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EQUIPMENT SYSTEMS IMPROVEMENT PROGRAM

METHODS FOR REDUCING POLICE CAR FUEL CONSUMPTION

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ABSTRACT

This report presents the results of a preliminary study on means for reducing the consumption of petroleum products by police cars. Major emphasis was placed on an examination of the adaptability and utility of smaller automobiles than are presently used by police agencies. Alternate measures that involve operating procedures and driving habits were also considered, and the potential benefits from applicable alternatives were quantitatively assessed. Because it appears that both the intermediate and compact-size cars have a far greater application than current usage would suggest, strategies to overcome barriers to wider police use of such smaller cars are presented. In Volume II, a proposed plan is presented for implementation by the Law Enforcement Assistance Administration that involves a comprehensive program for police fuel conservation.

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FOREWORD

In view of the short time during which this study was to be made, consulting aid from several sources was obtained. Each consultant was requested to provide specific data and, in turn, establish contact with numerous law enforcement car-user agencies and other related information sources. The three consulting sources contributing to this study and the specific areas of focus for each are:

G. Ray Wynne (Director, Police Transportation, Los Angeles Police Department): Metropolitan police vehicle requirements, selection and procurement procedures, vehicle test evaluation, operating and maintenance experience.

Arthur D. Little, Inc. (Washington, D.C.): Adaptability and potential utility of small and intermediate-size automobiles as police vehicles.

Overly, Schell Associates (Washington, D.C.): Strategies for overcoming barriers to the use of small police vehicles.

As part of the A. D. Little, Inc., effort, a questionnaire was prepared and submitted to a selected sample of police agencies. The purpose of this survey was to establish typical auto use activities, the characteristics of the automobiles involved, procurement and maintenance policies, and attitudes

toward using smaller autos. Data were obtained from 37 police agencies (see Appendix A).

Other contacts, both in person and by telephone, made during the course of this study by personnel of The Aerospace Corporation and the assisting consultant are also listed in Appendix A. The total number of contacts established during the course of this study are as follows:

- 46 city police agencies
- 12 county police agencies in 8 different states
- 17 state highway police agencies
- 8 law enforcement planning agencies
- 3 Federal agencies
- 8 associations
- 5 automobile manufacturers
- 4 research experts

The information obtained from these sources materially aided this study. In addition, the results contained in a report on patrol cars (Reference 1) and other reports from the National Bureau of Standards and the Mitre Corporation were utilized.

CHAPTER I. INTRODUCTION

The occurrence of a national shortage of petroleum fuel has caused rapid and varied reactions. Initial steps taken to meet this shortage involve an examination of user practice and an assessment of means for lowering the quantities of petroleum consumed. At the request of the National Institute of Law Enforcement and Criminal Justice of the Law Enforcement Assistance Administration, The Aerospace Corporation undertook a brief study of the feasibility of reducing the quantity of petroleum fuel consumed by law enforcement vehicles. Major emphasis was to be placed on the utility of smaller cars for law enforcement use; however, alternative fuel economy measures were also to be considered. Appropriate recommendations for implementing fuel economy measures among the law enforcement community were desired.

The study did not consider vehicles of foreign manufacture. Non-passenger car vehicles in the police fleet such as vans, motorcycles, etc., are specialty vehicles with limited application and use and were also beyond the scope of this study. Finally, any techniques proposed for reducing fuel consumption were constrained to current knowledge and available technology.

The results of this study are reported in two volumes. This volume presents a discussion of the pertinent issues and the conclusions reached. Also included in Volume I are recommendations for action that could be taken by the Law Enforcement Assistance Administration to encourage the use of smaller police cars, as well as other means, to reduce the petroleum fuel consumption by the law enforcement community.

Volume II is devoted to a detailed presentation of a suggested program plan by the Law Enforcement Assistance Administration for attaining improved fuel economy with police vehicles. The various phases involved are described, and estimated schedules and costs are provided. The steps proposed involve near-term and subsequent action and can be treated individually, if desired.

CHAPTER II. DISCUSSION

The discussion that follows is divided into the following five sections:

A. Police Energy Use Perspective

B. Trends in Automobile Characteristics

C. Police Automobile Use

D. Possibilities for Reducing Petroleum Fuel Use

E. Factors and Barriers that Influence Use of Smaller Cars

Section A examines the sources of energy used in the United States and relates petroleum fuel use by police agencies to total national consumption.

Section B traces the changes in automobile design trends and discusses their weight growth and resulting fuel consumption.

Section C focuses on the police use of automobiles, the functions performed, the types and size of automobiles currently utilized, and the selection and procurement procedures employed.

The major portion of this chapter is devoted to Section D. The numerous possibilities for reducing police agency use of petroleum fuel are examined and evaluated in this section.

Because the adoption of smaller cars raises unique problems, the factors that influence its wider use by police agencies and barriers to its wide adoption are discussed in the last section, Section E.

A. Police Energy Use Perspective

Data on the current sources and the use distribution of energy in the United States are largely based on estimates. The most reliable data

presently available, Reference 2, are for calendar year 1972. As indicated in Figure 1, petroleum provided 46% of the nation's energy. An examination of how this petroleum was distributed among its varied users, Figure 2, reveals that over half of the amount (52.5%) was devoted to transportation. It should also be noted that petroleum represents 96% of the total energy used in transportation, the remainder being natural gas and coal. Although the nation's petroleum consumption has increased markedly during the last decade, the actual percentage used for transportation and the portion of total transportation energy that petroleum represents have remained relatively unchanged.

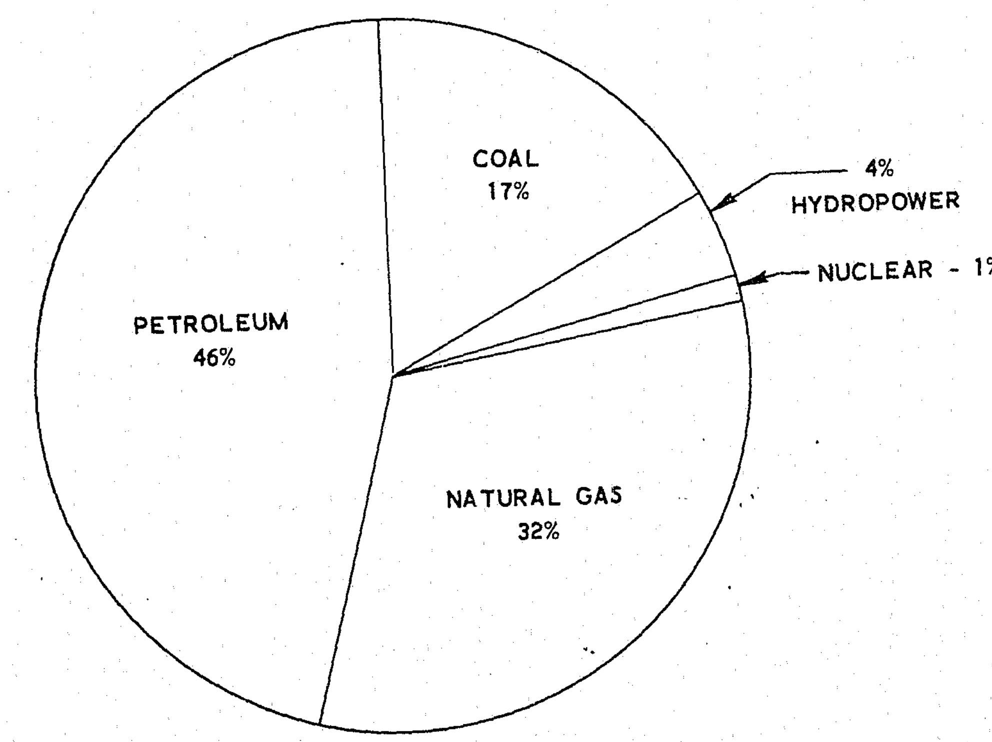

Figure 1. Distribution of U.S. Energy Consumption During 1972

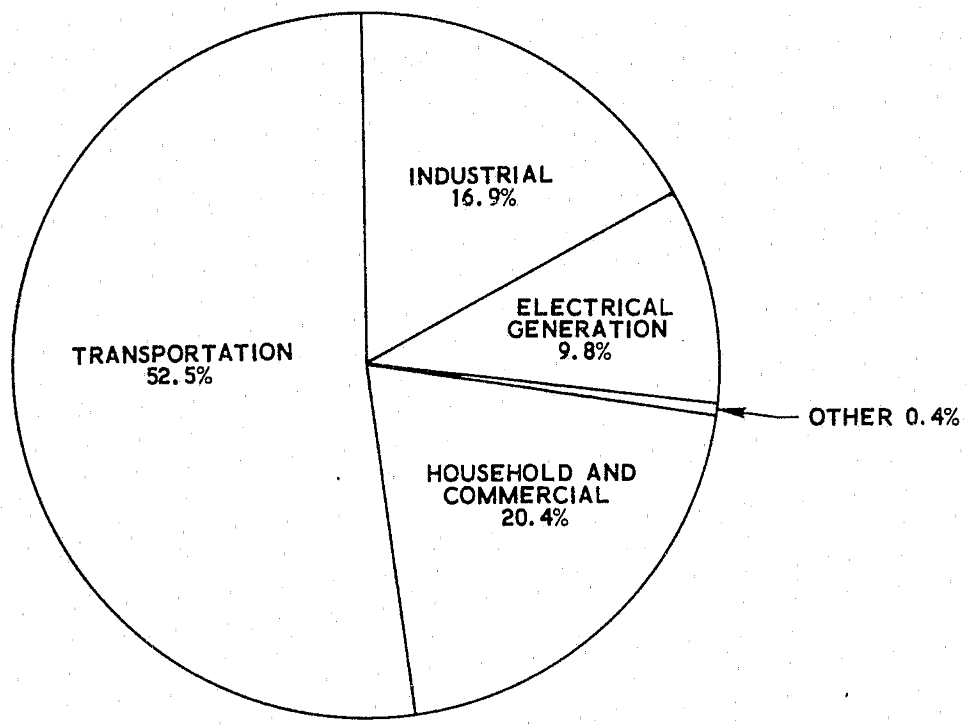

Figure 2. Distribution of Petroleum Consumption During 1972

Distribution among all users of petroleum devoted to transportation is given in Figure 3 for 1971 (Reference 2). The passenger car was by far the greatest user (59.3%) of the 117 billion gallons of fuel devoted to transportation that year. All told, passengers cars consume about 14% of the nation's total energy supply.

The police fleet has been conservatively estimated at 160,000 automobiles (Reference 1) out of an estimated total of 100 million passenger cars now on the road. The fuel consumption for police cars on a national basis is estimated to be about one billion gallons of gasoline annually. Thus,

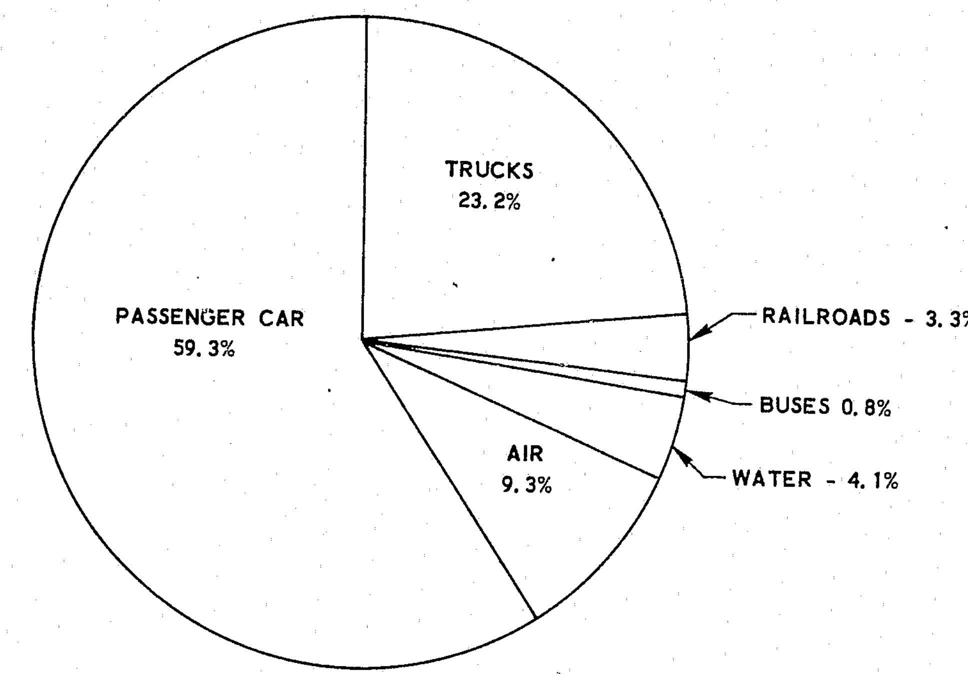

Figure 3. Fuel Consumption by Mode of Transportation During 1971

a realistic reduction in police petroleum use, 20 to 30% for example, would provide a fuel savings of 2 to 3 hundred million gallons of gasoline per year.

The nature of the energy shortage problem is such that no single measure offers large economies. Instead, numerous steps, each contributing a small saving, must be taken. A reduction in the police car use of petroleum is one such step. Moreover, the procedures followed to achieve a reduction will serve to demonstrate what other automobile operators could do to also reduce their fuel consumption. The potential savings possible through such amplification are truly significant.

B. Trends in Automobile Characteristics

Police automobiles are generally selected from among commercially available American models. A police car differs from a conventional car by some specially selected, but off-the-shelf options; a suspension system that provides significantly different handling characteristics; and a number of heavy-duty components. In general, production cars can be grouped into four size categories, namely, standard, intermediate, compact, and subcompact. Luxury and specialty production cars are obviously also available, but, except for special purchase needs, are rarely purchased by police agencies.

The characteristics of the four basic automobile size categories are summarized in Table 1, and examples of current models that fall into these

Table 1. Comparison of Automobile Size Categories

(1974 Model Year)

Size Category	Wheelbase, in.	Weight, lb	Engine		Typical Models
			Type	CID	
Standard	120 - 122	4,000 - 4,650	V-8	350 min	Chevrolet Impala Ford Custom or Galaxie Plymouth Fury AMC Ambassador Dodge Monaco Mercury Monterey (124 in. wheelbase)
Intermediate	114 - 118	3,550 - 4,100	V-8 6 cyl	300 min 225 min	Chevrolet Chevelle Ford Torino Plymouth Satellite AMC Matador Dodge Coronet Mercury Montego
Compact	103 - 111	2,850 - 3,300	V-8 6 cyl	300 min 225 min	Chevrolet Nova Ford Maverick Plymouth Valiant Dodge Dart AMC Hornet Mercury Comet
Subcompact	94.2 - 97	2,450 - 2,750	V-8 6 cyl 4 cyl	304 232 122 to 140	Chevrolet Vega Ford Pinto AMC Gremlin

categories are also listed. Police cars generally fall in the standard or intermediate-size category.

With each succeeding model year, it has been a characteristic of American-designed and produced cars to become larger and heavier and to have larger engines. Only when a new model concept is introduced does this trend change. These conclusions are readily confirmed by the weight-history trend presented in Figure 4, and the engine displacement trend presented in Figure 5. For a given size category, automobile curb weight increased consistently with time. In the last decade, automobile weights in the compact, intermediate, and standard categories have all increased 20 to 30%. In fact,

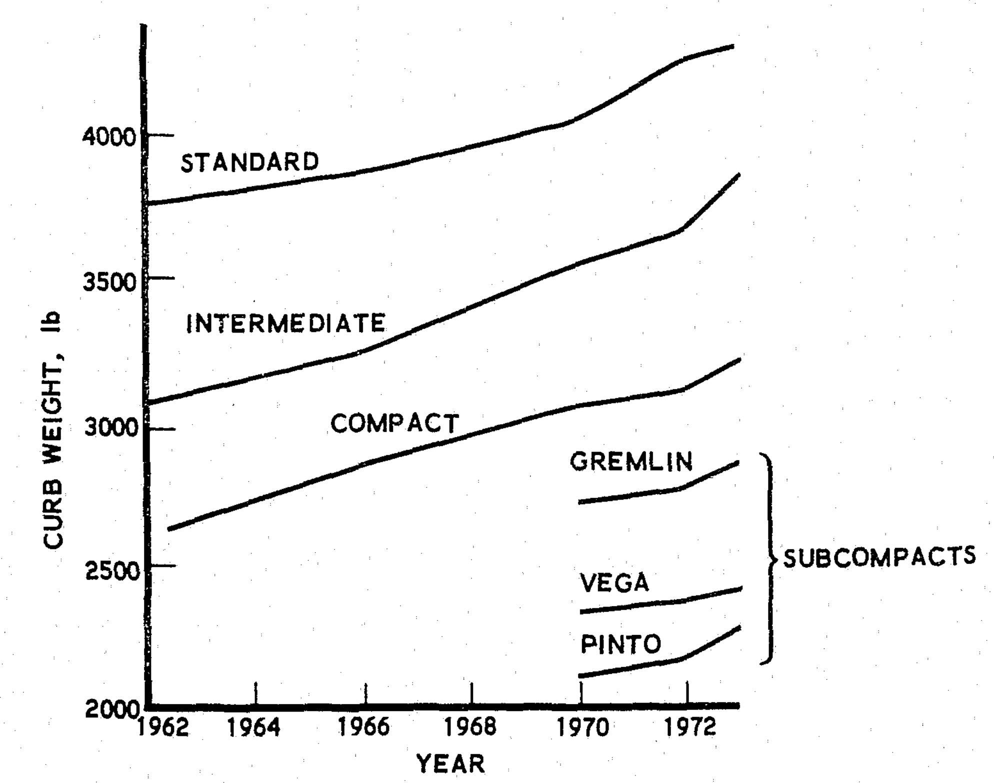

Figure 4. Vehicle Weight-History Trend

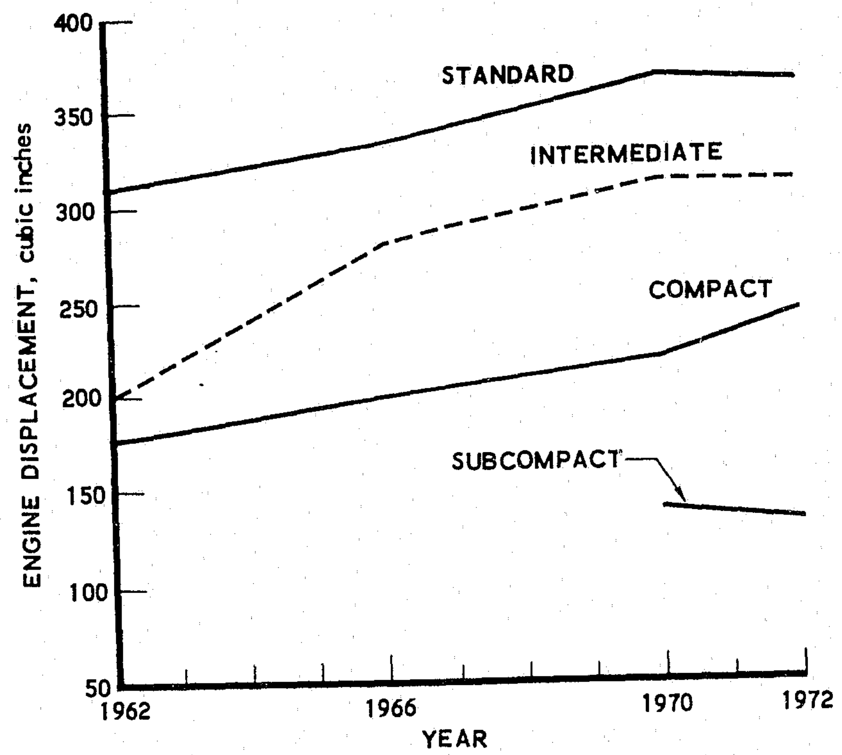

Figure 5. Passenger Car Engine Displacement Trends

the average intermediate of 1973 is about as heavy as the average standard of 1963, and the average compact of 1973 is about as heavy as the average 1963 intermediate.

Consistent with this weight growth is the attendant growth in engine size. Engine cubic inch displacement, while not directly convertable to horsepower, is a useful engine power trend indicator. In the last decade, the average displacement in the standard, intermediate, and compact categories have kept up with the weight growth. In fact, just as with weight, the current intermediate-category engine displacement is equivalent to that of

the standard category a decade ago (Figure 5). The engine displacement in the current compact category even exceeds the displacement of the average intermediate automobile of a decade ago.

Thus, although the registration (and sales) of standard-size automobiles has been steadily declining in favor of smaller vehicles (Figure 6), the fuel economy of the average car on the road has not improved. Instead, growing weight and larger engines have lowered miles achieved per gallon of fuel. The situation is further aggravated by the public's desire for

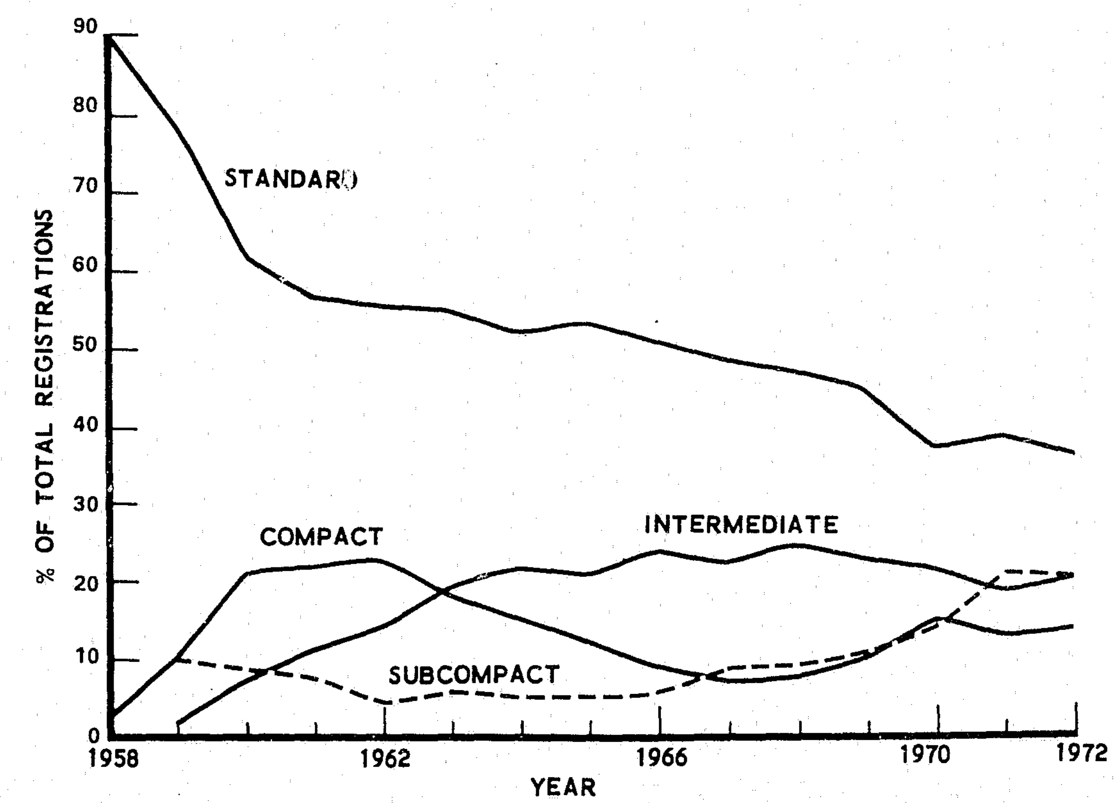

Figure 6. Passenger Car Registrations by Market Class

numerous accessories and power-assisted equipment, which also reduce fuel economy. The attitudes of both the consumer and the manufacturer have discouraged achievement of improved automobile fuel economy.

As later discussed in Section D, the fuel consumption of an average automobile is basically a function of weight. Obviously, the driving cycle and speed also have a significant impact on mileage, and cars involved solely in urban driving will, for example, use more fuel than is required for steady, highway driving. Further, about 1967, the issue of emission control was introduced, and subsequently Federal safety standards were also imposed. The latter caused additional weight increases and the former lowered engine operating efficiency, which lead to subsequent increases in engine displacement and the accompanying increase in engine weight.

Emission control requirements have been especially detrimental to automobile mileage. The initial requirements have already lowered obtainable mileage almost 20%, due to changes to the engine and its operation. If these changes that are easily eliminated were to be discarded, about one third of this decrement could be recovered, but at the expense of a large increase in emissions. The more stringent NO_x emission requirements about to be imposed could well cause a further reduction of significant magnitude. With existing knowledge and available technology, the decrements indicated in Figure 7 can be anticipated as the allowable NO_x emission is successively lowered. There is an obvious need for new technological

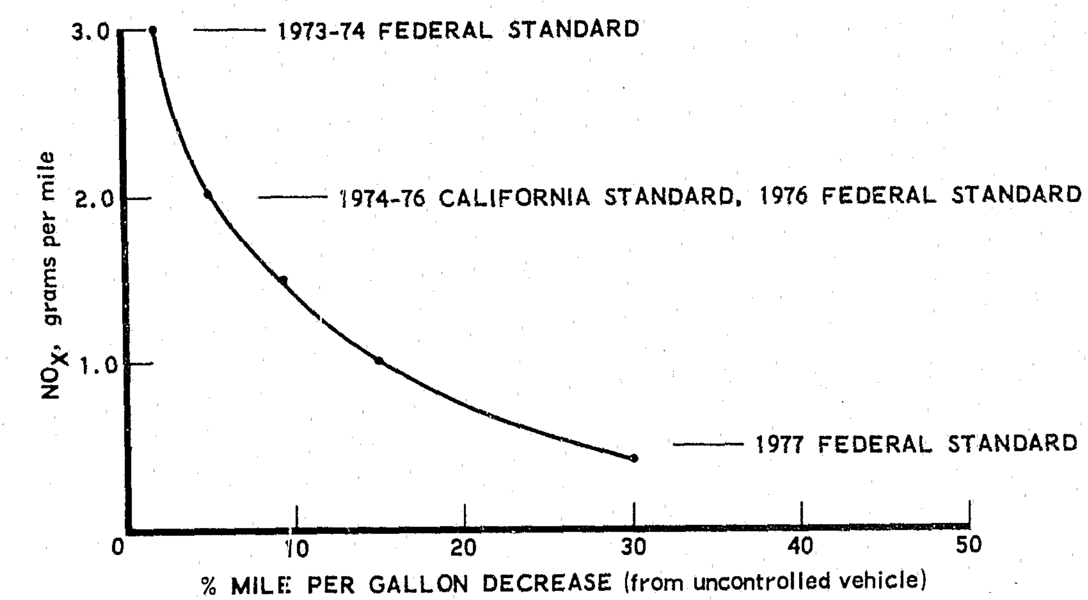

Figure 7. NO_x Emission Level Effect on Fuel Economy

developments. However, by direction, the scope of this study excluded consideration of new technology that might reduce the emission control penalty.

As reported by the Mitre Corporation (Reference 7), police car fuel economy has deteriorated significantly and their maintenance increased markedly since 1968. These changes are attributed primarily to the introduction of emission controls and the higher engine operating temperatures involved. This situation is expected to become even more severe with the current model automobiles.

It is in this environment that police cars are selected and procured. Limitations obviously exist on the types of automobiles available to police agencies, as well as on the steps that might be taken to improve their fuel economy. The next section (Section C) treats the extent and categories of police auto usage, and this is followed by a discussion of possibilities for reducing the fuel consumed by police agencies (Section D).

C. Police Automobile Usage

1. Functions. Police agencies are engaged in a variety of activities in which an automobile is a key supporting element. The purpose of the automobile is primarily to transport men and equipment during the commission of the police function, namely, to protect life and property. The specific police activities involved establish requirements for the automobiles used and serve as the basis for defining the important police automobile characteristics.

Police vehicle functions can be conveniently grouped into five general categories. These are

- Patrol
- Traffic
- Investigation
- Emergency Response
- Administration

There are, of course, exceptions to these functions, as well as varying degrees of specialization. The discussion that follows briefly examines the vehicle needs associated with each of these functions.

a. Patrol. The patrol function serves several purposes, including observation of crimes, deterrent to crimes being committed, making policemen readily available for citizen assistance, arresting and transporting suspects, and responding to a variety of emergencies. Patrol is the most visible area of police work and, in the public view, is associated with the protection of life and property. The requirements of an automobile to support patrol work usually include the following factors:

- Comfort - Head room; leg room; seat width; ease of entry and exit; seat support; driving effort; adequate ventilation, heating, and cooling
- Roominess - Personnel, equipment space, trunk storage, adequate rear seat
- Safety - Crashworthiness, prisoner containment
- Performance - Handling, maneuverability, braking, acceleration and speed, durability, dependability
- Special Characteristics - Visibility, equipment mount feasibility

These five patrol requirements vary somewhat among different agencies. In all cases, however, the patrol car is an essential element of the patrol activity for 8 to 24 hours a day. As such, it must provide adequate and dependable support to the patrolman, the other key element of the patrol activity.

b. Traffic. The traffic function can involve traffic patrol, apprehension of traffic law violators, emergency response to accidents, accident investigation, maintaining or restoring smooth traffic flow, or the enforcement of parking laws. The traffic patrol activity, as a combination of the two functions (patrol and traffic), requires a car much like the patrol car. The other traffic activities are much less demanding of a vehicle. They either require transportation to the scene of an accident or traffic snarl, for example, or they can be performed on foot (issuing parking tickets). As a result, the requirements for these latter functions are simpler and more straightforward than for the traffic patrol function. They are basically no different than those for a family or for a light commercial passenger vehicle, namely, to safely and rapidly take one to four persons on short, across-town trips.

c. Investigation. The investigative function is essentially single purpose, that is, to provide basic transportation to take one or two men on short trips. It is similar to the nonpatrol traffic function in its vehicle requirements. Where the investigative activity requires surveillance, a car not readily identifiable as a police car may often be needed (for example, undercover vice or narcotics work). For some surveillance and undercover work, the car may also be used as a pursuit car. In this case, high-speed performance capability is also required.

d. Emergency response. Emergency response functions include rescue service or ambulance calls, civil disorders, suicides, etc. Some of these needs can be met by patrol cars (which have already been discussed), others will require special vehicles, such as vans or ambulances. It seems clear that such special purpose needs can probably not be met by smaller cars. The few cases where smaller cars might meet these special purpose needs are expected to be minimal.

e. Administrative. In most police departments, cars may be assigned to individuals, to organizational units, or to a pool for a variety of administrative uses. This latter category can include the cars used by the chief and other senior police officials, those used in community relations work by juvenile workers and parole officers, and those used for messenger service and for a variety of other miscellaneous needs. The requirements for these vehicles are simple, perhaps even less demanding than for the traffic functions. Only two possible exceptions may require that this car have characteristics somewhat beyond simple transportation:

1. "Pool" cars may be used by so many different kinds of drivers that durability and toughness are very important.
2. Cars for senior police officials may have to be appropriate to their status, and thus somewhat more luxurious than mere transportation demands would imply.

f. Summary. In summary, police functions related to automobile requirements can be grouped into two categories — patrol and non-patrol. The patrol car requires fairly high levels of comfort, performance, and durability, and has special safety, roominess, and equipment needs. The car for nonpatrol use merely provides basic transportation as with commercial or private passenger cars.

Further discussion of police functions and their transportation requirements is presented in References 3 and 4.

2. Present automobile use. A determination of the number and types of automobiles presently in use is first necessary in order to establish a baseline for assessing the potential for reducing police car fuel consumption. The size and type of police department obviously influences both the number and kind of vehicles they use. Smaller departments have fewer automobiles than larger departments, and some vehicles must, therefore, be used for multiple functions.

For purposes of this analysis, all police jurisdictions were conveniently divided into the following five categories:

- State police or state highway patrol
- County police or sheriff's office
- Rural, townships, small city (population to 50,000) with 1 to 49 man force
- Suburban, medium city (population 50,000 to 250,000) with a force of 50 or more men
- Urban, metropolitan - 50 largest cities (population over 250,000)

a. Number of automobiles. A police equipment survey performed by the National Bureau of Standards for the Law Enforcement Assistance Administration estimated that in 1971 there were approximately 160,000 patrol cars (Reference 1).

The number of police automobiles other than patrol cars was estimated by the use of factors derived from survey data and information obtained as part of this study by Arthur D. Little, Inc. The survey suggests that patrol cars constitute 62.5% of the total police car fleet for urban and suburban forces and about 77% of the police car fleet for all other jurisdictions. On this basis, the total number of police automobiles, by jurisdiction, is estimated to be as follows:

	Patrol Car	Other	Total
States	29,100	8,730	37,830
Counties	70,900	21,270	92,170
Rural, small city	27,300	8,190	35,490
Suburban, medium city	15,900	9,540	25,440
Urban, metropolitan city	16,100	9,660	25,760
	159,300	57,390	216,960

b. Size of automobiles. An estimate of how the total number of police automobiles are distributed by vehicle size is given in Table 2. The estimate is based on the same sources of information as for the number of automobiles. For purposes of analysis, the patrol car and all other

Table 2. Estimated Police Automobile Distribution

Application	Standard	Intermediate	Compact	Total
Patrol Cars				
States	27,936 (96%)	1,164 (4%)		29,100
Counties	46,085 (65%)	24,815 (35%)		70,900
Rural/small city	24,570 (90%)	2,730 (10%)		27,300
Suburban/medium city	12,720 (80%)	2,544 (16%)	636 (4%)	15,900
Urban/metropolitan city	11,431 (71%)	4,508 (28%)	161 (1%)	16,100
Subtotal	122,742 (77%)	35,761 (22%)	797 (1%)	159,300
Administrative/Investigation/Traffic				
States	6,111 (70%)	2,182 (25%)	437 (5%)	8,730
Counties	10,635 (50%)	8,508 (40%)	2,127 (10%)	21,270
Rural/small city	6,552 (80%)	819 (10%)	819 (10%)	8,190
Suburban/medium city	4,102 (43%)	4,388 (46%)	1,050 (11%)	9,540
Urban/metropolitan city	4,926 (51%)	3,671 (38%)	1,063 (11%)	9,660
Subtotal	32,326 (56%)	19,568 (34%)	5,496 (10%)	57,390
Total	155,068 (71.5%)	55,329 (25.5%)	6,293 (3%)	216,690

categories are listed separately. Three auto sizes are in use, namely, standard, intermediate, and compact. The dimensional characteristics of these size cars are summarized in Table 3.

Although standard cars are generally favored, both the intermediate and compact sizes are used. It is especially clear that standard, full-size automobiles are not necessarily required for all patrol or nonpatrol duty. Thus, greater use of cars smaller than standard size would seem to be feasible and, more importantly, acceptable to some degree in all police jurisdictions.

3. Vehicle procurement.

a. Present procedure. The complete police vehicle procurement process, if competitive, can be represented by five discrete steps.

Table 3. Dimensions of 1974 Automobiles

Size Category	Height, in.	Length, in.	Width, in.	Trunk Space, cu ft
Standard				
Ford, Chevrolet, Plymouth, Ambassador Monaco	54.5 - 55.5	219.4 - 222.7	77.2 - 79.5	18.2 - 20.4
Intermediate				
Chevelle, Coronet, Torino, Montego, Satellite, Matador	52.8 - 55.4	210.3 - 219.5	77.2 - 79.3	15.3 - 19.1
Compact				
Nova, Dart, Maverick, Comet, Valiant, Hornet	52.4 - 54.3	187.0 - 203.2	69.6 - 72.4	10.1 - 16.2

Whether or not all five steps are utilized depends upon the specific jurisdiction involved, the fleet size, and the degree of vehicle function specialization.

(1) Specify police services provided and establish vehicle requirements. Theoretically, police transportation needs are established through detailed study and planning that take into consideration factors such as the area covered, the number and types of calls received, emergency and community services to be provided, investigative activity involved, etc. Realistically, however, this step is informal and rarely explicit. If the services involved are specified, they are usually based on past experience, and few changes in transportation needs are indicated. Superimposed on the requirements as stated by the police administration is the influence of

elected officials, police associations and unions, other agencies, and local pressure groups. In addition, constraints to change from existing practices provided by local charters and constitutions, as well as public commitment and subtle agreement between interested parties, are also involved. The net result is a tendency to define a car model rather than transportation or vehicle performance requirements.

(2) Establish technical specifications for cars and equipment. The usual practice is to start with the previous year's specifications and update them, as feasible, with available new hardware. Frequently, the specifications intentionally match currently manufactured cars equipped with the optional "police package." In these cases, the specifications resemble the manufacturer's brochure, and members of the staff of the individual police jurisdiction prepare the specifications. A few of the larger urban and state police agencies provide specialists in automotive engineering for this critical step, but, in the aggregate, they are a small percentage of the total. In any case, manufacturer's brochures represent the basic specifications input.

(3) Issue request for bids to qualified sources. Once prepared, the specifications are submitted for procurement action. Costs are estimated and a bid package is prepared for executive approval. Once approved, the bid package is normally advertised and then submitted to qualified bidders. If a dealer is interested, he requests his manufacturer to review the bid request to assess the ability to meet the specifications and delivery date (for large orders), and to quote costs. Frequently, dealer

qualification is limited to the jurisdiction of the buyer. In rare cases, large fleet buyers will request sample cars for test and evaluation prior to bid or award. (The city of Los Angeles, for example, has followed this procedure for a number of years.)

(4) Evaluate bids and select supplier. The procuring office determines the legality of all submitted bids and also assesses the bidder's ability to meet the commitment. The police agency involved evaluates any deviations of the bid from the specified vehicle characteristics and recommends the winning bidder. The selection will be influenced by fleet maintenance considerations, compatibility with other vehicles already in the fleet, officer preference, and even by the opinions of elected officials.

(5) Vehicle delivery and commission. Vehicle delivery and commission are based on the terms of the purchase contract. With a small procurement, all vehicles ordered are usually simultaneously delivered by the manufacturer to the dealer. Larger orders usually follow a delivery schedule specified in the contract and may extend over a period of weeks or months. It is not unusual for the dealer to merely process the paper work for large orders and for the cars to be delivered directly to the procuring agency from the factory.

Commissioning a car for police duty involves the installation of specialized equipment such as lights, sirens, radio equipment, special purpose brackets, etc. Some of this equipment is installed by the manufacturer or dealer and some by the procuring agency. Equipment that has a longer life than the police vehicle is transferred from the old vehicle to the new vehicle by the procuring agency. Other equipment, specially procured for the new vehicle, can be installed at the factory if so specified by the purchase agreement. Final acceptance of the delivered vehicles involves establishing that the contract specifications have been met and that all of the installed special equipment is in proper working order.

b. Jurisdictional differences. In those communities that operate small fleets (2 to 15 cars), only two or three people might be involved in the vehicle procurement process. The police chief or his delegate sets the specifications, a purchasing official prepares the bid package, and a limited number of local dealers respond. Because the jurisdiction is small, it is often not feasible to have a fleet of different types of cars for different purposes. The standard-size vehicle with "police package" options (see Appendix B) is often selected as the best all-purpose vehicle.

In larger jurisdictions, inputs from several sources aid in establishing vehicle specifications. The chief's office, a research and planning unit, and the police garage might all be involved. Further, other public officials, such as the fleet administrator for all city-owned vehicles, the city engineer, the mayor's budget representative, and city procurement officials, may also have some procurement responsibilities. Special interest groups will also make their views and desires known. The net result is a long and timely procurement process that requires deliberate and effective advance planning.

c. Police car specifications. The following factors are considered by a purchaser in establishing police car specifications:

Size	Top speed	Safety
Weight	Braking	Interior dimensions
Power	Handling	Comfort
Cost	Durability	Functional utility
Acceleration	Maintainability	

Each jurisdiction examines its perceived needs and then prepares specifications. Not only are there specification differences between jurisdictions, but the level of detail to which specifications are written varies considerably as well. Moreover, even within the same general type of jurisdiction, the requirements for a police automobile to be used for the same function can differ. Topographical and climatic conditions influence specifications. Other influencing factors are of political or visceral origins. As a result, automobile manufacturers report that only two or three individual requests out of the several thousand police bid requests they receive annually are met by the same car.

As the requirements are generally vague, the criteria from which vehicle specifications are derived are often highly subjective. Moreover, although the factors considered can be identified, providing a measurable description is not always possible.

d. Summary. Selection and procurement of new police cars is largely influenced by the vehicles currently in use and is adjusted by new vehicle and equipment availability. To a considerable degree, police car specifications are set to match what automobile manufacturers produce. They are not established from the basic police services and transportation requirements because of a lack of definitive data regarding functional requirements and candidate vehicle performance. In addition, there is a reluctance on the part of the automobile manufacturers to design and produce a special car for police use. Their attitude is based on the small volume that the individual police agency fleets represent. It is estimated that a market of at least 200,000 units is required to justify production of a special police car.

D. Possibilities for Reducing Petroleum Fuel Use

Some of the factors that affect passenger car fuel economy have already been identified in Section B. Vehicle configuration characteristics, such as size, weight, horsepower, and accessories, all influence auto fuel mileage. There are, of course, additional factors that also influence the fuel economy. The manner in which an automobile is operated and maintained can exert a major effect on the fuel mileage obtained. In addition, good driver technique and preventive maintenance are very effective in achieving higher fuel mileage.

A summary of some of the factors that fall into the configuration, operation, and maintenance categories and the magnitudes of typical impacts are given in Table 4. The values shown are typical for passenger car use and may not be directly applicable to police cars. However, their relative effect is valid.

Table 4. Factors Influencing Fuel Economy[a]

Item	Impact, mpg
Configuration	
Added weight	Standard: -0.1 mpg for each additional 100 lb Intermediate: -0.2 mpg for each additional 100 lb Subcompact: -0.4 mpg for each additional 100 lb
Engine size	-0.2 mpg for 10% increase in displacement (urban driving)
Compression ratio	+0.3 mpg for 10% increase (equivalent to ~5% acceleration gain)
Air conditioning	-2.0 mpg (urban driving)
Heavy duty alternator	-0.9 mpg (urban driving)
Power steering	-0.7 mpg (urban driving)
Radial tires	+0.5 mpg
Automatic transmission	-1.6 mpg (urban driving)
Operation	
Fast starts	-2 mpg or more in urban driving
Varying cruise speed 5 mph	-1 mpg in highway driving
12% idle time (parked)	-2 mpg in urban driving
Maintenance	
5° ignition retard	-1 mpg
One spark plug misfiring 50%	-1 mpg
Tires underinflated	-1 mpg
0.25 in. toe-in misalignment	-0.3 mpg

[a]Reference 5

It is clear that there are numerous possibilities for improving police vehicle fuel economy. For purposes of discussion, they have been grouped into the following categories:

- Car size
- Accessories and optional equipment
- Driving cycle and patrol strategy
- Personal driving habits
- Effective maintenance
- Fuel-saving devices

1. Car size. Car size and its effect on total weight are directly related to fuel economy. The larger and heavier the car, the lower the fuel mileage. It is the purpose of this section to examine the extent to which the proportion of smaller police vehicles can be increased and a fuel savings obtained.

As already discussed earlier, the use of smaller than standard-size cars by the police appears feasible. Smaller cars are already acceptable to a limited degree, and a wider adoption should be expected to reduce police gasoline needs. However, to quantify this conclusion, three fundamental issues must be addressed. They are:

- How much will smaller cars actually improve police fuel mileage?

- To what extent can police substitute smaller cars for the standard-size cars now in use?
- Do currently available smaller cars meet police needs?

Each of these questions is separately addressed in the next three sections.

a. Smaller car mileage. The steady-speed, level-road, fuel consumption for three different car sizes over a range of cruise speeds is shown in Figure 8. The curves clearly illustrate that for any specified cruise speed, the mileage improves as the car size (and weight) decreases.

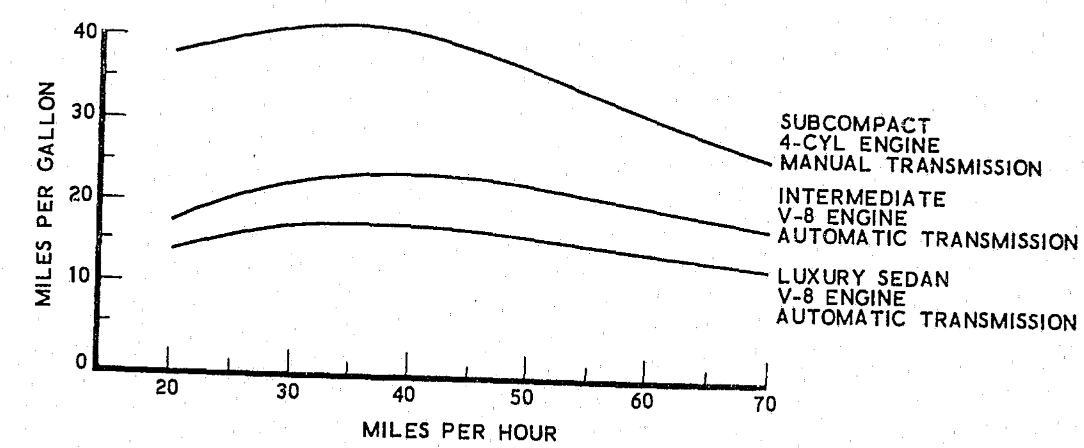

Figure 8. Steady-Speed, Level-Road Fuel Consumption

Urban driving mileage, for which an average speed of 20 to 25 mph is typical, falls below these curves because of the frequent stops, periods of engine idling, and acceleration and deceleration. An additional mileage penalty is suffered by urban patrol cars because their operating procedures accentuate all of these factors to a greater extent. Nevertheless, the effect of mileage differences between lighter and heavier police cars still prevails.

A National Bureau of Standards report in preparation (Reference 6) indicates the difference in the average fuel consumption between standard and intermediate-size patrol cars is nearly 1 mpg (7.9 vs 8.7). A similar mileage difference was found to exist with a standard-size patrol car in congested driving vs open (suburban type) driving (7.65 vs 8.78 mpg).

The survey information obtained by Arthur D. Little, Inc., in support of this study showed a wide variance in gasoline mileage experience of police agencies. The mileage ranged from a low of 4 to 6 mpg for a full-size car to a high of 17 to 18 mpg for a compact car. While the general trend of higher mileage with smaller cars existed, the data was inconclusive as different size cars are usually used for different purposes under different driving conditions.

A similar trend was apparent from information obtained from the New York City Taxi and Limousine Corporation. The gasoline mileage for compacts was 10 to 11 mpg; for intermediate, 9 to 10 mpg; and for full-size cars, 7 to 7.6 mpg. The full-size cars had V-8 engines, while

the others had 6-cylinder engines. All cars were exposed to the same kind of duty and similar driving style.

It can, therefore, be conservatively concluded that the adoption of a smaller police car (an intermediate where a standard-size car is now used, or a compact to replace currently deployed intermediates) would result in a 10% fuel saving per car.

b. Smaller car use. As discussed earlier, the manner in which current police car specifications are prepared is not necessarily based on an objective assessment of agency needs. Instead, a highly subjective approach, which often assumes that only the standard-size car can adequately meet police needs, prevails. To test this assumption, a comparative analysis was undertaken of the capabilities of intermediate and compact-size cars and the standard-size car. The characteristics considered included interior dimensions, handling characteristics, performance, safety, braking, etc.

With respect to general roominess and comfort, for example, the summary of appropriate body dimensions, Table 5, shows that there is little difference between the intermediate and standard-car size. Moreover, rear seat leg room (approximately 3-in. reduction) and shoulder room (approximately 7-in. reduction) are the only significant dimensional differences between the compact and standard-size car. Frequent transportation of two people in the rear seat of a 4-door compact automobile may prove to be unacceptable. In-service testing is probably the

Table 5. Interior Dimensions of 1974 Automobiles

Size Category	Head Room, in.		Leg Room, in.		Shoulder Room, in.	
	Front	Rear	Front	Rear	Front	Rear
Standard						
Ford, Chevrolet, Plymouth, Monaco Ambassador	37.4 - 39.6	36.5 - 38.4	41.6 - 42.5	35.4 - 38.8	60 - 64.3	60 - 63.5
Intermediate						
Chevelle, Coronet, Torino, Montego, Satellite, Matador	36.3 - 39.6	36.3 - 37.5	41.8 - 42.5	33 - 38.6	58.6 - 60	58.4 - 60
Compact						
Nova, Dart, Maverick, Comet, Valiant, Hornet	37.1 - 39.5	35.9 - 37.3	40.7 - 42.1	31.8 - 36.2	54.9 - 56.6	53.3 - 56.2

only feasible approach for assessing the roominess acceptability of the compact 4-door police car.

The space requirements for equipment installed or carried in police cars may vary considerably depending on the type of jurisdiction and degree of specialization. A summary of typical equipment involved, their sizes, and where they may be located is given in Table 6. The car radio and switch console, flashing lights, and siren are considered to be installed items of equipment (nonmovable). The remaining items of equipment are those that are carried in at least 50% of patrol cars, as reported in Reference 1. The approximate dimensional size of each item of equipment is given rather than volume to indicate the shapes involved. The total volume

Table 6. Police Car Equipment Storage Requirements

Equipment Item	Approximate Size, in.	Typical Mounting or Storage Location	Remarks
Car radio	4 × 11 × 22	Trunk	More than one unit may be required for multi-district frequency coverage
Radio mike/ switch console	8 × 10 panel	Under dash/between front seats	
Flashing lights(s)	8 × 8 × 8	Roof, behind grille	Other lights (rear deck)
Siren (electronic)	6 × 6 × 8	Roof bar, behind grille	Mechanical siren larger
Shotgun	40 (length)	Front compartment, trunk	
Batons	12 - 18 (length)	Door panel	
Fire extinguisher	8 diam × 24	Trunk	
First aid kit	6 × 8 × 15	Trunk	
Extra ammo	5 × 5 × 4 5 × 3 × 2	Glove box/trunk	Shotgun and 0.38 caliber
Clipboard	12 × 16	Front seat	LAPD has writing desk secured to dash
Flares	12 × 12 × 18	Trunk	
Blankets	8 × 12 × 18	Trunk	Varies with number of blankets
Brief case	8 × 16 × 18	Rear floor/trunk	Front seat in one-man patrol

of trunk-located equipment is about 5.6 cu ft. It is estimated that about twice this volume may be required to provide ready access to most items and to accommodate the shapes involved. Because all items are not necessarily carried in every car and some cars may carry additional items, it would appear that the trunk space available for all car sizes (see Table 3) is adequate. The front interior dimensions are not significantly different for all car sizes (see Table 5), and front compartment space also appears adequate. There understandably may be a compatibility problem using equipment designed for a standard-size car with a compact car (roof rack, for example). This is not considered to be a serious problem, however, as year-to-year changes in dimensions of the same model car present the same type of problem.

Considerable reluctance toward the use of smaller police cars is based on the issue of their safety and handling during high-speed pursuit and their crashworthiness and occupant protection. A discussion of this issue is presented in Appendix C. Statistics show that smaller cars are more frequently involved in accidents, and that, if involved in an accident, there is a greater risk of occupant injury in a smaller car than in a standard-size car. Safety experts suggest that the higher accident frequency may be due to the younger average age of drivers of smaller cars. They further suggest that there will be an improvement in safety for small car users as the proportion of the smaller car population increases, speed limits are lowered, manufacturers introduce structural improvements, and Federal safety standards are adopted.

Driver fatigue, especially during the long driving periods at high speed involved in patrolling highways, is another barrier to small-car use. The Alabama State Highway Patrol found, for example, that a compact-size car (AMC Javelin) had adequate acceleration and speed for highway patrol duty but caused greater driver fatigue than was caused by standard-size patrol cars. Intermediate-size cars are less susceptable to such criticism, because they are significantly larger and heavier than the compact car (see Table 1). In fact, as discussed in Section B, the intermediate of today is as large as the standard car of just a few years ago.

The following conclusions are offered regarding the use of smaller police cars:

(1) Intermediate-size cars are adequate for all urban uses and most patrol applications.

(2) Highway patrolling will continue to require some standard-size cars

(3) No significant constraint exists to the wide adoption of compact-size cars for nonpatrol duties.

(4) For any patrol use, heavy-duty modifications to the compact car are needed.

c. Availability of smaller cars. The standard and intermediate-size models listed in Table 1 are known to be available in police configurations. In some cases, the conventional passenger car may be acceptable, but in most cases, the car is equipped with selected optional equipment in order to increase its durability and change its handling characteristics to meet police needs. A sample police brochure published by one of the manufacturers (Appendix B) illustrates the extent of provisions available in the "police package." The items most frequently procured include a high-performance engine, heavy-duty brakes, a heavy-duty suspension system, and a heavy-duty electrical system.

At present, there is no compact-size car available with a "police package." One manufacturer has a 4-door compact model available with a taxi heavy-duty package. All manufacturers state that a visible market must exist before a firm development commitment for a compact police car would be made. Should development be undertaken, the lead time for design, test, and evaluation of a police version compact-size car would take from 2 to 3 years before it was offered on the market.

The subcompact-size automobile is available in 2-door models only and appears to have limited police applicability. The car width and rear seat dimensions are significantly smaller than that of a compact car. Also, this class of vehicle is not available with heavy duty equipment, and its use would be limited to ordinary street and highway driving. Subcompacts are practical as a runabout for messenger and administrative functions and are already so deployed for nonpolice use in Detroit and Los Angeles.

Approximately 2 years ago, Volkswagons were employed as patrol vehicles in test programs in the cities of Mamoronek and White Plains, New York. The objective of the programs was to see if Volkswagons could perform the work of foot patrolmen in policing neighborhoods, thus reducing the number of patrolmen needed for this duty. The cars were purchased from local Volkswagon dealers and were not modified for police

duty. Fuel saving was not a consideration at the time. Although successful, the tests were not followed by a large-scale procurement of Volkswagons equipped for police duty because of political pressures. As a result of the current energy crisis, interest is again being renewed.

d. Possible changes in the police car mix. The present distribution of standard, intermediate, and compact-size cars in the police fleet is given in Figure 9. Also included in Figure 9 are two alternate redistributions, both of which are based on a judgemental interpretation of the study survey results. Alternative No. 1 involves increasing the number

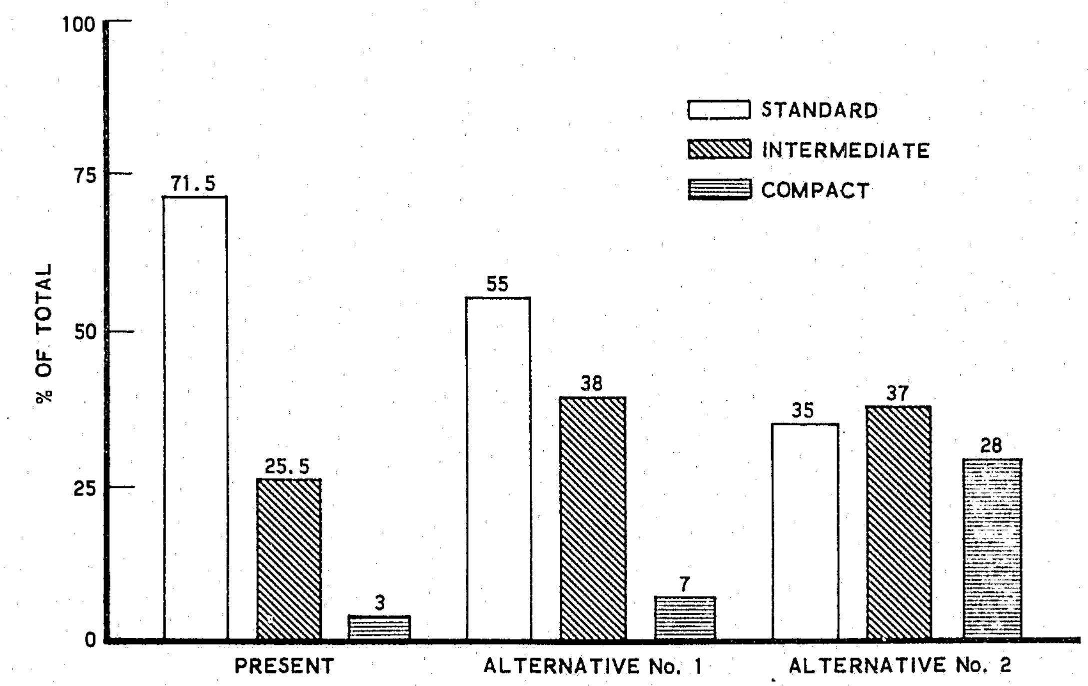

Figure 9. Present Distribution and Possible Redistributions of the Police Fleet Mix

of smaller cars in nonpatrol use and shifting to a significant number of intermediate cars for urban patrol. Some substitution of intermediate cars for small town and suburban patrol and minimal substitution for state and county patrol are also involved.

Alternative No. 2 is based on a maximum substitution of smaller cars, given present automobile technology and no significant change in police procedures. It is assumed that the heavy-duty components available in the larger car police package are also available for compact cars, thus permitting an even greater shift to compact cars for patrol and nonpatrol use than in Alternative No. 1. A greatly increased use of intermediate-size cars for state patrol use was also assumed. Because of the compact-car design changes involved and the effect of the procurement process on a major vehicle mix redistribution, it could take from 3 to 5 years to implement Alternative No. 2, as compared to 1 to 3 years for Alternative No. 1.

At best, it appears that the proportion of standard-size cars in the police fleet could be reduced to about half the current number of 155,000. The detailed breakdown by jurisdictional category from which this conclusion was reached is given in Table 7. Obviously, the alternatives shown in Figure 9 and Table 7 are estimates only and are intended to provide an initial perspective. Further examination and assessment is appropriate.

2. Accessories and optional equipment. A gallon of gasoline contains a fixed amount of energy. Through the combustion process in the automobile motor this energy is transformed, and a portion of it becomes

Table 7. Current Police Fleet Mix and Proposed Redistributions

Jurisdiction	Patrol			Other		
	Std, %	Inter, %	Compact, %	Std, %	Inter, %	Compact, %
Current						
State	96	4	-	70	25	5
County	65	35	-	50	40	10
Rural, small	90	10	-	80	10	10
Suburb, med	80	16	4	43	46	11
Urban, metro	71	28	1	51	38	11
Overall	77	22	1	56	34	10
Alternative No. 1						
State	90	10	-	60	30	10
County	60	40	-	40	40	20
Rural, small	70	30	-	20	60	20
Suburb, med	50	45	5	20	60	20
Urban, metro	30	65	5	10	40	50
Overall	63	36	1	32	45	23
Alternative No. 2						
State	50	50	-	20	50	30
County	50	40	10	20	50	30
Rural, small	50	40	10	10	40	50
Suburb, med	30	50	20	-	20	80
Urban, metro		30	70	-	20	80
Overall	43	42	15	12	24	64

available as mechanical work to drive the wheels and electrical power generating equipment. The overall efficiency of this energy transformation is no more than about 30% and depends upon the vehicle operating mode and speed. Accessories generally consume power and reduce the portion of energy in each gallon of gasoline available to the wheels. The result is a reduction in miles driven per gallon of gasoline consumed. Optional equipment can also be a source of reduced mileage, but certain options available can actually do the reverse and improve the mileage. Radial tires, for example, fall into this latter category. The impact of accessories and optional equipment on vehicle mileage is shown in Table 4. A discussion of each is presented in the paragraphs that follow.

a. Heavy-duty alternator. A heavy-duty alternator is required on a police car due to the extraordinary electrical load involved. The radios, lights, siren, and other special electrical devices impose a greater electrical requirement than can be met by the alternator ordinarily supplied. Little can be done to avoid this mileage reducing source.

b. Air conditioning and power steering. The need for air conditioning or power steering equipment is established by departmental policy toward personnel comfort and fatigue and vehicle-handling characteristics. Some air-conditioning systems operate the compressor continuously and mix warm air with the cooled air to achieve temperature control. Others control the compressor by thermostat, thus providing for intermittent operation and somewhat reduced fuel energy consumption.

Continuous air-conditioner operation introduces a fuel consumption mileage decrement of 2 mpg in urban driving. When turned off, the impact on fuel consumption is negligible. Disconnecting the compressor drive belt during the winter months is not recommended.

Power steering imposes a 0.7-mpg decrement in fuel consumption under urban driving conditions. If the car is equipped with power steering, its use cannot be avoided.

c. Radial tires. As indicated in Table 4, radial tires represent a means of raising fuel mileage. An improvement of 0.5 mpg can be anticipated. Unfortunately, due to their susceptability to sidewall breakage, their use on police vehicles is limited. Radial tires certified for high-speed use might be placed on highway patrol cars. However, due to a need for all-around toughness, a capability to withstand repeated curb bumping, and frequent off-road operation, general police use is not feasible.

d. Engine size. Engine size is one of the major options considered in specifying the "police package," and the average police car is equipped with a larger engine than the same vehicle would have in ordinary private use.

Theoretically, engine size and maximum horsepower capability do not control fuel economy. The engine merely meets the demand for power imposed on it. However, to develop more power takes more gasoline; with more power available, the acceleration rate is greater and the maximum speed higher. A larger engine does consume more fuel at idle, at low vehicle speeds, and to overcome internal friction, but these effects are small.

An additional factor that a larger engine introduces is vehicle weight growth. Not only does the engine weigh more, but its weight growth causes a concommittant growth in other vehicle components as well. The vehicle structure must be "beefed-up" to accept the added weight and a sturdier drive train (see the next section) may be required. The net result of this added weight is lower mileage per gallon of gasoline.

Federal emission standards also influence engine size and weight. As a result of meeting these standards, the horsepower capability of a given displacement engine is lower. Thus, to maintain the same delivered horsepower for a given size automobile, a larger displacement engine is required. The net result has been a heavier engine to which must also be added the weight of emission control accessory equipment. It should be noted that the accommodation of these emission standards has generally reduced the number of engine choices available for a specific size car. In fact, compression ratio options have been completely eliminated.

Short of reducing vehicle size and weight in order to reduce the required vehicle horsepower, little can be done to reduce fuel consumption.

e. Drive train. The drive train includes components involved in transferring the power delivered by the engine to the vehicle wheels. The transmission, rear axle differential gearing, and tire size are considered part of the drive train. These elements and the engine are matched to meet desired acceleration and speed characteristics. If performance requirements are not controlling, then changes that decrease engine rotational speed

for a given vehicle speed will, in general, improve mileage but reduce acceleration capability.

Use of an automatic transmission instead of a properly operated manual transmission lowers mileage 0.5 to 1.8 mpg, depending on the rear axle ratio and the type of driving (for example, 1.6 mpg in urban driving). However, consideration of driver fatigue and vehicle handling does favor the automatic transmission. Also, experience in the Los Angeles Police Department indicates that the manual transmission requires more maintenance.

A properly matched drive train that provides a balance between acceleration response and fuel consumption over a speed range is necessary, irrespective of transmission type. The optimum combination depends upon the type of driving involved, and is best determined by in-service testing.

f. Dual-exhaust system. With large V-8 automobile engines, some improvement in engine efficiency is possible by the use of a dual-exhaust system instead of the cheaper single-exhaust. The lowering of back pressure on the piston exhaust stroke achieved with the dual-exhaust system results in an increase in the net work output of the engine.

A dual-exhaust system is particularly advantageous for cars involved in extensive moderate-speed cruising. Under this condition, the potential benefit is estimated to be as much as a 10% improvement in mileage.

3. Driving cycle and patrol strategy. The duty to which police cars are assigned, the manner in which a car is deployed, and the operating procedures involved all influence fuel consumption. The duration of engine idling, intermittent stopping, cruising speed, trip length, and terrain all affect vehicle fuel consumption. These factors can be grouped under the general heading of either driving cycle or patrol strategy.

a. Driving cycle. Police patrol cars often spend an appreciable portion of their duty cycle parked but with the engine idling. As illustrated in Figure 10, the impact of idle time on mileage is quite significant. The data presented are for a 4450 lb, 1973 Chevrolet Impala. Also indicated is the portion of idle time (17.8%) involved in the urban driving cycle

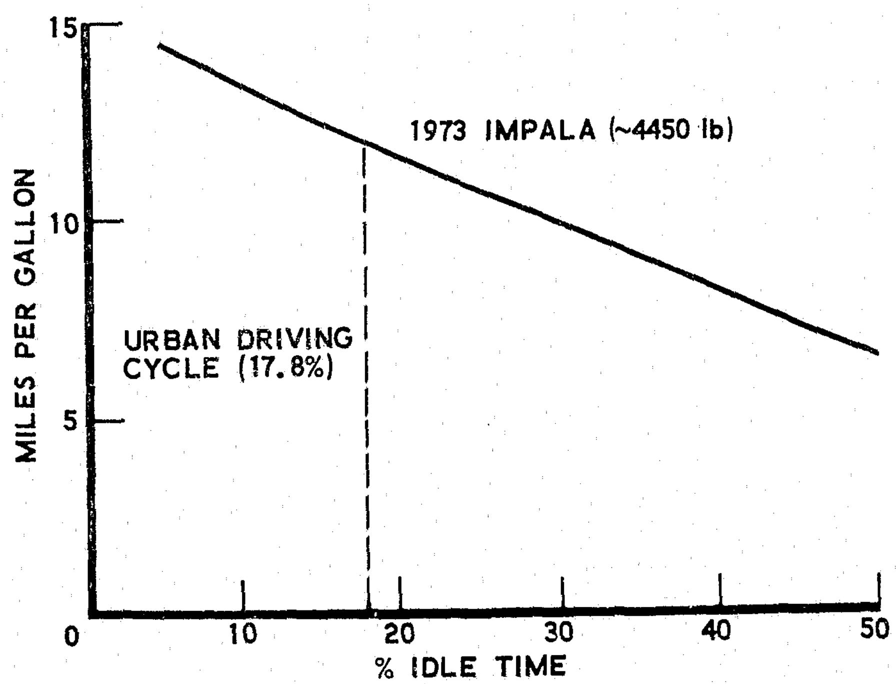

Figure 10. Effect of Idle Time on Mileage

used in Environmental Protection Agency mileage tests. Because patrol car idle times as high as 30% are not unusual, a total mileage reduction penalty of about 30% (relative to steady-state cruise) is imposed. City driving obviously requires some amount of engine idling at stop signs and in heavy traffic. However, if heater or air conditioner operation is not essential during parked observation or investigation, an improvement in fuel economy can be achieved by turning the engine off. (According to tests by the Los Angeles Police Department, a 401-cu in. engine consumes 1.25 gallons of fuel per hour at idle.)

During engine-off observation, power to operate needed equipment, such as radios, can be provided by the battery. However, battery drain should never be allowed to exceed one-third of its stored capacity, or difficulty might be encountered in starting the engine. A 60-ampere-hour battery could, for example, be allowed to support a 20-ampere load for about one hour. Use of a calibrated ammeter could aid in preventing excessive battery discharge.

The effect of steady-state cruise speed on fuel economy was presented in Figure 8 for typical luxury, intermediate, and subcompact vehicles, which represent the extreme range of passenger vehicle size. Peak mileage results at speeds between 35 to 40 mph. A mileage reduction in excess of 10% results for either the standard or intermediate size car if the speed is lowered to 25 mph or raised to 55 mph. From a fuel economy viewpoint, automobiles should be operated at conditions that give maximum efficiency, if at all possible.

Hilly, uneven terrain, trip length, and the extent of long, straight stretches of road all translate into an ability to maintain a constant cruise speed. Any deviation that requires frequent acceleration and deceleration causes increased fuel consumption and lower mileage. Little can be done to avoid this decrement.

b. Patrol strategy. There are a number of ways that patrol strategy could perhaps be altered to reduce the number of miles driven. They vary from simply parking in high visibility areas instead of continuous cruising to devising sophisticated simulation models for identifying optimum patrol strategy. This latter approach is intended to lead to a need for fewer patrol cars and reduced patrol mileage without sacrificing patrol effectiveness.

Although there have been efforts to improve patrol strategy in several cities, the results to date appear inconclusive. At present, there is no clearly definable approach for modifying patrol strategy that could assure no reduction in police effectiveness and simultaneously reduce fuel consumption. Pilot programs should be conducted to determine the practicality of suggested patrol strategy revisions and the fuel savings achieved would be proportional to the reduction in miles driven.

4. Driver technique. The driving habits of the individual driver can significantly effect automobile fuel consumption. The importance of reasonable acceleration and a steady gas pedal pressure have already been indicated in Table 4.

Experience of the Los Angeles Police Department is especially revealing. In 1972, the average mileage for a marked patrol car was 7.4 mpg

The mileage for an unmarked model of exactly the same car used by plain clothesmen was 10.7 mpg. Although there were some differences in the functions performed, the Los Angeles Police Department concluded that this large mileage difference may be attributed primarily to driver technique and the psychology of being in uniform and driving a marked car.

The effect of driver technique was further confirmed by an informal experiment conducted by the Los Angeles Police Department with an intermediate-size patrol car equipped with a 401-cu in. engine and driven over a 100-mile city test segment. The car was equipped with an intake manifold vacuum control device to maintain fixed acceleration levels. The acceleration level was constrained to three different conditions and the following results were obtained:

Vacuum Level, in.	Acceleration Level	Fuel Consumption, mpg
10	Mild	14.7
5	Normal traffic flow	12.5
~0	Maximum	8.5

The penalty for "flooring" the gas pedal to accelerate was a 30% mileage reduction. Except for emergency situations, this procedure should obviously be avoided.

A simple intake manifold vacuum gage is the first step in alerting drivers to this wasteful procedure. Somewhat more complex devices to provide gas pedal resistance to pulling high intake manifold vacuum levels or alerting the driver by a flashing light or buzzer to wasteful acceleration levels are already on the market. The Chrysler Corporation has, in fact, announced such a device as an available option for its late 1974 models.

A displayed vacuum gage is also useful in maintaining constant pedal pressure and attaining good fuel economy at cruise conditions. The effect of a varying cruise speed over a 5-mph range can, as shown in Table 4, reduce mileage by as much as 10%. Clearly, cruise speed should be maintained constant for good fuel mileage, but, in addition, the speed should also be close to the optimum value (see Figure 8).

"Coasting" in anticipation of a stop instead of maintaining speed and then braking hard can also help fuel economy. This and all the other techniques described can perhaps be best promulgated by some form of driver training program as well as a driver efficiency recognition award.

5. Effective maintenance. The frequency and effectiveness of periodic maintenance, including engine tuneups, have a significant impact on fuel economy (see Table 4). As a minimum, the tuneup should include the replacement of spark plugs, conventional breaker system points and condenser, and the adjustment of ignition timing, dwell, and idle speed. Additional items can include a check or replacement of the carburetor air filter, spark plug wiring, and a check and adjustment, if necessary, of the automatic choke operation and carburetor float level. Such periodic maintenance is generally performed at a frequency specified by the manufacturer or as shown by experience to be necessary for maintaining good vehicle performance.

Tire underinflation and front-wheel misalignment can each reduce fuel economy and should be checked periodically.

Police cars are generally maintained at near optimum levels. Whether or not a more intensive maintenance program could significantly improve fuel economy is uncertain and would have to be determined by initiating a pilot program.

6. Fuel-saving devices and adjustments. There are a number of commercially available devices that reportedly increase automobile fuel mileage. They include techniques to improve air and fuel mixing or mixture ratio, regulate fuel pressure, increase spark voltage, or to display intake manifold vacuum level ("mileage meter"). They can all be placed into either of two categories: (1) devices to improve the efficiency of the engine in converting available chemical energy to useful mechanical work, or (2) devices for aiding the driver to operate the vehicle in a more economical manner.

It is generally not obvious whether a device will offer improved fuel mileage, and a road test is usually necessary to assess any potential benefit. An out-of-service road test can be very misleading. In-service assessment is most reliable and is recommended. Of particular concern are the devices or adjustments that can effect vehicle emissions, especially the nitrogen oxides. For example, as pointed out in Section B, a reduction in the nitrogen oxide emissions of conventional internal combustion engines reduces their fuel economy. This is due to the approach currently being taken to control nitrogen oxide formation, namely, reducing combustion temperature, which, in turn, reduces the engine efficiency. Any devices or adjustments to increase combustion temperature as a means of improving fuel mileage would be unacceptable should there be a concomitant increase in nitrogen oxide emissions. It is essential that any evaluation of fuel-saving devices or adjustments include not only mileage but emission-level considerations as well.

One additional issue regarding evaluation of fuel-saving devices should be raised. As indicated in Section D4, driver technique can significantly influence fuel economy. Any evaluation and test of a proposed fuel-saving device must, therefore, be designed to eliminate driver bias.

Installation of an intake manifold vacuum gage appears to be a simple, inexpensive and effective approach to improved fuel economy. Its adoption is recommended. If other devices also prove to be significantly effective, their adoption should also be considered.

7. Estimate of potential benefits. The preceding discussions have identified numerous potentially effective measures for improving police fleet fuel economy. Some can be quickly achieved with the fleet as currently configured, whereas others are longer term and require some changes in the present fleet composition or vehicle configuration.

a. Feasible economies with current fleet. Means for quickly reducing fuel consumption of the existing police fleet fall into two general categories, operation and maintenance. Individual items in each category are listed below:

Operational Techniques	Maintenance Factors
• Engine idle time	• Engine tune up
• Patrol strategy	• Front-end alignment
• Driving habits	• Proper tire inflation

In general, a maximum potential benefit has been identified for each factor. However, to collectively add these maximum benefits is unrealistic and misleading. Similarly, to offer a quantitative estimate of possible national fuel saving is difficult, because the different jurisdictions involve dissimilar vehicle operating modes. Numerical examples for possible savings are as follows:

1. Gasoline Savings - A parametric estimate for the possible national fuel savings may be obtained from Figure 11. Based on the assumed mileage indicated in Table 8 and

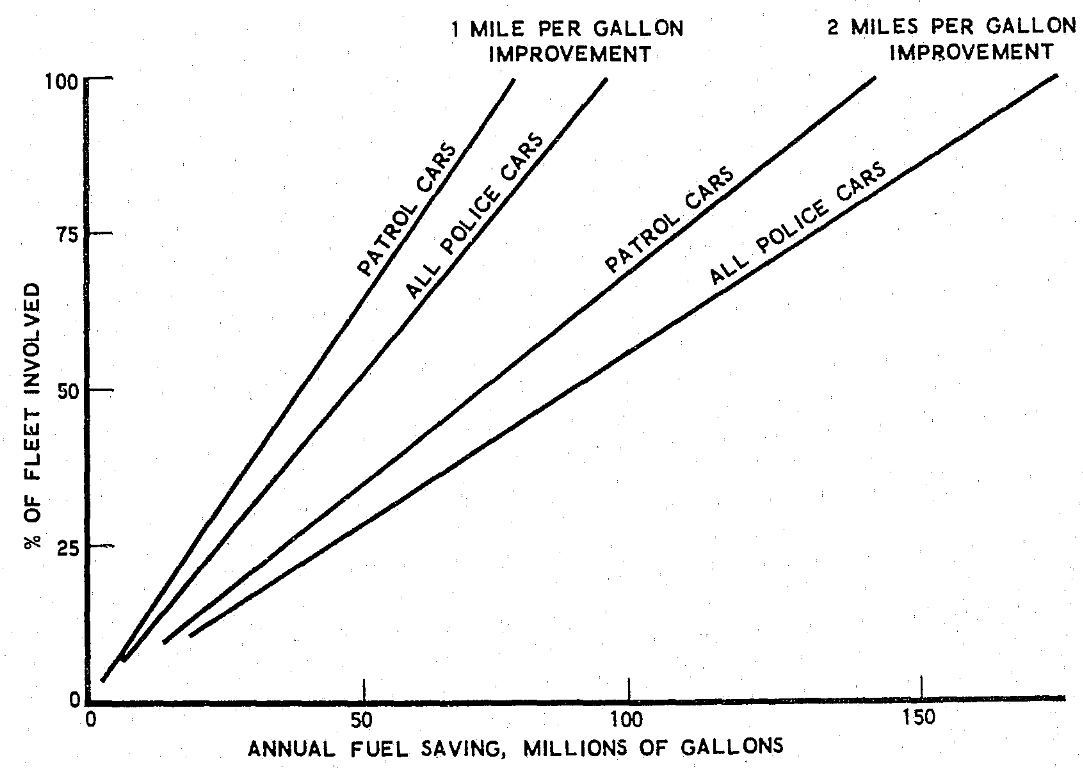

Figure 11. Effect of Improved Mileage on National Fuel Savings

Table 8. Estimated Average Police Fleet Mileage

Application	Miles Driven per Year	Miles per Gallon		
		Full Size	Intermediate	Compact
State				
Patrol	60,000	10	11	12
Nonpatrol	40,000	10	11	12
County				
Patrol	60,000	10	11	12
Nonpatrol	40,000	10	11	12
Rural/Small Town				
Patrol	50,000	10	11	12
Nonpatrol	30,000	10	11	12
Suburb/Medium				
Patrol	50,000	10	11	12
Nonpatrol	30,000	10	11	12
Urban/Metro				
Patrol	50,000	8	9	10
Nonpatrol	30,000	8	9	10

Note: The values in this table are intended for use as a basis for estimating potential gasoline savings (see Figs. 11 and 12) and do not necessarily represent actual mileage data.

the vehicle distribution presented in Table 2, parametric curves were calculated for both a 1- and 2-mpg mileage improvement as a function of the percent of the fleet involved. Results are presented for patrol vehicles only as well as for the entire police fleet.

This approach may be applied in estimating the incremental savings from a single factor as well as estimating the total savings

from collective factors. For example, if reducing the idle time offers a 2-mpg improvement in fuel mileage and the approach applies to 50% of the total national police fleet, the resulting fuel savings would be approximately 90 million gallons per year.

A second parametric trend in terms of the fuel savings possible by reducing police fleet annual mileage is shown in Figure 12. In this latter case, if the total annual mileage driven by the entire police fleet is reduced by 10%, then a savings in excess of 100 million gallons per year would result. This savings would provide enough fuel to drive 100,000 private cars in excess of 10,000 miles per year.

2. Motor Oil Savings - Reducing the total number of miles driven by the police fleet lowers motor oil consumption during operation and requires fewer oil changes as well. At an average police car mileage of 40,000 miles per year and an oil consumption rate of 7

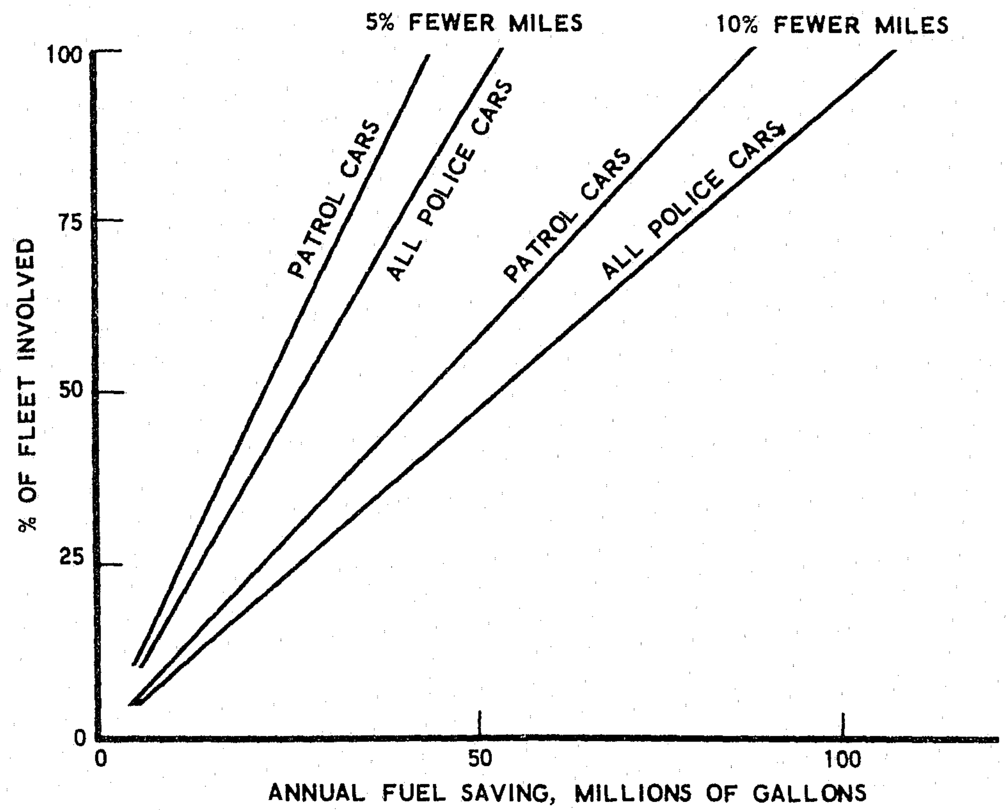

Figure 12. Effect of Reduced Miles Driven on National Fuel Savings

quarts every 4000 miles (primarily oil change), the total annual police fleet oil consumption is estimated as 3.8 million gallons. A 10% reduction in annual mileage could thus produce a 10% drop in oil consumption, or an estimated 380,000 gallons of oil per year.

b. Economies from fleet distribution changes. Fuel economies achieved by changing the fleet distribution result from reducing car size and weight as well as providing a more judicious selection of options and accessories. In general, this approach to fuel economy is, in itself, less effective than the several collective steps that could be taken with the existing fleet. Moreover, a complete police fleet changeover, including the time required for developing, testing, and delivering an acceptable compact-size car is estimated to take from 3 to 5 years.

1. Gasoline Savings - Two fleet mix alternatives were considered (see Figure 9 and Table 7). The annual fuel savings estimated for each (based upon the mileage values of Table 8) is as follows:

Alternative	Savings, gal/yr
No. 1	19.6 million
No. 2	57 million

Until revision of the fleet mix is entirely completed, these savings are obviously not achieved. (A linear distribution might be assumed during the change-over period.)

2. Motor Oil Savings - Assuming no change in either the total number of cars in the police

fleet or the total number of miles driven, any oil savings that might occur would result from either the reduced oil capacity of smaller car engines or their reduced consumption during operation. A smaller engine with fewer cylinders does contain and burn less oil. It is unlikely, however, that a significant number of 4 to 6 cylinder engines will find use in either Alternative No. 1 or No. 2. No major reduction in annual oil consumption can therefore be anticipated by merely changing the police fleet mix distribution. A concomitant reduction in the mileage driven would be required.

3. Materials Savings - The weight difference between a full-size and intermediate-size car is about 500 lb. Between a full-size and compact-size car, the weight difference is about 1000 lb. The material savings, particularly petroleum-based plastics as well as metal, and the energy saved in production of the material is expected to be significant if smaller size police cars are adopted. At an

annual procurement of 65,000 police cars, the total annual weight savings for fleet mix Alternatives No. 1 and No. 2 (see Figure 9) is estimated below:

Alternative	Weight Savings per Year, million lb
No. 1	4.7
No. 2	20

An estimate of the savings in production energy is not available.

c. Vehicle option economies. Prudent selection of vehicle options and accessories, including fuel-saving devices, can lead to appreciable fuel economies. Each individual item generally offers a small improvement and must be assessed separately.

The savings resulting from fuel economy measures varies with the extent to which they are applied. The incremental, as well as collective, benefit from these measures can be projected to the national level by use of Figure 11, as was done for operational and maintenance factors.

d. Summary. The maximum feasible reduction in police car fuel consumption is estimated as 40%. This reduction is an accumulation of benefits from several sources that are categorized into five contributing factors.

Contributing Factor	Reduction in Fuel Consumption, %
Driving techniques	11
Patrol operations	10
Optional equipment	9
Smaller cars (Alternative No. 2)	5
Improved maintenance	5
Total	40%

These estimates are based on the calculations presented in Appendix D. It should be noted that although this maximum savings is less than 0.4% of the total passenger car fuel consumption, the potential national benefit is very great, especially if the police become the pacesetter for means of reducing the fuel consumed by large automotive fleets.

E. Barriers to Small Car Use

The potential utility of smaller cars for meeting police needs is far greater than present police practice would indicate. However, conversion of a significant portion of the police fleet to smaller cars will undoubtedly be resisted in spite of its feasibility.

There are four general sources of resistance to the adoption of smaller police cars, namely, user attitude, inadequate dissemination of pertinent and available information, bias in the police vehicle procurement process, and the manufacturer-imposed limits on available candidate vehicles. Each of these issues is addressed in this section. Also treated in this section are strategies for improving the current attitude toward smaller cars.

1. User attitude. The survey conducted as part of this study confirmed that smaller-than-standard cars have already received limited user acceptance (see Table 7). Intermediate-size cars are now in use as patrol or traffic cars in nine of the cities sampled and as investigative or administrative vehicles in six additional cities. Moreover, police departments in six of the cities surveyed now use compact cars for some functions.

None of the state police forces surveyed (except Alabama*) presently use smaller-than-standard patrol cars. However, two states, Georgia and Washington, expressed a willingness to try smaller patrol cars. Three other states already use intermediate or compact-size cars for either traffic, investigative, or administrative functions.

The less recent but broader survey performed by the National Bureau of Standards (Reference 1) also examined police agency use of smaller cars. Based upon the data presented in Reference 1, it was estimated that 25.5% of the police fleet is composed of intermediate-size cars and 3% of compact-size cars (see Table 2).

*The Alabama State Highway Patrol is now phasing out AMC Javelins (a short wheel-base specialty car). These cars were found to have adequate acceleration and speed but are judged too small to satisfactorily transport prisoners. Also, driver fatigue is greater than with standard-size cars.

User attitude toward smaller cars is also discussed in Reference 1 and the results presented are summarized below:

Agency Type	Favorable, %	Unfavorable, %	No Comment, %
State	13	85	2
Metropolitan	28	72	-
Suburban	35	64	1
Rural	25	74	1

The greatest number of unfavorable responses came from state highway patrol agencies. This is not unexpected, for their high-speed patrol and pursuit requirement favors the larger, standard-size car. Nonhighway patrol duty in which state police agencies engage does include investigative and administrative functions, and it is primarily for use in these latter activities that a favorable attitude was expressed. The other agency types place less emphasis on the high-speed patrol and pursuit function and are, therefore, more amenable to use of smaller-than-standard size cars.

The police community's general attitude toward smaller cars has been consistently negative. The most frequent criticisms given have been summarized in Table 9. It is instructive to compare the validity of these observations with the findings of this study.

Comfort — A comparison of the interior space dimensions between standard, intermediate, and compact cars (see Tables 3 and 5) indicates that a significant portion of the

Table 9. Police Community Image of the Smaller Car

Factor	Critique
Comfort	Inadequate leg, head, shoulder room. Entrance/egress difficult. Bumpier ride and vibration, especially in pursuit. Excessive fatigue for a 8-hr shift.
Convenience/efficiency	Inadequate space for storage of equipment. Clearance of rear door inadequate for placement of prisoners. No space for installing panel between seats.
Dependability/maintenance	Inferior quality, cannot withstand police use. More down time, would impair response.
Economy	Savings in purchase and fuel costs offset by: increased maintenance and repair, shorter life, more down time, requires more units, incompatibility with auxiliary equipment, reduced trade-in value.
Compatibility with auxiliary gear	Insufficient size and power for transfer of gear. Inadequate electrical power. Impossible to install.
Performance	Poor acceleration, top speed too low. Inadequate braking.
Safety	Intractable at high speed. Inadequate braking for panic stops. Less safe for pursuit. Not competitive with the car population.

critique could well be psychological and not based on fact. Except for shoulder room and rear seat leg room, the difference between standard, intermediate, and compact-size cars is very small. For even two occupants, the front seat roominess is not significantly reduced. As indicated by Alabama State Highway Patrol experience, fatigue may be a problem with compact cars for extended high-speed patrol duty (a use not recommended by this study).

Convenience and Efficiency — The storage space in smaller cars for police equipment is believed to be adequate. Some redesign of the rear door may be appropriate to improve the entry of recalcitrant prisoners. Inserting a panel or screen between seats can crowd the rear seat area.

Dependability and Maintenance — No valid statistics have been found to support this critique. Existing comparisons were made between standard-size cars modified for heavy-duty police use and smaller cars without such modification. Appropriately modified and equipped, there is no reason to expect properly selected smaller cars to be less durable or less reliable.

Economy — In-service use of appropriately modified and equipped intermediate-size cars does not support the contention of an increased maintenance requirement, greater down time, and shorter life. There may be some incompatibility of compact cars and the auxiliary equipment currently in inventory. In the present environment, the depreciation of smaller cars (especially compact-size cars) is anticipated to be less than that of standard-size cars.

Compatibility with auxiliary gear — Intermediate-size cars, properly equipped with auxiliary gear are already in use. With compact-size cars, some repackaging may be required, but installation in some of the compact designs is believed feasible.

Performance — When equipped with heavy-duty brakes and an appropriately selected optional engine, the performance of intermediate-size cars can meet police use requirements, as well as the standard-size car. Similarly equipped compact-size cars are adequate for urban patrol.

Safety — Insurance statistics for private passenger cars indicate that smaller cars are more frequently involved in accidents than larger cars. Moreover, the chance of an injury to an occupant is greater than for a standard-size car. However, the smaller car population trend is rapidly increasing and experts anticipate improving safety for small-car users as they become a larger part of the total car mix and as manufacturers introduce new structural changes.

2. Limited information dissemination. The lack of adequate information flow between the police car user and the manufacturing source not only reduces the effectiveness of the procurement process (see C3)

but also severely limits the favorable consideration of smaller cars. Unless the potential user is provided with a clear understanding of the features and capability of available smaller cars, it is reasonable for him to continue acquiring the type of equipment with which he is familiar and experienced.

Catalogs and brochures on the "police package" and other options are available to prospective police purchasers. Unfortunately, purchaser and even the dealer's knowledge is generally limited to such published material. Other features available through the factory may not be widely publicized, thus restricting the acquisition of desired and available features. Such technical information exists at the factory and is provided upon direct request. But even though development of such special-purpose equipment is completed and the option is available, there is no incentive to widely disseminate knowledge of its existence.

It is unreasonable to conclude that this situation is intended by the manufacturer, as information dissemination is generally limited for standard-size cars as well. Moreover, the customer often does not meet his responsibility of realistically defining for the manufacturer those modifications to conventional production cars desired for improving their police utility.

3. Procurement process bias. The current police vehicle procurement process tends to discourage consideration of smaller cars. Instead of specifying needs and functional requirements that might allow competition

between standard and smaller cars, there is a tendency to deal in vehicle-specific terms. Moreover, the attitude of the participants in the procurement process, particularly their subjective view toward smaller cars, is especially significant in establishing the acceptability of smaller cars.

The patrol officer who uses the car has considerable influence on its selection, and his opinion cannot be ignored. However, he generally lacks technical knowledge of the relative merits of cars. Further, he has insufficient incentive to distinguish between a vehicle he wants and one that is just sufficient for his needs. He is frequently concerned about his public image and the lack of respect a small car might engender. The most ardent opponents of smaller cars are officers who feel that the capability for high-speed pursuit is of overriding importance. Others feel that larger cars are a deserved benefit of rank.

The administrative head of a police agency respects the opinions of his car-using officers and his fleet operating and maintenance personnel. His background is usually nontechnical, but his own knowledge and experience obviously affect his attitude. If budget is not a problem, the administrator has little incentive for considering smaller police cars.

Elected officials, such as the Mayor, have in principle the ultimate decision authority. However, the recommendation of the agency administrator is usually accepted. Elected officials generally avoid the political vulnerability that a public debate with the police administration would engender.

4. Manufacturer-imposed bias. Automobile manufacturers and their dealers impose a barrier to police use of smaller cars. Dealers prefer to sell full-size cars to police for the same reason they prefer to sell them to the general public – they are more profitable. Consequently, available alternatives to standard-size cars are not greatly emphasized. On the other hand, unless the manufacturer provides a durable smaller car with a "police package" and appropriate other options, police agencies are restricted to using larger cars. Until recently, automobile manufacturers offered a "police package" primarily on standard-size vehicles. One result of this product-restricting practice is that police-car users have largely accepted the currently manufactured standard-size vehicle as the basic police car.

From the manufacturer's point of view, it is clear that there is no large incentive to bear the risk of developing specialized police car features for smaller-size vehicles. Unless an aggregated police car market is developed, a major development expenditure cannot be justified.

As a group, automobile suppliers have not voluntarily discussed the utility of smaller cars with the police. Moreover, they have in the past discouraged the use of smaller cars through longer delivery schedules and frequently no cost savings.

5. Means for changing the attitude. There is, as a result of the existing energy crisis, a national trend toward smaller cars. This trend will undoubtedly also occur within the police community. A normal police

transition to smaller vehicles can be accepted, or if desired, this transition can be accelerated by providing encouragement at both the user and supplier levels. The steps involved to provide this encouragement can be identified, and how rapidly the smaller car adoption process is accelerated depends upon how many of these steps are implemented. A central focal point to identify and coordinate any accelerating activities would be required.

One of the more important steps involved in accelerating police agency use of smaller cars would be an activity to change existing small car bias. Any strategy on this issue should include as its objectives the following four items:

- Upgrading user knowledge
- Influencing the procurement process
- Increasing the market size
- Assuring compatibility with auxiliary equipment

a. Upgrading user knowledge. The process of upgrading user knowledge involves both improving the dissemination of available information, as well as providing technical assistance to those agencies who desire it. Specific action to achieve these objectives include the following:

1. Improving information dissemination
   a. Obtain complete information on available smaller cars.
   b. Conduct seminars and conferences on suitability of smaller cars for police use.

c. Document currently available experience with intermediate and compact cars by police agencies and recommend how to improve utility.

d. Prepare, disseminate, and maintain vehicle procurement specifications proven to be suitable for police operations.

2. Technical assistance

a. Conduct a study of the vehicle needs of rural, suburban, urban, and state police agencies.

b. Conduct tests in two phases of available candidates for use as smaller police cars. The first phase should involve assessment of performance and handling, and the second phase should involve field tests with representative user agencies.

c. Provide on-site technical support to agencies seeking assistance in defining their vehicle needs and preparing their vehicle procurement specifications.

d. Promote development of a strong technical capability on vehicle use and operation within the larger police jurisdictions.

e. Financially encourage the knowledgable larger agencies to provide technical assistance to their smaller neighboring police agencies.

b. Influencing the procurement process. Important steps can be taken to eliminate the bias in the procurement process and to encourage a more effective approach to the fragmented procurement by the smaller police jurisdictions:

1. Provide an effective public relations program for stressing smaller car suitability to both elected officials and the general public.
2. Encourage multi-jurisdictional purchasing procedures through a combined purchase order for similar (or identical) equipment.

c. Increasing the market size. Unless vehicle equipment that meets user requirements is available, little can be done to foster a broader adoption of smaller cars. The manufacturers have already provided some intermediate-size cars that meet police agency needs. However, little has been done to date to provide a compact car that can replace a significant number of either the standard or intermediate-size cars now in use. Clearly, the availability of candidate compact cars that satisfy police requirements must be improved. To achieve this end, manufacturers must be induced to recognize both the need and the market potential that smaller police cars represent. Action to achieve these objectives includes:

1. Identify deficiencies of currently available smaller vehicles and recommend changes and improvements to the manufacturers in order to broaden their acceptability and utility.
2. Provide incentives for the manufacturer (subsidies, tax, etc.) to improve the suitability of smaller cars for police agency use.
3. Aggregate the police car market to increase the size of individual purchase orders. The design and production of a special car for police agency use might be considered but would undoubtedly require a manufacturing subsidy similar to that involved in the procurement of military hardware.

d. Compatibility with auxiliary equipment. Auxiliary equipment installed in many police cars, such as radios, lights, sirens and public address speaker, as well as accident and other kits carried for emergency use, can outlast the life of the vehicle. In certain cases, it is economically necessary to transfer such equipment from the car being retired to the new car with which it is being replaced. It is obviously prudent to facilitate the

transfer of such auxiliary equipment to smaller cars if favorable consideration of smaller cars is desired. Appropriate steps include:

1. Technical assistance to individual jurisdictions for the adaptation of the existing auxiliary equipment inventory.
2. Subsidizing equipment replacement or modification where an incompatibility with smaller cars exists.
3. Sponsor development of modular small-car equipment packages.
4. Require that all equipment purchased or being developed with federal funds include smaller car compatibility considerations.

CHAPTER III. CONCLUSIONS

In general, the dissemination among police agencies of information on police vehicle performance, test evaluation, operating experience, and maintenance technique is very limited. Thus, a necessary prerequisite to any police agency fuel savings program such as might be derived from the findings of this study are an effective information exchange and a source for expert technical data.

Numerous specific conclusions were reached on the feasibility of and techniques for reducing police fuel consumption. They have been combined into three separate categories and are presented in the paragraphs that follow.

A. General

1. The total fuel consumption of the entire police agency fleet is about 1% of the nation's passenger car fuel consumption. Thus, any anticipated benefit by reducing police fuel consumption will be a very small part of the needed total reduction in petroleum energy consumption.
2. A fallout benefit, which could well exceed the direct police fuel saving, is the large saving that could result if other automobile operators were to adopt any steps demonstrated by police agencies as effective fuel-saving measures.
3. Short of reducing the total number of miles driven, there is no single step that can be readily taken to provide a significant saving in police vehicle petroleum consumption.

4. Several separate steps, each of which is feasible and contributes a small fuel saving, can be combined to provide a reduction in fuel consumption of up to 40%.

B. Use of Smaller Cars

1. The intermediate-size car is currently available with the durability and special provisions needed for police patrol use. It is estimated that intermediate-size cars have a potential application of nearly 40% of the national police fleet compared with the 25% that they currently represent.

2. Compact-size cars equipped with the necessary provisions for police patrol use are not currently available. Such cars have some nonpatrol use and currently represent 3% of the national police fleet. Properly modified and equipped, the compact-size car has a total potential application of nearly 30% of the national police fleet.

3. Although technically feasible, the full benefit from greater use of smaller police cars would not occur immediately. It could take 3 to 5 years for a turnover of the entire police fleet to smaller cars, assuming the availability of a compact-size car for police patrol use in 2 to 3 years.

4. The adoption of a smaller police car (an intermediate where a standard-size car is now used, or a compact to replace

currently deployed intermediates) would result in a 10% fuel saving per car.

5. Barriers to wider police use of smaller cars are introduced by the police vehicle procurement process itself as well as by the negative image of smaller vehicles held by participants in that process.

C. Other Fuel-Saving Procedures

1. <u>Driving techniques</u>. There are specific driving techniques that offer a direct means of lowering fuel consumption that are applicable to any size of car. Eliminating fast starts and maintaining a steady gas-pedal pressure can combine to improve fuel mileage as much as 20% in individual cases. By apportioning these techniques to those agencies and types of patrol to which each is applicable, it is estimated that a national police fuel savings of up to 11% is possible.

2. <u>Patrol operations</u>. Changing the driving cycle and the patrol strategy also offers a direct means of reducing fuel consumption. Imposing a 12% idle period during urban patrol reduces mileage up to 2 mpg, while lowering highway patrol cruise speed by 5 mph improves mileage by 1 mpg. Judicious planning of patrol deployment and strategy offers a means for reducing the total miles driven without necessarily compromising police services. Collectively, it is estimated these techniques could save up to 10% of the present fuel consumed.

3. Improved maintenance. Effective automobile maintenance that emphasizes the goal of fuel economy, as well as performance and service, is still another approach. A revision of some procedures and their frequency can yield an additional savings of up to 5%.

4. Optional equipment. The judicious selection of options available and restriction of unnecessary power-consuming accessories can lead to some fuel savings. These options and a minor reduction in use of power-consuming accessories are estimated to provide a potential fuel savings of up to 9%.

CHAPTER IV. RECOMMENDATIONS

There are numerous individual steps that will contribute to an effective police fuel conservation program. In all cases, these steps must be taken at the local operating level. It is, however, appropriate that the Law Enforcement Assistance Administration not only identify the means for reducing petroleum fuel consumption, but also disseminate the information and promulgate recommendations for implementation as well. A detailed plan, suggested for sponsorship by the Law Enforcement Assistance Administration and including schedules and estimated costs, is presented separately in Volume II.

In summary, it is recommended that the Law Enforcement Assistance Administration undertake steps necessary to:

1. Provide at the local police agency level an awareness of fuel-economy measures that can be immediately implemented with the existing vehicle fleet.
2. Foster an awareness of the utility and encourage the availability and adoption of the smaller police vehicles.
3. Provide technical assistance to evaluate local police vehicle requirements and to identify available automobile models that satisfy these needs.

The procedures for implementing these steps should include:

1. A driver training program that emphasizes fuel economy, as well as the capability of smaller cars.

2. A national test and evaluation center to assess the performance, safety, and handling characteristics of candidate patrol cars and to identify for manufacturer action required vehicle improvement.
3. Studies to establish police vehicle requirements, to define appropriate vehicle specifications, and to identify desired design changes in existing vehicles and equipment.
4. Establishment of a police vehicle information clearing house and dissemination center for dealing with technical inquiries concerning vehicle selection and for widely distributing pertinent operating and maintenance information as it becomes available through user experience.
5. Guidelines and training for maintenance personnel that emphasize fuel economy.
6. A public relations program to ensure an awareness of available methods for readily reducing auto fuel consumption both among the police community as well as among drivers of passenger cars.

REFERENCES

1. E. D. Bunten and P. A. Klaus, LEAA Police Equipment Survey, National Bureau of Standards Report 73216, Draft dated 9 July 1973.
2. Energy Statistics, Department of Transportation Report No. DOT-TSC-OST-73-34, September 1973.
3. G. R. Wynne, Police Transportation Management, Coda Publications, 1965.
4. Report on Police, National Advisory Commission on Criminal Justice Standards and Goals, 23 January 1973.
5. Automobile Fuel Economy, Motor Vehicle Manufacturers Association, 21 September 1973.
6. R. T. Ruegg, Police Vehicle Life Cycle Costing of Police Patrol Cars - Efficiency in Vehicle Acquisition, Operation, and Disposition, National Bureau of Standards, Draft dated October 1973.
7. S. Halpern, Patrol Vehicle Emission Control, The Mitre Corporation Problem Identification Report 2/053/2006/13/01/6/76, 16 July 1973.
8. Initial Results for 1973 Models Compared to 1972 Models, Highway Loss Data Institute, September 1973.
9. O'Day, Colomb, and Cooley, A Statistical Description of Large and Small Car Involvement in Accidents, HIT Lab.Report, Vols. 3 and 9, Univ. of Michigan, Highway Safety Research Institute, May 1973.

BIBLIOGRAPHY

A Report on Automobile Fuel Economy, Environmental Protection Agency, Washington, D.C., October 1973.

Autin, T. C., and K. H. Hellman, Passenger Car Fuel Economy – Trends and Influencing Factors, Paper No. 730790, Society of Automotive Engineers, Milwaukee, Wisconsin, 10-13 September 1973.

Huebner, G. J., and D. J. Gasser, Energy and the Automobile – General Factors Affecting Vehicle Fuel Consumption, Paper No. 730518, Society of Automotive Engineers, Inc., SP-383, July 1973.

Liston, L. L., and J. E. Ullman, Are We Running Out of Gas?, Department of Transportation Publication, 1973.

Ludwig, H. G., Study of the Police Patrol Vehicle, Wayne State University, 1970.

Ludwig, H. G., The Ownership of Police Vehicles, The Mitre Corporation, McClean, Virginia, Draft dated 16 November 1973.

Morton, Jan P., Police Automotive Fuel Survey, International Association of Chiefs of Police, July 1973.

Weight Trends of Passenger Vehicles, The Aerospace Corporation, El Segundo, California, to be published.

APPENDIX A. CONTACTS ESTABLISHED DURING STUDY

1. A. D. Little, Inc., Survey

   a. State Police Agencies

   Alabama
   Florida
   Georgia
   Illinois
   Massachusetts
   Missouri
   Pennsylvania
   Texas
   Virginia
   Washington

   b. County Police Agencies

   Charles County, Maryland
   Los Angeles County, California
   St. Louis County, Missouri

   c. Large City Police Departments

   Atlanta, Georgia
   Baltimore, Maryland
   Boston, Massachusetts
   Cincinnati, Ohio
   Columbus, Ohio
   Dallas, Texas
   El Paso, Texas
   Memphis, Tennessee
   Oklahoma City, Oklahoma
   Seattle, Wasington
   Tucson, Arizona
   Washington, D.C.

   d. Medium City Police Departments

   Des Moines, Iowa
   Durham, North Carolina
   Orlando, Florida
   Richmond, Virginia
   Salt Lake City, Utah

e. Small City Police Departments

Anniston, Alabama
Bradford, Pennsylvania
Jacksonville, North Carolina
Joplin, Missouri
Laramie, Wyoming
Paris, Texas
Winter Park, Florida

2. Other Contacts

a. State Police Agencies

Arizona
Arkansas
California
Colorado
Connecticut
Michigan
New Mexico
New York

b. County Police Agencies

Orange County, Florida
Cook County, Illinois
Prince Georges County, Maryland
Charles County, Maryland
Wayne County, Michigan
Arlington County, Virginia
Independence County, Missouri
Jackson County, Missouri
King County, Washington

c. City Police Departments

Austin, Texas
Arkadelphia, Arkansas
Bedford, Ohio
Charleston, South Carolina
Chicago, Illinois
Denver, Colorado
Detroit, Michigan
Fredericksburg, Virginia

Harrisburg, Pennsylvania
Hartford, Connecticut
Houston, Texas
Little Rock, Arkansas
Los Angeles, California
New Orleans, Louisiana
New York, New York
Philadelphia, Pennsylvania
Pocatello, Idaho
Portland, Oregon
Provo, Utah
San Francisco, California
St. Louis, Missouri
Wenatchee, Washington

d. Law Enforcement Planning Agencies

Maryland
Seattle
Michigan
Washington, D.C.
Connecticut
Arkansas
Little Rock
Texas

e. Federal Agencies

National Institute of Law Enforcement and Criminal Justice
National Bureau of Standards
National Highway Traffic Safety Administration

f. Associations

University City Science Center
Pennsylvania Science and Engineering Foundation
National Association of Fleet Administrators
National Conference of State Planning Agencies
National Institute of Governmental Purchasing
National Sheriffs' Association
International Association of Chiefs of Police
Insurance Institute for Highway Safety

g. Automobile Manufacturers

American Motors

Chrysler Corporation

Volkswagen

Ford Motor Company

General Motors Corporation

h. Research Experts

Mitre Corporation

Herbert G. Ludwig, Associate Professor, Wayne State University

M. Radnor, Professor, Northwestern University

R. Michaels, Associate Professor, Northwestern University

CONTINUED

1 OF 2

APPENDIX B. POLICE VEHICLE SAMPLE BROCHURE

1974 MONTEGO POLICE PACKAGE

(Package Content Subject To Change)

Model Availability: Montego and Montego MX Two Door Hardtop and Four Door Sedan
N/A on Station Wagons

Wheelbase: Four Door Sedan — 118 inch
Two Door Hardtop — 114 inch

	AVAILABILITY						
Engines:							
Displacement (CID)	(1) 250-1V	(1) 302-2V	351-2V	(1) 351-4V CJ	400-2V	460-4V	(1) (2) 460-4V P.I.
(3) Horsepower (SAE Net)							
(3) *Torque (lbs-ft) (SAE Net)*							
Compression Ratio	8.0:1	8.0:1	8.0:1	8.0:1	8.0:1	8.0:1	8.8:1
Fuel	Regular	Regular	Regular	Regular	Regular	Regular	Regular
Exhaust	Single	Single	Single	Dual	Single	Dual	Dual
Automatic transmission H.D.	Man Opt	RPO	Man Opt	Man Opt	Man Opt	Man Opt	Man Opt
Low Gear Lock Out (A.T. only)	RPO	RPO	RPO	RPO	RPO	RPO	RPO
Rear Axle Ratios - Lock & *Non-Locking*	3.00	3.00	(4) 3.25	3.25	(4) 3.25	(4) 3.25	3.00
Power Steering	Opt	(5) Opt	Man Opt	Man Opt	Man Opt	Man Opt	Man Opt
(5) Power Steering Oil Cooler	N/A	Std.	Std.	Std.	Std.	Std.	Std.
(7) Power Disc Brakes 11 inch *(H.D. organic)*	Std.	Std.	Std.	(6) LPO	Std.	(6) LPO	(6) LPO
(8) Power Disc Brakes H.D. 11 inch							
(Calif. Pack) Semi Metallic	N/A	N/A	N/A	Std.	LPO	Std.	Std.
Maximum Handling Package							
H.D. Front Springs	Std.	Std.	Std.	Std.	Std.	Std.	Std.
H.D. Rear Springs	Std.	Std.	Std.	Std.	Std.	Std.	Std.
Extra Control Shock Absorbers	Std.	Std.	Std.	Std.	Std.	Std.	Std.
Front Stabilizer Bar	Std.	Std.	Std.	Std.	Std.	Std.	Std.
H.D. Frame	Std.	Std.	Std.	Std.	Std.	Std.	Std.
No. 4 Body Mount	Std.	Std.	Std.	Std.	Std.	Std.	Std.
Rear Stabilizer Bar	Std.	Std.	Std.	Std.	Std.	Std.	Std.
Maximum Cooling Package							
Radiator Fan - Shroud	Std.	Std.	Std.	Std.	Std.	Std.	Std.
Coolant Recovery System	N/A	Std.	Std.	Std.	Std.	Std.	Std.
Parking Brake Warning Light	Std.	Std.	Std.	Std.	Std.	Std.	Std.
Alternator:							
70 Amp	Std.	Std.	Std.	Std.	Std.	Std.	N/A
90 Amp	N/A	Opt	Opt	Opt	Opt	Opt	Std.
Transistorized Voltage Regulator	Std.	Std.	Std.	Std.	Std.	Std.	Std.
Battery - 77 Amp	Std.	Std.	Std.	Std.	Std.	Std.	Std.
H.D. Seat:							
Front	Std.	Std.	Std.	Std.	Std.	Std.	Std.
Rear	Opt	Opt	Opt	Opt	Opt	Opt	Opt
Interior trim - Standard Passenger Car							
(Cloth or Vinyl)	Std.	Std.	Std.	Std.	Std.	Std.	Std.
High Series Sound Package	Std.	Std.	Std.	Std.	Std.	Std.	Std.
Speed O Meter (0 to 140 MPH - 2 MPH Inc.)	Std.	Std.	Std.	Std.	Std.	Std.	Std.
External Crankcase Oil Cooler	N/A	N/A	—	—	—	—	Std.
Interior Hood Latch Release	Std.	Std.	Std.	Std.	Std.	Std.	Std.
Battery Compartment Shield	N/A	N/A	DSO	(9) Std.	DSO	Std.	Std.
Solid State Ignition	N/A	N/A	(10) N/A	N/A	Std.	Std.	Std.
Wheels:							
15x6.5 Inch with 5 Inch Bolt Circle	Std.	Std.	Std.	Std.	Std.	Std.	Std.
Tires:							
G78x15 BSW *Belted* (Non Police)	Std.	Std.	N/A	N/A	N/A	N/A	N/A
G78x15 BSW 4 Ply Nylon Police	LPO	LPO	N/A	N/A	N/A	N/A	N/A
H78x15 BSW Belted (Non Police)	N/A	N/A	Std.	N/A	N/A	N/A	N/A
H78x15 BSW 4 Ply Nylon Police	N/A	N/A	LPO	Std.	Std.	Std.	Std.
HR70x15 BSW & WSW Radial (Non Steel)	N/A	N/A	LPO	LPO	LPO	LPO	LPO

(1) N/A in California
(2) Electric Fuel Pump in Gas Tank - Std.
(3) *Preliminary Ratings*
(4) 3.00 to 1 Rear Axle Mandatory in California
(5) Power Steering Man Opt with A/C (Cooler Std with all P.S.)
(6) *Available as a delete option in lieu of Semi Metallic*
(7) H.D. Organic Lining with Large Air Scoops & Police Booster
(8) H.D. Semi Metallic Lining with Large Air Scoops & Police Booster necessary to pass Los Angeles *Police Test*
(9) Battery *Heat Shield Std. on all* 460-4V - Std. on 351-4V CJ with A/C Only (Otherwise DSO)
(10) Standard California only

NOTE:
Air Conditioning N/A with 250 Engine
H.D. Rubber Floor Mats optional at Extra Cost
Carpets Std. on Montego *and Montego MX*

RPO — Regular Production Option
Man Opt — Required Mandatory Option
Std. — Standard - Included in Package
Opt — Option
LPO — Limited Production Option
DSO — *Special Order*
N/A — Not Available

1974 MERCURY POLICE PACKAGE

(Package Content Subject To Change)

Model Availability: Monterey, Monterey Custom, Marquis Two Door Hardtop and Four Door Sedan and Monterey, Marquis Station Wagon

	AVAILABILITY		
	(1) 400-2V	460-4V	(2) 460-4V P.I.
Engines:			
Displacement (CID)			
(3) Horsepower @ RPM (SAE Net)			
(3) Torque (lbs-ft) @ RPM (SAE Net)			
Compression Ratio	8.0:1	8.0:1	8.8:1
Fuel	Regular	Regular	Regular
Exhaust	Single	Single	Dual
Automatic Transmission (H.D. 460- P.I. only)	Std.	Std.	Std.
Rear Axle Ratios (Locking & Non Locking)	(4) 3.25	(4) 3.25	3.00
Alternator 90 Amp W/WO A.C.	Std.	Std.	Std.
Transistorized Voltage Regulator & Solid State Ignition	Std.	Std.	Std.
Battery 80 Amp	Std.	Std.	Std.
Brakes:			
Power Disc (H.D. Organic)	Std.	(5) LPO	(5) LPO
Power Disc - H.D. Calif. Package (Semi Metallic)	DSO	Std.	Std.
Maximum Handling Package			
Extra H.D. Front Springs	Std.	Std.	Std.
Extra H.D. Rear Springs	Std.	Std.	Std.
H.D. Front & Rear Shock Absorbers	Std.	Std.	Std.
H.D. Front & Rear Stabilizer Bar	Std.	Std.	Std.
H.D. Rear track Bar & Upper Arm Bushings	Std.	Std.	Std.
H.D. Front Strut Bushings	Std.	Std.	Std.
H.D. Front Upper Suspension Arm Bushings	Std.	Std.	Std.
H.D. Front Spindles	Std.	Std.	Std.
H.D. Frame	Std.	Std.	Std.
Automatic Parking Brake Release	Std.	Std.	Std.
Speed O Meter 0 to 140 MPH (2 MPH Increments)	Std.	Std.	Std.
Maximum Cooling Package: (7 Blade Flex Fan - Extra Cap. Radiator - Shroud)	Std.	Std.	Std.
(6) Front Seat H.D.	Std.	Std.	Std.
Interior Hood Latch Release	Std.	Std.	Std.
Remote Electric Deck Lid Release	Std.	Std.	Std.
Power Steering With Oil Cooler	Std.	Std.	Std.
(7) Battery Compartment Shield	(7) Std.	Std.	Std.
Closed Coolant Recovery System	Std.	Std.	Std.
Single Key Locking System	Std.	Std.	Std.
Engine Crankcase Oil Cooler (External)	—	—	Std.
Low Gear Lock Out (Auto trans)	LPO	LPO	LPO
H.D. Flasher Unit	Std.	Std.	Std.
Wheels (H.D. 15x6.5 Inch)	Std.	Std.	Std.
Tires:			
J78x15 BSW 4 Ply Police Nylon (Bias Ply)	Std.	Std.	Std.
JR78x15 BSW Police Radial (Non Steel)	LPO	LPO	LPO
JR70x15 BSW & WSW Police Radial (Non Steel)	LPO	LPO	LPO
LR78x15 BSW - 8 Pass. Station Wagon	Std.	Std.	N/A
J78x15 BSW - 6 Pass. Station Wagon	Std.	Std.	N/A

(1) N/A on Marquis
(2) Electric Fuel Pump in tank - 460 P.I. N/A on Marquis and Station Wagons - N/A in California
(3) Preliminary Ratings
(4) 3.00 to 1 Rear Axle Mandatory in California
(5) Available as a delete option in lieu of Semi Metallic Lining
(6) H.D. Seat N/A on Marquis
(7) Battery Heat Shield Std. on 460 and 460 P.I. W/WO A.C. - Std. on 400 with A.C.

Wheelbase: Sedans 124 Inch
Wagons 121 Inch

NOTE:
Monterey Custom Sound Package Standard on all Montereys
Heavy Duty Rubber Floor Mats Optional at Extra Cost

Std. — Included in Package
N/A — Not Available
LPO — Limited Production Option
DSO — Special Order

SPECIAL EQUIPMENT OPTIONS

Outlined below is a list of some of the equipment that may be available on a special order basis. Because of engineering and procurement lead time, firm delivery dates cannot be quoted without prior approval of the Special Order Section of the General Sales Office.

- Spotlights
- Single Key Locking System
- Radio Shielding
- Load Levelers
- Special Paint
- Hand Throttle Control
- Engine Block Heater
- Ammeter
- Oil Pressure Gauge
- Water Temperature Gauge
- Roof Lights
- Additional Dome Light
- Roof Wiring
- Roof Reinforcement
- Radio Antenna Cable
- Radio Wiring Conduit
- Radio Speaker
- Electric Deck Lid Opener
- Manual Deck Lid Opener
- Tinted Windshield
- Siren Mounting Platform
- Siren & Roof Light Wiring and Switches
- Vascar Split Cable
- Pull Cord for Routing Radio Antenna
- Sirens
- Zippered Headliner
- Magnetic Drain Plugs
- H.D. Rear Seat
- H.D. Floor Mats

TIRE AVAILABILITY

Because of the many makes, sizes and types of tires available in the tire industry it is not possible for the Lincoln-Mercury Division to list every tire approved or not approved for Law Enforcement use. Customers frequently request specific tires by size, make and type. Dealers should not commit to availability and prices on these requests until the local District Sales Office has confirmed by wire or telephone firm prices and availability dates. Information should be secured by forwarding an inquiry by wire to the Special Order Section, Lincoln-Mercury Division, Dearborn. Prices and availability on specific tires should not be quoted without prior approval of the Special Order Section or Leasing and Fleet Sales Department.

The above are some of the items which are frequently requested. Other items may be available. To determine availability and pricing, a special inquiry on each item desired must be forwarded through the District Sales Office, Special Order Section. Dealers and District Sales Offices cannot quote prices and delivery dates on Special Order items without confirmation of the Special Order Section.

All vehicles are designed and engineered to meet the Federal Motor Vehicle Safety Standards. Therefore requests for modifications which involve the basic vehicle, safety systems and lighting cannot be accomplished by the manufacturer or dealer.

Lincoln-Mercury Division
Leasing and Fleet Sales Department
3000 Schaefer Road
Dearborn, Michigan 48121

Telephone: 313/322-6182

APPENDIX C. SMALL CAR SAFETY

The issue of occupant safety with small cars necessarily involves the use that such cars are given as well as their design and human factors considerations. Although smaller-than-standard size cars can be equipped with sufficient power to permit operation at the same acceleration and top speed levels as standard cars, the absolute level of performance desired is a matter of departmental policy. Police strategies that do not expose the driver to the dangers of very high speed chase may be utilized, or alternatively, the functions for which cars are used may be established by their size.

Among the elements involved in assessing vehicle safety are such items as crash deceleration levels, occupant compartment size, occupant restraint systems, side rail and roof supports, maneuverability, and stopping distance. Some of these considerations favor the large standard-size car, whereas others favor a small car. Operational experience is probably the best way of quantitatively assessing their influence on and difference with car size.

A summary of accident data obtained from several police agencies is given in Table C-1. The lowest accident rate was reported by a metropolitan police agency using intermediate-size cars (Los Angeles). It should be noted that car size is not the sole factor that involves fleet miles driven per accident. Operating conditions such as traffic density, number of intersections per mile

Table C-1. Examples of Police Agency Accident Experience

Department	Number of Cars	Total Miles	Accidents	Miles per Accident
State				
New York	1620	28 M	209	134,000
California	2313	118 M	689	172,000
New Jersey	1025	195 M	216	90,000
Metropolitan				
Philadelphia	1366	29 M	1199	24,000
Kansas City	355	11 M	480	23,000
Los Angeles[a]	1960	29 M	727	39,000

[a]Intermediate-size cars, all other full-size.

travelled, defensive driving habits, and extent of driver training are also contributing factors. A more complete analysis of the data is recommended before any conclusion concerning the relation between police car size and accident frequency is reached.

Accident information on nonpolice passenger vehicles, Table C-2, shows an opposite trend. There is a distinct increase in accident claims per 100 automobiles between standard-size cars and intermediate and compact-size cars. There is another significant increase with subcompact-size cars. Some experts explain the increase in accident rate as car size is reduced by the young average age of the driver of such cars and the use that such cars are given. Additional analysis of such nonpolice accident data is also recommended.

Table C-2. Passenger Car Accident Data[a]

Subcompact	Rate[b]	Compact	Rate[b]
Pinto station wagon	10.9	Dart	7.8
Volkswagen	11.2	Valiant	10.7
Pinto	12.3	Nova	8.9
Gremlin	12.6	Hornet	10.7
Vega	12.6	Maverick 2 dr	12.2
Average	11.9	Average	10.1
Intermediate		**Full Size**	
Century	8.4	Catalina	7.7
Monte Carlo	10.7	Caprice	7.4
Chevelle	9.5	Impala	8.4
Torino	11.8	Delta 88	7.4
Cutlass	9.9	Ford LTD	9.4
Average	10.0	Average	8.1

[a]From Reference 8.

[b]Rate is expressed in claims per 100 insured vehicle years.

An evaluation of the risk of injury to occupants of small cars is reported in Reference 9. It was concluded that injuries are more likely with small cars. Once involved in an accident, the chance of injury to the occupants of the car increased about 2.5% for each decrease of 100 lb in car weight. In head-on collisions, for example, injury occurred to small car occupants about 44% of the time in small-to-small or small-to-large car accidents. On the other

hand, injury in similar collisions occurred to large car occupants only about 35% of the time for large-to-large or large-to-small car accidents. Information on the degree of injury was not available. These data include few post-1970 small American cars and define a small car as weighing 3100 lb or less. An analysis of more recent injury data is also recommended.

APPENDIX D. CALCULATION OF ACCUMULATED BENEFITS

The following methods and assumptions were used in calculating the estimated maximum fuel savings that could be achieved by means of each of the methods identified in Chapter II, Section D7.

1. Driving Techniques

The conditions under which improved driving techniques can be employed are related to the type of agency patrol. It was rationalized that the avoidance of fast starts was applicable to all urban agencies, that the maintenance of a steady cruise speed was applicable to all state agencies, and that although both are applicable to rural/county agencies, the latter is the major source of a potential fuel saving. The benefits obtained from each technique have been discussed in Chapter II, Section D7 (see Table 4). By using an average of 10 mpg and the information from Table 4, a percentage improvement in fuel economy was derived. In order to estimate the national savings, this value must be weighted by the percentage of the national fleet to which it applies. These weighting factors were derived from the information given in Table 2. The total national savings determined in this manner are given in Table D-1.

Table D-1. Gas Savings from Driving Techniques

Technique	Type of Agency	Improved Fuel Economy, %	Total Fleet, %	Savings, %
Slow start	Urban	20	10	2
Steady cruise	State	10	20	2
Both	Rural/county	10	70	7
			Total	11%

2. Patrol Operations

A large part of many patrols are spent in "joy riding" to maintain police visibility. It is also not uncommon to spend considerable time, approximately 12% (about 1 hour per 8-hour shift) at engine idle. It is believed that both practices can be changed significantly without affecting the goals or services of patrol. Perhaps of most importance is the lack of any guidelines being provided to patrol officers for improving the efficiency of their beat coverage. An accurate estimate of the degree of improvement that can be achieved can only be provided by further study and simulation of patrol strategies and operations, as has been recommended in this report. However, based on agencies contacted in the survey conducted for this study and on available literature on patrol administration, it is estimated that savings of from 10 to 30% could be obtained. For example, if idle time were reduced by half for 40% of the fleet, i.e., urban and suburban, a national fuel savings of 4% would result. Combining this value with a conservatively estimated reduction in patrol mileage of 6% yields a total fuel saving of 10%.

3. Optional Equipment

The estimate for savings in this category used the same rationale developed above for that of driver techniques. The benefits from the allocation of dual exhausts to the national fleet are shown in Table D-2. This technique is not useful for urban, slower speed driving. Thus, it is assumed that this equipment is installed on 50% of the state, rural, and county agency cars. The resultant national fuel saving is 4.5%. It is estimated that the same amount could result from the use of a cooling system clutch-fan (or similar device). Such a device reduces the power used for fan operation when maximum cooling is not required. Further, minor adjustments in the use of power-consuming accessories such as air conditioning would yield additional small savings. The collective savings for optional equipment are estimated to be 9%.

Table D-2. Savings from the Use of Dual Exhausts

Type of Agency	Improved Fuel Economy, %	Total Fleet, %	Modified, %	Savings, %
State	10	20	50	1
County	10	70	50	3.5
			Total	4.5%

4. Improved Maintenance

It is difficult to estimate the benefit that could be obtained by this means because the quality of the present agency maintenance procedures on a national scale is unknown. It is reasonable to assume that not all are excellent, and that there is room for improvement. Further, the prime goal of present procedures is performance rather than economy. For purposes of this study, it is estimated that a fuel savings of up to 5% could be achieved.

END