition, there are other advantages attributed to the program, which pertain to internal department operations, rather than direct provision of services to the public. These advantages include higher officer morale, improved vehicle safety, better appearance, and improved public image of the police. The program is offered in some jurisdictions as a low-cost solution to a need for increased police presence, because the costs of the program are thought to be less than the cost of buying equivalent patrol service in other ways.

3.4.2. Vehicle Costs Under the Personal Car Program: Empirical Evidence

There are basically two kinds of costs associated with the personal car program: (1) Vehicle capital cost and (2) vehicle running cost.[53] To compare cost of the personal car program with cost of a multishift operation, account must be taken of the cost of additional cars to implement the program, and the net change in total operating and maintenance cost for the fleet, including cost of existing cars and new cars, both during and after regular duty hours.

First, let us examine the cost experience of departments which have adopted personal car programs. Table 30 presents, in four parts, reported costs for a large city

[51] For more detailed descriptions and evaluations of personal car programs in operation, see the following reports: Donald M. Fisk, *The Indianapolis Police Fleet Plan*, Washington, D.C.: The Urban Institute, October 1970; Officers Flowers and Griswold, *Take Home Program*; Don H. Wilson, *The Take-Home Car Program of Arlington County Virginia Police Department*; Government Research Institute, *The Car Saturation Program of the Cahokia, Illinois Police Department*, an evaluation report prepared for the Illinois Law Enforcement Commission, St. Louis, Mo., May 1972; Cpl. Giacamo (Jack) San Felice, *The Personal Patrol Car Program; An Evaluation Report*, Prince George's County, Md., Police Department, February 1973.

[52] Since all department members do not benefit equally from the program, problems of equity may arise. Not only staff who are not patrolmen, but also patrolmen who live out of the jurisdiction, are generally denied full participation. (Partial participation may be allowed, whereby officers living out of the jurisdiction are assigned personal cars which must be left at the station whenever the officer leaves the jurisdiction.) Services, however, are exchanged in return for benefits received and car use is supposedly not bestowed out-of-hand.

[53] In some cases, officers receive overtime pay for extended calls during off-duty hours, but salary cost of the program appears generally small. Also, the increased fleet size may give rise to the need for expanded garage facilities. This analysis assumes for simplicity that existing facilities can accommodate the increased fleet.

police fleet operating first under a multishift plan and then under a personal car program. The following points are noteworthy: (1) Fleet size was nearly tripled to implement the program; (2) the plan was put into effect by purchasing more new vehicles than usual and, at the same time, retaining part of the existing fleet normally scheduled for replacement; (3) additional equipment purchase was necessary; (4) total fleet mileage increased by slightly more than half; off-duty mileage appeared to average between 50 and 60 percent of on-duty mileage; (5) individual car mileage averaged much lower with the personal car program; (6) due to lower car mileage, the department expected to extend the replacement period from about 2 years to somewhere between 2 1/2 and 3 years, while maintaining the former 50,000 mile (80,000 km) replacement target; (7) direct operating costs for gas, oil, and maintenance was reported to have declined on a per mile basis from about 5.6¢ (3.4¢/km) under the old plan to about 4.0¢ (2.4¢/km) under the personal car program, a decline of almost 30 percent; (8) due to higher total mileage under the personal car program, total annual gas, oil, and maintenance costs increased by about 10 percent (or about $28,000), despite the lower cost per mile; (9) uniform annualized cost of the personal car program appears in this case to be close to 40 percent (or nearly $200,000) more than the old, multishift plan.

In general, of course, the capital cost of implementing a personal car program will depend on departmental car utilization practices and existing fleet size. A fleet starting with a three-shift-per-car-per-day plan will generally require about a threefold increase in vehicles and related equipment. However, the required increase in cars may vary considerably depending on the distribution of the work load among the three daily shifts; on the number of officers patrolling in each car, i.e., single or multiple-officer staffing, and on the size of the existing backup fleet. If the work load varies substantially among shifts, the minimum number of cars for the multishift car plan will be larger than would be required if the work load were evenly distributed. The effect will be to reduce the number of additional cars needed to implement a personal car program. If, on the other hand, there were multiple-officer staffing of cars rather than single officer patrols, the difference in the number of cars required for a full personal car program as compared with a minimum multishift car plan would be widened. The larger the size of the existing backup fleet, the less the difference in the number of cars required for the two plans. In any case, from car and equipment price data, it is fairly easy to estimate the capital cost of implementing a personal car program, given the nature of the existing operation.

The annualized capital cost of keeping the personal car program in operation can likewise be estimated, based on the new replacement schedule. Since conversion from a multishift plan to a personal car plan generally reduces average mileage per car per period—and since average running costs per mile are probably no more (and are perhaps less) for the personal car program—the probable effect on time of replacement is a lengthening of the cycle.

Comparative running expenses are more difficult to estimate since the effect of the personal car program on this cost has not been clearly established. Part of the problem stems from limited experience with the program; part from lack of data for those programs in operation; and part from the interpretation of existing data. Claims of substantial reductions in car running costs (ranging higher than a 50% reduction) have been attributed to the program. However, an analysis of data samples by this study suggests that there may be little difference in per mile running costs between the two car plans.

Having already examined in table 30 the reported operating cost for a large city department (where per mile cost of gas, oil, and maintenance was estimated to drop almost 30% upon conversion to the personal car program), let us review quantitative information from other sources. According to an evaluation report of the personal car program in operation at one police department, annual maintenance cost per car under

TABLE 30. *Experience of a large city police department with a Personal Car Program*

I. Background Information

Fleet Size

Old Plan: 170 patrol cars
New Plan: 455 patrol cars (2.7 × old fleet size)

Mileage (approximate figures)

Old Plan: Total annual fleet mileage = $5,000,000
Average miles per car month = 2,400
Average miles per car per year = 29,000

New Plan: Total annual fleet mileage = approximately 7,700,000 (1.54 × old mileage)
Average miles per car per month = 1,400
Average miles per car per year = 17,000

Reported Running Costs

	Gas	Oil	Labor (¢/mile)	Parts	Total	($) Fleet insurance
Old Plan:	3.344¢	0.090¢	0.750¢	1.416¢	5.600¢	$17,000
New Plan:	2.430¢	0.089¢	0.530¢	0.906¢	3.955¢	$45,500

Replacement Policy

Old Plan: 2 years
New Plan: 2-1/2 to 3 years

II. Cash Outlay Necessary to Implement the Personal Car Program

No. new cars purchased in excess of annual purchases required under old plan = 235
Purchase price of new cars = $1,860
Expenditure for additional new cars = $437,100
Cost of Retaining 50 old cars in the fleet which would usually be sold for $400 but which will now be sold for $200 each in a year [1] = $10,909
Expenditure for additional equipment to outfit 285 cars at a cost of $740 per car, excluding radio. (Assume equipment for existing 170 cars is reused, leaving 285 without equipment) = $210,900
*Total cash outlay to implement program = $658,909

III. Uniform Annualized Cost of the Personal Car Program

Vehicles:

Yearly replacement of 1/3 of the fleet or 152 cars @ $2,000 each = $304,000
Yearly resale receipt on 152 cars sold after 3 years @ $760 each = $115,520
Annualized cost of vehicles = $188.480

Equipment:

Sirens, lights, partitions, etc. for 455 cars, assuming an average life of 10 years, no salvage value, and a purchase price of $740 per car = $54,815 (i.e., $336,700 × Uniform Capital Recovery Factor, 10 yrs., 10%)
Radio lease cost @ $144 per car per year = $65,520
*Annualized Cost of Equipment = $120,335

Annual Operating Expenses:

Gas, oil, maintenance (parts and labor) for annual fleet mileage of 7,700,000 @ 4.0¢ per mile = $308,000
Liability insurance @ $100 per car per year = $45,500
*Annual operating cost = $353,500
*Total annualized cost, after implementation of program = $662,315 [2]

[1] In order to implement the program, only 35 existing cars were traded instead of the usual 85. The 50 cars retained were not to be replaced until the following year. Since release values were not readily available and were not taken into account in the evaluation study (Fisk, *Indianapolis Plan*), they are estimated here, based on the purchase price of $1,860 and about an 80 percent depreciation over 2 years. Normally, an estimated $20,000 would be received from sale of used cars. However, in order to implement the personal car plan, the $20,000 is forgone and, instead, $10,000 will be received a year later.

[2] In absence of actual resale values, and in view of the fact that personal patrol cars are usually in much better condition than the average patrol car, a depreciation typical of a private car is used to estimate resale values. (See table 5). Had the same resale value been used as was used in computing annual cost of the old program, total annual cost would have been equal to $717,000 rather than $662,315.

Note: Information was not available on all cost elements and some items may be omitted from the comparison.

Source: Fisk, *Indianapolis Plan*, pp. 43-50. The basic data were taken from the Fisk Report, but the subsequent computations and the method of presentation differ from that in the report.

*Denotes subtotals and totals.

IV. Uniform Annualized Cost of the Old, Multishift Plan

Vehicles:

Yearly replacement of 1/2 of the fleet or 85 cars @ $2,000 each = $170,000

Yearly resale receipt on 85 cars sold after 2 years @ $400 each = $34,000

*Annualized cost of vehicles = $136,000

Equipment:

Sirens, lights, partition, etc. for 170 cars (assuming an average life of 10 years, no salvage value, and a purchase price of $740 to outfit each car) = $24,480, i.e., $125,800 × Uniform Capital Recovery Factor, 10 yr., 10%

*Annualized cost of equipment = $44,960

Annual Operating Expenses:

Gas, oil, maintenance (parts and labor) for annual fleet mileage of 5,000,000 @ 5.6¢ per mile = $280,000

Liability insurance @ $100 per car per year = $17,000

*Annual operating cost = $297,000

*Total annualized cost under multishift program = $477,960

the old pool plan averaged about $1500. Under the personal car plan, average annual maintenance cost per car is reported as $350, a drop of 77 percent per car—a large drop, the decline in average car mileage per month notwithstanding.[54] It is further noted in the report that the number of vehicles was doubled, but total maintenance cost increased by only 14.8 percent. However, when reported operation cost is looked at on a per mile basis, rather than a per vehicle basis, the results appear different. Reported total fleet mileage increased from 7.5 million miles (12.1 million km) the year prior to implementation of the program, to 8.1 million (13 million km) in the first year the program was in operation. On a per mile basis, the reported costs for maintenance and repair, cleaning, battery replacement, tire and tube replacement, and gas and oil appear to have increased slightly in each case, from one year to the next.

Similarly, two studies of another police department's personal car program reported drastically lower maintenance and operating cost for cars operated under the personal car program. Running costs were reported to have declined from $255 per car per month to $115 per car per month for cars in the program as compared with pool cars. However, a comparison of running costs for a small sample of multishift cars and personal cars of the same model and year, taken by this study from the department's records, failed to show a statistically significant difference in the two.

Another sample of data for a take-home car program showed the following costs for new pool and personal cars operated for a short time:[55]

	Mechanical components: parts and labor		Total maintenance and repair (includes tires, preventive maintenance, body work, towing, as well as items in the first column)	
	¢/mile	¢/km	¢/mile	¢/km
Take-home cars	1.5	0.9	3.0	1.8
Multiple-shift cars	3.7	2.2	6.8	4.1

As may be seen, pool cars are reported to cost more than twice as much as personal cars for maintenance and repair.

[54] Firm-handed management of fleet maintenance under the leadership of new maintenance personnel which occurred about the same time may account for part of the decline in average maintenance cost on vehicles.

[55] The data were provided by Mainstem, Inc., Princeton, N.J., for an unidentified police department.

In order to examine the cost effect of the *individual assignment* of cars alone, as opposed to both individual assignment and *personal use* of cars, two samples of cars were drawn from the records of a state highway patrol department. One sample group consisted of patrol cars originally assigned to individual officers but later converted to pool use. The other sample was a control group of cars similar with respect to model, age, and mileage, but which remained individually assigned. The sample costs rose almost 10 percent following conversion to pool use, while average cost per mile of cars in the control group appeared essentially unchanged. However, a statistical test of significance indicated that the difference might be merely attributed to chance.

It has also been reported that the rate of vehicle accidents and accident-related costs are reduced by personal car programs. The accident rate for pool patrol cars operated in one police department was said to be almost three times as great as the rate for personal patrol cars and in another police department, nearly half again as much for pool cars as for personal cars.

The assignment of a car to a single driver might reduce costs in two ways: (1) Individual car assignment provides accountability in case of driver abuse, whereas it is difficult to assign responsibility for the car's condition if several officers drive the same car. (2) Direct car assignment may generate pride in the vehicle, resulting in better care. In addition, when cars are used for patrol only 8 hours per day, there is more time to schedule and perform maintenance during off-duty hours. Otherwise the work may be frequently postponed, perhaps leading to more serious problems or downtime during duty hours. Quality of repair work is probably improved if an interested driver describes the nature of the problem to the mechanic and checks more closely on the repair job.

In conclusion, there is evidence—but not conclusive proof—that running costs for individually assigned, single-shift cars used by officers for personal use are substantially less than for multishift pool cars. There is some evidence that personal patrol cars may cost only about half as much per mile to operate as pool cars. However, there is also some evidence that the difference may be slight. (The rise in gasoline prices relative to other prices has increased the difficulty of achieving a reduction in per mile running costs by converting to a personal car program, because the use of personal cars does not appear to impact as much on fuel costs as on maintenance and repair costs.) Further research is needed to establish the impact of personal car programs on running costs. A thorough evaluation is needed to examine the expected benefits from the program, as well as the expected costs.

3.4.3. A Cost Comparison of a Personal Car Program With a Minimum Fleet/Multishift Car Plan: A Hypothetical Example

The purpose here is to compare capitalization and running expenses of a personal car program (PCP) with costs of a minimum fleet/multishift program (MSP). First the cash flow associated with each plan is identified, and then, lacking more definitive measures of the effect of the personal car program on fleet running cost, a breakeven model is used to determine the reduction in running cost which would be necessary to make a personal car program as cheap to operate as a multishift plan.

For simplicity, the cost of alternative car plans are developed and examined for a hypothetical police department just setting up its fleet. It is assumed there are 200 officers who require patrol cars and that the department operates 20 shifts per week—5 shifts per officer of 8.4 hours each—and assigns 50 officers to each shift, each of whom requires a patrol car. (As indicated above, in actual practice work loads will vary among shifts and two-officer patrols are common. Variation in work load would tend to reduce the difference in the costs of the two plans; two-officer patrols would increase the difference in the costs of the two plans if every officer received a car under the personal car plan.)

In order to implement an MSP of 3 shifts per car per day, 5 backup cars are added (in the ratio of 1 backup to every 10 regular cars, in accordance with a popular "rule-of-thumb") to the basic fleet of 50 cars to allow for downtime. For the PCP, it is assumed 200 cars are required and a backup fleet unnecessary. A backup fleet is no longer necessary because scheduled maintenance during regular duty hours is reduced by shifting it to off-duty hours, and unexpected downtime due to car breakdown is accommodated by borrowing off-duty cars from personal use.

The pool cars average 60,000 miles (97,000 km) per year each, for a total of 3.3 million miles (5.3 million km) per year. (This mileage is high compared with the experience of many departments, but it is reasonable for a minimal multishift fleet as is depicted here.) The 200 personal cars accumulate the same total fleet mileage of 3.3 million (5.3 million km) during on-duty use, or 16,500 miles (26,600 km) per personal car per year. But personal cars are also used during off-duty hours. Assuming that annual off-duty mileage amounts to 4,000 miles (6,400 km) per car, i.e., approximately 24 percent of on-duty use, each car is used about 20,500 miles (33,000 km) per year. This amounts to 4.1 million total fleet miles (6.6 million km) annually. The personal car, therefore would take almost 3 years to accumulate 60,000 miles (97,000 km). Replacement of cars under both plans is set at 60,000 miles (97,000 km). Additional assumptions employed in the analysis are explained in footnotes to table 31.

Table 31 shows the amount and timing of expenditures and receipts associated with both programs. Notice that a value has not been assigned to running cost per mile for the PCP. We can use a breakeven model (used in cost analysis to determine the value of a preselected unknown variable which will make alternative programs or decisions equal in costs) to get an idea of the magnitude of the difference in running expenses necessary to equate the costs of the two plans, given the stated assumptions.

To construct a breakeven equation, we first develop a cost equation for each plan, and then set the two equations equal to each other. We then solve for that value of the unknown variable—running cost per mile—which will equate the costs of the two alternatives. Uniform annual costs of each vehicle plan can be calculated from the information in table 31 as follows:

$$A_i = (C_i - S_i) \left[\frac{r(1+r)^{N_i}}{(1+r)^{N_i} - 1} \right] + S_i(r) + E_i \left[\frac{r(1+r)^{Y_i}}{(1+r)^{Y_i} - 1} \right] + I_i + M_i\,(R_i),$$

where,

A_i = Uniform annual cost of the vehicle plan, where the subscript i indicates the type of vehicle plan. (Below, subscript 1 designates the PCP and 2, the MSP.)

C_i = Total purchase price of vehicles in car plan i in present dollars.

S_i = Total resale value of vehicles in car plan i, resold after NC years of use in present dollars.

N_i = Number of years after purchase at which time cars in car plan i are resold, i.e., $N = 60{,}000/M_i$.

r = A real rate of discount, i.e., excluding inflation.

E_i = Total purchase price of equipment required for car plan i in present dollars.

Y_i = Number of years of life of equipment under car plan i.

I_i = Annual insurance cost for car plan i.

M_i = Total annual fleet mileage incurred under car plan i.

R_i = Cost per mile of running expenses under car plan i, in present dollars.

In the equation, the resale value, S_i, is subtracted from the purchase price, C_i, and the result is multiplied by the capital recovery discount formula, in order to convert the capital cost of cars into an equivalent stream of uniform annual values. The next term in the equation, $S_i(r)$ is included to take into account the fact that the resale value

TABLE 31. *Expenditures and receipts for a Personal Car Program (PCP) and a Multishift Plan (MSP)* [1]

Type of cash flow	PCP	MSP
No. of cars purchased [2]	200 every 3 yrs.	55 each yr.
Purchase outlay for new cars [3]	$600,000 every 3 yrs.	$165,000 each yr.
Receipts from sale of used cars [4]	$280,000 every 3 yrs.	$82,500 each yr.
Purchase outlay for car equipment [5]	$240,000 every 10 yrs.	$66,000 every 10 yrs.
Insurance premiums [6]	$20,000 each yr.	$5,500 each yr.
Running cost [7]	4,100,000 (R)	3,300,000 ($.08)= $264,000 each yr.

[1] The cost data are realistic values in 1973 prices.
[2] Lower average annual mileage results in a longer replacement cycle for personal cars.
[3] A purchase price of $3,000 is assumed.
[4] Resale value on the MSP car, which is replaced annually, is assumed to be $1,500. This is based on typical patrol car depreciation for a standard-size car operated by a medium-size city department, as developed in table 9. For the personal car, resale value is assumed to be $1,400, after being used for 3 years. Depreciation fnr the PCP cars is based on rates typical of a private car, and reflects the fact that they are normally in good conditinn.
[5] This assumes an expenditure of $1,200 to equip each car and an equipment life of 10 years with no salvage value remaining.
[6] This is based on insurance premiums of $100 per car for both car programs. According to an insurance company representative, there would generally be little or no differential in insurance rates for patrol cars based on mileage incurred or on whether they are pool or take-home cars.
[7] Running cost per mile (R) is the unknown variable in the analysis. Bnth direct and indirect costs, including overhead items such as costs of inventory and service garage facilities are assumed to be included in the per mile cost.

is not immediately forthcoming as is implied in the previous term, but is received at a later time. The annual cost of deferring the receipt of the resale value until later is the annual opportunity cost forgone; hence, cost of the vehicle plan is raised by an amount equal to the resale value multiplied by the discount made. (Alternatively, in the first term to the right of the equation, S_i could have been converted to present value by applying the single present worth formula, prior to subtracting it from purchase price. The remainder would then have been multiplied by the capital recovery formula, and then there would have been no need for the term $S_i(r)$.)

The third term on the right side of the equation takes into account equipment cost. The total purchase price of equipment is multiplied by the capital recovery formula to convert the present value cost to a uniform annual cost basis. Since salvage value is assumed equal to zero in the case example, no term for resale value of equipment is included. Insurance, I_i, and running costs $M_i(R_i)$ are already stated on an annual basis, and hence may be entered directly into the equation without discounting.

Setting the annual cost equations for the two plans equal to each other we have

$$A_1 = A_2$$

$$(\$600{,}000\text{-}\$280{,}000) \left[\frac{.10(1+.10)^3}{(1+.10)^3-1}\right] + \$280{,}000(.10)$$

$$+ \$240{,}000 \left[\frac{.10(1+.10)^{10}}{(1+.10)^{10}-1}\right] + \$20{,}000 + (4{,}100{,}000)\,(R_i)$$

$$= (\$165{,}000\text{-}\$82{,}500) \left[\frac{.10(1+.10)}{(1+.10)^{10}-1}\right] + \$82{,}500(.10)$$

$$+ \$66{,}000 \left[\frac{.10(1+.10)^{10}}{(1+.10)^{10}-1}\right] + \$5{,}500 + (3{,}000{,}000)\,(.08)$$

Solving for R_i, we find that $R_i = \$.04$.

This shows that given the stated assumptions for capital cost and mileage, running costs per mile under the PCP must be reduced by approximately half what it would be under the multishift plan, (i.e., from 8¢ to 4¢ [4.8¢ to 2.4¢/km]), in order for the two programs to be cost equivalent. Hence, the PCP must impact quite heavily on running costs in order to reduce total fleet costs to the level attainable under an MSP.

Table 32 shows total life-cycle costs of the two plans for various per mile running costs, off-duty mileages, and depreciation rates. This table provides an indication of the sensitivity of cost calculations to the assumptions employed in the analysis. It allows us, for example, to compare the costs of an MSP having a running cost of 8¢ per mile (col. 2, row 1) with the costs of a PCP not used at all off-duty and having a running costing cost of 6¢ per mile (col. 3, row 2). The costs of these programs can be compared in turn with a PCP for which the cars are used nearly as much for off-duty driving as for on-duty driving, and for which running cost per mile is, say, 4¢ (col. 6, row 3). The comparative costs are $379,000, $414,000, and $597,000, respectively.

From the table (col. 2, row 1 and col. 4, row 3), we can also confirm the results of the breakeven analysis; that is, costs of the two plans are about equal ($379,000 versus $380,000) if PCP cars are used off-duty sparingly, are replaced every 3 years rather than annually, depreciate much more slowly than MSP cars, and incur running costs less than half as great as for the MSP.

By comparing column 2 with columns 5 and 6, we can see that a PCP would cost much more than a MSP—about double in this case—if PCP cars are used extensively off-duty, are consequently replaced every 2 years instead of 3, and incur about the same operating cost per mile as MSP cars. The reduction in operating cost necessary to offset higher capitalization and insurance cost would be drastic. Futhermore, if a much slower rate of depreciation were not achieved by the PCP, the PCP would, in this example, cost substantially more than the MSP even if operating costs were greatly reduced by the program.

Of course, if PCP cars are not used off-duty (col. 3)—as might be the case where the program is adopted for reasons other than crime reduction—the cost differential between the MSP and the PCP is reduced. (By like token, program benefits from off-duty use of the vehicles are not forthcoming to offset the cost of the PCP.)

In examining table 32, note that the proportional relationships between costs of the PCP and the MSP have broader applicability than the single hypothetical case upon which the cost figures are based. To the extent that costs of the two fleet plans are linear functions of fleet size, the cost proportions derivable from table 32 will hold over all fleet sizes, all other things being equal. This means that in absence of any significant net economies or diseconomies of scale associated with larger or smaller fleets, under the stated conditions, the cost of a full PCP as compared with a minimal MSP would be in the same proportions as are derivable from table 32, regardless of fleet size. Thus, a PCP with the attributes described by column 6, row 1, would cost about twice as much as the MSP described by column 2, row 1 (i.e., $834,000/$379,000=2.2), whether the police department were to have 50, 100, 200, 300, or some other number of officers. The table therefore offers to police departments of various sizes some indication of the relative costs of the two programs under the conditions stated.

There are some limitations to the applicability of these specific cost figures. For example, these calculations are based on representative prices given in 1973 dollars. Furthermore, a given police department may discover items of costs associated with the two programs which have not been taken into account here. For example, it may find differences in the parking facilities required for the two plans, which may alter their comparative costs. However, given the fact that a PCP involves more cars but generally does not require parking for off-duty vehicles, the direction of impact in this case is not immediately clear. As noted above, to the extent that there are economies or diseconomies of scale associated with larger or smaller fleets, costs of the two fleet

TABLE 32. *Annual ownership and operating costs of a Personal Car Program (PCP) and a Multishift Plan (MSP) for a 200-officer department, under alternative conditions* [1]

	Running cost (¢/mi)	Uniform annualized cost (Thousands of dollars)				
		MSP	PCP			
		With 1 yr. replacement and typical police car depreciation rates	With PCP fleet mileage = MSP fleet mileage, 3 yr. replacement, and private car depreciation rates	With PCP fleet mileage = 1.24 MSP fleet mileage, 3 yr. replacement, and private car depreciation rates	With PCP fleet mileage = 1.80 MSP fleet mileage; 2 yrs. replacement [2]	
					Private car depreciation rates	Typical police car depreciation rates (i.e., equal to MSP depreciation rates)
	(1)	(2)	(3)	(4)	(5)	(6)
(1)	8	379	480	544	737	834
(2)	6	313	414	462	618	715
(3)	4	247	348	380	500	597
(4)	2	181	282	298	381	478

[1] Cost calculations are based on cost data presented in table 31, although some alternative assumptions are introduced as indicated by column headings. Columns 2 and 4 correspond most closely to assumptions on which table 31 and the break-even analysis were based. The data represent realistic costs in 1973 dollars.

[2] Additional off-duty mileage raises total fleet mileage to nearly 6 million miles (9.6 million km); or about 30,000 miles (48,000 km) per year per car. With a 60,000 mile (96,000 km) replacement policy, cars would be replaced in 2 years. Using private car depreciation rates, car value would decline by 50% in 2 years leaving a salvage value of $96,000.

plans would not be linear function of fleet size, and the cost relationships between the two fleet plans might vary depending upon the specific sizes of the PCP and MSP fleets.

Other limitations of the cost figures pertain to the way in which the PCP and MSP are here defined. There are two points to note. One is that the size of the MSP which is minimal depends upon staffing, utilization and maintenance practices. Multi-officer staffing of cars, for example, would reduce the size of the minimal MSP below that assumed here; the particular practice of preventive maintenance might increase or decrease the need for backup cars above or below the 1:10 ratio assumed here for the MSP. The comparisons in table 32 are made for a "bare-bones," minimal-size MSP and a full PCP. It should be noted that most departments probably operate an MSP with some degree of slack, and that those departments having a PCP usually do not provide a personal car for every officer. Hence, conversion to a PCP might not require in practice as large an addition to the fleet as is assumed in table 32.[56] (However, a lower cost of converting from an MSP to a PCP than that shown in table 32 does not necessarily imply economic efficiency of a PCP; rather it may simply signal inefficiency in the current car plan.)

Table 32, therefore, provides some measure of the comparative costs of the two car plans under qualifying conditions. For those departments whose costs are not adequately described by the table, the annual cost formula developed above and used to generate table 32 can be applied with specific department data.

3.5. Patrol Car Replacement Decisions

Another important management decision is when to replace vehicles. Although the "physical life" of a vehicle can usually be greatly extended by increasing maintenance and repair, there is a point beyond which it becomes uneconomical to do so. The optimal time for replacement, which corresponds to the end of the "economic life" of the vehicle, is that point at which the combined present value or annual cost of ownership and operation of the vehicle are a minimum.

The idea of an economic life, or optimum replacement point, is grounded in the fact that per unit running costs do at some point begin to increase with higher mileage and/or age. If unit costs of operating a vehicle declined or were constant with respect to time and use—and barring obsolescence—it would never be economical to replace. The combined costs per unit of time of the vehicle would decline continuously, since the largely fixed capital cost would be spread over increasing mileage and time. But if annual running costs do, at some point, start to rise with increased age and use, then it is possible to make tradeoffs between increasing annual running cost and decreasing annual depreciation cost, and to determine that point at which annual (or present value) total costs are a minimum.

The two critical factors in determining replacement are, then: (1) the trend in resale values over the physical life of the vehicle; and (2) the change in running expenses as mileage/age of the vehicle increases. Exhibit 8 shows schematically the typical relationships between these cost elements and vehicle mileage/age.

Both depreciation and running costs will, of course, differ among vehicles, among departments, and over time, hence it is not advisable to think in terms of a "standard" economic replacement time for all patrol cars. A more efficient approach is for individual departments to determine optimal replacement policies in light of their applicable cost experience.

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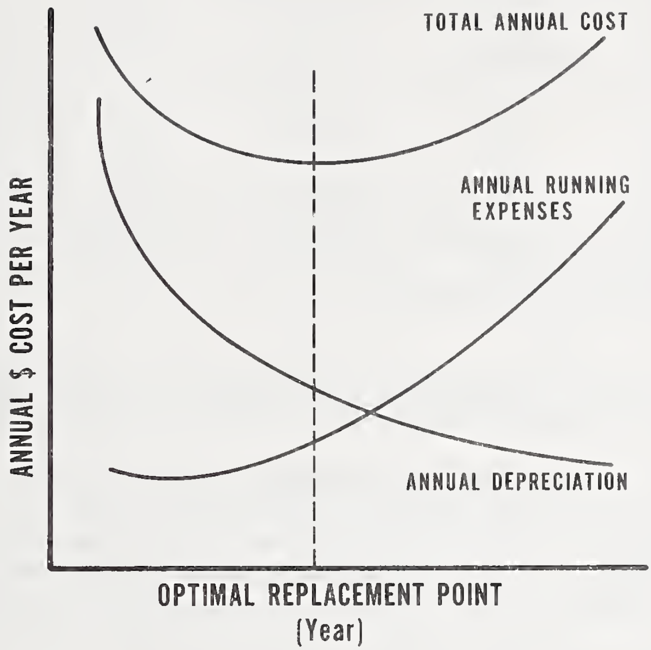
[56] Empirical cost studies of fleet plans probably tend to understate the real difference in relative cost of a full personal car program as compared with a minimum fleet/multishift plan, because the personal car program is typically compared with an existing plan which itself falls short of full car utilization; hence the small reported differences in program costs.

Exhibit 8. *The optimal replacement point.*



NOTE: Optimal replacement point does not necessarily coincide with the intersection of depreciation and running expenses. Costs are assumed discounted to an annual basis.

The purpose of this part of the study, therefore, is not to define the economic life of patrol vehicles—since there is no single answer—but rather (1) to explain the approach to determining optimal replacement, (2) to illustrate the approach with police department data, and (3) to indicate the effect on economic life of different fleet characteristics. In the examples, the cost effects of alternative replacement decisions are assessed.

3.5.1. Replacement Methodology

Replacement problems occur frequently and "replacement theory" has been developed as a technique of operations research analysis to handle these problems. Techniques range from crude models, which merely calculate the minimum mean cost per year, to more sophisticated models which take into account the time value of money and find the replacement point which minimizes either the uniform annual cost or the present value of long-run fleet costs.

Related to the optimal timing of replacement is the problem of optimal choice of vehicles when alternatives exist. That is, if the available replacement vehicle is not identical to the existing vehicle, it is necessary to compare the costs of alternative vehicles when the cost of the new has been evaluated at its optimal life. Techniques exist for dealing with replacement by unlike vehicles.

Simple—but crude—approaches to determining replacement assume replacement with identical vehicles and a zero interest rate. One such approach is to replace the vehicle whenever its expected depreciation and operating cost over the coming period exceeds that of the previous period. Another approach is to replace the vehicle when average cost reaches its lowest value. Cumulative running cost and depreciation are summed, and the total is divided by the number of periods, yielding average cost per period. This model may be expressed as follows:

Find that n for which AC(n) is a minimum, where

$$AC(n) = \sum_{j=1}^{n} \frac{R(j)+D(j)}{n},$$

and

AC(n) = Average (mean) cost per unit of time of a vehicle replaced after n periods.

R(j) = Maintenance and operating costs incurred in the jth period.

D(j) = Depreciation in the jth period.

n = Replacement period.

This method of calculating replacement is illustrated in table 33. As may be seen in column 7, for this example, average cost per period is lowest if vehicles are replaced in the second year.

A more accurate approach to determining a vehicle's optimal life takes into account the time preference of money, using either an annualized cost model or a present value model to place costs on an equivalent basis. In either case, the objective is to find that replacement period (n) for which discounted costs are minimum.

The uniform annualized cost model to determine replacement may be expressed as follows:

Find the value of n for which A'(n) is a minimum, where

$$A'(n) = \left[C - \frac{S(n)}{} + \sum_{j=1}^{n} \frac{R(j)}{(1+i)^j}\right] \cdot \left[\frac{i(1+i)^n}{(1+i)^n-1}\right],$$

and

A'(n) = Annualized costs associated with replacing vehicles at the end of the nth period.

C = Purchase price of a new vehicle.

S(n) = Resale value of the vehicle at time n.

R(j) = Maintenance and operating costs in jth period.

n = Replacement period.

i = Discount rate.

$\frac{S(n)}{(1+i)^n}$ = Resale value discounted to present value.

$\frac{R(j)}{(1+i)^j}$ = Maintenance and operating costs in period j discounted to present value.

$\frac{i(1+i)^n}{(1+i)^n-1}$ = Uniform capital recovery interest formula for converting a present amount to a series of uniform annual payments.

TABLE 33. *Illustration of simple approach to calculation of optimal replacement point: Minimizing the cumulative average cost per year*

Year	Yearly repair cost	Cumulative repair cost	Yearly depreciation	Cumulative depreciation	Cumulative total cost [1]	Average yearly cost [2]
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	$150	$150	$400	$400	$550	$550
* 2	250	400	250	650	1050	525 *
3	350	750	200	850	1600	533
4	450	1200	150	1000	2200	550
5	550	1750	150	1150	2900	580
6	650	2400	100	1250	3650	608

[1] Column 3 plus column 5.
[2] Column 6 divided by column 1.
*Denotes minimum average cost.

NOTE: Cost data are hypothetical and are not indicative of costs incurred by police cars. Average yearly cost figures are simple mean values; they are not discounted.

TABLE 34. *Illustration of the use of an annual cost model to determine optimal replacement point*

Year	Yearly repair cost	Estimated resale value	Annual cost [1]
1	$150	$1,600	$750
2	250	1,350	707
* 3	350	1,150	700 *
4	450	1,000	704

[1] $A(n) = [C-S(n)\,(SPW, n,i) - \sum_{j=1}^{n} R(j)(SPW,j, i)](UCR, n, i)$

A(n) = Annual cost of replacing vehicle, at the end of the *n*th period,
C = Purchase price of a new vehicle,
S(n) = Resale value of a vehicle at time *n*,
R(j) = Sum of relevant maintenance and operating costs in *j*th period,
SPW = Single Present Worth Factor, and
UCR = Uniform Capital Recovery Factor.
A_1 = [2,000−(1,600) (.9091)+(150) (.9091)] (1.1)=$750
A_2 = [2,000−(1,350) (.8264)+(150) (.9091)+250 (.8264)] (.5762)=$707
A_3 = [2,000−(1,150) (.7513)+(150) (.9091)+250 (.8264)+350 (.7513)](.4021)=$700
A_4 = [2,000−(1,000) (.6830)+(150) (.9091)+250 (.8264)+350 (.7513)+450(.6830)](.3155)=$704

*Denotes minimum annual cost.

NOTE: The cost data used to compute annualized cost in this table are the same as those used in tables 32 and 33.

Employing discount factors, the above question may be stated equivalently in the following terms:

$$A(n) = [C-S(n)\,(SPW,i,n) + \sum_{j=1}^{n} R(j)\,(SPW,i,j)]\,(UCR,i,n)$$

where

SPW = Single Present Worth Factor
UCR = Uniform Capital Recovery Factor

Table 34 shows the annualized costs associated with various replacement periods, computed for the same basic data as used in table 33, but here taking into account the time value of money. It may be seen that the optimal replacement time is changed from 2 years to 3.

The use of a present value model to determine optimal replacement is similar to the above method, and may be described as follows:

Find the value of n for which PV(n) is a minimum, where

$$PV(n) = \frac{C+R'(n)-S'(n)}{1-(1+i)^{-n}},$$

and

PV(n) = Present value of the relevant costs associated with purchasing a new vehicle and an infinite chain of identical replacements, each with a life of n years.

C = Purchase price of a new vehicle.

$R'(n) = \sum_{j=1}^{n} R(j) \quad (1+i)^{-j}$, the present value of operating and maintenance costs from j=1 to j=n.

$S'(n) = S(n)\,(1+i)^{-n}$, the present value of the resale value in period n.

i = Discount rate.

n = The length of the replacement cycle.

The model assumes that a series of periodic payments of [C+R′(n)−S′(n)] will be made every n years in perpetuity.

Table 35 shows the present value of vehicle costs for different replacement cycles, again using the same basic data as in tables 33 and 34. As would be expected, the results of this calculation are in agreement with the findings of the annualized cost model. Both are considered more reliable than the simple average approach.

If the replacement vehicle differs from the existing vehicle, the replacement calculation is slightly more complex. Here the problem is to find how long it pays to continue operating the existing vehicle before replacing it with the alternative vehicle.

One approach begins by determining the optimal life of the replacement vehicle so that the cost of keeping the existing vehicle may be compared with the cost of the new vehicle at its optimal life. The optimal life of the new vehicle may be determined from the above equation for present value, PV(n). This information can then be used in the following equation to find the optimal remaining life of the existing vehicle:

Find the value of k which minimizes the present value of vehicle cost, where

$$PV'(k) = \frac{PV(n)}{(1+i)^k} + M'(k) - E'(k)$$

$$= \frac{(C+R'(n)-S'(n)}{[1-(1+i)^{-n}](1+i)^k} + \sum_{j=1}^{k} \frac{D(k)}{(1+i)^k} - \frac{E(k)}{(1+i)^k}$$

and

PV′(k) = Present value of all relevant costs associated with replacing an existing vehicle at the end of period k with a new vehicle which has an economic life of n periods.

$$M'(k) = \sum_{j=1}^{R} \frac{M(j)}{(1+i)^j},$$

the present value of the operating and maintenance costs of the existing vehicle in period k, where M(j) is defined as the operating and maintenance cost of the existing vehicle in the jth period.

$$E'(k) = \frac{E(k)}{(1+i)^k},$$

the present value of the resale or salvage value of the existing vehicle in period k, where E(k) is defined as the resale value of the existing vehicle in period k.

k = The length of the replacement cycle for the existing vehicle.

C, R′(n), S′(n) = As defined previously.

For example, assume that the new vehicle is described by the data in table 35, and therefore has an economic life of 3 years. Assume also that the vehicle can be expected to give 2 more years of satisfactory service, at an operating cost of $400 in the first year and $475 in the second year. Further assume that the salvage value is expected to be $500 at the end of the first year and $300 at the end of the second year. The calculations to determine whether the vehicle should be replaced at the end of the first or second year, are shown in exhibit 9.

Since the present value of the new vehicle is $7,004, at its optimal replacement cycle, immediate replacement of the old with the new means a cost of $7,004. Keeping the existing vehicle for either 1 or 2 more years prior to replacement, at a cost of either

TABLE 35. *Illustration of the use of a present value model to determine optimal replacement point*

Year	Yearly repair cost	Estimated resale value	Present value[1]
1	$150	$1,600	$7,491
2	250	1,350	7,068
* 3	350	1,150	7,004
4	450	1,000	7,035

[1] $$PV(n) = \frac{[C + R'(n) - S'(n)]}{1 - (1+i)-n}$$

$$PV(n)_1 = \frac{[2000 + 150(SPW, j{=}1, 10\%) - 1600\ (SPW, n{=}1, 10\%)]}{1 - (1+i)^{-n}}$$

$$= \frac{200 + 150(.9091) - 1600(.9091)}{1 - (1.10)^{-1}}$$

$$= \frac{681}{.0909}$$

$$= \$7{,}491$$

$$PV(n)_2 = \frac{2000 + 150(.9091) + 250(.8264) - 1350(.8264)}{1 - (1.10)^{-2}}$$

$$= \frac{1227}{.1736}$$

$$= \$7{,}068$$

$$PV(n)_3 = \frac{2000 + 150(.9091) + 250(.8264) + 350(.7513) - 1150(.7513)}{1 - (1.10)^{-3}}$$

$$= \frac{1742}{.2487}$$

$$= \$7{,}004$$

$$PV(n)_4 = \frac{2000 + 150(.9091) + 250(.8264) + 350(.7513) + 450(.6830) - 1000(.6830)}{1 - (1.10)^{-4}}$$

$$= \frac{2230}{.317}$$

$$= \$7{,}035$$

NOTE: The same basic cost data which were used in tables 33 and 34 are used here.

*Denotes minimum present value cost.

EXHIBIT 9. *An illustration of the replacement calculation when the replacement vehicle differs from the existing vehicle*

Existing vehicle: Remaining effective life: 2 years
Expected operating cost: $400, 1st year; $475, 2nd year
Expected salvage value: $500, 1st year; $300, 2nd year

New vehicle: Purchase price: $2,000
Expected operating cost: $150, 1st year; $250, 2nd year; $300, 3rd year; $450, 4th year
Expected salvage value: $1,600, 1st year; $1,350, 2nd year; $1,150, 3rd year; $1,000, 4th year

Problem: Find the replacement time, k, which minimizes the present value [PV'(k)] of all relevant costs associated with replacing an existing vehicle in period k with a new vehicle which has an economic life of n periods.

$$PV'(k) = \frac{PV(n)}{(1+i)^k} + M'(k) - D'(k), \text{ (terms are defined in the text)}$$

A. Present value of immediate replacement of existing vehicle:

$$PV'(k=0)=PV(n) = \frac{2{,}000+\$150(.9091)+\$250(.8264)+\$350(.7513)-\$1{,}150(.7513)}{1-(1.10)^{-3}} = \$7{,}004$$

B. Present value of replacing the existing vehicle after one more year of use:

	"Delay *discount*"	Operating cost for old car[M'(1)]	Resale for old car[E'(1)]
PV(k=1) = [PV for the new car, n = 3, as shown above]	$(1+.10)^{-1}$	+ $400(.9091)	−500(.9091)=$6,226.

C. Present value of replacing the existing vehicle after 2 or more years of use:

	Delay discount	M'(1)	M'(2)	E'(2)	
PV(k=2) = [PV for new car, n = 3, as shown above]	$(1+.10)^{-2}$	+ $400(.9091)	+ $475(.8269)	− $300(.8264)	= $6,299.

$6,226 or $6,299 respectively, is therefore cheaper than immediate replacement. It appears slightly more economical, however, to replace the present vehicle with the new vehicle after only 1 more year of use, rather than 2 years. (Other factors not included in this model, such as model changeover costs, may make replacement more or less costly than this model shows.)

Regardless of the method used to calculate replacement time, an effort should be made to utilize realistic and comprehensive cost data. Conceptually, operating or running costs should include costs associated with declines in vehicle performance, and reliability, and increases in downtime, all of which may come about with increased mileage or age. In practice, however, it is usually difficult to get operating cost data for expenses other than parts and labor. Dollar estimates of the costs of reduced performance and downtime are difficult to estimate and subject to question. A simpler and less controversial approach is to indicate separately, as far as possible and in whatever measures are convenient, any costs (or reduced benefits) in addition to parts and labor costs, which accrue as the fleet ages. Then the estimated ownership and maintenance costs associated with shortening or lengthening the replacement period can be compared with these other types of costs. As a consequence, the trade-offs are more clearly specified, and decision making should be improved.

Some types of operating expenses may be omitted from the replacement analysis without significantly affecting the results. Costs which accrue at a relatively constant rate over the life of the vehicle, such as cost of gas, oil, tires, and insurance, usually have no effect on the optimum replacement time and, therefore, need not be considered. Whether to include or omit certain items may therefore depend on convenience, given the format of data records.

For practicality and efficiency, a dual approach to replacement determination is generally needed. (1) For the purpose of budgeting and for control of a large fleet, the economic lives of particular types of vehicles have to be predicted. This may be done by use of statistical methods to develop profiles of running expenses and depreciation costs as a function of mileage/time for different vehicle types, based on past costs and resale values. Prediction of the average economic age for each type of vehicle will indicate the approximate number of replacements which probably will be required over the coming period. Where review on an individual vehicle basis is infeasible, the manager of the large fleet will be able to set an informed, rather than completely arbitrary, replacement rule. (2) For maximum efficiency, a decision mechanism is needed for replacing individual vehicles within a particular group. Individual vehicles may differ greatly in their costs—especially maintenance and repair cost. Samples of cost data gathered from several police departments showed variation among like vehicles throughout their lifetimes, and particularly at higher mileages. The more efficient replacement plan will identify and make provision for individual vehicles whose costs are higher or lower than average.

A number of replacement programs are currently available for purchase. One of these, developed by the Local Government Operations Unit, Reading, England, consists of a set of charts which may be used to simplify replacement determination.[57] The charts are geometric representations of equations, and are provided for different rates of discount and depreciation. To use the charts, it is necessary to have a record of total maintenance and repair cost over the life of the vehicle to date, and further, an estimate of the cost expected to be incurred over the coming period. The charts define the maximum amount which can be spent on a vehicle in the coming period without increasing annualized cost. If the estimate exceeds this limit, replacement is indicated. While the charts might aid computations, they do not overcome the more difficult part of replacement analysis—the development of good historical cost data and the ability to forecast future costs on an individual basis.

Computer programs are available to assist in determination of vehicle replacement, as well as time for repair of vehicles. Again, implementation of these programs requires vehicle operating and maintenance cost data and resale values. The expense history file is used in programs which determine cost parameters by vehicle type.

Regardless of whether the department aims at developing an in-house replacement policy or purchases outside assistance, it is clear that up-to-date cost information will be needed. In developing necessary cost records, there are also extant guides, programs, and cost control systems which may aid the manager.[58]

It should also be noted that the methodology for determining car replacement described in this section for patrol cars is applicable to a wide range of vehicles and to other kinds of assets.

3.5.2. Replacement of Police Cars: Illustrative Cases

This section uses a present value replacement model and maintenance cost data drawn from police departments to examine replacement of police patrol cars. The purpose is to determine the kinds of replacement schedules which are generated when actual police maintenance cost data are used to exercise the replacement model, and to test the sensitivity of the results to variations in the cost data.

No attempt has been made to explore fully the intricacies of the data bases used as sources for this analysis, or to refine the analysis so as to derive precise replacement schedules for those departments from which data were gathered. Furthermore, not all of

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57 Local Government Operational Research Unit, Royal Institute of Public Administration, *Vehicle Replacement Charts; Operating Manual*, Report No. C.81, Reading, England, January, 1971.

58 Aids to vehicle management are offered by both commercial and public organizations. For example, Mainstem, Inc. offers a cost accounting and expense control system; Public Technology, Inc. offers a municipal vehicle replacement package; American Association of Public Works has developed an equipment management program and offers a group of vehicle-related management services; the Municipal Finance Officers Association of the U.S. and Canada provides a guide to accounting practices for government owned and operated vehicles; IBM's Field Development Program has developed a vehicle maintenance and cost analysis system which provides programs to assist in controlling vehicle maintenance cost. (No attempt has been made by this study to assess the utility of individual programs and services, and no endorsement of the above programs and services is intended.)

the data were empirically determined; depreciation data are largely estimated. *The reader is reminded and cautioned that findings in this selection are based on specific assumptions and costs, and may not be generally applicable.*

As was seen already, the critical elements in replacement determination are how running expenses and depreciation behave with vehicle age and use. With respect to depreciation, we saw earlier that the resale value of patrol cars appears typically to drop faster than for private cars, but the general pattern of decline appears about the same. Hence, even though there is substantial variation in depreciation rates among departments, the range of depreciation which would be experienced by most departments can likely be covered by exercising the replacement model with depreciation rates ranging from a rate comparable to that on private cars to a very high rate of, say, 50 percent of remaining car value per year. For this reason, it appeared unnecessary to trace in detail police car resale or trade-in values specifically matched with empirical maintenance and repair cost data. These may be easily approximated.

Establishment of the "typical" relationship between running cost and police vehicle mileage/age proves to be more difficult. Both intuitively and on the basis of the literature, the expected relationship is a rise in maintenance and repair cost with a vehicle's age and use. The rate of change is, however, by no means clear. From an empirical standpoint, data samples are generally distorted by existing replacement policies. For instance, replacement at 50,000 miles (80,000 km) precludes obtaining cost data for vehicles with higher mileages. And, to the extent such data exist, they will likely be biased, representing vehicles with lower than average costs which have been retained in the fleet longer than usual.

Despite these problems, an attempt was made to establish the approximate relationship between maintenance and repair cost and mileage for a sample of police departments. Cumulative maintenance cost data for different mileages were collected for sample vehicles from several fleets.

Statistical techniques were used to fit a curve of "best fit" to each set of data and to predict maintenance costs based on mileage at 1,000 mile (1,600 km) intervals. The samples were designed to include vehicles of similar functional type. Because of the relatively high usage rates for patrol cars, there was little difference in the model years of cars contributing high and low mileage data within a sample. The rate of accrual of mileage was ignored, the only mileage distinction being accumulated mileage. Thus, the cost predicted for any given mileage reflects the average cost experience of all cars in the sample then at that mileage.

Table 36 shows the computed costs per mile of maintenance and repair at the sample police departments for successive intervals of 5,000 miles (8,000 km) each. Exhibits 10, 11, and 12 are plots of actual cumulative maintenance and repair data, along with a "best fit" curve for each of three groups of sample data.

Only the sample group of 29 medium-size city departments shows continuously rising maintenance and repair cost per period or per mile as vehicle age and usage increases. Each of the three samples drawn from individual departments showed increasing maintenance cost per mile up to at least 35,000 miles (56,000 km). One of the three samples subsequently showed a falling cost per mile for all mileage over 35,000 miles (56,000 km). Another showed declining maintenance cost per mile from 35,000 (56,000 km) to 65,000 miles (105,000 km), but rising thereafter, while the third showed increasing cost per mile up to 60,000 miles (97,000 km), but decline thereafter.

What accounts for the behavior of these cost data? It was beyond the scope of this study to make the in-depth inquiry necessary to fully understand the behavior of the data, but there are several simple reasons which might account for an apparent declining running cost as mileage increases. For one thing, costs are accrued at different rates of price inflation. Then, too, "lemons" are culled from a fleet over time, hence mechanical failure rates decline. In addition, it is possible that departments tend

patrol cars, by type of department
($/mi)

	Mileage interval									
	0 to 5,000	5,001 to 10,000	10,001 to 15,000	15,001 to 20,000	20,001 to 25,000	25,001 to 30,000	30,001 to 35,000	35,001 to 40,000	40,001 to 45,000	45,001 to 50,000
Medium-size city department[1]	---	---	.025	.052	.0690	.077	.080	.077	.071	.064
Large city department[2]	.018	.026	.029	.032	.035	.037	.038	.040	.041	.041
State highway patrol[3]	.024	.034	.047	.057	.064	.068	.070	.069	.064	.057
County department[4]			.02		.03		.03		.03	
Group average for 29 city departments	.026		.027		.035		.037		.041	

	50,001 to 55,000	55,001 to 60,000	60,001 to 65,000	65,001 to 70,000	70,001 to 75,000	75,001 to 80,000	80,001 to 85,000	85,001 to 90,000	90,001 to 95,000	95,001 to 100,000
Medium-size city department[1]	.056	.051	.049	.052	.062	.080	.108	.148	.200	.270
Large city department[2]	.041	.041	.040	.039	.037	.035	.033	.030	.026	.023
State highway patrol[3]	.048	.035	--	--	--	--	--	--	--	--
County department[4]	.03		.04		.05		.05			
Group average for 29 city departments	.043		.046		.052[5]		.057[5]		.063[5]	

[1] See exhibit 10. Cost data include tire expenses and maintenance and repair.

[2] See exhibit 11. Cost data include tire expenses and maintenance and repair.

[3] See exhibit 12. Cost data include gasoline, oil, and tire expenses, in addition to maintenance and repair cost.

[4] Costs per mile computed from simple averages of the raw data.

[5] See table 27; data provided by Mainstem, Inc. Values for mileage intervals above 60,000 miles are estimated. It was assumed that cost would continue to increase at a rate of 10 percent for every 10,000 miles.

NOTE: Cost per mile data for each mileage interval were computed on the basis of cost incurred in that interval only. To calculate cost per mile for each interval, the average cumulative cost at the beginning of the mileage interval was subtracted from average cumulative cost at the end of the mileage interval. Remaining costs were then attributed to that interval.

EXHIBIT 10. *Cumulative maintenance and repair cost as a function of mileage for patrol cars of a large city.*

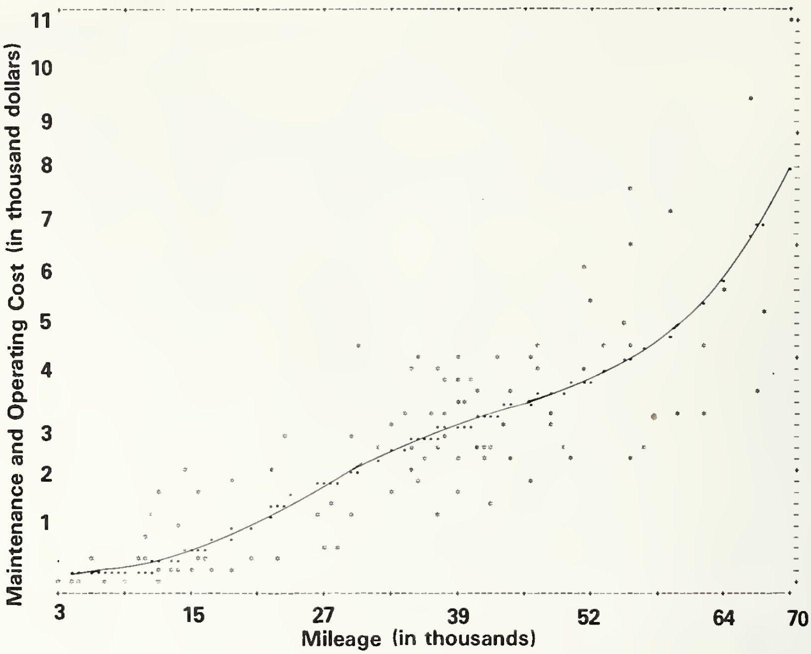


EXHIBIT 11. *Cumulative maintenance and repair cost as a function of mileage for patrol cars of a large city.*

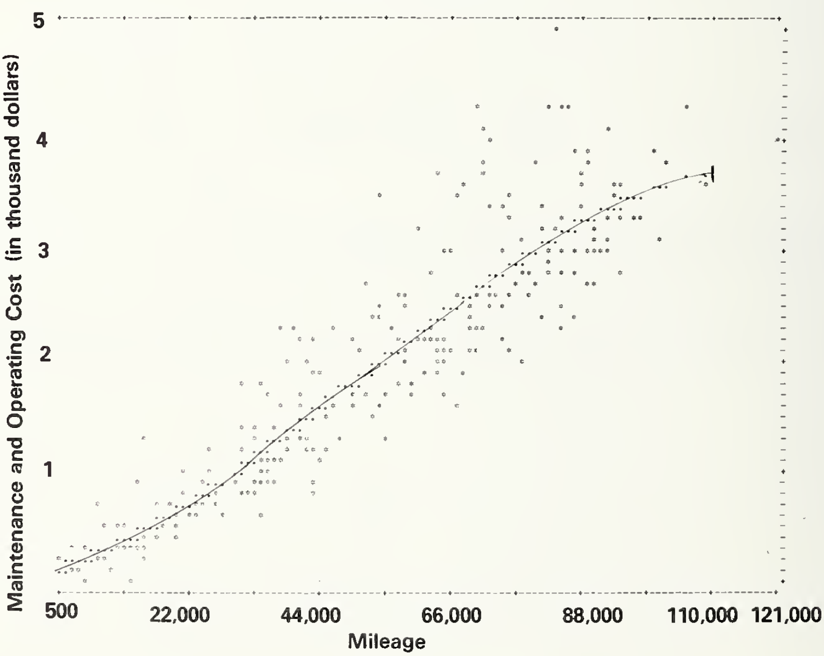
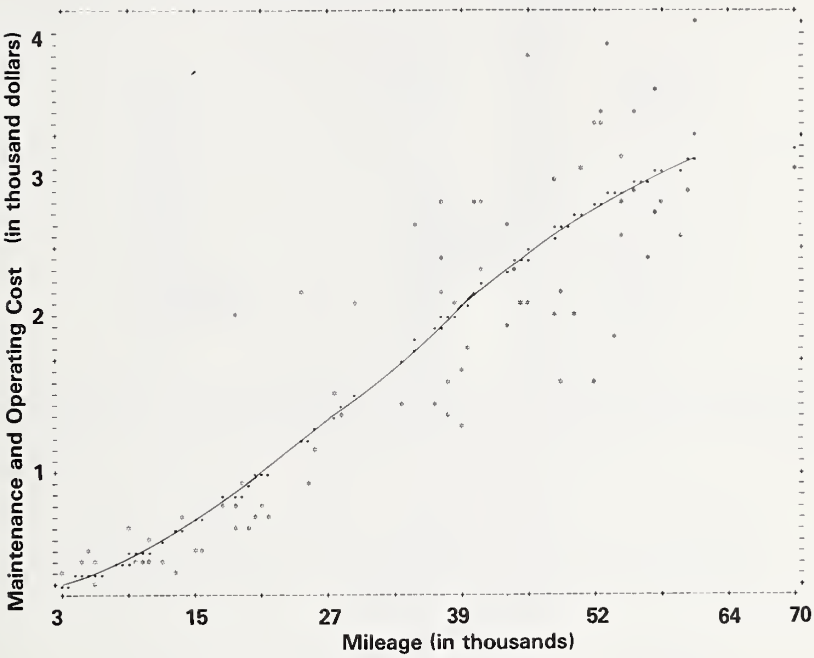


EXHIBIT 12. *Cumulative maintenance and repair cost as a function of mileage for patrol cars of a State highway patrol department.*



to reduce the level of preventive maintenance as vehicles approach the usual replacement age or mileage. If the vehicles are replaced shortly thereafter, the reduced preventive maintenance might not yet be reflected in higher breakdown and repair, and the net impact may therefore be a reduction in maintenance and repair cost. Additional research and more extensive data collection would be required to provide more accurate measure of parts and labor requirements for patrol cars as they age.

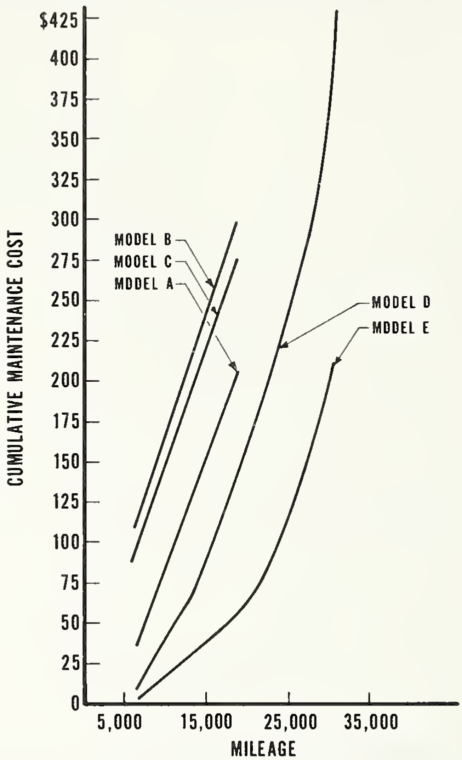
Despite possible distortions in the data, they are nevertheless useful for testing the replacement model and also for illustrating the large variation in costs among individual cars. In particular, it should be noted that the graphs display a large dispersion of data about the fitted curves, especially at higher mileage. This variation underscores the need to review vehicles on an individual basis when evaluating the best time for replacement.

Substantial variation in maintenance for different cars by make and model is indicated by Exhibit 13, which shows average cumulative repair costs based on mileage for five different car makes and models, all operated in the same state highway patrol department. The average economic lives of the different makes and models also differ.

Optimal replacement time will now be determined for a patrol car, based on the maintenance cost data shown in table 36, for alternative levels of car utilization and rates of depreciation. These calculations are presented in a series of tables from 37 through 44.

First, consider the effect which changes in the rate of depreciation have on the optimal replacement schedule. Tables 37, 38, and 39 are all based on an average annual car mileage of 40,000 miles (64,000 km) and maintenance data for the sample group of 29 cities (partially estimated). As shown in table 37, with a very low and gradually declining rate of depreciation and relatively high and increasing maintenance cost, very early replacement (after only one-half year) is economical. However, the information gathered by this study indicates that the rate of depreciation assumed in this table is probably unrealistic for patrol cars.

Exhibit 13. *Average cumulative maintenance cost as a function of mileage for patrol cars of different make and model.*



*Cost does not include gasoline; does not include tires.

NOTE: A, B, C are 1972 models; D, E are 1971 models.

Table 37. *Optimal patrol car replacement, based on maintenance and repair cost for a sample of 29 cities, assuming annual mileage of 40,000 (64,000 km) and a 6 percent quarterly depreciation rate*

Period (quarters)	Cumulative mileage	Quarterly maintenance and repair	Estimated resale value[1]	Present value[2]
1	10,000	$256	$2,533	$6,876
* 2	20,000	273	2,381	6,832 *
3	30,000	345	2,238	6,964
4	40,000	366	2,104	7,022
5	50,000	408	1,978	7,090

[1] Depreciation is computed on a middle-of-the line, intermediate-size car, costing $2,695 in 1973. Six percent of the declining balance is taken each time for that quarter's depreciation. This amounts to a decline of 22 percent of the purchase price over the first year and 17 percent of the purchase price over the second year, lower rates than those usually experienced by patrol cars.

[2] $PV(n) = \frac{[C+R'(n)-S'(n)]}{1-(1+i)^{-n}}$ (terms are defined on page 89)

*Denotes optimal point of replacement.

In table 38 the rate of depreciation is assumed to be 10 percent per quarter over the life of the vehicle: this amounts to 34 percent decline in the new car price over the first year and 23 percent of the original price over the second year. This is probably less than typical patrol car depreciation, but is probably attainable by departments which follow good resale practices. Under the stated conditions, optimal replacement is at one and one-half years and 60,000 miles (97,000 km).

TABLE 38. *Optimal patrol car replacement, based on maintenance and repair cost for a sample of 29 cities, assuming annual mileage of 40,000 (64,000 km) and a depreciation rate of 10 percent per quarter*

Period (quarters)	Cumulative mileage	Quarterly maintenance and repair	Estimated resale value [1]	Present value
1	10,000	$256	$2,425	$7,965
2	20,000	273	2,182	7,780
3	30,000	345	1,964	7,789
4	40,000	366	1,768	7,744
5	50,000	408	1,591	7,724
* 6	60,000	430	1,432	7,695 *
7	70,000	473	1,289	8,182

[1] Depreciation is computed on a middle-of-the-line, intermediate-size car, costing $2,695 in 1973. Ten percent of the declining balance is taken each time for that quarter's depreciation. This amounts to a decline in value of 34 percent of the purchase price over the first year, and 23 percent of the purchase price over the second year—rates which appear lower than typical police car depreciation, but obtainable by some departments.

*Optimal point of replacement.

TABLE 39. *Optimal patrol car replacement, based on maintenance and repair cost for a sample of 29 cities, assuming annual mileage of 40,000 (128,000 km) and a depreciation rate of 20 percent per quarter*

Period (quarters)	Cumulative mileage	Quarterly maintenance and repair	Estimated resale value [1]	Present value
1	10,000	$256	$2,156	$10,649
2	20,000	273	1,725	9,954
3	30,000	345	1,380	9,566
4	40,000	366	1,104	9,177
5	50,000	408	883	8,884
6	60,000	430	706	8,634
7	70,000	473	565	8,447
8	80,000	520	452	8,311
9	90,000	572	362	7,798
10	100,000	629	290	7,375
*				*

[1] Depreciation is computed on a middle-of-the-line, intermediate-size car, costing $2,695. Twenty percent of the remaining value is taken each time for that quarter's depreciation. This amounts to a decline of 59 percent in the original car price over the first year, and 24 percent of the new car price over the second year—high depreciation rates, but not unlike those which appear to be experienced by many city and county police departments.

*Optimal economic point of replacement; in this case not occurring within the time frame examined.

Very rapid depreciation is examined in table 39. It is usually uneconomical to replace a patrol car early if it quickly loses most of its resale value. In this circumstance, the car should be retained in service, as long as performance and safety criteria will permit, in order to minimize long-run cost.

Car utilization rates also affect optimal replacement schedules. Table 40 shows very early replacement for a car which accumulates mileage rapidly, even though depreciation is also assumed to be rapid. In contrast, table 41 shows that it can be uneconomical to replace a car early if it averages low annual mileage, even if depreciation is also low.

The sample data from three departments (see tables 42, 43, and 44) indicate that their maintenance and depreciation experience makes it uneconomical to replace cars until required for safety, performance, or other similar criteria.

Table 40. *Optimal patrol car replacement, based on maintenance and repair cost for a sample of 29 cities, assuming annual mileage of 80,000 (128,000 km) and a depreciation rate of 20 percent per quarter*

Period (quarters)	Cumulative mileage	Quarterly maintenance and repair	Estimated resale value[1]	Present value
* 1	20,000	$529	$2,156	$13,377 *
2	40,000	711	1,725	13,468
3	60,000	838	1,380	13,510
4	80,000	993	1,104	13,622

[1] Depreciation rate of 20 percent of the remaining balance. See footnote 1 to table 39 for a fuller explanation.
*Optimal point of replacement.

Table 41. *Optimal patrol car replacement, based on maintenance and repair cost for a sample of 29 cities, assuming annual mileage of 20,000 (32,000 km) and a depreciation rate of 6 percent per quarter*

Period (quarters)	Cumulative mileage	Quarterly maintenance and repair[1]	Estimated resale value[2]	Present value
1	5,000	$128	$2,533	$5,638
2	10,000	128	2,381	5,467
3	15,000	137	2,238	5,384
4	20,000	137	2,104	
5	25,000	173	1,978	
6	30,000	173	1,859	5,212
7	35,000	183	1,747	
8	40,000	183	1,642	
9	45,000	204	2,543	
10	50,000	204	1,450	5,053
11	55,000	215	1,363	
12	60,000	215	1,281	4,991
13	65,000	237	1,204	
14	70,000	237	1,132	
15	75,000	260	1,064	
16	80,000	260	1,000	4,904
*				*

[1] The breakdown of maintenance cost was for 10,000 mile (16,000 km) intervals; no attempt was made to estimate maintenance cost by 5,000 mile (8,000 km) intervals.
[2] See footnote 1, table 37.
*Optimal point of replacement, in this case not occurring within the time frame examined.

Table 42. *Optimal patrol car replacement, based on sample data for maintenance and repair cost from a medium-sized city police department, assuming annual mileage of 30,000 and rapid depreciation*

Year	Cumulative mileage	Yearly maintenance cost[1]	Estimated resale value[2]	Present value
1	30,000	$1,650	$1,720	$37,800
2	60,000	1,980	560	35,559
3	90,000	2,490	140	33,784
*				*

[1] Derived from table 36. Average cost per mile over the assumed annual mileage range was multiplied by the number of miles to obtain yearly maintenance cost (e.g., the average cost per mile over the range 30,000 to 60,000 is $.066; 30,00×$.066–$1,980).

[2] Based on resale values for a middle-of-the-line, standard-size car purchased for $3,500, as estimated in table 11.

*Optimal economic point of replacement, in this case not occurring within the time frame examined.

Table 43. *Optimal patrol car replacement, based on sample data for maintenance and repair cost from a large-sized city police department, assuming annual mileage of 30,000 and rapid depreciation*

Year	Cumulative mileage	Yearly maintenance cost[1]	Estimated resale value[2]	Present value
1	30,000	$ 885	$1,500	$28,889
2	60,000	1,200	410	26,745
3	90,000	1,080	30	23,205
*				*

[1] Derived from table 36. For explanations, see footnote 1, table 42.

[2] Based on resale values for a bottom-of-the-line, standard-size car purchased for $3,185. The estimates of resale value were derived by the procedure described in footnote 1 of table 39.

*Optimal economic point of replacement, in this case not occurring within the time frame examined.

Table 44. *Optimal patrol car replacement, based on sample maintenance and repair cost from a State highway patrol, assuming annual mileage of 30,000 and moderate depreciation*

Year	Cumulative mileage	Yearly maintenance cost[1]	Estimated resale value[2]	Present value
1	30,000	$1,470	2,310	30,099
2	60,000	1,710	1,610	28,329
3	90,000	1,988[3]	1,190	27,539
*				*

[1] Derived from table 36.

[2] Based on resale values for a middle-of-the-line, standard-size car purchased for $3,500, and depreciation 34 percent in the first year, 20 percent of original value in the second year, and 12 percent in the third year. The relatively low rate of depreciation reflects actual experience of the department from which the maintenance cost data were taken.

[3] Estimated. The department from which the sample data were drawn replaced cars at approximately 60,000 miles. Hence, no costs were available for cars operating at higher mileage. Here it is assumed that the rate of increase in costs from the first year to the second would continue over the third year. (The estimate was not based on an extrapolation of the fitted curve shown in exhibit 12, because the data were fitted by a high-order polynominal function which allows good fit of existing data, but is poor for the purpose of making projections.)

*Optimal economic point of replacement, not occurring within the time frame examined.

A recent study by the General Accounting Office of the General Services Administration's (GSA) interagency motor pool recommended a 1-year replacement policy for sedans instead of the existing 6-year/60,000 mile (97,000 km) policy.[59] (Five other GAO studies over the previous 16 years also concluded that substantial cost reductions could be achived by shortening the replacement period.) A comparison of the present value cost of alternative replacement cycles showed minimum cost for a 1-year cycle and increasing cost for cycles from 2 to 4 years in length. However, this result appeared mainly attributable to the fact that there was essentially no depreciation on the cars over the first year.

GSA purchases cars at a sufficient discount to offset most of the normal first year decline in value, and cars can be sold after a year for close to the original price. Maintenance and repair cost per period and per mile, on the other hand, were found to increase progressively with time. The study finding of a 1-year optimal replacement period is, therefore, completely consistent with the conclusions of this report. (In table 37 it was shown that early replacement is efficient when maintenance and repair costs per mile are rising relatively fast and the rate of depreciation is low.) However, depreciation of the typical patrol car does not appear to be the same as that for GSA motor pool cars, and, therefore, the recommended GSA policy may not be appropriate for police cars.

To summarize the foregoing, there are no hard and fast rules for vehicle replacement. On the contrary, emphasis should be on the sensitivity of replacement policy to specific departmental characteristics. In particular, optimal replacement policy will depend on the rate of depreciation, the rate of car utilization, and the change in maintenance cost with increased vehicle mileage and age. These factors differ with individual cars, makes and models of cars, functional types of vehicles, and among departments. Nevertheless, the following generalizations can be made:

(1) The greater the depreciation at the outset, 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.

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

3.6. Life Cycle Costs of a Typical Patrol Car

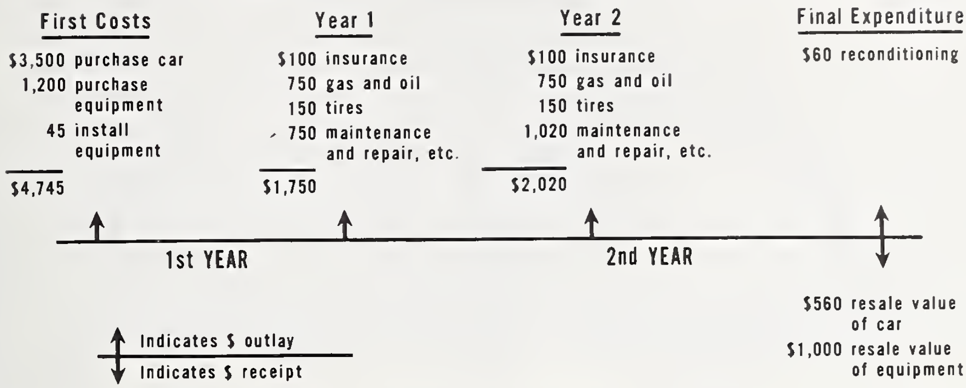
Exhibit 14 shows the cash flow (direct expenses only) of a "typical" patrol car purchased and operated in the 1972-73 period. The initial cash outlay is close to $5,000 including purchase of new equipment (which is assumed to have a 10-year life). In each of the 2 years the car is in operation, close to $2,000 is expended for gas and oil, tires, maintenance and repair, cleaning, towing and insurance. At the end of 2 years, $60 is spent for reconditioning and $560 is returned from resale of the car; the equipment has maintained about $1,000 of its original value.

Table 45 restates each direct cost item in terms of uniform annualized cost. Thus the initial expenditure for the car ($3500) and the receipts at resale ($560) 2 years later are equivalent to a uniform stream of constant dollar payments of $1,750 annually. The total direct costs (including maintenance, gas, oil, tires, insurance, etc.) amount to $3,918 annually. Adding an overhead cost equal to approximately 10 percent of direct costs, results in a total annualized cost (in constant dollars) of $4,318.

The pie chart in exhibit 15 depicts the components of direct costs of a representative patrol car. Depreciation normally accounts for the largest single part of

[59] General Accounting Office, *Potential Savings by Replacing Government-Owned Sedans Each Year*, Report to the Congress by the Comptroller General, No. B-158712, Washington, D.C., June 9, 1971.

Exhibit 14. *Expenditures and receipts for a typical patrol car: Cash flow diagram.*



NOTE: The cash flow is based on a standard-size, middle-of-the-line car, operated by a medium-size city police department, used 30,000 miles per year, and replaced at 2 years or 60,000 miles. Figures are approximations, not necessarily applicable to individual departments. It is assumed that equipment is bought new and has a 10-year life, that the labor wage rate is $7.75 per hour, and that gasoline costs 19¢ per gallon, with vehicles getting 8 mpg.

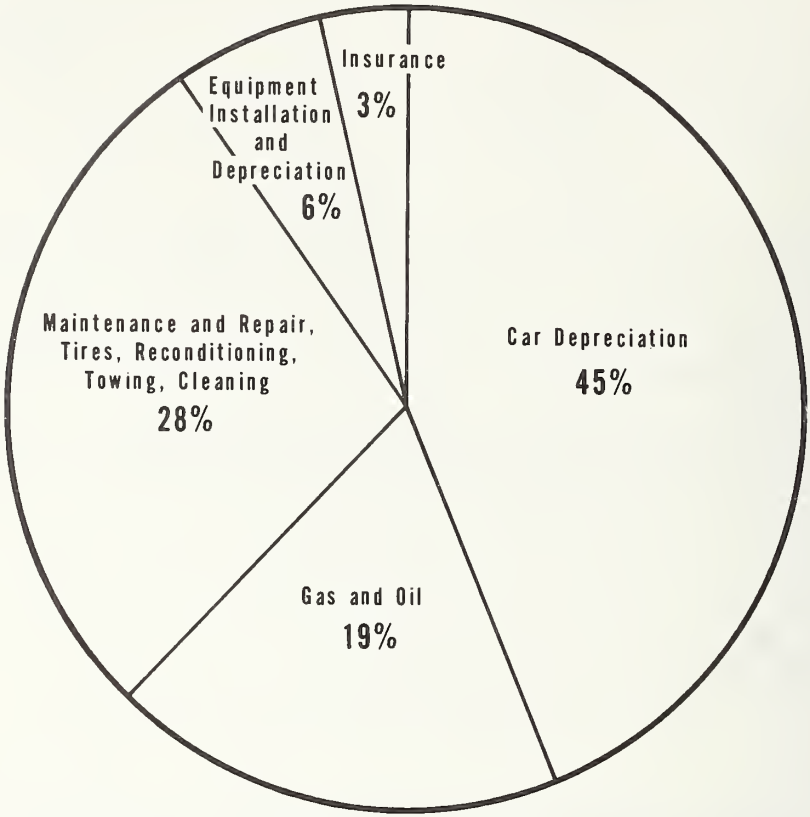
Table 45. *Annual life cycle cost of a typical patrol car operated in 1972-1973*[1]

Type of expense	Cash flow and conversion to equivalency		
Direct cost:			
Car depreciation	= [$3,500–($560) (SPW, 2 yr., 10%)] (UCR, 2 yr., 10%)	=	$1,750
Equipment depreciation	= $1,200 (UCR, 10 yr., 10%)	=	195
Equipment installation	= $45 (UCR, 2 yrs., 10%	=	26
Insurance	= $100	=	100
Gas and oil	= $750	=	750
Tires	= $150	=	150
Maintenance and repair	= $[750+(1,020) (SPW, 2 yr., 10%)] (UCR, 2 yrs., 10%)	=	918
Reconditioning	= $60 (SPW, 2 yrs., 10%) (UCR, 2 yrs., 10%)	=	29
Total direct cost		=	$3,918
Estimated indirect cost (overhead)[2]		=	$ 400
Total direct and indirect cost		=	$4,318

[1] Based on cost data from exhibit 13.

[2] Overhead varies greatly among departments, both in actual terms and in terms of reporting methods. Some departments include items in vehicle overhead which are omitted by other departments. Furthermore, since overhead costs are to some extent fixed, it is difficult to allocate on an individual car basis. The rough assumption here is that overhead is equal to between 10 and 20 percent of indirect cost. (Based on estimated costs of equipment, building and administrative personnel developed in sec. 3.2, overhead cost per car for a fleet of 100 cars would be about $300.)

Exhibit 15. *Composition of patrol car costs, direct cost only.*



*Based on cost data from exhibit 14 and table 45. With the recent large increase in fuel prices relative to other prices, gas and oil costs would now be expected to constitute a larger percentage of total costs.

total direct cost, with maintenance, repair, tires, gas and oil combining to account for a comparable part.

While these costs may be regarded as "typical" for the situation described (see footnote to exhibit 15) the study has found that life cycle costs of patrol cars can be raised or lowered considerably by fleet managerial decisions.

4. SUMMARY[60]

This report has addressed some of the issues important to the acquisition, operation, and disposition of police patrol cars. In section 1, the major decisions in police fleet management were outlined, the specific questions to be addressed by the study were set forth, and areas for further research were identified. Section 2 of the report explained the life cycle costing methods which are used subsequently in the report to compare the costs of alternatives in fleet provision. Section 3, the main body of the report, identified the critical elements of costs in providing a patrol car fleet, and analyzed a number of key decision problems in police fleet management.

Practices regarding car model selection; length of ownership; selection of car accessories, color, and equipment; reconditioning; timing of resale; and method of car disposal were examined for ways to reduce vehicle depreciation costs.

Another issue examined in section 3 was the relative desirability of ownership as compared with leasing vehicles. The different types of lease arrangements were described, and both cost and noncost advantages and disadvantages of leasing were identified. In connection with leasing and ownership, the study compared contract

[60] Principal findings of the study are summarized in the Executive Summary and will not be repeated here.

maintenance of cars in private garages with in-house maintenance in police garages. Based on assumptions regarding wage rates, staffing requirements, and other factors, a break-even fleet size was determined, at which point the cost of contracting maintenance to private garages or performing it in-house would be equal.

Section 3 of the report also looked at operating and maintenance costs for patrol cars. Empirical data for cars of different sizes and cars used at different levels and in different environments were presented and analyzed for possibilities of cost reduction.

Another major question addressed in section 3 was the comparative economic efficiency of alternative vehicle driver assignment plans. The types of potential costs and benefits associated with a personal patrol car program were identified. A general method for evaluating and comparing the costs of a personal car program and a multishift, pool car program was described. The cash flows associated with each of the two vehicle programs are illustrated with realistic data, and the life-cycle costs of a personal car program and a multishift plan were compared under alternative assumptions.

The fifth part of section 3 investigated replacement of patrol cars. Methods of determining the point of optimal car replacement were explained and illustrated with data drawn from police departments. Selected vehicle characteristics were examined for their direction of impact on the economic life of a patrol car.

The final section of section 3 provided a brief overview of the life-cycle costs of a typical patrol car. Each of the main components of direct car costs were shown as a share of total direct costs.

This study has demonstrated that there are considerable opportunities in police fleet management to alter costs of fleet services. It is hoped that the discussions herein will contribute to greater economic efficiency in the acquisition, operation, and disposition of patrol cars.

APPENDIX A—POLICE FLEET PRACTICES

Through a series of tables, this appendix provides an overview of various aspects of the management of patrol car fleets. The tables are grouped according to subject:

1. Police Function, Fleet Size, and Fleet Composition

Table A-1 shows that nearly half of all patrol cars are in county police departments, and nearly one-fifth are in state police and highway patrol departments. There is considerable variation in the average number of patrol cars by type of department.

Table A-2 illustrates the variability among departments with respect to vehicular functions to be satisfied. It shows a relatively large demand by state highway patrolmen and county sheriffs for a long distance, high performance car, and priority by city police to an urban, general purpose car and one suitable for patrolling narrow and congested city streets.

Table A-3 depicts fleet composition for a small sample of departments. The patrol car is the overwhelmingly dominant type of vehicle. The special emphasis of this report on the patrol car seems well placed.

2. Patrol Car Selection, Accessorization, and Price

Tables A-4 and A-5 show the principal choice of patrol car, by type, to be the standard size, 4-door car (wheel-base 119-123 in).

Tables A-6 and A-7 indicate the frequency with which the different types of departments select available options, and table A-8 shows the frequency of various modifications.

Table A-9 indicates the types of tires used on a sample of patrol vehicles in 1970. At that time, most departments in the survey equipped their vehicles with bias-belted or 4-ply bias ply tires. Radial ply tires, while not in great use, were the next most popular type.

Tables A-10 through A-12 provide price information. According to table A-10, most departments surveyed paid between $3,000 and $4,000 for patrol cars in 1973; the remaining departments were about evenly divided in paying higher and lower prices.

Table A-11 shows more detailed price information for most State police and highway patrol departments and for a few counties and cities. The apparently substantial variation in bid price on like make and model cars may reflect differences in accessories, dealer services, time and location of purchase, as well as dealer profit.

Table A-12 lists price estimates for differently equipped police cars based on 1971 averages. The low end of the price range applies to police cars with commonly specified features, such as heavy duty components, automatic transmission, and air conditioning. The high end of the range represents the same car with added special equipment, such as armor protection, other non-standard devices, and special equipment usually installed after receipt by the department.

3. Vehicle Utilization

Table A-13 shows the average number of different drivers per patrol car in the different types of departments. On the average, 66 percent of state police departments have only one driver per patrol car per day. This is in sharp contrast to the practice of more than 90 percent of medium and large cities of having 3 or more different drivers per car each day. Across all department types, the prevailing practice is to have an average of at least 3 different drivers daily for each patrol car.

Table A-14 indicates the amount of daily usage of patrol cars by department type. Consistent with their smaller car/officer ratio and multiple drivers per car, cities--and, again, particularly large cities—report high average daily use of patrol cars. In contrast, more than one-fourth of state and county departments use their cars only one shift per day; most of the remaining state and county departments use their cars no more than two shifts per day.

Table A-15 shows typical average annual miles driven by a sample of patrol cars, as well as the range of miles driven by sample departments of each type. Average mileage of sample county patrol cars is substantially higher than average mileage of sample city or state patrol cars, which are about equal to one another.

Table A-16 shows average driving speeds by department type and provides further information on driving conditions for patrol cars. Between 80 and 90 percent of driving by officers in city departments is at slow speeds, with many stops. In contrast, 86 percent of driving by state patrolmen involves little stopping, and 64 percent is at speeds of 50 mph or greater.

4. Maintenance and Repair

Table A-17 indicates maintenance work reported by a sample of police departments. As may be seen, the percentage of departments performing maintenance work decreases for the more specialized or equipment-intensive kinds of jobs. Almost all sample departments lubricate, change oil, add anti-freeze, and tune engines; many repair tires, replace fan belts and hoses, shocks and mufflers, clean parts, maintain the electrical system and repair the fuel pump and carburetor; but relatively few do body repair or paint jobs. Nearly 20 percent of the sample group do not dispense fuel and oil.

5. Patrol Car Replacement Practices

Table A-18 indicates that almost all state police and highway patrol departments use mileage as the main criterion for replacement. It shows that most state patrol departments do not replace their cars until they have accumulated at least 50,000 miles. The highest reported mileage limit was 100,000 miles. Of the 13 cities shown, most replace between 60,000 and 65,000 miles and/or 2 or 3 years.

TABLE A-1. *Distribution of patrol car population in the United States*
(By department type, 1972)

Type of department	No. of departments	Estimated total number of patrol cars[1]	Percent of total	Mean number of patrol cars per department	Average number of officers per patrol car
State	50	29,150	18	583	1.5
County	3,137	70,896	44	23	2.6
City (1-9 officers)	5,486	10,897	7	2	4.0
City (10-49 officers)	1,985	10,123	6	5	4.4
City (50 + officers)	554	15,900	10	29	4.6
50 largest cities	50	16,055	10	321	7.8
Township	1,574	6,296	4	4	3.5
Total		159,317			

[1] Source: E. D. Bunten and P. A. Klaus, LEAA Police Equipment Survey of 1972, Volume VII: Patrol Cars, National Bureau of Standards Special Publication 480-7, June 1977, pp. 11-12. Mean number of cars per department were multiplied by the number of departments of that type.

Table A-2. *Patrol car functions reported by a sample of police departments*

Vehicle function	City police	County sheriff	State highway patrol
	(Numbers of respondents recognizing a given need)		
Inner city and urban freeway (narrow streets, congested traffic)	61	7	1
Urban general purpose (general patrol)	74	8	2
Suburban (high performance)	15	9	6
Highway patrol sheriff (long distance, high performance)	4	51	39
Other	6	4	2
Total number of respondents in the survey	122	91	45

Source: Ford Motor Co., *Police Car Survey Summary*, p. 4.

TABLE A-3. *Fleet composition by department type*
Percent of fleet comprised by each kind of vehicle[1]
(The mean appears first and the range is in parentheses)

Department type	Vehicle type: Patrol car	Administrative car	Vans and wagons	Cycles and scooters[7]	Special purpose[7]
State police or highway patrol[2]	76% (43-99)	16% (1-52)	1% (0-9)	2% (0-19)	3% (0-23)
Large city[3]	35% (28-43)	39% (19-52)	4% (n.a.)	16% (11-20)	4% (n.a.)
Medium city[4]	45% (40-60)	30% (26-34)	5% (2-7)	22% (20-23)	3% (0-5)
Small city[5]	44% (41-57)	44% (43-44)		3% (0-11)	
County[6]	54% (n.a.)	n.a.	n.a.	n.a.	n.a.

[1] These data are based in part on a small and unstructured sample of departments contacted during the course of this study, and may not be representative of fleet composition in general. The fragmentary nature of the data reflects the fact that fleet composition was not the focus of this study. Available information is, however, included for the purpose of extending the profile of existing fleet operations. Due to the small number of departments upon which this table is based, ranges—in addition to means—are given to highlight the variations.

[2] Percentages are based on data from most state police and highway patrol departments. Source: International Association of Chiefs of Police (IACP), *Comparative Data Report*, 1972, pp. 49, 50.

[3] Percentages are based on data from Los Angeles, Philadelphia, and Chicago.

[4] Percentages are based on data from Seattle, Atlanta, and St. Paul.

[5] Percentages are based on data from Pasadena, California; Ladue, Mo.; and Bay City, Michigan.

[6] Percentages are based on data from Prince Georges County, Md.

[7] Due to the fact that the breakdown of fleet composition was not complete for all departments included, it was necessary to omit certain of them from this category. For this reason, the percentages across vehicle types may not add to 100%.

TABLE A-4. *Proportion of full size, intermediate size, compacts, and station wagons used as patrol cars, by department type*
(In percent)

Model	All department types	State	County	City (1-9 officers)	City (10-49 officers)	City (50 or more officers)	50 largest cities	Townships
Full size 2-door	3	5	4	9	2	4	0	1
Full size 4-door	84	88	53	80	83	72	81	84
Intermediate size 2-door	2	3	3	0	0	1	0	0
Intermediate size 4-door	9	3	35	7	7	18	15	10
Station wagon	2	2	4	4	4	3	3	5
Compact	1	0	2	0	4	3	1	0
Total	101	101	101	100	100	101	100	100

Source: Bunten/Klaus survey, p. B-4. Some totals exceed 10% due to rounding errors in the original report.

Table A-5. *Number of departments specifying various sizes of patrol vehicles (1970)*

Size of 1970 model	State police and highway patrol	City and county police departments	Total
Compact (under 114 in wheelbase)	--	--	--
Intermediate (115 to 118 in)	--	4	4
Standard (119 to 123 in)	42	24	66
Large (over 123 in)	3	2	5
	45	30	75

Source: NAFA Law Enforcement Group. *Police and Highway Patrol Vehicles Specifications Survey*. National Association of Fleet Administrators, Inc., New York.

Note: This survey comprises comprehensive coverage of state highway patrol departments, but very small coverage of city and county police departments.

Table A-6. *Percentages of departments which specified each option the last time they bought patrol cars*
(In percent)

Options	All dept. types	State	County	City (1-9 officers)	City (10-49 officers)	City (50 or more officers)	50 largest cities	Townships
Automatic transmission	95	98	87	95	98	85	100	90
Eight-cylinder engine	94	98	85	95	94	93	100	93
Power steering	90	91	79	85	94	95	89	93
Power brakes	86	96	82	80	88	84	89	83
Disc brakes	84	98	79	77	82	86	96	83
Heavy duty suspension	83	98	68	76	87	84	91	90
Air conditioning	59	81	53	43	59	71	63	52
Tinted glass	52	70	39	41	51	67	54	45
Interior hood release	49	81	47	37	43	42	63	45
Light in trunk	45	66	46	44	42	37	30	59
Interior trunk release	37	60	32	21	38	36	30	62
Other[1]	30	55	19	16	27	31	50	31
Locking gas cap	10	17	8	9	8	7	28	0
Bucket seats	4	2	4	2	3	4	15	0
Bullet-proof glass	0	0	0	0	0	0	2	3

[1] The questionnaire omitted from the list a number of options which appear to be frequently specified, as indicated by the "write-in" response. Some of these additional options are typically part of the "police package" and would likely appear with about the same frequency as "heavy duty suspension." These would include "heavy duty battery, alternator or electrical systems," "special engine," "heavy duty seats," "heavy duty axle" and special clutches and transmissions. Other options added by write-in to the above list were:

Special tires/tire size	Power windows
Special cooling system	Floot mats/carpet
Special gauges or dials	Special traction device
Special interior light	Special mirrors
Rear window & defroster	Special hand throttle
AM radio	Fuel transfer kit
Spotlight	Split-bench front seat

Source: Bunten/Klaus survey, p. B-18.

Table A-7. *Engine and equipment specifications on 1970 patrol cars*

	(Number of respondents indicating each item)					
	State police and highway patrol		City and county police depts.		Total	
Engine specified in 1970 vehicles:						
6 cylinder	----		1		1	
standard V-8	6		23		29	
high performance V-8	41		7		48	
Cars equipped with:	Yes	No	Yes	No	Yes	No
Power steering	33	11	24	5	57	16
Power brakes	43	1	24	5	67	6
power drum	9		5		14	
power disc	43		21		64	
heavy duty	14		14		28	
Air conditioning	32	12	18	11	50	23
Bucket seats	2	38	2	26	4	64
Automatic transmission	44	--	28	--	72	--
Do you use a console?	7	34	4	24	11	58

Source: NAFA *Police Vehicle Survey*.

Table A-8. *Proportion of departments making modification to the patrol cars, by department type and type of change*

(In percent)

Modification	All dept. types	State	County	City (1-9 officers)	City (10-49 officers)	City (50 or more officers)	50 largest cities	Townships
Install siren	98	96	96	100	98	99	98	93
Install mobile radio	98	98	94	99	98	99	98	97
Install P.A. system	75	74	64	60	83	84	85	83
Install bar flashing lights	69	47	56	61	87	84	65	72
Install spotlights	61	23	64	68	66	61	65	79
Install gun racks	56	34	37	55	69	66	65	62
Install bubble light	54	62	47	59	43	51	72	62
Install mounting racks	51	17	39	48	67	65	52	55
Install barrier between seats	43	17	35	44	51	43	61	45
Install trunk racks	38	26	26	33	47	45	37	52
Special engine changes	2	0	0	2	2	4	2	7
Other[1]	29	60	17	22	32	20	43	21
Remove chrome	0	0	0	0	0	1	0	3
No answer/none	0	0	1	0	0	0	0	0

[1] Other additions or changes specifically noted by respondents to the questionnaire are the following:

Special tires
Writing desk
Seat covers/floor mats
Interior trunk release
Radar installation
Remove door/window handles
Disconnect interior lights
Map/interior light
Wiring
Electronic device to compute speed
Fuel changeover system
Fire extinguisher mount
Console/controls for lights/sirens
Push bumpers
Baton/flashlight holder
Rear flashing lights
Grille lights
Flashing headlights
Painting/decals

Source: Bunten/Klaus survey, p. B-15.

Table A-9. *Type of tires used on patrol cars, 1970*

Type of tires used	State police & highway patrol	City & county police departments	Total
Radial	5	6	11
Bias belted	15	11	26
4 ply bias ply	17	14	31
4 ply bias/2 ply belt	3	--	3
6 ply nylon	4	1	5
4 ply nylon	3	--	3
Police special (4 ply)	1	--	1
5 ply	--	1	1

Source: NAFA, *Police Vehicle Summary*.

Table A-10. *Distribution of purchase prices for new patrol cars in 1973, by department type*

	Percentage of departments purchasing in each price range			
Department type	$4,000 or more	$3,000-$3,999	Under $3,000	No Answer
Township	24	62	13	0
County	23	55	13	8
City (1-9 officers)	19	69	12	0
City (10-49 officers)	16	73	10	2
State	9	91	0	0
City (50 or more officers)	5	83	12	2
50 largest cities	4	74	22	0
All department types	14	72	12	2

Source: Bunten/Klaus survey, p. 25.

Table A-11. *Details of recent patrol car purchases by police departments*[1]

Department	Make[2]	Bid price[3]	Department	Make[2]	Bid price
Michigan	Plymouth Fury I	3,019	Massachusetts	Ford	3,372
Oregon	Plymouth Fury I	3,110	South Carolina	Ford	3,323
New Hampshire	Plymouth Fury I	3,231	Georgia	Ford	3,247
LaDue, Missouri	Plymouth Fury I	3,285	Florida	Ford	3,761
Colorado	Plymouth Fury I	3,329	Alabama	AMC Javelin	3,047
Vermont	Plymouth Fury I	3,341	Alabama	AMC Javelin (73)	3,242
Minnesota	Plymouth Fury I	3,579	Wisconsin	AMC Brougham	3,289
Seattle, Washington	Plymouth Fury I (73)	3,600	Pasadena, California	AMC Matador	3,268
New York	Plymouth Fury II	3,200	North Dakota	Oldsmobile	2,614
North Carolina	Plymouth Fury II	3,258	Nebraska	Mercury Hardtop	3,697
Pennsylvania	Plymouth Fury II	3,464	Indiana	Mercury 4-door	3,796
New Jersey	Plymouth Fury III	3,553	Wyoming	Chrysler Cl-41	2,890
Texas	Plymouth Fury III	3,569	West Virginia	Chevrolet Impala	3,688
Delaware	Plymouth Fury	3,180	Maine	Chevrolet Bel-Air	3,400
Virginia	Plymouth Fury	3,259	LaJava, Colorado	Chevrolet Biscayne (71)	4,142
Michigan	Plymouth Fury (73)	3,300	Arizona	Chevrolet	3,493
Seattle, Washington	Plymouth Satellite (73)	3,600	Iowa	Dodge Polara	2,884
Aguilar (Denver), Colorado	Plymouth (70)	3,178	California	Dodge Polara	3,265
Ohio	Plymouth	3,295	Oklahoma	Dodge Polara	3,344
Tennessee	Plymouth	3,400	Idaho	Dodge Polara	3,348
South Dakota	Plymouth	3,655	Illinois	Dodge Polara	3,384
Louisville, Colo.	Plymouth (71)	4,592	Nevada	Dodge Polara	3,393
Kentucky	Ford Custom 500	3,358	Prince Georges County,		
Maryland	Ford Custom 500	3,626	Maryland	Dodge Polara (73)	3,469
Kansas	Ford Custom 500	3,904	New Mexico	Dodge Polara (71)	3,515
Montana	Ford Sedan	3,850	Washington	Dodge Polara	3,812
Connecticut	Ford Interceptor	3,002			

[1] Coverage is mainly for State police and highway patrol departments, but some county and city departments are included.

[2] Cars, grouped by make and model, may not have the same accessories. Model year is assumed to be 1972 unless otherwise designated.

[3] For departments which trade in their old cars, the bid price on the new car does not account for trade-in allowance. Likewise, the evaluation of the used car disposed of in other ways is not deducted.

Sources: IACP, *Comparative Data Report*, p. 51; computer printouts on LEAA grants involving patrol cars, LEAA information files, interviews with police fleet administrators.

Table A-12. *Estimates of car prices by police departments, 1971*

	With standard features[1]	With optional features[1]
Highway patrol and sheriff car	$3,500	$5,000
Suburban police car	3,200	4,500
Inner city and urban freeway car	3,000	3,500
Urban general purpose car	3,000	4,000

[1]"Standard features" include the heavy duty components of the police package, automatic transmission, air conditioning and other features usually included on police cars; "optional features" refers to such add-ons as armor protection, vandalism and external fire protection devices, special pusher bumper, rear seat isolation and restraining kits, built-in speed measurement device, 4-wheel drive, front mounted winch, self-reeling starter jumper, lights, flashers, sirens, bullhorns, etc.

Source: Ford Motor Co., *Police Car Survey*, pp. 16-19.

Table A-13. *Number of drivers per patrol car in state, county, and city departments*

	Percentage of departments having an average of 1, 2, 3 or more different drivers each day			
Department type	One	Two	Three	More than three
State	66	28	4	2
County	51	25	18	7
City (1-9 officers)	12	20	45	23
Township	10	17	55	14
50 largest cities	4	2	52	41
City (50 or more officers)	1	10	64	27
City (10-49 officers)	0	4	61	34
All department types	19	14	45	22

Source: Bunten/Klaus Survey, p. B-7.

Table A-14. *Average daily patrol car use by department type*

	Average daily hours of patrol car use (by percentage of departments)			
Department type	17-24 hours	9-16 hours	4-8 hours	Under 4 hours
50 largest cities	80	20	0	0
City (50 or more officers)	80	19	0	0
City (10-49 officers)	79	18	3	0
City (1-9 officers)	62	30	2	5
Township	52	34	14	0
County	17	47	20	7
State	6	68	26	0
All department types	57	32	9	2

Source: Bunten/Klaus Survey, p. B-7.

Table A-15. *Patrol car mileage, by department type*

Department type	Annual miles per patrol vehicle	
	Mean	Range
Cities [1]	34,000	17,000–48,000
Counties [2]	53,000	40,000–70,000
States [3]	35,000	10,000–55,000

[1] Based on interview and published data from 10 cities—2 small, 3 medium, and 5 large in size. Means for each size group were 36,000, 32,000, and 35,000, respectively.
[2] Based on interview data from three counties in northeastern states.
[3] Based on interviews and published data from IACP, *Comparative Data Report*, p. 49.

Table A-16. *Mean percentages of total driving time expended in each speed/type category, by department type*
Mean percentage of total driving

Speed type	All dept. types	City (50 or more officers)	City (1-9 officers)	City (10-49 officers)	50 largest	Town-ship	County	State
25-30 mph, many stops	44	63	59	59	54	23	13	4
30-50 mph, many stops	24	26	25	22	28	41	22	10
35-50 mph, few stops	12	6	6	8	8	25	19	22
50-70 mph	15	4	5	6	6	8	37	51
Over 70 mph	4	1	2	2	2	2	7	13

Source: Bunten/Klaus Survey, p. B-11.

Table A-17. *Performance of police departments performing maintenance function, by specific type of maintenance performed*

Maintenance function	Percent of police departments performing maintenance functions (35 departments reporting)
Lubrication	91
Engine tune-up	89
Electric maintenance	83
Brake relining	69
Tire repair	80
Engine major overhaul	66
Fuel pump and carburetor	80
Wheel balancing	51
Fuel and oil dispensing	83
Body repair	31
Car washing	57
Car painting	34
Fan belts and hose	86
Shock replacement	83
Muffler replacement	83
Parts cleaning	86
Oil filter change	89
Radiator winterizing	91

Source: "AF's Car Fleet Market Study," Automotive Fleet, June 1970, pp. 24, 25.

Table A-18. *Replacement criteria for patrol cars at selected departments*

Department	Mileage Criteria 30,000 39,000	40,000 49,000	50,000 59,000	60,000 69,000	70,000 79,000	80,000	Age criteria (years) 1	2	3	4	Condition, and availability of replacement
State Police and Highway Patrol											
Alabama						X		X			
Arizona				X				X			
California					X			X			
Colorado						X					
Delaware				X					X		
Florida			X						X		
Illinois			X					X			
Indiana			X								
Iowa			X					X			
Kansas					X						
Maryland					X			*			
Massachusetts				X							
Minnesota				X							
Missouri	X										
Nevada				X				X			
New Hampshire				X				X			
New Jersey			X								
New Mexico						X					
North Carolina			X								
Ohio			X								
Oklahoma					X						
Oregon				X							
Pennsylvania			X								
South Carolina						X					
Texas						X					
Utah				X	X			*			
Vermont			X								
Virginia					X						

Table A-18. *Replacement criteria for patrol cars at selected departments*—Continued

Department	Mileage Criteria 30,000–39,000	40,000–49,000	50,000–59,000	60,000–69,000	70,000–79,000	80,000	Age criteria (years) 1	2	3	4	Condition, and availability of replacement
Washington				X							
West Virginia		X		X				*			
Wisconsin				X	X			X			
TOTALS, States	1	1	10	11	7	5	0	11	2	0	
Counties											
Arlington County, Va.									X		
Baltimore County, Md.					X			X			
Nassau County, N.Y.				X							
Prince Georges County, Md.			X								
Suffolk County, N.Y.											X
TOTALS, Counties	0	0	1	1	1	0	0	1	1	0	1
Cities											
Bay City, Mich.				X					X		
Ladue, Mo.		X									
Pasadena, Calif.								X			
Seattle, Wash.				X		X					
St. Paul, Minn.								X			
Indianapolis, Ind.									X		
Jacksonville, Fla.									X		
Group of Small and Medium Size Cities Served by a Leasing Company				X							
Philadelphia, Pa.				X							
Washington, D.C.				X							X
Chicago, Ill.					X						
Los Angeles, Calif.				X							
New York, N.Y.				X				X			
TOTALS, Cities	0	1	0	7	1	1	1	3	3	0	1

*Denotes that age was the primary replacement criterion.

X Indicates a range for the mileage criterion. If a department's replacement criterion extends over a range of several mileage intervals, that criteria is counted for each of the intervals for the purpose of deriving total departments having each replacement criterion.

Sources: Replacement policies of state police and highway patrol departments were obtained from a composite of practices compiled by Mr. John Grow, Manager of Transportation Services, California State Highway Patrol, Sacramento, California, and from IACP, *Comparative Data Report*, p. 51. Replacement policies of counties and cities were obtained through interview, correspondence, and department files. Replacement criteria are those reported in 1973, and may no longer be in effect at these departments.

B-1

B-1: Sample Maintenance-Lease Contract

(For Vehicle Lease With Service Provided)

THIS AGREEMENT, made this ______________________ day of ______________________, __________ by __________ and __________ between ______________________________, referred to __________ as "The Leasing Co." and the CITY OF ______________________________ referred to as "the City";

In consideration of the mutual covenants herein stated, the parties agree as follows:

1. **Term.** The term of this agreement shall be one (1) year from and after the date hereof, and shall renew itself for additional annual terms of one (1) year each unless either party cancels in writing at least thirty (30) days prior to the end of the original term or renewal thereof.

2. **Motor Vehicles Covered.** During the term of this agreement, the Leasing Company will perform the maintenance hereinafter set forth, and will perform all of the other covenants herein, on the terms and conditions specified, with respect to motor vehicles owned by the City, and purchased from ______________________________

The Leasing Company which has the specifications set forth in Schedule "A", attached hereto and made a part hereof. Any such vehicles to be covered by the terms of this agreement shall be set forth in a memorandum, dated and signed by the parties, which thereafter shall be an addendum to this agreement.

3. **Applicability of Agreement to Other Vehicles.** The Leasing Co. will provide the maintenance hereinafter set forth and perform all of the other covenants herein, with respect to other motor vehicles owned by the City, on the same terms and conditions, except that the per mile maintenance charge and the minimum mileage shall be as mutually agreed upon by the parties for any such vehicles. Any such vehicles to be covered by the terms of this agreement shall be set forth in a memorandum, dated and signed by the parties, which shall specify the term, per mile maintenance charge and minimum mileage, and which thereafter shall be an addendum to this agreement.

4. **Maintenance Charges.** For each motor vehicle covered by this agreement, the City will pay to the Leasing Company, a maintenance charge of ______________________ per mile for each mile said motor vehicle is driven, or such other per mile maintenance charge as may be specified in any addendum to this agreement; provided, however, that in any event, the City will pay to the Leasing Co., maintenance charges at the specified rate for a minimum of ______________________ miles per year, for the entire fleet of motor vehicles covered hereunder. The maintenance charges aforesaid shall be payable by the City in monthly installments, based upon the specified rate per mile, for each mile said motor vehicle is driven during the month. The City shall report in writing to the Leasing Company the number of miles driven by each vehicle each month, on or before the 10th day of the succeeding month, and shall at the same time make payment to the Leasing Company at the rate specified.

a. The City agrees to return said motor vehicles to the Leasing Co. or to such place as the Leasing Co. shall designate after each 4,000 miles said motor vehicle has been driven, but in any event at least once in every sixty (60) days, and to leave said motor vehicle at such times for such reasonable periods which may be required to permit the Leasing Co. or its agents or subcontractors to properly service and maintain said motor vehicle in good working condition.

[61] These documents are included merely to illustrate the kinds of leasing and maintenance agreements which police departments might enter into, and are in no way recommended for adoption by police departments in general.

b. During the term of this agreement, the Leasing Company will furnish to the City, from 8:00 a.m. to 5:30 p.m., Monday through Friday, at its place of business or at a service headquarters located convenient to the storage place of said vehicles in the City, all the necessary oils, lubricants, tires, parts, and labor necessary to maintain said units in good operating condition and repair for the term of this agreement and to wash the exterior and clean the interior of each unit once each week. The Leasing Co. further agrees to call or cause to be called for any said unit which may be disabled and to furnish or cause to be furnished wrecker service if necessary in connection therewith. Such maintenance services shall be furnished or caused to be furnished at the following times:

General maintenance	Every 6,000 miles or sixty (60 days)
Operating repairs	As required
Repair parts	As required
Tire maintenance	As required
Tire repair	As required
Lubrication	Every 4,000 miles or sixty (60) days
Oil change	Every 2,000 miles or sixty (60) days
Anti-freeze	Permanent type
Washing	As needed
Oil	Premium brand or per factory specifications; as required

Snow Tires for Winter, or Acceptable Alternate

c. The Leasing Co. further agrees that it will provide or cause to be provided to the City priority in the maintenance, repair or replacement of parts and equipment.

d. The Leasing Co. further agrees to furnish or cause to be furnished emergency maintenance for tire repair or replacement and breakdown repairs or parts on a twenty-four (24) hour basis daily seven (7) days a week, whether furnished by the Leasing Co. or by such persons or firms satisfactory to the City who shall subcontract.

e. The Leasing Co. shall not be obligated to repair, nor be liable for, any damage to said vehicles caused by accident, or other casualty, including vandalism, riot, civil disorder, insurrection, fire theft or windstorm, nor for any repairs or service made necessary by failure of the City or the City's drivers, agents or employees to use ordinary care and diligence in the maintenance or operation of the motor vehicles or to follow written instructions furnished by the vehicle manufacturer.

f. The City shall furnish all gasoline necessary for the operation of each motor vehicle according to the manufacturer's specifications and shall furnish any and all other maintenance or service desired which is not specifically the obligation of the Leasing Co. hereunder.

5. **Performance Bond.** The Leasing Co. shall furnish a surety performance bond in the amount of TEN THOUSAND ($10,000.00) DOLLARS, conditioned that the Leasing Co. or its subcontractors shall perform the obligations assumed by the Leasing Co. under this contract with regard to maintenance.

6. **Use of Vehicles.** This agreement contemplates that the motor vehicles hereunder are to be used for municipal police department service only, and the City may not put the unit to a different use substantially affecting the amount of service required by the Leasing Co. in carrying out this agreement, without first obtaining the written consent of the Leasing Co. thereto, and renegotiating a mutually satisfactory maintenance rate per mile.

7. **Purchase of Vehicles.** The Leasing Co. agrees that at the end of three (3) years after the date of each memorandum attached hereto with respect to a motor vehicle covered hereunder, or after said vehicle has been driven 60,000 miles, whichever occurs first, the Leasing Co. will, if so notified by the City, purchase said

vehicle from the City at the original dealer invoice cost of said vehicle. In the event the City elects to have the Leasing Co. purchase any of said vehicles hereunder, it shall so notify the Leasing Co. in writing within thirty (30) days after the expiration of said three (3) year term, and the purchase shall be consummated as soon thereafter as is practicable. In such event, the City shall deliver each of said vehicles to the Leasing Co. free from all liens and encumbrances, and in good condition and repair, reasonable wear and tear expected.

8. Destruction or Loss of Vehicle. In the event any motor vehicle hereunder is lost or stolen, or damaged beyond repair, then all obligation of ______________ Leasing to repurchase said vehicle under the provisions of paragraph 7 hereof, shall cease and terminate; provided, however, that ______________ Leasing will, in the case of damage beyond repair, repurchase said vehicle for its salvage value.

9. Emergency Conditions. It is agreed that delay or failure by either of the parties hereto in the performance of any of their respective obligations in accordance with the terms of this agreement because of circumstances beyond the control of such parties shall not be construed as a breach of this agreement. Included in such circumstances, but not by way of limitation, are: war, riot, fire, acts of God, and inability to procure materials from any source. However, in the event of a strike or lockout involving the Leasing Co., it shall be obligated to make other arrangements at its expense so as to uninterruptedly continue the service required of it under this agreement.

IN WITNESS WHEREOF, the parties have hereunto caused their names to be signed and their seals to be affixed, the day and year first written above.

IN THE PRESENCE OF: LEASING COMPANY

______________________ By ______________________

Its ______________________

Appendix B-2: Sample Maintenance Arrangement with Private Vendors, for Provision of Services Only

Attention is called to the following features of the terms of bid aimed specifically at cost control: (1) Labor charges are not to exceed the schedule suggested in the Flat Rate and Parts Manual or the manufacturer's recommended flat rate schedule. (2) Maximum permissible charges are stated for specific jobs, and no bids in excess of these maximum rates are to be accepted by the department. (3) The department reserves the right to cancel any contract, and to allocate work among vendors as it desires. The price and time limitations are aimed at avoiding possible price collusion among private vendors; and retention of the freedom to allocate work among vendors provides the flexibility needed to promote competition and to obtain economical maintenance service on a continuing basis. Other provisions regarding the priority of service, etc., are included to make the contract service effective.

Sample

You are invited to submit, hereon, your quotation for providing vehicle service and/or repair as required by the County Government. Vehicles serviced or repaired under the terms of this bid shall include, but not necessarily be limited to, administrative sedans, police automobiles, and light trucks.

PRICES AND PROPOSALS: Prices quoted shall apply to any and all vehicles to be serviced under the terms of this bid. Note: Prices and rates are to be entered in *two (2) places* on attached forms. The Quotation Sheet *and* Summary Sheet provided.

The time (labor) charged for any and all service or repair rendered under the terms of this bid shall in no way exceed the suggested schedule as outlined in the current edition of "Motors" Flat Rate and Parts Manual, or the manufacturer's flat rate schedule. Note: Bid Award will be made to the lowest responsive bidder. However, bids in excess of the maximum permissable rates noted herein, will not be considered.

AWARD OF BID: This bid will be awarded to the vendor or vendors quoting the lowest prices and meeting the needs and requirements of the County, by District. The County reserves the right to reject any or all bids, or any portion thereof, if such action is deemed to be in the best interest of the County. Further, the County reserves the right to extend or alter District lines as may be required to obtain the most complete and economical coverage.

PRIORITY SERVICE: County vehicles shall receive priority repairs and service with Police and Fire vehicles (marked and unmarked) being given first priority. Failure to comply with the above stated condition shall constitute grounds for the rejection of your bid or immediate termination of subsequent contracts.

TERM OF CONTRACT: Prices, discounts and labor rates quoted herein shall remain firm for a period of fifteen (15) months.

Subsequent contracts may be cancelled, by the Vendor, by giving a thirty (30) day written notice of their intention to do so. The County reserves the right to cancel the contract at any time and without notice if such action will best serve the interest of the County.

ORDERS: Blanket Purchase Orders will be issued to suppliers, and service will be drawn on a priority basis, i.e., the prices and rates quoted and location of the vendor's facility, in relationship to the vehicle requiring maintenance or service, will be the prime criteria for the selection of the vendor.

The County reserves the right to purchase any, all, or none of its maintenance requirements from vendors awarded contracts as a result of the bid.

The County further reserves the right to segregate, bid and purchase separately, any item or service, when the interest of the County may best be served by such action.

The County further reserves the right to add additional vendors if because of distance, price or availability the County finds it more expedient or economical to do so.

GUARANTEE: The bidder, if executing a contract embodying the terms and conditions of this bid request, warrants that the products supplied to the County shall remain fully in accord with the original equipment manufacturers specifications and to be of the highest quality. In the event the products and service furnished to the County are found to be defective or do not conform to the specifications, the County reserves the right to make the necessary change, correction or repair and to return the defective part(s) to the supplier at the supplier's expense. The cost of such change, correction or repair shall be considered liquidated damage and shall be charged to the vendor found to be at fault.

Sample Questionnaire for Screening Applicant Vendors

1. Normal Operating Hours—Weekdays ______________________________

2. Normal Operating Hours—Saturdays ______________________________

3. Normal Operating Hours—Sundays ______________________________

4. Normal Operating Hours—Holidays ______________________________

5. Can you provide emergency road service? ______________________________

6. Can you provide 24-hour emergency road service? ______________________________

7. Number of employees on your regular payroll ______________________________

8. Number of qualified mechanics on your regular payroll ______________________________

9. Are you an Authorized State Inspection Station? ______________________________

10. Do you specialize in any one area, i.e., electrical, front end, transmission, etc.? ______________________________

11. If the answer to Item #10 is Yes—please list the speciality areas below:

    ____
    ____
    ____

    Note: On the enclosed road district map, please mark your approximate location and return with your bid.

12. List below diagnostic and/or special equipment in your facility:

    ____
    ____
    ____

13. List below major fleet-type accounts you are currently serving:

    ____
    ____
    ____

Firm Name ______________________________

Address ______________________________

Person to Contact ______________________________ Phone No. ______________________________

Payment Terms ____________ (Net-30 unless otherwise stated)

****

1. Tune up $____________

2. Carburetor overhaul A. $ ________ E. $ ________
B. $ ________ F. $ ________
C. $ ________ G. $ ________
D. $ ________ H. $ ________

3. Brake adjustment-minor $ ________

4. Brake adjustment-major $ ________

5. Combination brake adjustment, major $ ________

6. Air condition service $ ________

6a. Freon $ ________ /lb.

7. Reseal transmission A. $ ________ B. $ ________

8. Adjust transmission A. $ ________ B. $ ________
C. $ ________ D. $ ________
E. $ ________ F. $ ________
G. $ ________ H. $ ________

9. Transmission overhaul. Discount on major components: ______ %.
100% guarantee for a period of ______ months.
A. $ ________ A1. $ ________
B. $ ________ B1. $ ________
C. $ ________ C1. $ ________
D. $ ________ D1. $ ________
E. $ ________ E1. $ ________
F. $ ________ F1. $ ________
G. $ ________ G1. $ ________
H. $ ________ H1. $ ________

10. Front end align $ ________

11. Spin balance $ ________ per wheel

12. Mount tubeless tire $ ________

13. Mount tubed tire $ ________

14. Valve stem $ ________

15. Repair tubeless tire $ ________

16. Repair tubed tire $ ________

17. Install skid chains $ ________

18. R & R wheel $ ________

19. Engine oil $ ________ qt.

20. Transmission oil $ ________ qt.

21. Change oil (labor) $ ______________

21a. Change county-furnished oil $ ______________

22. Lubricate $ ______________

23. Install and charge new battery $ ______________

24. Charge battery $ ______________

25. Service and inspection $ ______________

26. Electrical A. $ __________ D. $ __________ G. $ __________
B. $ __________ E. $ __________ H. $ __________
C. $ __________ F. $ __________ I. $ __________

27. Labor rate $ ______________

28. Optional labor rate $ __________ per hour

29. Parts discount __________ %

29a. What price list? ______________

30. Tow to your facility $ ______________

31. Tow to other facility—5 miles $ ______________

32. Tow to other facility—10 miles $ ______________

33. Tow to other facility—15 miles $ ______________

All discounts other than prompt payment shall be included in bid price. Prompt payment discounts of less than twenty (20) days will not be considered in determining low bid.

Unless otherwise stated above, payment terms shall be Net/30 days.

Invoices clearly indicating the work performed, parts used, vehicle number, license number, mileage, and name of the individual (and badge number when applicable) shall be prepared for each job. A monthly statement, with a copy of all invoices, shall be submitted to the using department or agency.

NOTE: Illegible invoices will be returned and no payment be made until such time that a readable copy is submitted. ______________________________

Firm Name & Address: ______________________________

Handwritten signature by authorized officer of firm or agent: ______________________________

Printed or typewritten name: ______________________________

Phone No.: ______________________________

NOTE—COMPLETE QUOTATION SUMMARY SHEET

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