Prepared for:

THE AEROSPACE CORPORATION

Alternate Police Patrol Car
Body Design

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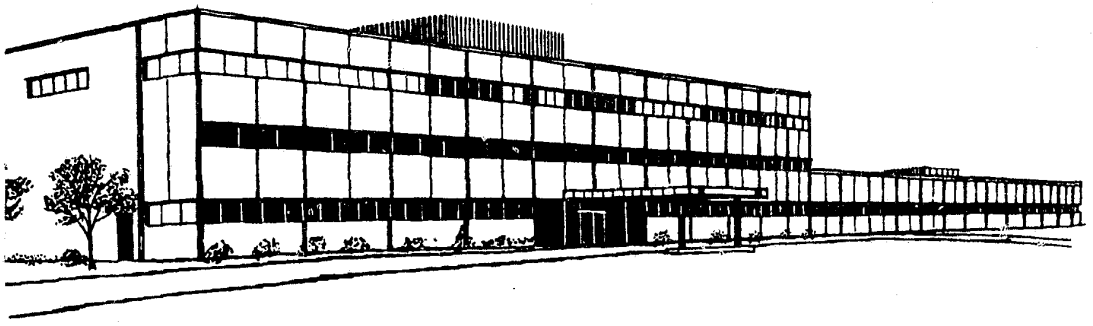

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ALTERNATE POLICE PATROL CAR BODY DESIGN

for

The Aerospace Corporation
P.O. Box 92957
Los Angeles, California 90009

Contract No. J-LEAA-025-73
Subcontract No. 44373

by

Pioneer Engineering & Manufacturing Co.
2500 E. Nine Mile Road
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February 3, 1976

This project was supported by Contract J-LEAA-025-73 awarded by the Law Enforcement Assistance Administration - U.S. Department of Justice under the Omnibus Crime Control & Safe Streets Act of 1968, as amended.

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PREFACE

The Law Enforcement Assistance Administration was established June 19, 1968, by the Omnibus Crime Control and Safe Streets Act of 1968 as amended by the Crime Control Act of 1973. Its purpose is to assist state and local governments to reduce crime. "Law enforcement" as defined in the Act encompasses all activities pertaining to crime prevention or reduction and the enforcement of the criminal law.

The agency's programs are administered by four offices. The research and development and technical assistance activities are operated by the National Institute of Law Enforcement and Criminal Justice. The Institute makes grants to public agencies, colleges and universities, and private organizations to encourage research and development to improve and strengthen law enforcement. These grants are to conduct projects which will develop new approaches, systems, techniques, and equipment in the criminal justice field.

The effort covered by this particular project is intended to result in a preliminary design concept for an alternate patrol car body configuration that provides significant weight reduction potential, while enhancing human and equipment interfaces functionally. The developed concept to reflect what could realistically be provided by the automotive industry at relatively low-volume production and competitively priced with current police car models in use.


POLICE

EXECUTIVE SUMMARY

This project was undertaken to provide a vehicle for urban police use which would provide significant improvements in fuel economy vs. the commonly used full-sized cars, and would also provide meaningful improvements in body layout and space utilization which would contribute to the comfort and operating effectiveness of police personnel.

Project activity was undertaken in five phases:

I. Establishment of Significant Characteristics

This phase consisted of the establishment of those body characteristics which are significant to the comfort and operating effectiveness of police personnel. Background information was obtained from the LEAA Police Equipment Survey - Patrol Cars,* and from personal contact with police departments, in particular the test and evaluation program conducted by the Los Angeles County Sheriff's Department.

Based on the foregoing sources of information, the following significant body characteristics were established:

- Seating comfort for driver and partner.
- Ease of front seat entrance and egress.
- Operating convenience and accessibility of controls and equipment.
- Ease of entrance and egress and room in rear compartment.
- Rearward vision.

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* See Bibliography 1

II. Specifications for Significant Characteristics

The second phase of this project involved analysis of those characteristics established as significant and selection of dimensions, or other specifications, to define them for an optimum body design for a police patrol car. Recommended values were then established for all dimensions. The most important dimensions were:

- Head room and leg room.
- Shoulder and hip room.
- Door opening angle and seat to door clearance.
- Front to rear seat distance.

It was established that individual front seats should be specified both for optimum driver/partner comfort and to provide necessary space between seats for convenient and accessible location of communications equipment.

Project guidelines specified the need for accommodating only two passengers in the rear seat and that this seat was to be considered primarily for the transport of prisoners. On this basis, comfort was not considered important and the rear seat design could be modified to provide for increased rear compartment room.

It is also recommended that the typical rear slope of the rear door opening above the belt line be straightened up to provide better head clearance when entering or leaving the vehicle.

III. Selection of Body Configuration

Several possibilities for the basic vehicle layout were analyzed to establish the optimum configuration for this vehicle. Principal ones considered were:

- Conventional 4-door sedan.
- Conventional 4-door station wagon.
- Conventional front seat with rear facing second seat.
- Conventional front seat with side facing second seat.

The 4-door sedan was selected because it has inherent weight and handling advantages vs. a station wagon. Police personnel also prefer the concealment plus ready access of equipment in a trunk to that of a wagon rear compartment. Rear and side facing second seats were rejected because of difficulty of entrance and egress particularly for a handcuffed prisoner.

IV. Selection of Basic Design Approach

The previously established characteristics and vehicle layout could be achieved in several ways. Modification of a production vehicle was selected as the only approach which could meet the guidelines of cost competitive with current police cars and availability in 1977. Selection of either a new and unique design vehicle or a completely new body on an existing chassis would not only be beyond the cost and timing guidelines, but would also involve extensive development activity to insure that the resultant design would perform to the rigorous requirements of police use.

Because of the weight saving potential, use of a compact car was preferred if acceptable performance and recommended interior dimensions could be achieved. Two compact sedans (Chevrolet Nova and Dodge Dart) demonstrated acceptable performance for a police vehicle in the Los Angeles County Sheriff's tests. Front compartment dimensions were found to be close to those of full-size sedans and modifications to the rear compartment to provide optimum dimensions were feasible. Modifications were:

- Raising and squaring off rear roof line.
- Moving rear seat back (thinner back cushion) and shortening seat cushion.
- Squaring off of rear door upper to match roof line thus increasing door opening width above belt line.

V. Design of Recommended Vehicle

Based on the previously established specifications and ground rules, a design program was conducted to define the recommended vehicle. The specific modifications to the base vehicle (a compact 4-door sedan) are:

- Replace the rear portion of the roof (aft of the center pillar) with a raised and squared off design. The new roof section is plastic to reduce weight and minimize tooling cost.
- Replace the rear window with plastic for weight saving.
- Replace the rear door window and upper door frame to provide squared off and wider opening above belt line for improved entrance and egress. The window is plastic and fixed to further reduce weight.
- Replace the rear seat with a new design providing a 2.4" rearward seating position for optimum leg room. The rearward position is achieved by using a thinner seat back cushion and raising and squaring off the roof line. The rear seat is also limited to two seating positions (no seat over tunnel). The seat cushion is also shortened and trimmed on the corners to provide additional space between seats and improve entrance and egress conditions.
- New individual front seats are recommended for optimum comfort and to provide for installation of the specified communications equipment between seats.
- A new hood and integral grille of plastic for weight reduction.
- A new rear deck lid of plastic for weight reduction. Lid also is raised for added room in trunk and to be more visible for guidance in backing the vehicle.
- New front and rear bumpers (aluminum face bars) and energy absorber units to reduce weight.

Provision was made for convenient and accessible location for all the special communications equipment specified. Those requiring access or operation by driver or partner are located in the front compartment with the remaining items mounted in the trunk. A protective shield between front and rear compartments was also provided as requested by many police departments.

The design was reviewed in relation to all current and anticipated (1977) FMVSS requirements and judged to comply.

The design also provides for all significant features and most equipment storage provisions requested in the LEAA Survey of police car use.

Significant specifications of the design are:

Estimated Weight	- 3,325 lbs.
Weight saving vs. typical compact car	- 225 lbs.
Weight saving vs. typical full-size car	- 1,317 lbs.
Estimated fuel economy improvement vs. full-size car	- 36 %
Net saving per car vs. full-size car (2 year - 70,000 mi. life)	- $1,472

Approximate dimensions -

Wheelbase	-	112"
Length	-	196"
Width	-	72"
Height	-	57"

Estimated program costs -

Prototype (4 cars)	- Approximately	$300,000
Production	-	$1,000,000 plus

CONCLUSIONS AND RECOMMENDATIONS

On the basis of the results of this project, it is concluded that it is feasible to modify a compact size 4-door sedan to provide significant improvements in fuel economy without sacrifice of police performance. Furthermore, the interior dimensions of the modified vehicle provide front compartment dimensions equal or superior to current full-size cars and rear compartment dimensions superior to full-size cars. The result is improved comfort and operating effectiveness for police personnel.

It is therefore recommended that a prototype design, build, and development program be initiated to evaluate the operational effectiveness of this design. A minimum of four prototype cars should be scheduled to provide for concurrent evaluation by different size police departments in various sections of the country. One of the cars should also be assigned to the base vehicle manufacturer or an independent agency such as the Transportation Research Center of Ohio, for development and endurance testing. Upon successful completion of the evaluation and testing activity a production design and build program should be established.

It is also recommended that concurrent programs of driver training and vehicle maintenance should be established to insure maximum benefit from the program to improve the police patrol car system.

ALTERNATE POLICE PATROL CAR BODY DESIGN

This project was initiated by The Aerospace Corporation under an on-going program to improve the police patrol car system. The program is one of several devoted to equipment systems improvement for law enforcement agencies contracted by the Law Enforcement Assistance Administration of the United States Department of Justice. A Statement of Work for this project, prepared by The Aerospace Corporation, is included in this report (see Appendix A). Also included in Appendix A is a list of "Suggested Ground Rules for Alternate Body Configuration Study" as provided by Aerospace.

I. Establishment of Significant Characteristics

The initial phase of this project consisted of the establishment of those body characteristics which are significant to the comfort and operating effectiveness of police personnel. Basic information on police patrol cars was obtained from the LEAA Police Equipment Survey - Patrol Cars.* This report provides a great deal of pertinent information applicable to the specifications of an optimum vehicle for police patrol use. The survey information was obtained in the form of answers to twenty questions covering patrol car use, equipment, features, etc.

Of particular interest in this first phase is Question 15 - "Which of the following features do you think should be on all of your patrol cars?" Table I lists those features from Question 15 which would pertain to the basic body design and column 1 indicates the percentage of all types of departments which voted affirmatively for those particular features (from Table 15-1, p. B-23 of Survey).* While the report shows some variation between department types (size and whether state, county, or city), the differences were not considered significant as far as general guidelines are concerned.

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* See Bibliography Item I

TABLE I

PATROL CAR FEATURES EFFECTING BODY DESIGN

Feature	% Total - "It Should Be On All Patrol Cars"	% Total - "It is One of Three Most Important"
Additional Head Room	63%	14%
Additional Leg Room	44%	5%
360° Mirror	63%	6%

Of more significance is the ranking of these features in answer to Question 15A - "Which three of the above features (items checked in Question 15) would be most important to have in all your patrol cars?" The second column in Table I shows the rather low ranking of most of the basic body design related features.

Consideration will be given to the other features included in Question 15, as well as other questions and answers which were considered to be of interest to this project in a later section of this report (Part V, Design of Recommended Vehicle, Section F).

In addition to the foregoing survey information, it was deemed desirable to have some degree of personal contact with police departments in order to gain further insight into those factors primarily affecting body design. The time frame and budget of this project limited the contact to a few agencies, but some extremely valuable insights into patrol car operating procedures and human factors aspects of patrol car design were obtained. The agencies and personnel contacted are listed in Appendix B. Contact with the Los Angeles County Sheriff's Department was particularly significant because:

- They conduct the only known comprehensive and technically oriented patrol car testing and evaluation program in the United States.

- Results of their tests, or their selection of a patrol car based on these tests, are used as a basis for patrol car selection by a large number of police departments in all parts of the county.*

A summary of the Los Angeles County test procedure is included in Appendix B. Of particular importance to this project are the Ergonomics (Human Factors) and Communications evaluations. The timing of the Los Angeles contact was such that tests of three vehicles (Chevrolet Nova - Dodge Dart - Plymouth Fury) for the 1976 purchase were in process and the Sheriff's Department was extremely cooperative in allowing observation of the tests. They also conducted a special human factors evaluation of the Nova for the Pioneer representative, including discussion of the rationale for the various ratings. A much better insight into the human factors aspect of patrol car body design was derived from participation in this evaluation. A better grasp of all factors of patrol car requirements resulted from all of these face-to-face interviews. The courtesy and cooperation extended by all police agencies contacted was greatly appreciated.

Based on the foregoing sources of information, the following significant characteristics were established for defining the areas of body design most important to the comfort and operating effectiveness of police personnel.

- Seating comfort for driver and partner.
- Ease of front seat entrance and egress.
- Operating convenience and accessibility of controls and equipment.
- Ease of entrance and egress and room in rear compartment.
- Rearward vision.

The second phase of this project consisted of analyzing each of the above characteristics and establishing optimum dimensional specifications to define them.

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* It is of interest to note that purchase of vehicles by the Birmingham, Mich. Police Department is based on results of Los Angeles County tests and evaluation.

In addition to the above body design characteristics, the police departments interviewed all stressed the importance of the following general vehicle characteristics:

- Performance
- Ease of Maintenance
- Reliability and Durability
- Operating Economy

These characteristics will be considered in the design of the recommended vehicle later in the report.

II. Specifications for Significant Characteristics

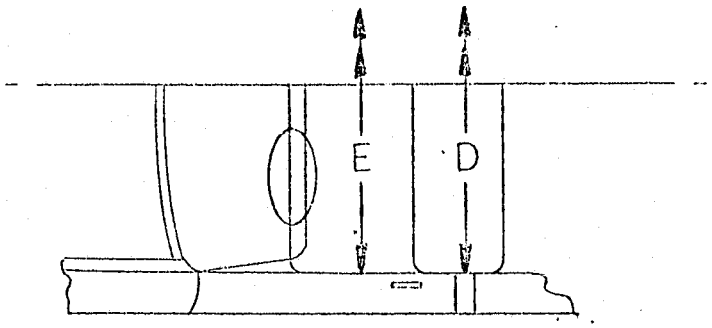
The second phase of this project involved analysis of those characteristics of patrol car body design established as significant to the comfort and operating effectiveness of police personnel (see page 3), and establishment of dimensions to define them for an optimum body design for a police patrol car.

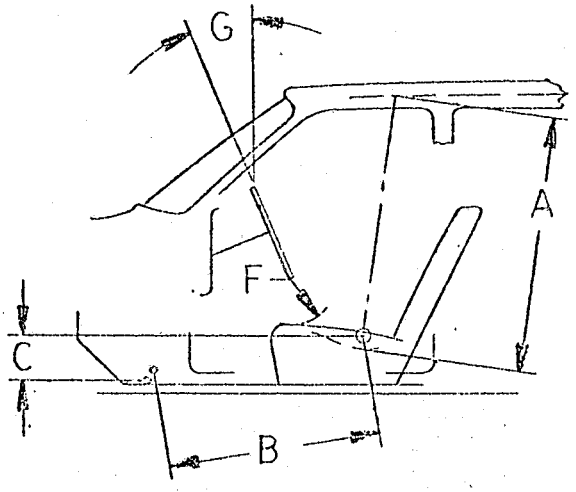
A. Seating Comfort for Driver and Partner

The basic body dimensions which define a comfortable front seating position are:

- Head Room
- Leg Room
- H-Point to Heel Point
- Shoulder Room
- Hip Room

Optimum values for the above dimensions were established using SAE Recommended Practice (SAE J1100a - see Appendix C). Figure 1 illustrates the dimensioning system. Definitions for the dimensions will be found in Appendix C. Figure 1 also lists the values established for each of the above basic dimensions. The following discussion is presented in support of these values.





	SAE No.		Recommended Value
A.	H61	Head Room	40.0"
B.	L34	Leg Room	43.0"
C.	H30	H-Point to Heel Point	8.5"
D.	W3	Shoulder Room	56.0"
E.	W5	Hip Room	56.0"
F.	H74	Steering Wheel to Seat Cushion (Seat in Rear-most Position)	6.0"
G	H18	Steering Wheel Angle - Vertical	22.0°

Figure 1. Front Compartment Seating Dimensions

Head Room. Additional head room is often heard as a recommendation for modern passenger cars and was requested by 63% of the departments inquired in the LEAA Patrol Car Survey (Table I - page 2). However, only 14% rated it as one of the three most important features. Since provision of head room greater than necessary would involve weight and cost penalties, head room provision was limited to that required for minimum acceptable clearance for a 95 percentile male. Again, using SAE Standards, (SAE J826a and SAE Paper 267A) dimensions for the 95 percentile male are:

- Height - 74.01" (1)
- Weight - 209.69# (1)
- Seated Erect Height - 38.11" (2)
- Seated (Car Posture) Height - 37.11" (3)

Based on experience and some experimental evaluations, a head-to-roof dimension of 3" was established as adequate. The resulting recommended value of 40" was therefore the sum of the 95th percentile male seated height and the above clearance.

To further support this value, the police departments contacted were asked to rate the Chevrolet Nova, which they were all familiar with from recent evaluations, and all rated its front seat head room (39.3") as acceptable. (The full size Chevrolet has a head room of 38.5".)

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(1) SAE Paper 267A - Table I - p. 34

(2) SAE Paper 267A - Table III - p. 36

(3) SAE Paper 267A - Appendix IV - p. 57

Leg Room. Since there are no publicized procedures for establishing leg room similar to those used for head room, it was necessary to conduct some personal evaluations to establish optimum values. Evaluations were conducted on a full-size Chevrolet which has a leg room dimension of 42.6". It was judged to be completely acceptable.

It should be mentioned that the relationship between seat, pedals, and steering wheel is critical to comfort, and deviation from presently accepted values can result in a deterioration of driver comfort. For example, increasing leg room beyond the value specified (measured to accelerator pedal) would require moving the steering wheel rearward to prevent an excessive reach to the wheel which would result in a tiring arm position for extended driving. Moving the wheel rearward would in turn result in a cramped arm position for those who desire the seat in a shorter leg room position. The value selected was judged to be about the maximum before disruptions in the above relationship would occur, resulting in a negative comfort impact.

H-Point to Heel Point. This dimension defines the height of the seating position relative to the accelerator and is important for a comfortable seating position. Again, evaluations indicated a height of 8.5" to be optimum. While values higher than 8.5" might be considered comfortable by some drivers, larger values would require a higher roof line to maintain head room. Conversely, lower values would require an increase in leg room for equivalent comfort. 8.5" therefore, was judged to be optimum for the previously selected head room and leg room values.

Shoulder Room. Shoulder room for this design, as recommended in Figure 1, is the distance between flat inner door panels measured just below the belt line. As such, it is the truest measure of interior room. Greater values of shoulder room (car interior width) would appear desirable, but would also increase body width and weight. Keeping in mind the basic objective of minimum weight,

the vehicle body should be as narrow as possible consistent with providing comfortable seating for two officers (see Suggested Ground Rules - Appendix A). Based on two individual seats of 22" approximate width each and an 8" tunnel width between seats, optimum shoulder room was judged to be 56".

Hip Room. Hip room measurements for a given basic body width depend on the contour and trim of the inner door panel. The values in Figure 1 are based on a flat inner door panel and as such measure the same as shoulder room. This provides ample seating room.

Another dimension affecting front seating comfort is the distance between the bottom edge of the steering wheel rim and the undepressed surface of the front seat cushion. A value of 6" is optimum. The steering wheel angle with the vertical is also important; 22° is judged to be optimum.

Front seating comfort, of course, must also include proper design of the seats themselves. This project will not attempt to design or specify in detail the front seat construction except to specify a comfort level comparable to the front seat in the 1976 Chevrolet Nova 4-Door Sedan Police Vehicle. This seat was given a high rating in the Los Angeles County Sheriff's Department Ergonomic Evaluation. In addition, individual front seats will be specified to provide a maximum comfort level for both officers regardless of height difference. This specification is considered essential because reductions in minimum height level are now occurring in many police departments, as is the assignment of women officers to patrol car duty. Furthermore, use of individual front seats will also allow approximately 8" of space between seats to facilitate installation of specified communications equipment. The seat trim will also be specified as individual bench seats rather than bucket type to assure

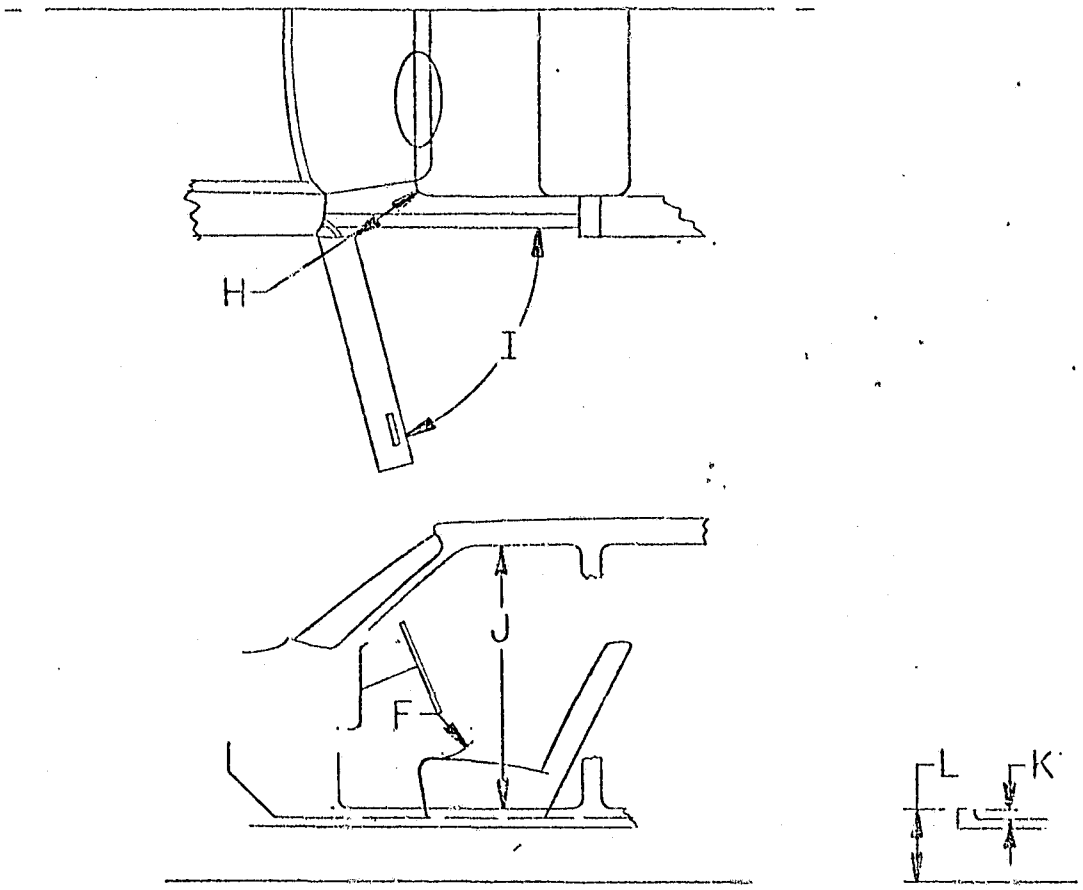
Maximum comfort when wearing a holstered gun, handcuffs, etc. Police officers also appear to object to the confined seating position resulting from the contouring of typical bucket seats.

B. Ease of Front Compartment Entrance and Egress

The basic body dimensions facilitating entrance and egress are illustrated in Figure 2, which also shows the recommended values established for each dimension. These dimensions were established by an independent evaluation of full-size cars which police departments indicate provide a satisfactory condition. Door opening width is not considered critical since the front door hinge pillar location and open door location define the critical dimension for foot and leg clearance when entering or leaving the front compartment. Center pillar (B-Post) location on all contemporary body designs provides ample clearance for entrance or exit. A typical door opening width would be approximately 36". The door opening, of course, should not be compromised by intrusions, such as the reverse slope windshield lines of the late 1950's.

The seat-to-door dimension (H) must be sufficiently large to enable the foot to pass through freely without cramping the foot at the ankle. The recommended value of 16" is equal to the largest dimension currently available and takes into account the reduction of this dimension as the seat is adjusted forward. Door opening angle (I) can seriously affect entrance and egress and should be 75° to insure against interference when rapidly entering or leaving the vehicle. A front door height (J) of 38" is recommended as optimum. While a higher opening would be desirable, the cost of bringing the upper door opening into the roof is not considered to be justified.

A difference of more than 3.0" (K) between floor and sill (floor below sill) could tend to catch the foot during a rapid exit. Ramping of the floor upward to the sill should be used to facilitate moving the foot up over the sill. Excessive sill width could also be a problem, but all contemporary body designs utilize a narrow sill.



		Recommended Value
F.	Steering Wheel to Seat Cushion (Seat in Rearmost Position)	6"
H.	Seat to Door Clearance (Seat in Rearmost Position)	16"
I.	Door Open Argle	75°
J.	Door Opening Height	38"
K.	Sill to Floor Height	3"
L.	Sill to Ground Height (Curb Weight)	15"

Figure ?. Front Compartment Entrance and Egress Dimensions

Sill-to-ground height (L) should not be greater than 15" at curb weight, or the "step-up" becomes awkward and slows entry. A clearance of less than 6" between steering wheel and seat can result in thigh contact with the wheel during entrance and exit making the operation awkward and slower.

C. Operating Convenience and Accessibility of Controls and Equipment

Because of the extensive communications equipment specified as part of this project (Appendix A), the location of equipment will be covered in the Design section of the report (Part V - Section C). Careful attention to operating convenience and accessibility of equipment will be included.

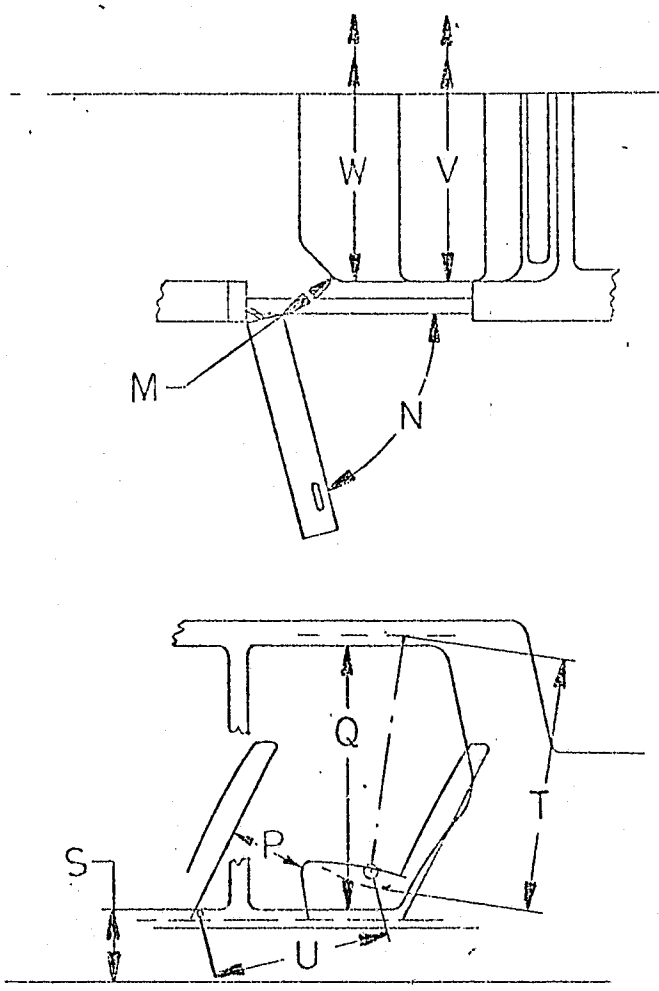
With regard to operating controls for the vehicle, the results of the 1976 Los Angeles County Ergonomics evaluation gave the Chevrolet Nova an average score of 8.99 and the Dodge Dart 8.65. These scorings are on a 1-10 scale with 5 "average" and 10 "superior". While these ratings cover more than controls, the "controls" section of the special evaluation conducted for Pioneer on the Nova resulted in a similar rating of 8.0. Since there is little basic difference between the cars in this area, these evaluations indicate that current practice on control locations is more than acceptable. In evaluating controls, the following factors should be considered:

- Clear view of speedometer and other instruments between steering wheel rim and spokes.
- Controls for lights, windshield wipers/washer, heat-defrost-vent-A/C should be located so that they can be operated with minimum movement of the hands from the steering wheel and eyes from the road.
- Operation of the gearshift lever should not require awkward hand motion or result in interference of the hand with the instrument panel or anything mounted on it.

- Parking brake and hood release controls should be visible from normal driving position and operation should not require appreciable body movement.

D. Ease of Entrance and Egress and Roominess of Rear Compartment

The dimensions defining the above characteristics are illustrated in Figure 3 together with the recommended values established for each dimension. Seat-to-door (M) and door opening angle (N) considerations are similar to those applying to the front compartment, except that a smaller seat-to-door dimension can be tolerated because allowance for seat adjustment is not required and entrance and egress time is not critical, allowing time for adjusting foot position to the opening. A distance of 12" seat-to-seat (P) is recommended to provide adequate leg room in the rear compartment. Door opening and sill height considerations are similar to the front. It is recommended, however, that the typical rear slope of the opening above the belt line be straightened up to provide better head clearance when entering or leaving the vehicle (see Figure 4). The restriction at this portion of the door opening was noted by police personnel contacted. This area is particularly important because handcuffed prisoners usually enter the rear compartment backward often resulting in head contact in this area with current body designs. The intrusion of the wheelhouse clearance into this opening must also be limited to approximately that of a typical full-size car. Rear door opening conditions are particularly critical because of the practice of transporting handcuffed prisoners in the rear seat. This physical limitation, as well as their possible resistance to the forthcoming ride, is the reason police departments are concerned about the ease of entrance to the rear seat. This usual use of the rear seat is why comfort is not considered a significant characteristic. The roominess of the rear seat compartment refers to the space between the seats which facilitiates entrance and egress and also better accommodates individuals who would be seated in the rear compartment during questioning (not prisoners).



	SAE No.		Recommended Value
M.	-	Seat to Door Clearance	12"
N.	-	Door Open Angle	75°
P.	-	Seat to Seat Clearance	12"
Q.	-	Door Opening Height	38"
S.	-	Sill to Ground Height (Curb Weight)	15"
T	H63	Head Room	39"
U	L51	Leg Room	39"
V	W4	Shoulder Room	56"
W	W6	Hip Room	56"

Figure 3. Rear Compartment Dimensions

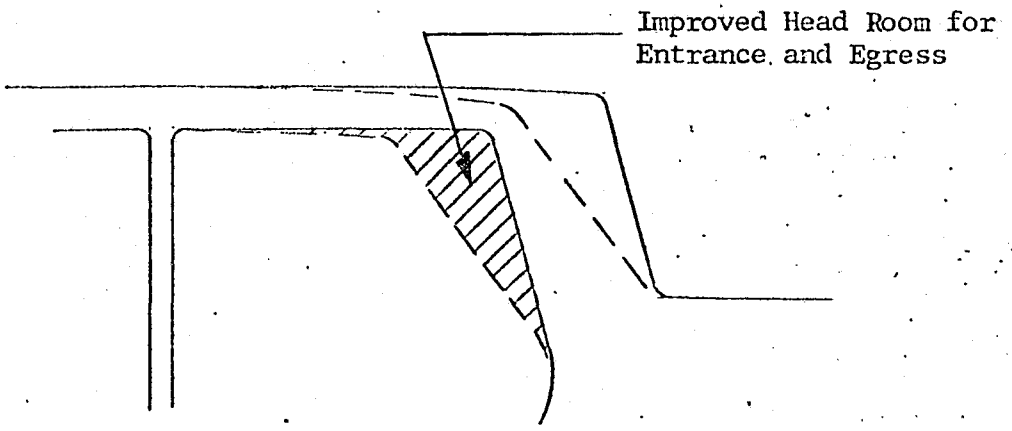


Figure 4. Rear Door Opening Modification

Because of the less critical nature of rear seating comfort, it is recommended that one inch less head room (39") be specified. This takes into account the usual need to have the H-Point up to 1" higher in the rear than the front for underbody clearance reasons. Likewise, evaluations established that 39" of rear compartment leg room would be adequate for the use specified (primarily prisoner transport). The specifications (Appendix A) call for accommodations for two passengers in the rear seat, therefore, shoulder and hip room dimensions similar to the front compartment (56") are recommended as satisfactory.

E. Rearward Vision

The recommended design should have maximum rear window area and minimum rear corner blind area in order to provide optimum rear visibility. The importance of this characteristic was stressed in connection with backing up the vehicle in congested conditions and also to minimize the possibility of someone sneaking up close to the vehicle without being observed. Raising the rear corners of the vehicle surfaces is also recommended to serve as a guide in backing the car in congested situations.

The use of complex wide angle and periscope type mirrors was investigated and rejected as complicated and costly without sufficient operating benefit for this design. Outside mirrors on both sides of the vehicle will be specified.

III. Selection of Body Configuration

This phase of the project consisted of establishing the best body configuration for application of the significant body characteristics dimensions developed in Phase II. The first consideration was a 4-door sedan layout as shown in Figure 5. This configuration has the basic advantage of being able to utilize current production 4-door sedans, either as produced or with modifications. Seating relationships are conventional and offer the potential of maximum comfort and ease of entry and egress.

An alternate would be a conventional 4-door station wagon (Figure 6) which would have the same basic seating configuration as the 4-door sedan, but with greater equipment storage capabilties. The standard station wagon configuration was rejected for the following reasons:

- Approximately 300 lbs. weight penalty vs. a comparable size 4-door sedan.
- A unit cost penalty representative of the above weight penalty.
- A negative handling performance (transient dynamic behavior) compared to a comparable size 4-door sedan.
- A lost time interval for removing emergency equipment from the rear compartment. This is based on a remote control opening of the deck lid on 4-door sedans which makes the equipment immediately available in a sedan trunk compartment. A similar remote control for a station wagon rear opening would involve use of a top hinged door plus considerable extra cost for the remote control mechanism because of the door size. Police departments also object to having the equipment exposed to view requiring a secondary cover which would further delay access to the equipment.

While the station wagon configuration has unquestioned advantages for maximum equipment storage space, this advantage was not judged to outweigh the added weight, cost, and operational deficiencies. The wagon configuration is therefore not recommended except as a secondary vehicle for special usage requiring the additional equipment carrying capacity.

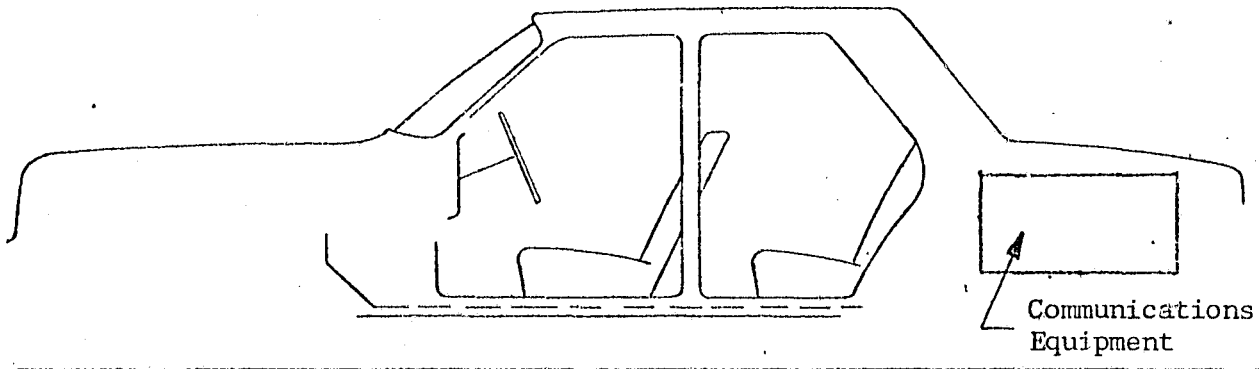


Figure 5. Conventional 4-Door Sedan Layout

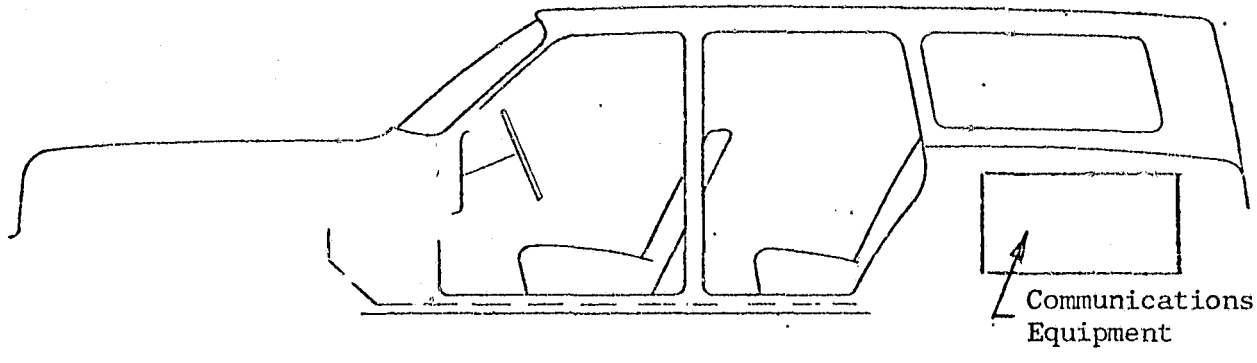


Figure 6. Conventional Station Wagon Layout

The next basic configuration considered was a conventional front seating with a rear facing second seat (Figure 7). This layout has the advantage of an excellent location for the communications equipment directly behind the front seats which provides a minimum connecting cable length between units, plus optimum ease of installation and service. It also provides maximum separation between driver and prisoner to be transported.

On the other hand, this configuration has, to a lesser degree, the inherent weight and cost disadvantages of a station wagon, plus a less satisfactory rear seating position from the standpoint of head room and leg room. The problem of entrance and egress, particularly for a handcuffed prisoner, would also be a negative. Improvement of rear entry and seating comfort by provision of a drop floor aft of the rear seat and a step built into the rear bumper would result in extensive redesign and a further weight and cost penalty. General customer reaction to a rear facing seat and its attendant entrance and egress have been evaluated by use of such a configuration for the third seat of many contemporary station wagons. The reaction has been mixed, but generally has been negative except for children. Currently, only Chrysler uses this rear facing seat configuration for both full size and intermediate station wagons with GM and Ford using other configurations for their full size models.

Storage for auxiliary equipment (other than communications gear) would be far from ideal. Since it would detract from leg room in the rear compartment, provision would have to be made in the communications equipment area behind the front seat. This would require use of a second door on one or both sides of the vehicle further adding to weight and cost for this proposal. (The original concept of this configuration was a two-door minimum wheelbase vehicle with access to communications equipment via fold-down front seat backs.)

A second version of the above configuration with a side facing rear seat (Figure 8) was also considered. This version has the same advantages and disadvantages of the rear facing seat with the only plus being a potential emotional advantage of not facing rearward. No improvement in leg room is possible and the same entrance and egress problems and equipment

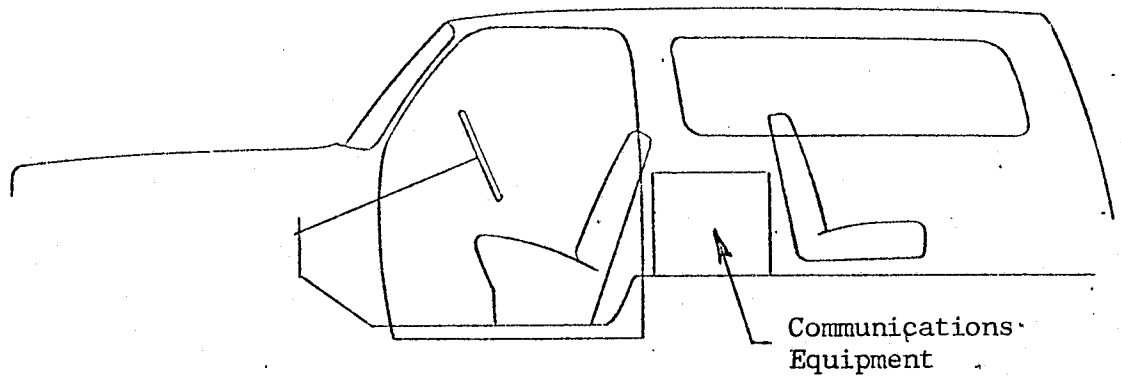


Figure 7. Rear Facing 2nd Seat Layout

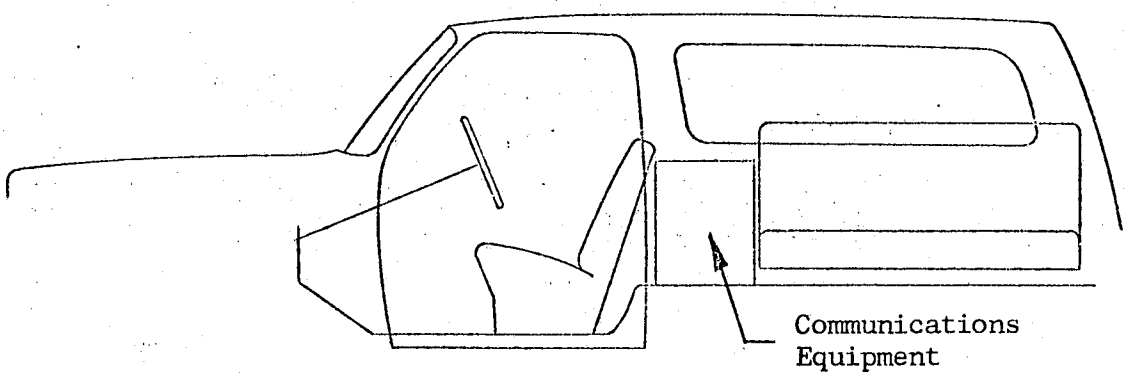


Figure 8. Side Facing 2nd Seat Layout

stowage difficulties encountered with a rear facing seat are inherent. After extensive consideration of all factors, it was agreed that the rear or side facing second seat configurations should not be recommended.

A third configuration in which the second man of the crew sits in back with a control console, plus most of the communications equipment located beside him was also considered. This layout frees the trunk area for maximum extra equipment storage, but limits the prisoner or extra passenger capability to one person per car (beside driver). It also would require a screen between passenger and driver which would prevent the driver from egress through the right front door.

From the overall standpoint, it was the opinion of Pioneer that the 4-door sedan provides the optimum package considering all aspects of human factors and equipment installation.

IV. Selection of Basic Design Approach

The fourth phase of this project involved selection of the optimum method of achieving a vehicle design incorporating the previously established dimensional requirements and body configuration.

While the design of a completely new and unique vehicle for this purpose would allow optimizing dimensional and performance characteristics, the design, development, tooling, production and service costs of such a vehicle would add substantially to the cost vs. current police cars which are basically production models.

Expenditures in excess of $100,000,000 and a penalty of several thousand dollars per vehicle could be anticipated. This would obviously not be in accord with the program objective of a concept "competitively priced with current police car models".* Furthermore, the time frame specified for this project (1977-1980)* would rule out a program of this magnitude. For the above reasons, this concept was not considered.

Furthermore, the requirement that the vehicle be competitively priced would also rule out the use of a completely new body on an existing chassis. While the program costs and unit penalties would be less than for a unique vehicle it could not be priced competitively with current production models. In the opinion of this Contractor, the program requirements essentially limit the choice of design direction to modification of an existing vehicle. All changes from current production should be justified on the basis of significant improvements in operational effectiveness and performance...primarily fuel economy.

The range of vehicles selected for consideration is shown in Table II. Only domestic built vehicles were included because of cost and/or restrictive size. Also, domestic models smaller than current compact size were excluded because they obviously could not meet the dimensional and performance requirements. Light truck and utility vehicle models were included for comparison

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* Appendix A

TABLE II

Production Vehicles by Class*

	W.B.	Engine	Curb Weight
Full Size Cars			
Chevrolet Impala	121.5"	454 CID V8	4,661#
Ford LTD	121.0"	460 " "	4,620#
Plymouth Gran Fury	121.5"	440 " "	4,646#
Intermediate Size Cars			
AMC Matador	118.0"	360 " "	4,121#
Chevrolet Chevelle	116.0"	400 " "	4,095#
Ford Torino	118.0"	400 " "	4,278#
Plymouth Fury	117.5"	400 " "	4,216#
Compact Size Cars			
AMC Hornet	108.0"	304 " "	3,411#
Chevrolet Nova	111.0"	350 " "	3,529#
Ford Granada	109.9"	351 " "	3,610#
Ford Maverick	109.9"	302 " "	3,261#
Plymouth Volare	112.5"	360 " "	3,548#
Plymouth Valiant	111.0"	360 " "	3,408#
Light Truck (Pickup)			
AMC J10	118.7"	360 " "	3,975#
Chevrolet C10	117.5"	350 " "	3,867#
Dodge D100	115.0"	360 " "	3,682#
Ford F100	117.0"	390 " "	3,822#
Utility Vehicle			
AMC Cherokee	108.7"	360 " "	4,140#
Chevrolet Blazer	106.5"	350 " "	4,338#
Dodge Ramcharger	106.0"	360 " "	4,022#
Ford Bronco	92.0"	302 " "	3,992#
Truck Based Station Wagon			
AMC Wagoneer	108.7"	360 " "	4,345#
Chevrolet Suburban	129.5"	350 " "	4,586#

* Duplicate models from the same manufacturer having a different sales name are not shown (i.e., Dodge Dart same as Plymouth Valiant).

NOTE: All vehicles equipped with maximum size engine available (except trucks and utility vehicles), automatic transmission, power steering, power disc brakes, and heavy duty suspension.

since they have an obvious advantage in flexibility of space utilization. They also offer advantages in the availability of sources to perform modifications since this procedure is common in the commercial vehicle field. The van type of truck vehicle has been omitted because its seating and general vehicle layout was judged to be unexceptable for police patrol car use.

Prior to a comparison of significant body dimensions, an overall analysis of basic vehicle characteristics was made to establish suitability of each of the vehicles as a base for this project. As far as general characteristics are concerned there was not sufficient difference between car lines in a given size category to warrant a comparison by car make. Table III, therefore, compares base vehicles by general size and type. This analysis yields the following conclusions:

- The compact car because of its significantly lower weight (Table II, p. 22) offers a major advantage in fuel economy.
- The light truck chassis because of its basic size offers a major advantage in the area of interior room and flexibility for placement of personnel and equipment. However, it should be noted that achievement of the above characteristics would require a major body design and building program which would place it out of the specified cost range.
- Use of a truck type chassis in a utility or multipurpose vehicle would provide a body, but it would require extensive changes to adapt to police requirements.
- The inherently higher weight of truck based vehicles puts them at a serious disadvantage which could not be justified on the basis of superior functional advantages.
- With proper engine application, all passenger cars offer very good acceleration and high speed performance. Truck models would not be as good if limited to the normal maximum engine size as shown. Larger engines could be used at a considerable sacrifice in economy.

TABLE III

Comparison of Vehicle Characteristics

	Potential For Weight and Fuel Savings	Potential For Improved Interior Space	Potential for Performance	
			High Speed and Acceleration	Handling
Full Size Car	Minimum	Good	Very Good	Very Good
Intermediate	Moderate	Moderate	Very Good	Very Good
Compact	Good	Moderate	Very Good	Very Good
Light Truck	Moderate	Very Good	Good	Questionable
Utility Vehicle	Moderate	Very Good	Good	Questionable

- Handling performance of all passenger cars can be very good if equipped with the proper chassis components. Truck models are questionable for police type handling requirements. The significantly higher C.G. of the truck models would place them at a serious disadvantage in both transient and steady state maneuvers.

On the basis of the above comparison, the compact car would appear to be the most desirable unless its basic size resulted in excessive compromises in the previously established dimensional values.

The next analysis was therefore based on a dimensional comparison between the previously established optimum dimensions and those of compact size vehicles. Table IV lists key dimensions for all sizes of passenger cars for comparison to the recommended values.

It is interesting to note that there is not a great deal of variation in front compartment head and leg room values between all sizes of passenger cars (except for leg room on AMC and Ford compacts). For easier comparison, the range and averages are shown in Table V. This comparison refutes a commonly held belief that front seat room is seriously compromised in going from a full-size to a compact size car. Of course, width (as reflected in shoulder and hip room) is less for the compacts, but this is not significant as long as it is adequate for two persons and equipment.* In this area, use of a compact size vehicle is particularly advantageous because they have been designed for more efficient use of vehicle size. For example, the Chevrolet Nova is 9" narrower in overall width than the full-size Chevrolet, but only $7\frac{1}{2}$" less in interior shoulder room.

Further investigations disclosed that only two of the compact models (Chevrolet Nova and Dodge Dart) have power plant and chassis options providing performance levels suitable for police patrol car use. However, Table IV**shows that these makes come closest to full-size cars (and recommended dimensions) in front compartment room. On the other hand, rear compartment room is considerably less than full-size models and the recommended values.

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* Appendix A

** Dodge Dart is same as Plymouth Valiant in interior dimensions.

TABLE IV

Comparison of Body Interior Dimensions* - 4-Door Sedans

	Front Compartment					Rear Compartment			
	Head Room	Leg Room	Shoulder Room	Hip Room	H-Point to Heel Point	Head Room	Leg Room	Shoulder Room	Hip Room
Recommended Police Vehicle	40.0	43.0	56.0	56.0	8.5	39.0	39.0	56.0	56.0
Full Size Passenger Cars									
Chevrolet	38.5	42.6	64.0	59.4	8.2	37.8	38.5	63.1	59.6
Ford	37.9	41.9	61.3	57.8	8.9	37.0	38.0	61.4	58.0
Plymouth	38.7	42.1	61.5	58.6	8.4	37.8	36.9	61.6	58.8
Intermediate Passenger Cars									
AMC	39.6	42.8	59.7	59.9	9.5	37.5	39.6	60.0	59.8
Chevrolet	37.9	42.1	59.6	54.7	8.8	37.2	36.9	58.9	57.8
Ford	38.3	42.6	58.5	59.2	7.9	36.9	37.4	58.2	56.7
Plymouth	38.6	42.3	59.2	59.2	7.6	37.3	35.2	59.3	59.2
Compacts									
AMC	38.1	40.6	54.9	54.9	8.5	37.0	35.5	54.3	54.4
Chevrolet	39.3	41.7	56.6	53.3	7.8	36.6	35.1	56.7	46.4
Ford (Granada)	38.5	40.9	55.8	55.9	9.2	37.6	35.6	55.8	51.2
Ford (Maverick)	37.8	40.6	54.3	53.6	9.0	36.7	36.2	54.5	40.3
Plymouth (Volare)	39.2	42.3	55.8	57.4	8.6	37.5	36.6	55.8	57.3
Plymouth (Valiant)	38.3	41.9	55.4	56.9	8.0	37.2	35.2	55.5	56.9

* From MVMA Specifications (Bibliography #5) per SAE J1100a - Recommended Practice (Appendix C)

TABLE V

Front Compartment Room Comparison - 4-Door Sedans

	Head Room		Leg Room	
	Range	Average	Range	Average
Full Size	37.9/38.7	38.4	41.9/42.6	42.2
Intermediate	37.9/39.6	38.6	42.1/42.8	42.4
Compact	37.8/39.3	38.5	40.6/42.3	41.3

Because of the obvious weight and full economy advantages of the compact car, plus the closeness of critical front compartment dimensions to those of full-size cars, it was judged desirable to proceed with a design study to determine if significant improvements in rear compartment dimensions could be achieved without detrimental changes to vehicle size or weight.

At this point in the project, a new 1976 compact model (Plymouth Volare/ Dodge Aspen) was available for comparison. The comparison is even more favorable for the compact size car when this newest compact on the market is compared to the average of full-size cars.

	Front Compartment	
	Head Room	Leg Room
Average of 1976 Full-Size Cars	38.4	42.2
1976 Plymouth Volare	39.2	42.3

Chrysler Corporation plans to have a police package for this model in 1977 comparable in performance to the 1976 Dodge Dart evaluated. Being new for 1976, this vehicle will unquestionably be available in the 1977-1980 time frame of this project.* Other manufacturers have assured us that they will have competitively sized vehicles in this weight range (3,500#) in the 1977-1980 time frame. Therefore, it was decided to proceed with the design analysis of the suitability of a compact car dimensionally on the basis of the Plymouth Volare.

Table VI compares the recommended values for a police patrol car (previously establish - Section II) to comparable dimensions for the 1976 Plymouth Volare. This comparison shows the only major dimensional deficiencies to be in rear compartment head room, leg room, and seat-to-seat dimensions. The results of the design study to improve rear compartment room are shown in Column 3 of Table VI. In all three significant dimensions, the values were increased to the recommended values. These dimensional improvements were

* Appendix A

TABLE VI

Comparison of Significant Body Dimensions

	Recommended	Plymouth Volare	Proposed Design
Front Compartment			
Head Room	40.0"	39.2" (-0.8")	39.7" *
Leg Room	43.0"	42.3" (-0.7")	42.8" **
H-Point to Heel Point	8.5"	8.6"	8.1" *
Shoulder Room	56.0"	55.8" (-0.2")	-
Hip Room	56.0"	57.4"	-
Steering Wheel to Seat	6.0"	5.5"	6.0" *
Steering Wheel Angle	22.0°	21.6°	-
Seat to Door	16.0"	16.0"	-
Door Opening Angle	75.0°	65.0°	-
Door Opening Height	38.0"	37.0"	-
Sill to Floor Height	3.0"	3.0"	-
Sill to Ground Height	15.0"	15.0"	-
Rear Compartment			
Head Room	39.0"	37.5" (-1.5")	39.0"
Leg Room	39.0"	36.6" (-2.4")	39.0"
Shoulder Room	56.0"	55.8" (-0.2")	-
Hip Room	56.0"	57.3"	52.0"
Seat to Door	12.0"	12.0"	-
Door Opening Angle	75.0°	75.0°	-
Seat to Seat	12.0"	9.0" (-3.0")	12.0"
Door Opening Height	38.0"	37.0"	-
Sill to Ground Height	15.0"	15.0"	-

** Remove 1/2" shims in seat mounting.

** If seat back cushion can be 1/2" thinner.

accomplished by substituting a raised rear roof panel and modifications to the rear seat structure and location (Figure 9). The roof panel change gave a $1\frac{1}{2}$" head room increase while the squared off roof line allowed the rear seating position to be moved back 2.4" without loss of head room. The revised rear seating position could be achieved because of the two passenger requirement* which removed the limitation of the tunnel restriction on the middle seating position. The rearward movement of the seating position was achieved by thinning the rear seat back cushion 2.4" and moving the seat cushion rearward a similar amount. The rear seat cushion was also shortened 0.6" to provide a total increase of 3" between seats. Moving the seat rearward reduced hip room from 57.3" to 52", but this is still acceptable for the two passenger seating requirement. The thinner cushion back and revised seating position are judged acceptable for comfort since the seat is only used for short intervals. Shortening of the seat cushion and trimming off of the outer corner also significantly improve entrance and egress conditions.

A further improvement was achieved by the squared off rear door upper corner (Figure 4, page 14). Since these changes to roof and seat were achieved using new materials and construction methods, a significant weight reduction was also accomplished. Additional details on the design and material changes will be found in a later section of this report on "Recommended Design" (Section V).

With the accomplishment of the recommended rear compartment dimensional requirements, the dimension deficiencies in the front compartment were then reviewed. Head room could be increased to the recommended value by lowering the H-Point of the front seat 0.8". For persons below the 50th percentile in stature, this lower seating position would not be desirable, but the seat mounting structure could be designed to accept shims which would provide a means of adjusting seat height to suit the individuals using the vehicle. Lowering of the seat would also provide the desired steering wheel to seat cushion dimension. However, the lower seat would reduce the H-Point to heel point a similar amount which would again be desirable only for very tall

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* Appendix A

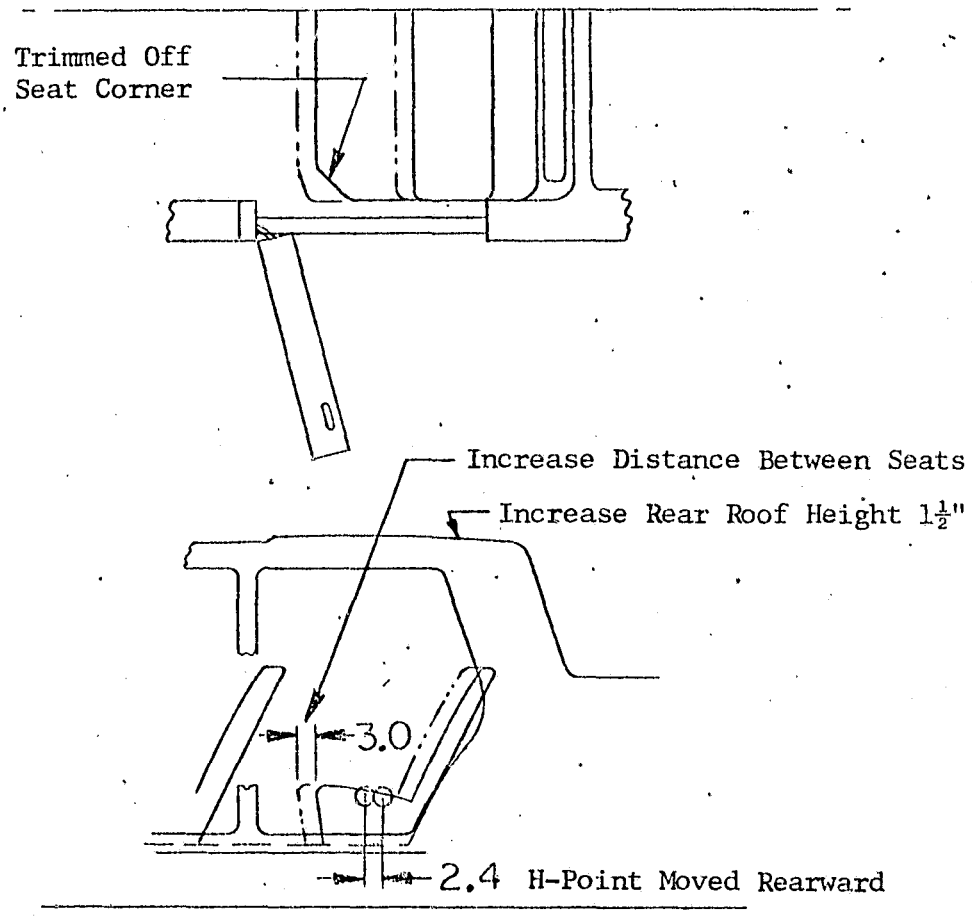


Figure 9. Rear Seating Modifications

persons. The lower H-Point would also reduce effective leg room slightly, but the difference would be too small to be significant. It would also be possible to raise the roof over the seating area, but because of the added modification complexity and cost this approach is not recommended.

Leg room could be increased the desired 0.7" by one or a combination of the following:

- Thin the seat back cushion and move the seat cushion back the same amount.
- Move entire front seat back and reduce space between the seats.
- Move the front seat back and reduce rear seat cushion depth by a corresponding amount.

It appears that either the first or third of the above would be acceptable. It is recommended that the new seat design reduce the rear cushion thickness as much as possible without sacrifice of comfort. (Latest design approaches would appear to make some reduction feasible.) Any remaining deficiency would be compensated for by a further reduction in rear seat cushion depth.

Because of the expense of making major modifications to the front compartment, achievement of the optimum dimensional goals should be put in perspective. The values exceed anything currently available on even full-size models. Experience indicates that few of even the 95th percentile officers would feel that the full values were necessary.

Evaluation of a Plymouth Volare gives the indication of very acceptable head and leg room. It is recommended, therefore, that only those changes indicated for the front seat (thinner back cushion and provision for 1/2" shims) be included in this design. Prototype testing would establish whether further changes are desirable. All of the other front compartment discrepancies are not considered important enough to warrant design changes.

To further substantiate the desirability of using a compact car as the base vehicle, the weight difference between a compact and other potential base vehicles is shown in Table VII along with the potential fuel saving vs. the other choices. Table VII also indicates the potential for further weight and fuel economy savings as a result of design changes recommended

TABLE VII

Weight and Fuel Economy Comparisons

	Weight	Engine Size CID	Fuel Saving Potential[1] Weight	Engine	Total
Full Size Car	4,650#[2]	450[4]	-	-	-
Intermediate	4,200#[2]	400[4]	6%	6%	12%
Compact[3]	3,500#[2]	350[4]	15%	12%	27%
Truck					
Pickup	3,850#[2]				
Utility	4,100#[2]				
Wagon	4,450#[2]				
Recommended Compact Car Based Vehicle	3,150#[5]	315[7]	19%	18%	37%
Truck Based Vehicle	4,000#[6]	400[7]	8.5%	6%	14.5%

(1) Vs. full size car - based on EPA formula of 10% weight or disp. change = 3 to 6% fuel economy change.

(2) Average weight to nearest 50#.

(3) AMC Hornet and Ford Maverick not included because of smaller size than other compacts.

(4) Typical - not exact for all makes.

(5) Average compact minus 10%.

(6) Based on average of Chevrolet Blazer/Suburban minus 10%.

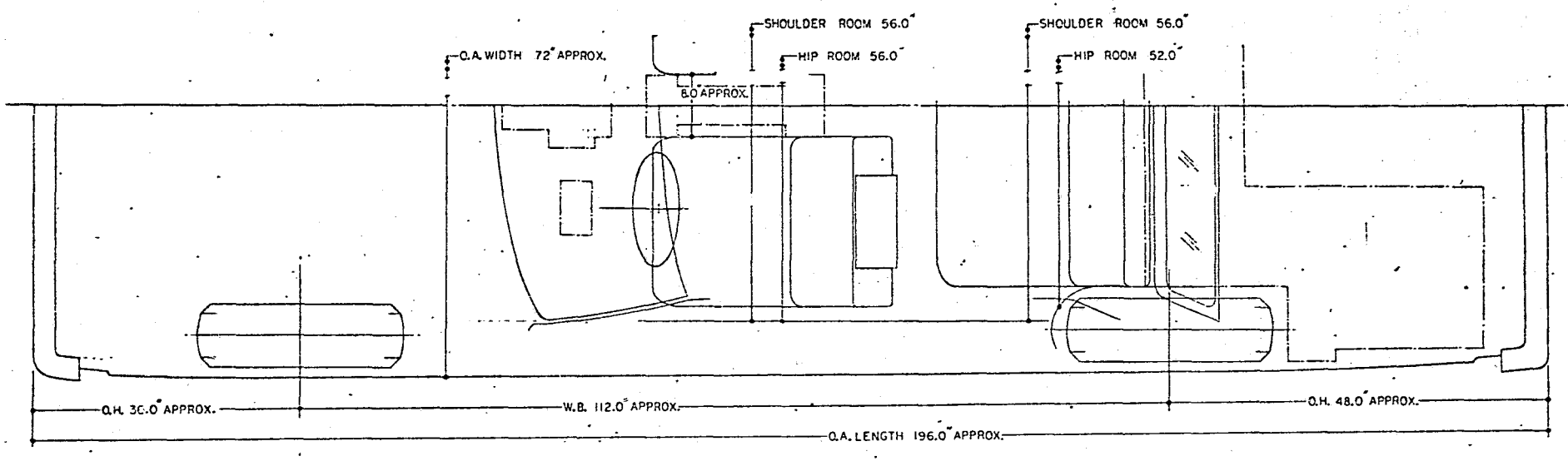
(7) Sized for comparable performance to average passenger cars.

as part of this project. These changes and their potential weight savings are reviewed in detail in a later section of this report (Section V - Recommended Design). It should be noted that the estimated weight of a truck based vehicle is an average of a utility type and a truck station wagon. This average was used because the existing utility vehicles do not have sufficient rear compartment room and the wagon (Chevrolet Suburban) has excessive size. The above average weight was then further reduced by the same percentage factor applied to the compact passenger car although it is questionable if this value could be achieved.

Further fuel savings resulting from reduced engine size are also estimated. The lower weights permit these displacement reductions without sacrifice of performance. Fuel economy savings are based on the use of EPA estimates.

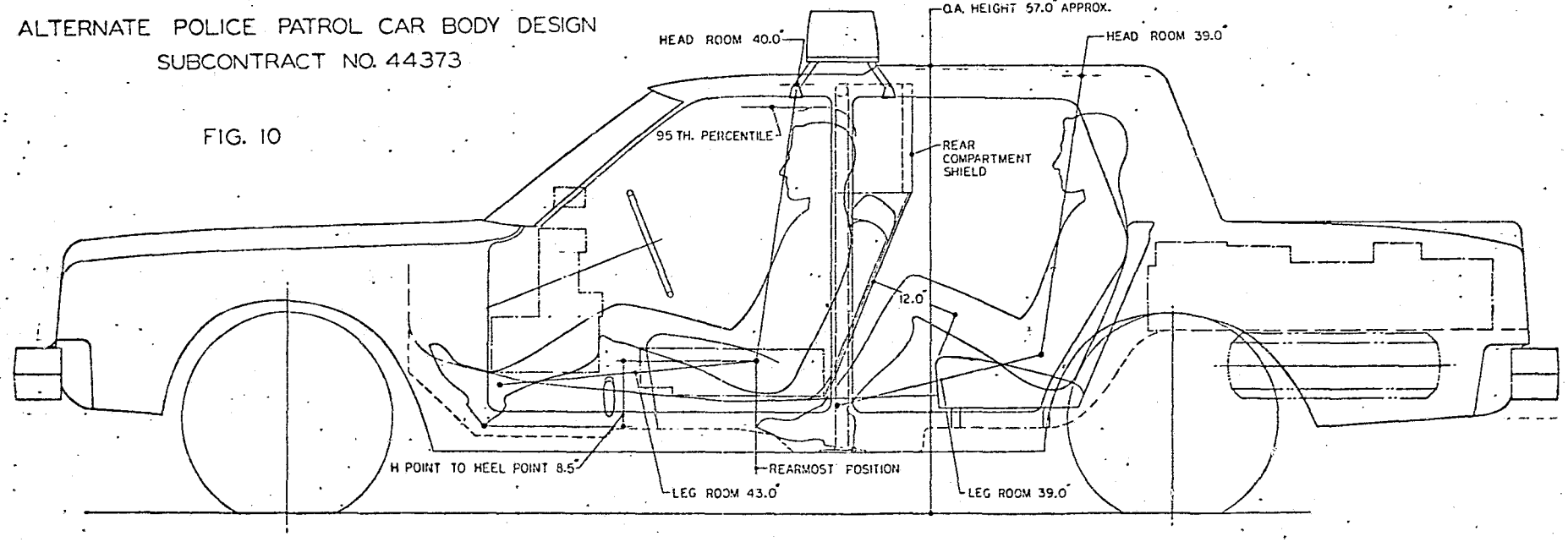
Since fuel saving is one of the most important end results of this program, it is obvious that the compact car has a significant advantage over other base vehicles. Since no significant dimensional deficiencies resulted from use of the compact car as a base vehicle (when modified as indicated), it is the conclusion of this Contractor that a compact car, modified as detailed in the following section of the report (Figure 10), would provide significant improvements in fuel economy and comfort and operating effectiveness for police personnel.

It is therefore recommended that a program to design, build and evaluate such a vehicle for urban police patrol car use be initiated as soon as possible.



ALTERNATE POLICE PATROL CAR BODY DESIGN
SUBCONTRACT NO. 44373

FIG. 10



V. Design of Recommended Police Patrol Car

A. New Components

Accomplishment of the previously established body dimensional improvements and maximum weight reduction was achieved by the following base vehicle modifications:

New Rear Roof. A new rear roof aft of the body center pillar (B-Post) is incorporated to provide:

- A $1\frac{1}{2}$" improvement in rear head room. (The roof is raised 1" - see next item.)
- A squared off roof line allowing the rear seating position to be moved back 2.4" without loss of head room. (Because of the squared off roof line an additional 1/2" of head room is provided.)
- An enlarged rear door upper opening for improved entry and egress.
- Weight reduction of approximately 8 lbs.

The proposed design removes the production roof by cutting it just aft of the center pillar and around the joint line between roof panel and quarter panel and upper deck panel (Figure 11). The replacement roof panel is a one piece plastic molding of structural foam. The rationale for selecting structural foam is discussed in a separate section later in the report because the material is common with that used for other replacement panels.

While the basic panel is a one piece molding for minimum weight, tooling cost and assembly labor, a separate rail molded of the same material is required to provide adequate surface area and rigidity around the upper door frame. Use of a separate piece in this area prevents an unacceptable heavy roof panel section and provides for easy withdrawal of the panel from the mold. A typical section through the door frame and top rail is shown in Figure 12. It is

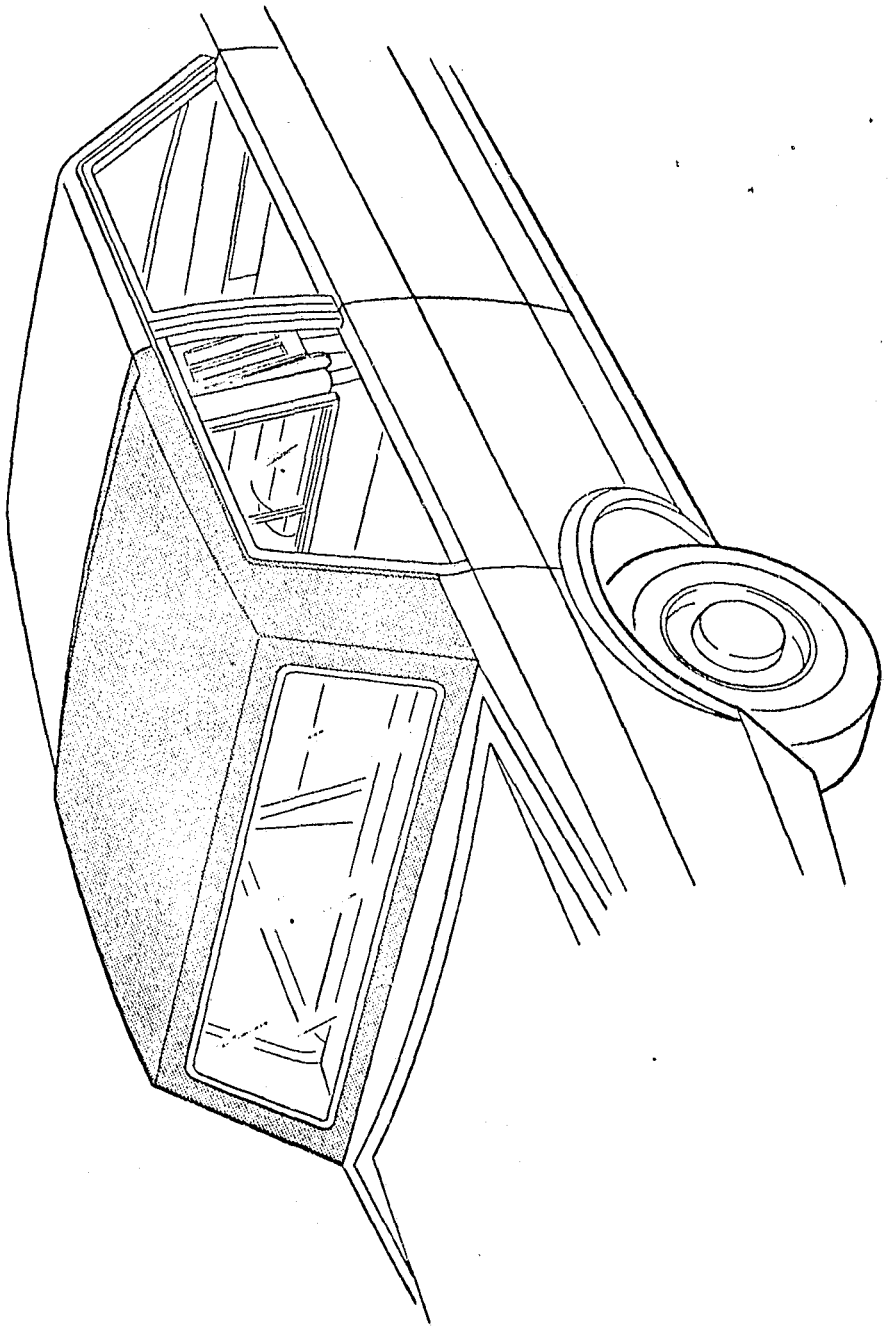


FIG. 11 NEW REAR ROOF

CONTINUED

2 OF 3

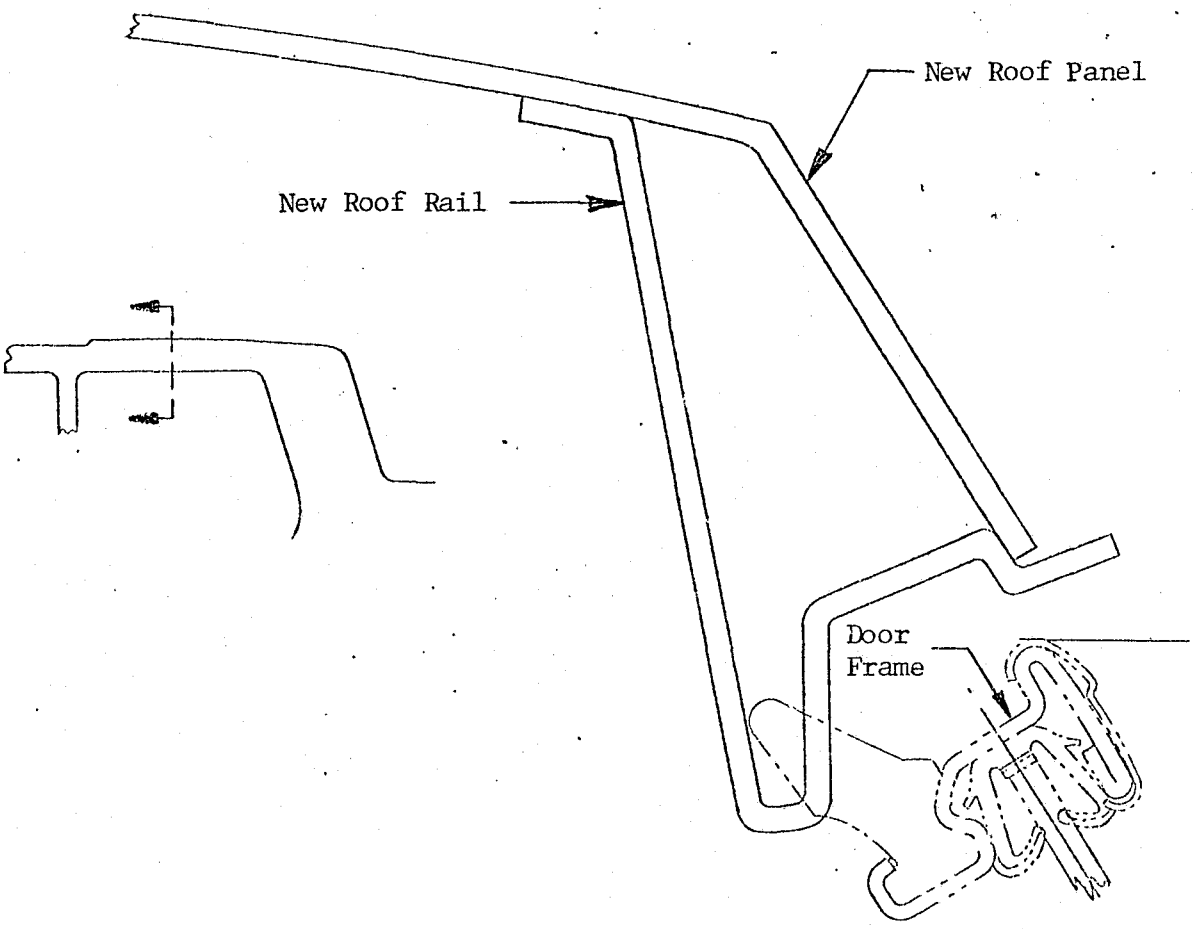


Figure 12. Upper Door Frame - Roof Rail Section

planned to utilize adhesive attachment for joining the rails to the roof panel. Conventional door opening seals would be used.

A typical section through the rear corner of the roof panel is shown in Figure 13. The C-Post reinforcement is molded integral with the roof rail. Installation of the rear window is also shown in this view.

The proposed method of attaching the roof panel to the base vehicle is illustrated in Figures 14 - 16. All attachments would use an adhesive for permanent sealing, plus rivets for a secure mechanical connection. Figure 14 illustrates the joint between the existing front roof and the added new plastic rear section. The section shown in Figure 15 is representative of the quarter panel joint area, but the detail would vary depending on the base vehicle used. A typical joint at the roof to deck upper panel is shown in Figure 16. Again, this area will vary depending on the design of the base vehicle in that area. Both Figure 15 and 16 show a separate filler panel rather than a flange integral with the roof to facilitate manufacture and assembly.

The rear window would be installed in a conventional manner, but would be plastic to provide a weight saving of approximately 12 lbs.

To save piece cost and assembly cost, no inner trim would be used on the roof panel. The natural surface of the molded material would provide an acceptable appearance. The one exception would be a molded trim strip applied at the connection between the plastic roof and the original steel roof (Figure 14). It is also proposed to dispense with the rear compartment dome light for additional cost saving. A reading light will be specified as part of the equipment console.

As mentioned in an earlier section of this report, the roof line of the new rear section is raised 1" for improved head room and the rear section is squared off to permit moving the rear seating position backward 2.4" without loss of head room (Ref. Figure 9 - p. 31). The

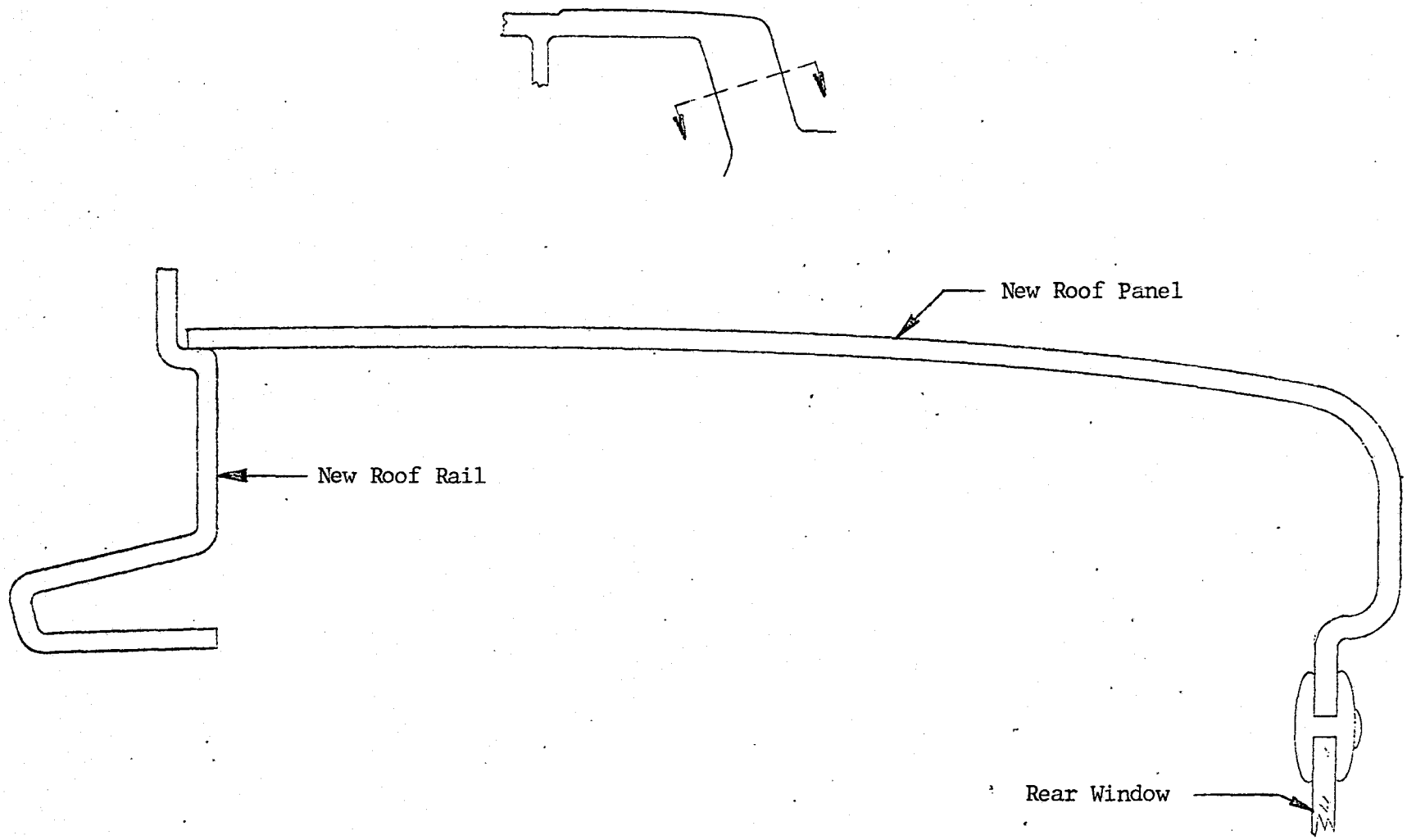


Figure 13. Rear Corner of Roof

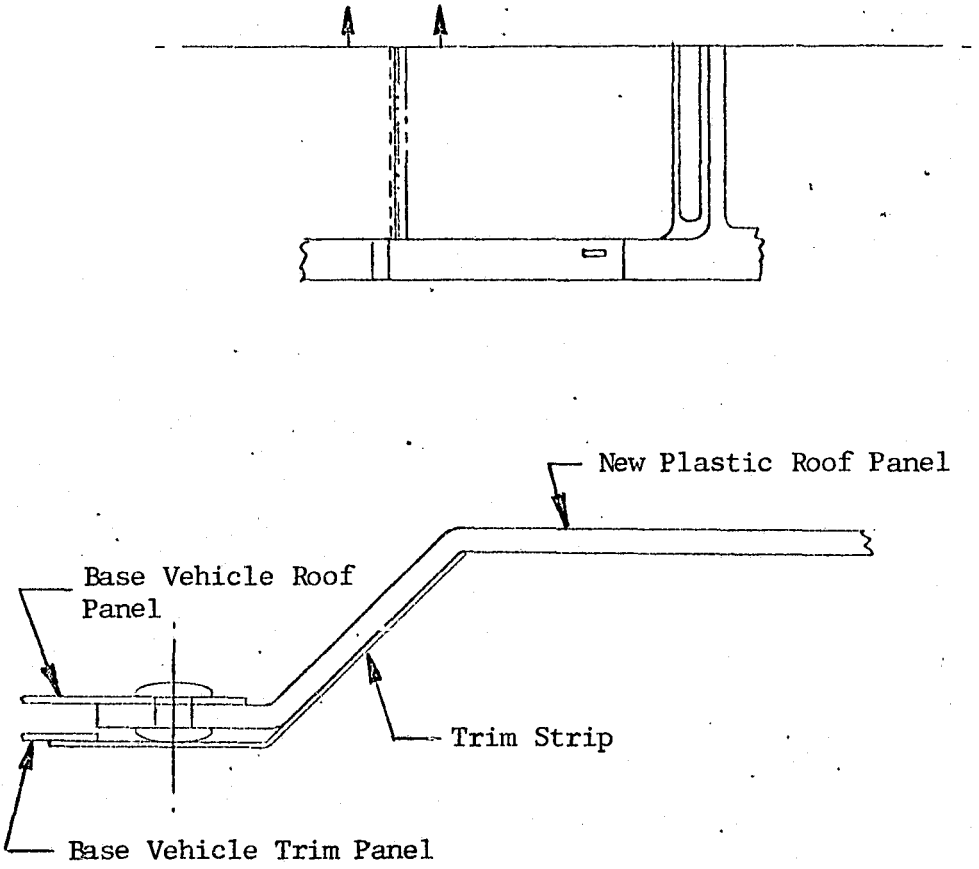


Figure 14. Front to Rear Roof Panel Attachment

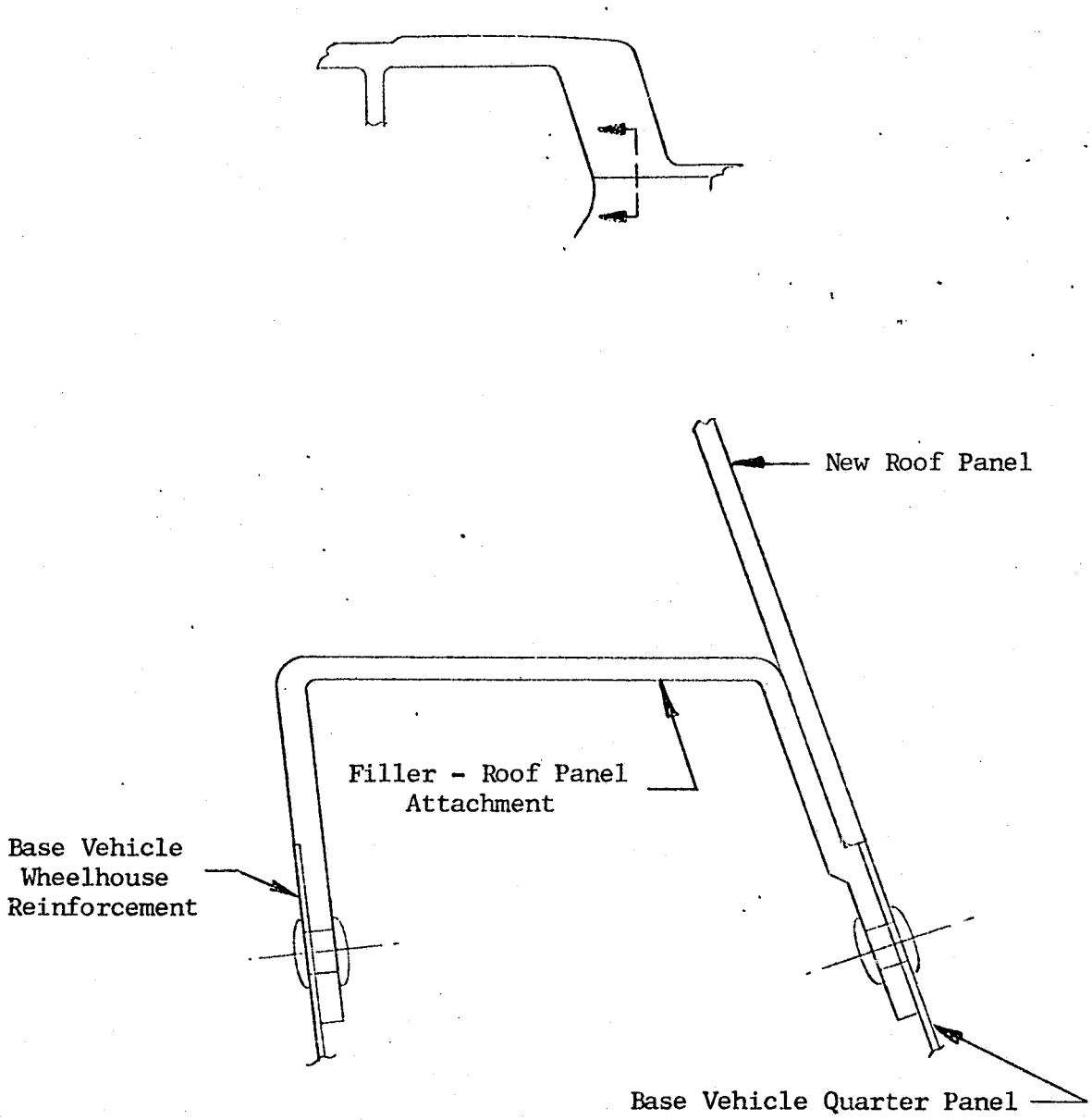


Figure 15. Roof to Quarter Panel Attachment

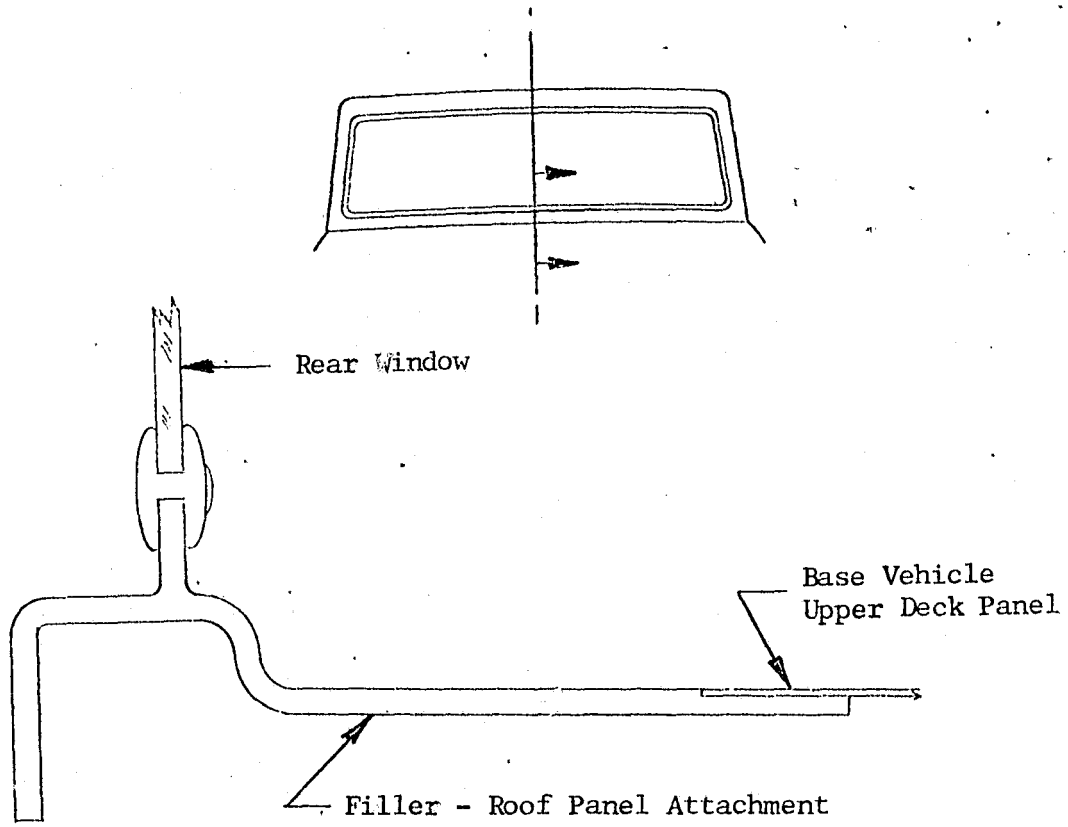


Figure 16. Roof to Upper Deck Panel Attachment

rear door opening is also straightened up along the rear edge to provide more head clearance during entry and egress (Figure 4 - p. 14).

It is proposed to leave the plastic roof panel in its natural white color as it comes from the mold to save finishing and painting costs. The natural finish has a slightly grained surface somewhat similar to the currently popular vinyl roof covers.

New Rear Door Upper. A new rear door window frame would be required to match the revised rear door opening lines (Figure 11). It is proposed to match the front door opening top surface to avoid the expense of bringing the door opening line into the roof section. The rear door frame would be of similar construction to the front frame of the base vehicle selected. An upper door frame is considered essential for adequate rigidity during the operation of placing prisoners in the rear seat. It is also proposed to use plastic for the new rear door window to save weight. It is further proposed to rigidly fasten the window into the frame and remove the door glass operating mechanism for further weight saving.

New Rear Seat and Revised Seating Position

The new rear seat design achieves:

- A 2.4" rearward seating position for improved leg room.
- A 3.0" increase in distance between front and rear seats to improve entry and egress and comfort when seated.

The 2.4" rearward seating position is achieved by thinning the seat back cushion by that amount and revising the seat cushion accordingly (Figure 17). The rearward seating position is possible by providing for only two persons...one on each side of the tunnel. A new roof line, as previously discussed, is also necessary to achieve specified head room in the new seating position.

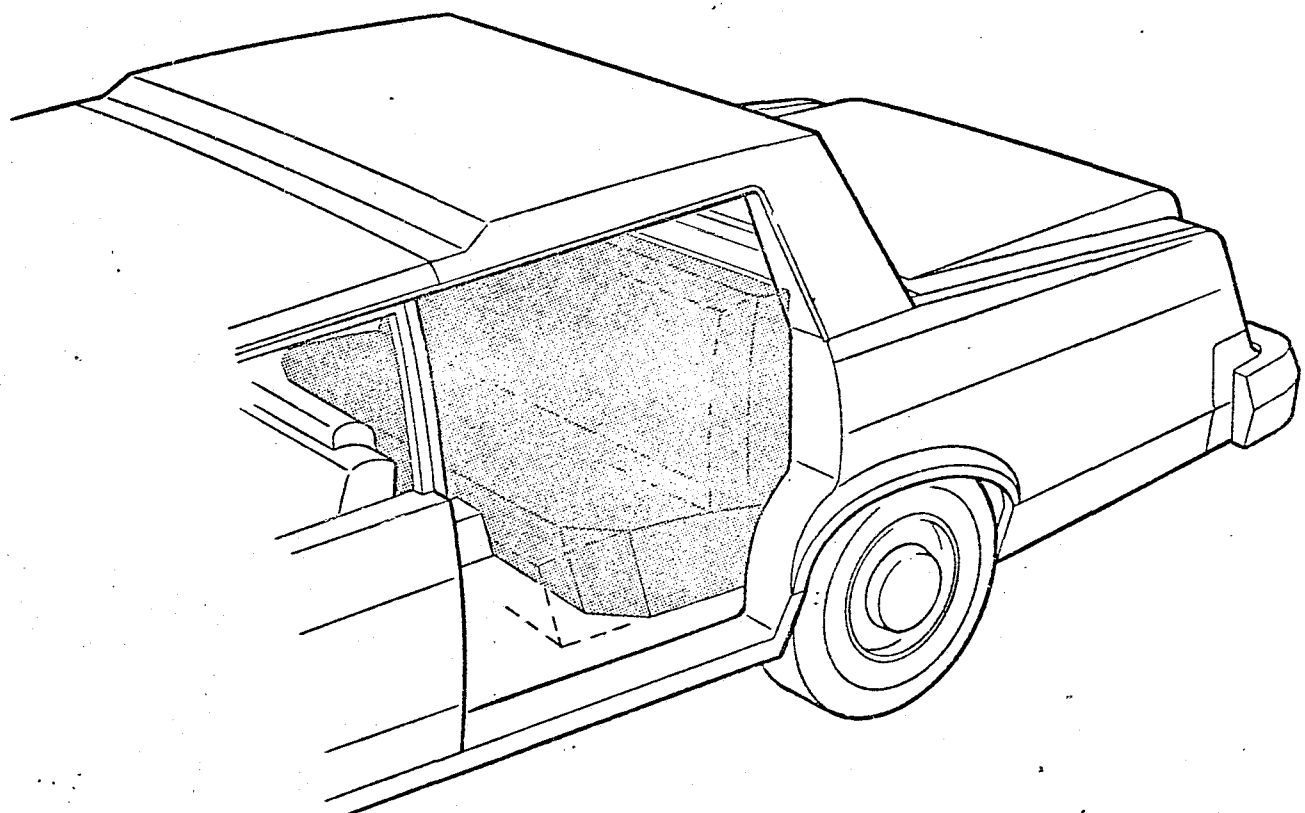


FIG. 17 NEW REAR SEAT AND REVISED SEATING POSITION

The thin seat back is achieved by utilizing a molded cushion of full foam polyurethane with expanded vinyl cover. The seat cushion will be formed of similar material in order to gain the weight saving advantage. A somewhat softer construction will be used and it will be shortened 0.6" to give a 3.0" total increase in distance between front and rear seats (Ref. Figure 9, p. 31). The outer corners of the cushion are also trimmed off (Figure 9) to further improve entrance and egress foot clearance. Molded structural foam will be investigated for the seat and seat back cushion supports for minimum weight.

It is recognized that the seat will not have the comfort of a conventional passenger car seat, but should be comparable to a mass transit (bus) vehicle. Since the rear seat of this vehicle will normally be used only to transport suspects to the police station, or to question witnesses (vehicle stationary), this type of seating should be perfectly acceptable.

The seat cushion pad will be molded in two pieces joining over the tunnel with a one piece cover giving the appearance of a conventional bench seat so that a person can conveniently slide across from one side to the other. The cover will have patterns indicating the two seating positions as there will be negligible cushioning over the tunnel.

A carpet extension (rubber mat) and revised quarter panel trim (plastic molding) will be required to finish off areas exposed by the rearward movement of the seat.

New Front Seats. The conventional front bench seat is replaced with separate individual bench seats. These will be designed to have the same comfort level as current heavy duty bench seats.* A bench type configuration is specified because many police officers object to individual bucket type seats because of interference of the "bucket"

* Similar to compact Chevrolet Nova which was judged to be very comfortable in L.A. County Sheriff's Department ergonomics evaluation.

padding with their holstered revolver and handcuffs. The bench configuration also allows for some degree of seating position change which many officers feel is essential when they are in the seat for an extended period of time. Several officers interviewed objected to the confined feeling of a bucket seat.

Individual seats are also considered essential from a comfort standpoint because of the wider range of height now permitted by many police departments. A 6'2" officer could be extremely cramped in a seat position selected as optimum by a 5'8" driver. The use of individual seats also provides a tunnel area between seats for installation of communications equipment. A convenient and functionally acceptable equipment installation would not appear to be feasible without the availability of this space.

An attempt will be made to thin the back cushion by 1/2" to improve leg room. Seat mounting structure will provide for 1/2" shims to permit lowering the seat for those requiring optimum head room.

New Hood. During the program activity directed toward maximum weight reduction, numerous components were examined for potential material or design change. It was established that from a vehicle assembly standpoint only those components which could be left off in the normal assembly sequence or easily replaced in an "off-line" operation could be justified on the basis of economics.* The hood was one component which met the above ground rule. Also, considerable background is available on the use of lighter weight materials for this particular part. On the basis of available data, the use of a one-piece plastic molding of structural foam was selected (Figure 18). It is common with the previously described rear roof panel material (see later section on Material). Use of a one piece

* The one exception in this proposal is the previously discussed roof panel replacement which is justified on the basis of improved performance, i.e., head room, leg room, and entrance/egress conditions.

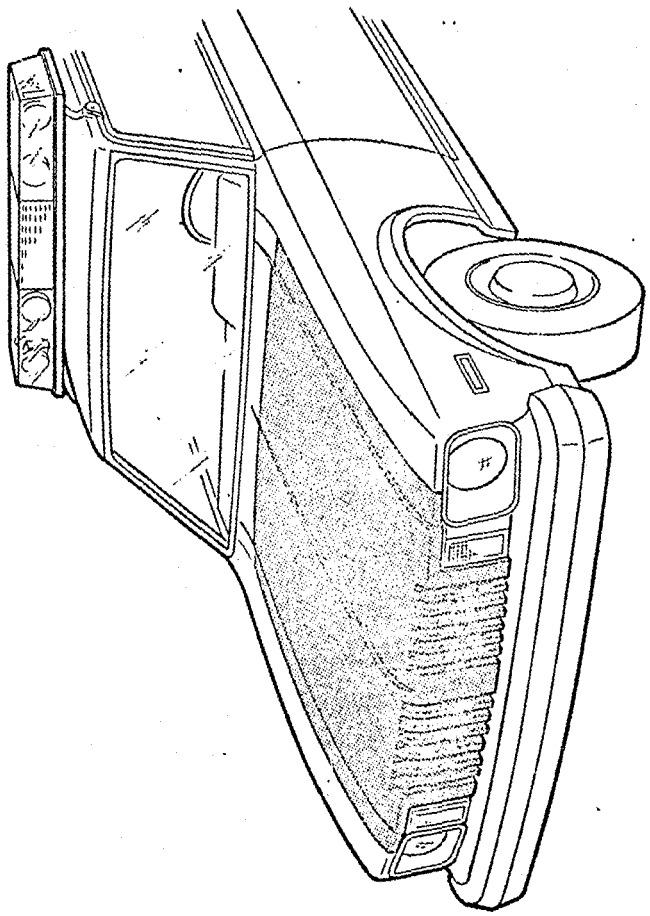


FIG. 18 NEW HOOD

molding saves considerable component assembly time vs. the several parts making up the conventional steel hood. The weight saving is estimated as 42 lbs. Hood hinges and hold down mechanism of the base vehicle would be retained because of the cost of tooling lighter versions. Instead of tooling revised counterbalance springs, it is proposed to utilize a single rod type of hood prop. The lighter hood weight eliminates the need for counterbalance springs to assist in raising the hood. It is also proposed to make the grille integral with the hood to save assembly labor (Figure 18). However, if an alternate material should be selected for the final design, a separate grille might be required (see later section on Materials). Final decision on this item would also be influenced by the weight of the base vehicle grille. Some of the latest versions could be lighter than the integral design and would therefore be retained. Like the roof, the hood panel would be left in natural white to save finishing and painting costs.

New Rear Deck Lid. The deck lid was also selected for replacement by a one piece plastic molding of structural foam. In addition to the weight saving of 22 lbs., the new deck lid has a raised area to provide more usable storage space in the trunk (Figure 19). It also is more visible through the rear window to assist the driver in guiding the vehicle during backing-up maneuvers.

Production hinging would be used because the weight reduction would not justify the tooling cost of new hinges. Counterbalance springs would require adjustment because of the lighter component weight. Base vehicle latching and locking mechanism will be used except that a remote unlocking control, actuated by a button on the left side of the instrument panel, will be specified as requested by many police departments. Like the roof and hood, the deck lid will be left in natural white color to save finishing and painting costs.

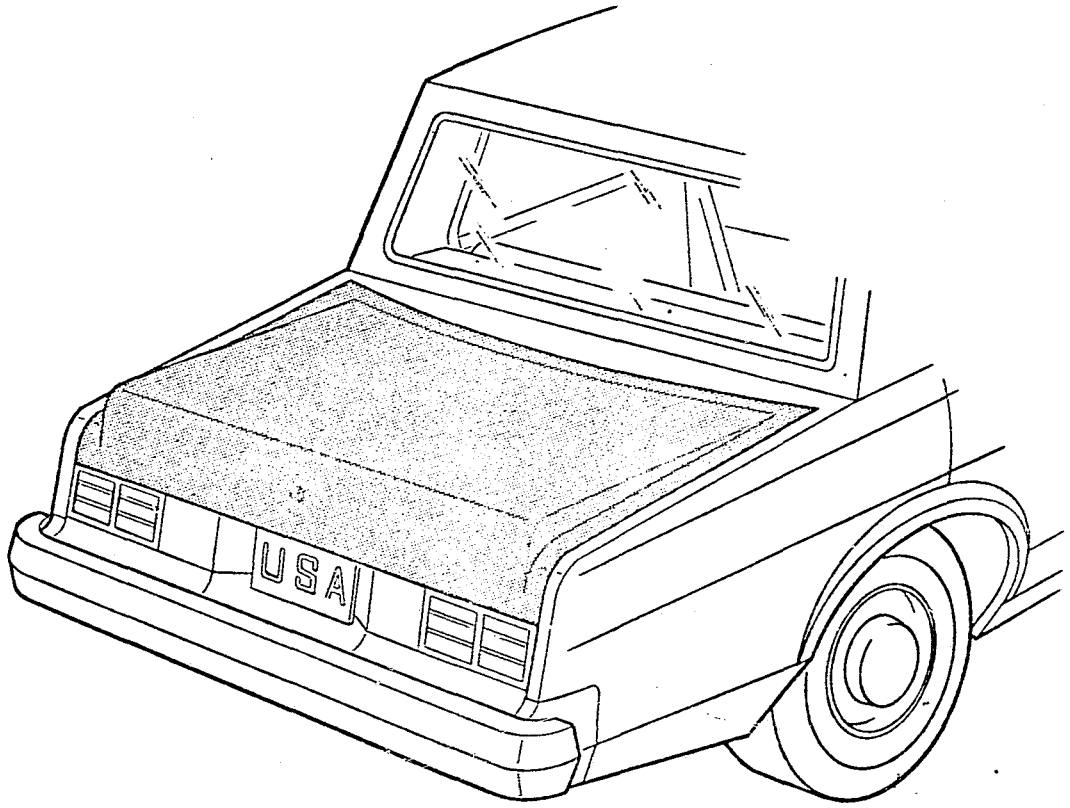


FIG. 19 NEW REAR DECK LID

New Front and Rear Bumpers. The requirements of MVSS No. 215 imposed a need for greatly improved energy management capabilities on passenger car bumper systems. Within the limited time frame available for design and development, the automobile companies chose to adopt conservative systems utilizing hydraulic absorbers. Several supplier companies have been working on the development of alternate systems to meet MVSS No. 215 requirements at significantly less cost and/or weight vs. those currently in use. It is proposed to use one of these systems...the INCO Energy Management System... for this vehicle (Figure 20). It is planned to use identical units - front and rear - except for structural attachnents which would be different because of variations in base vehicle structural design - front to rear.

Pioneer has been involved with the design and development of this system and therefore is familiar with its construction and advantages. The system has successfully passed a MVSS No. 215 barrier conformance test on a vehicle of the approximate size and weight of the police vehicle recommended in this report. The design consists of a relatively simple 'C' section face bar of high strength aluminum alloy. To reduce tooling costs, front and rear bars would be common. Face bar surface would be anodized to save plating cost. Considering the utility use of this vehicle, the non-bright finish should be acceptable. Elastomeric energy absorbers of EPDM material - 2 per bumper - are used (Figure 21). The filler panel between face bar and body sheet metal would be eliminated for further cost and weight saving. Weight estimates indicate that this system would save 96 lbs. per car.

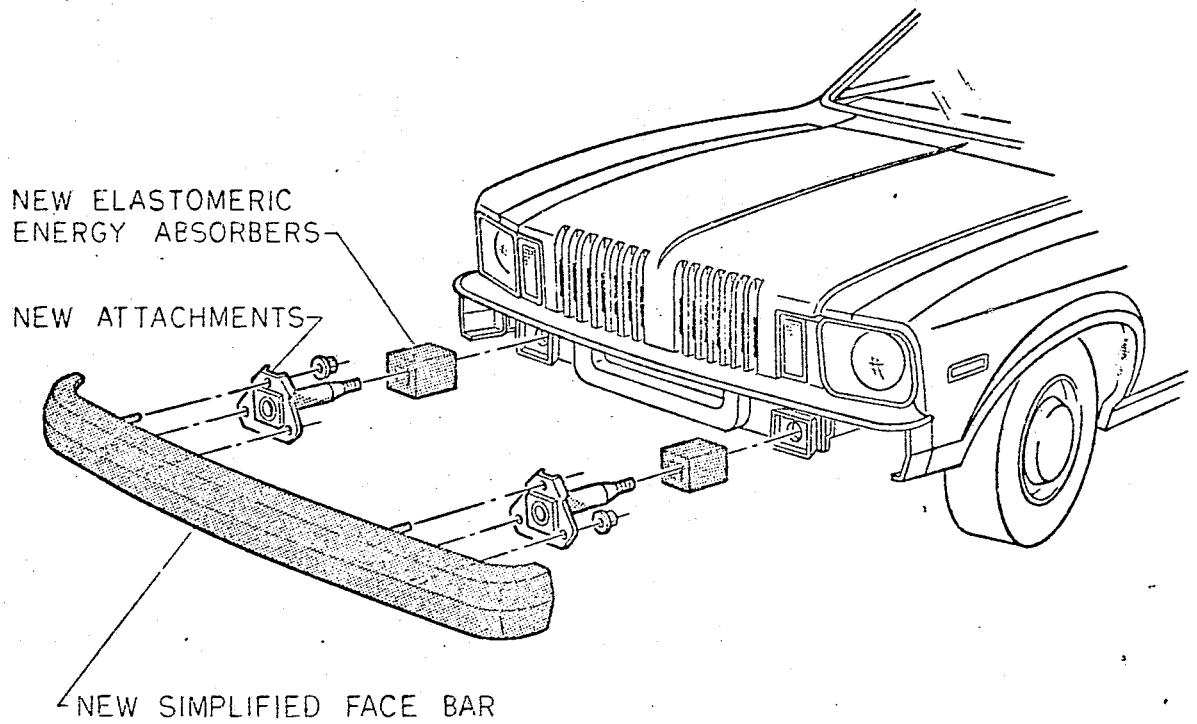
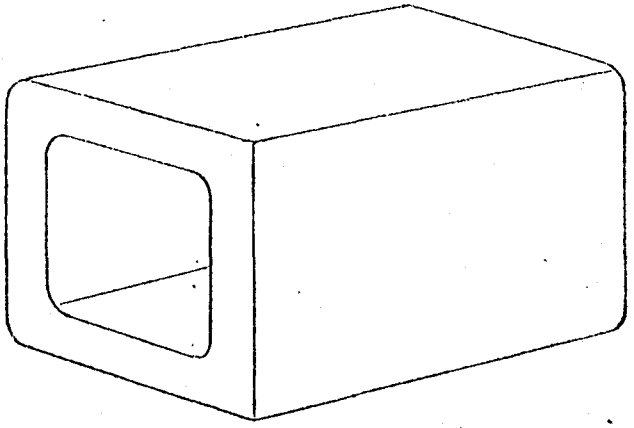


FIG. 20 NEW BUMPER AND ENERGY ABSORBERS

ELASTOMERIC
ENERGY
ABSORBER



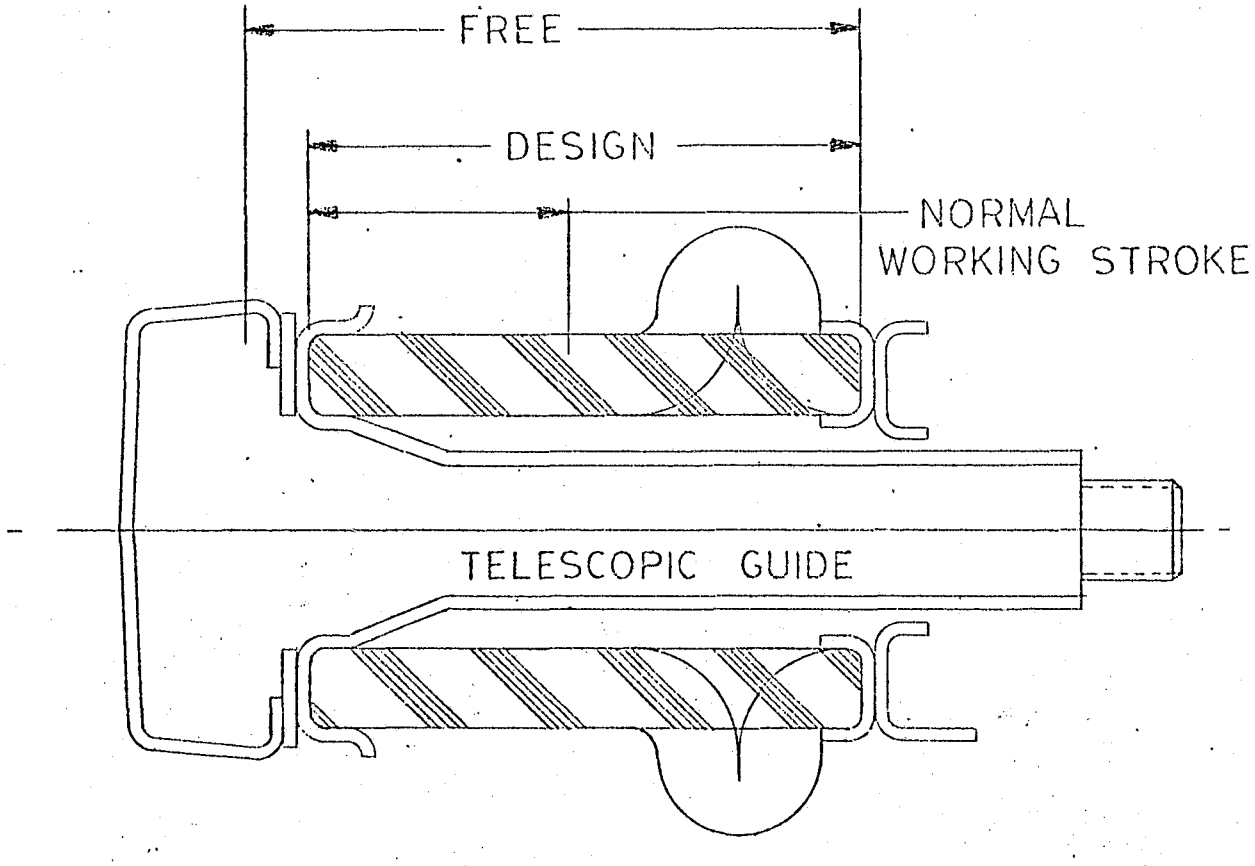


FIG. 21 ELASTOMERIC ABSORBER

B. Material Selection

It is recommended that plastic structural foam or a similar plastic composite be used for the replacement hood, deck lid and rear roof section. Because of their high stiffness to weight ratio, parts made by these new processes provide the necessary structural strength and rigidity for parts this size at a substantial weight reduction vs. current steel components.* While the weight saving vs. aluminum is not as great, tooling costs are substantially less than for either steel or aluminum. Since the processes recommended use low pressure molds, tooling and equipment can be lighter and cheaper than other plastic molding as well as less costly than steel or aluminum stamping dies. Use of the molding process usually results in a one piece part vs. several pieces in the current steel component. This provides a further assembly labor saving. Labor and weight savings should provide a competitive cost level in spite of the higher cost of the base material. It is proposed to use the material in its natural white color as it comes from the mold in order to save finishing and painting costs. The slightly grained surface should be acceptable for a utility vehicle of this type.

A considerable amount of development work on structural foam parts of this size has been conducted by the Plastics Division of General Electric. Using the engineering resin, polycarbonate, several parts in the 50 lb. range have been successfully molded. A hood panel has been satisfactorily developed for Oldsmobile Division of GM and a 75 lb. roof panel is in production for the 1976 Jeep Model CJ-7. General Electric has recommended use of one of the new plastics in structural foam for the parts involved in this project.

An alternate process that might be equally attractive is known as Elastic Reservoir Molding. It is currently under development in the U.S. by Composite Technology, Inc., Warren, Michigan.** They have also prepared an application study using their process.

* See Bibliography Item 6-7. ** See Bibliography Item 8-9.

Use of plastic sheet such as Lexon, one of the new engineering plastics, is recommended for the rear window and rear door windows. These materials have better transparency and greater resistance to scratches or abrasion and therefore should be acceptable for this application.

The substitute bumper design utilizes energy absorber units of EPDM as supplied experimentally by Goodyear Tire & Rubber Co. Aluminum was selected for the face bars to gain maximum weight reduction. Tests by Alcoa (Aluminum Company of America) indicate they have an alloy suitable for this application.

C. Communications Equipment Provision

In addition to the human factors improvements and weight and fuel savings, an additional phase of this study involved the placement of units required for a more extensive and sophisticated communications system (see list in Appendix A). The basic ground rule for this design approach was to provide space for the specified equipment and convenient access to it for operation and service without involving the cost and complexity of major changes in the base vehicle. This has been accomplished. Figure 22 shows the front compartment equipment installation. Included are those items whose location is specified as convenient for observation or operation by driver or observer. Specified items are:

1 - Sensor Signal Conditioner
2 - Printer
3 - Heads Up Display
4 - Control Panel
5 - Keyboard
6 - Main Display
7 - Hand Held Terminal
8 - Main Display Power Supply
9 - Main Display Electronics
10 - Peripheral Interface Box
11 - Sensor A/O Converter

The only base vehicle change required for this equipment layout is the use of individual front seats in place of the standard bench type seat. Use of these seats involves a small weight and cost penalty, but it can be justified because they are also essential for optimum driver/observer comfort (see Section V, p. 47 on Front Seat). A map light will be included for night illumination. The placement of equipment is such that an emergency exit by a person in either seat through the opposite side door can be accomplished without undue restriction.

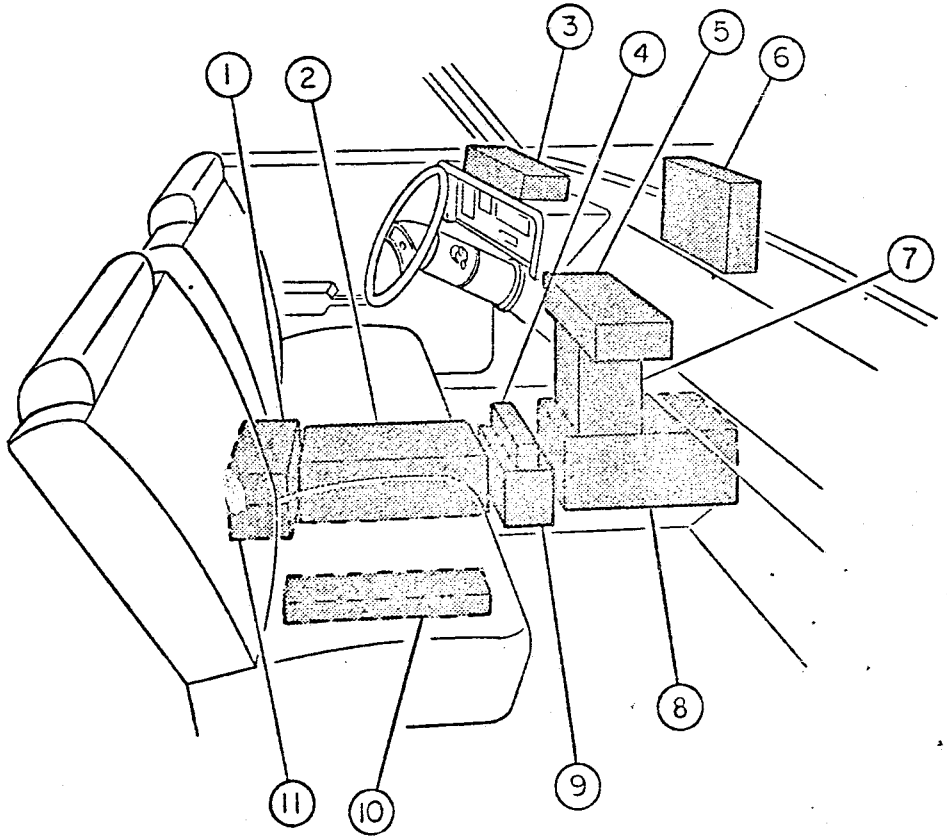


FIG. 22 FRONT COMPARTMENT COMMUNICATIONS EQUIPMENT INSTALLATION

Placement of the remaining items of equipment not having specific location constraints is in the trunk compartment (Figure 23). Specified items are:

1 - Power Supplies
2 - Digital Cassette
3 - Auxiliary Battery
4 - Inverter
5 - Communications Controller
6 - Siren Recorder
7 - Digital Transceiver
8 - Hand Held Terminal Transceiver
9 - Sensor Interface Box
10 - C/O Monitor
11 - Microprocessor
12 - Supplemental Memory
13 - Voice Transceiver
14 - Voice Recorder

The proposed arrangement provides reasonable access to all items and leaves approximately 8 cu. ft. of clear space for storage of other items of equipment...flares, first aid kit, fire extinguisher, etc. Additional volume is also available around the communications equipment. Exact placement of units and optimum storage locations for other items can be established after final specifications for the communications equipment units, including wiring connections and position limitations, are available. These preliminary location studies do indicate that this size vehicle can accommodate the specified equipment.

The trunk compartment shown has a flat floor with the spare tire stored under the floor. The cover panel over the tire could have mounting provisions for the extra equipment so that they could all be removed as a unit. It is anticipated that final location of the communications equipment will allow sufficient clear floor

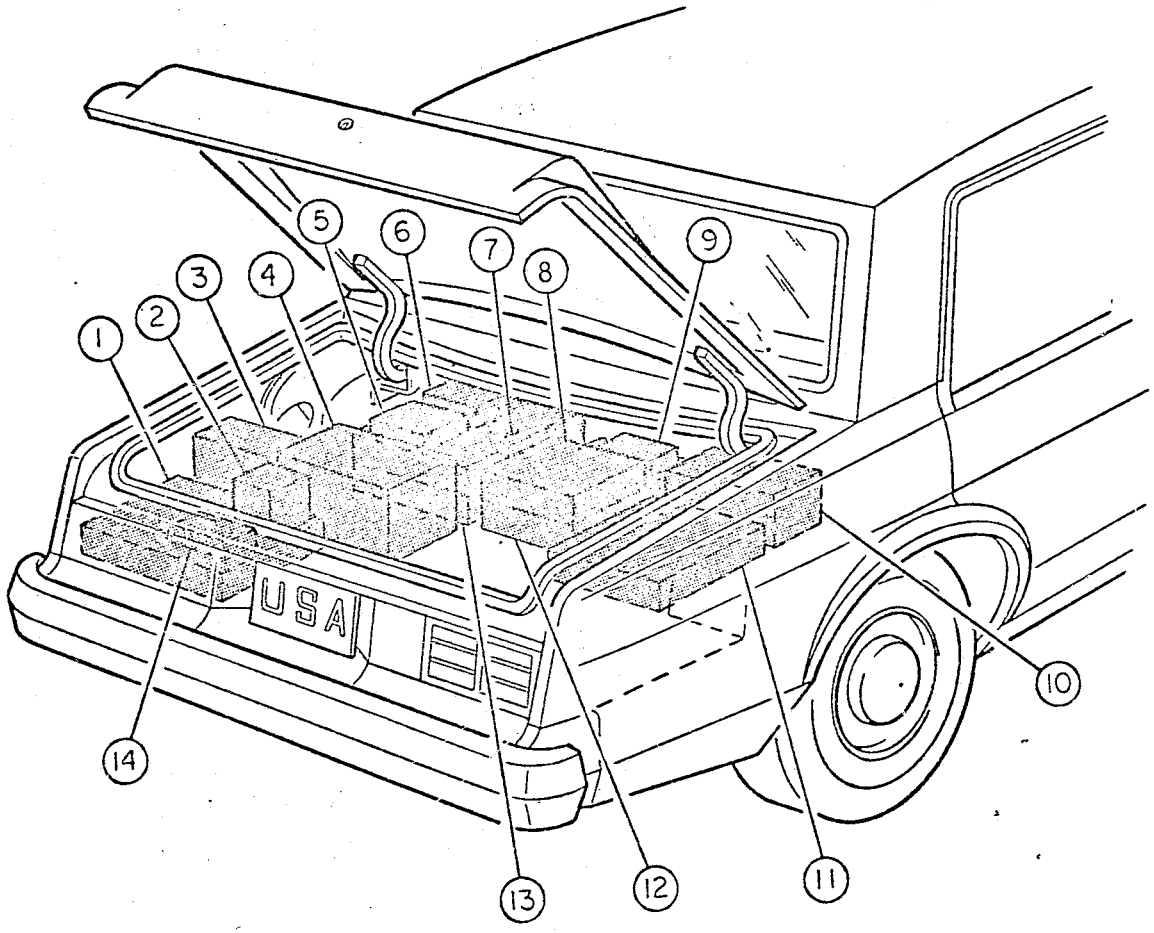


FIG. 23 TRUNK COMPARTMENT COMMUNICATIONS
EQUIPMENT INSTALLATION

space for removal of a standard spare tire and wheel. If space does not permit, a smaller size collapsible spare would have to be used. It is also anticipated that the clear space available will provide sufficient room for the usual equipment carried by an urban use patrol car (see Section F). Where additional carrying capacity is required, it is recommended that a compact size station wagon be used. Normally, one vehicle of the latter type, per department or precinct, would be adequate for carrying this type of specialized equipment.

D. Rear Compartment Shield

Since a high percentage of police departments (72% in LEAA Survey)* now desire a protective shield between front and rear compartments of their vehicles, a shield was included in this design. Installation of a typical commercial shield, as supplied by the Novelty Carriage Works, Inc. of Spokane, Washington, is shown in Figure 24. They have a model designed specifically for compact sedans which has only a .078 thickness of metal detracting from rear seat leg room. While this design results in a minimum of leg room reduction, the upper portion follows the backward slope of the front seat back and does intrude into the upper portion of the rear compartment. A roll bar is included as part of the shield structure, but again the rearward slope detracts from its structural effectiveness in a rollover.

A revised version as shown in Figure 10 is therefore recommended. A protective panel of .078 steel is provided which is tight against the back of the front seat when the seat is in its rearmost position (same as Novelty design). However, above the seat back, the revised design is straightened up to a vertical position to offer minimum intrusion in the rear compartment. Construction of the upper section is the same as the Novelty model, providing a

* See Bibliography 1

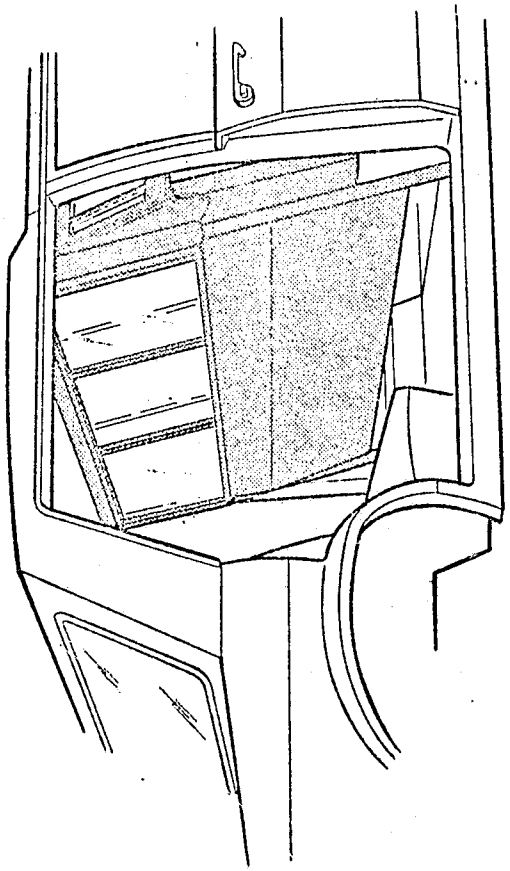


FIG. 24 REAR COMPARTMENT SHIELD

transparent shield of high impact 1/2" plexiglass mounted in an aluminum track frame. It is made in three sections with the center section sliding to the right for communications with the rear compartment. It is provided with a front compartment operated lock for security.

The steel portion of the shield behind the seat is carried around to a roll bar for support and to close in the gap at the end of the seat. A closure panel is also provided at the ends of the upper transparent panel for complete security.

Roll bar which forms the support for the shield is mounted vertical for maximum effectiveness in a rollover. It is attached to the center pillar as well as the floor pan thus providing increased side impact as well as rollover protection.

E. Compliance - Federal Motor Vehicle Safety Standards and Regulations

A basic requirement of the vehicle design study is that the recommended product comply with all applicable and anticipated (1977) FMVSS and regulations. All changes and modifications have been reviewed against current requirements and full compliance is anticipated. The method of certification will depend on whether the modified vehicle is completely assembled by the base vehicle manufacturer or an intermediate and/or final-stage manufacturer modifies and completes the vehicle.

With the exception of the Standards listed below, the modifications to the base vehicle recommended in this design should have no effect on the compliance of the vehicle.

105 - Hydraulic Service Brake, Emergency Brake, and Parking Brake Systems - Passenger Cars

The reduced weight of the vehicle should improve certain aspects of brake performance, such as fade. Reductions in rear roof, deck lid and rear seat will remove more weight from the rear wheels than the front which will not be offset entirely by

reduced hood weight. This change in weight distribution could effect light load performance, however, the addition of the communications equipment in the trunk should more than offset weight reduction effects. Since the exact weight of components, particularly the communications equipment, is not available, the final effects on brake performance must be checked on the first prototype. It is recommended that a compliance test be conducted on this vehicle, but no problems of conformance are anticipated.

105a - Hydraulic Brake Systems

See above. Same except for more stringent requirements apply for 105-76.

110 - Tire Selection and Rims - Passenger Cars

Since the recommended vehicle will be lighter than the base vehicle, no tire loading problems should exist. Tires and rims recommended for police use by the base vehicle manufacturer will be used to insure optimum performance.

111 - Rearview Mirrors - Passenger Cars and Multipurpose Vehicles

The replacement rear window will be as large or larger in area than the production window and therefore should have no effect on the required field of view from the production mirror of the base vehicle.

113 - Hood Latch Systems - Passenger Cars, Multipurpose Passenger Vehicles, Trucks and Buses

The hood latch system of the base vehicle will be retained to insure compliance.

115 - Vehicle Identification Number - Passenger Cars

Vehicle identification will be supplied by base vehicle manufacturer and the area used for attachment of the number will not be disturbed.

201 - Occupant Protection in Interior Impact - Passenger Cars

No change in instrument panel, interior compartment doors (glove box), sun visors, or armrests are included, so that compliance of base vehicle should apply. Design of individual front seat backs will be such as to conform to requirements of S3.2.

202 - Head Restraints - Passenger Cars

The new front seats will be designed to include head restraints which conform to the requirements of this Standard.

204 - Steering Control Rearward Displacement - Passenger Cars

Change of the hood material for weight reduction should have no effect on the vehicle structure system which controls the amount of rearward displacement of the steering control. The problems of providing a front end structure and steering system which meets the requirements of this Standard is a major reason for not recommending a change in these components as part of this project.

205 - Glazing Materials - Passenger Cars, Multipurpose Passenger Vehicles, Motorcycles, Trucks and Buses

The substitution of plastic for glass in the rear window and rear door window for weight saving is predicated upon the assurance of the material suppliers (GE Plastics Division) that they can certify this material to meet all requirements of this Standard.

207 - Seating Systems - Passenger Cars, Multipurpose Passenger Vehicles, Trucks and Buses

The new front and rear seats will be designed to conform to the requirements of this Standard. The seat supplier contacted for this initial concept study (Bostrum Division of Universal Oil Products Co.) assures that the concepts previously presented should have no problem meeting the requirements.

208 - Occupant Crash Protection - Passenger Cars, Multipurpose Passenger Vehicles, Trucks and Buses

Utilizing the front roof and other structural and restraint systems of the base vehicle, it is anticipated that this modified vehicle will meet all requirements of this Standard. Based on development data available, the rear roof section should have adequate strength and rigidity to not impair conformance.

209 - Seat Belt Assemblies - Passenger Cars, Multipurpose Passenger Vehicles, Trucks and Buses

Seat belt assemblies as supplied by the base vehicle manufacturer will be used and therefore will be certified as complying with the requirements of this Standard. Middle position belts will be eliminated because of the 4-passenger seating configuration.

215 - Exterior Protection - Passenger Cars

Utilizing the base vehicle hinging and latching mechanisms for the replacement hood and deck lid should insure that these components will operate normally after the specified impact.

The proposed bumper design has satisfactorily passed a barrier impact test on a car of the approximate weight of this proposed police vehicle. Therefore, compliance of the basic system should be assured. The ends of the face bar will be designed and positioned relative to the sheet metal to insure compliance in the pendulum portion of the test.

216 - Roof Crush Resistance - Passenger Cars

This proposed design does not alter the forward section of the vehicle roof (forward of the center pillar - 'B' Post) including windshield frame and header, roof rails and center pillar. The structural rigidity of the base vehicle in this area should not be affected and therefore compliance to the requirements of this Standard will be assured. The requirement of this Standard is a major reason why it is not proposed to alter this portion of the base vehicle structure.

302 - Flammability of Interior Materials - Passenger Cars, Multipurpose Passenger Vehicles, Trucks and Buses

The specified seat covers will be of a contemporary material meeting the requirements of this Standard.

A review of current activity did not indicate any new requirements for 1977 which would be of concern to this program. The question of passive restraints, if they ever reach production, would be provided in the base vehicle and none of the modifications recommended for this design should affect these provisions. The potential for a hood intrusion requirement (219) would again be provided for in the hood rear hold down of the base vehicle which would not be disturbed. The replacement plastic hood would be designed to conform to the collapse pattern of the base vehicle hood.

F. Provision for Stowage of Extra Equipment

It is recognized that the design must include provision for items of equipment normally needed by police officers in their daily operations. Results from the LEAA Survey* were again used as a basis for establishing requirements.

The equipment, the percentage requesting (from Table 14-1, p. B-19 of Survey), and provision for accommodating in this design is shown below:

Feature	%	Accommodation Provided
Hand-Held Radio	30	Part of Communications Equipment Layout
Shotgun	73	Transverse on Front Compartment Floor Ahead of Seats
Flares	81	Trunk
First Aid Kit	79	Trunk
Extra Ammunition	55	Trunk
Batons	67	Front Door Holster
Camera and Film	32	Glove Box

* Bibliography 1

Feature	%	Accommodation Provided
Clipboard	84	Side of Communications Console
Briefcase	53	Under Glove Box
Fire Extinguisher	83	Trunk
Blankets	64	Trunk
Fingerprint Kits	19	Trunk
Field Detection Kits	6	
Riot Equipment	28	

The two items for which specific provision has not been provided are not sufficiently standardized in content or usage to permit space allocation in this program. Some space will be available in the trunk for above items. Specialized equipment for riot duty, however, should be carried in a special vehicle not carrying the large consignment of communications equipment.

As far as problems encountered in the installation of the above equipment, only the shotgun was listed by any significant number (16%). In this design, it is proposed to mount the shotgun on the front floor ahead of the seat in a position currently found acceptable by many departments (Figure 10). The communications equipment in this area, (4 and 9) would be mounted off the tunnel surface enough (approximately 4") to allow the gun barrel to pass underneath.

G. Other Vehicle Characteristics

While the principle objectives of this project are to reduce weight and improve those characteristics of the body which affect the comfort and operating effectiveness of the personnel, other vehicle characteristics were studied in preparation of the background for the resultant design activity. These other characteristics are covered in this section of the report for whatever value they may be to the overall effort of improving police patrol car effectiveness.

Referring again to the LEAA Police Equipment Survey - Patrol Cars,* Question 15 asks, "Which of the following features do you think should be on all of your patrol cars? (Check each item that applies regardless of whether you know it is available or not)." The answers (Table 15-1, p. B-23 of Survey) are listed in Column 1 of Table VIII.

Of greater significance is Question 15A, "Which three of the above features (items checked in Question 15) would be most important to have in all your patrol cars?". The answers to the second inquiry (Table 15A-1, p. B-24 of Survey) are listed in Column 2 of Table VIII.

It is interesting to note that many of the features although desirable are not given a very high priority. However, except for those items marked (x), all features have been provided for in this design or could be provided as special equipment on the base vehicle. The (x) items appear to be difficult and expensive to obtain and it is the opinion of this Contractor that the benefits would not justify the cost. This evaluation is supported by the low priority of these particular features as indicated in Column 2 of Table VIII.

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* See Bibliography Item 1

TABLE VIII

DESIRABLE FEATURES FOR PATROL CARS

Feature	% Total Saying It Should Be On All Patrol Cars (Q. 15)	% Total Saying It Is One of Three Most Important (Q. 15A)
Air Conditioning	85	42
Tinted Glass	83	3
Additional Head Room	63	14
Additional Leg Room	44	5
Bucket Seats w/Console	37	8
Better Vent. Upholstery	71	7
More Durable Seat Springs	72	7
Fold-Out Desk in Front	37	3
Communications Console	69	24
Larger Glove Compartment	40 (x)	2
Barrier Between Seats	72	31
Built-In Shelves in Trunk	56	6
Noise Soundproofing	33	1
Built-In Mounting Brackets	62	7
Bullet-Proof Glass	38	10
Interior Map Lamp	76	1
Built-In Crash Bars	70	32
Locking Gas Cap	50	2
Bumpers With Push Bars	58	6
360 Degree Obsrv. Mirrors	63 (x)	6
Trunk/Hood Releases Inside	85	7
Central Door Lock	71	10
Heavy Duty Suspension	94	38

The features felt to be the three most important by 25% or more of the responding departments were:

- Air Conditioning. Nothing in this design should affect the performance of the base air conditioning system. Particular emphasis was placed on not disturbing the air outlets or duct work when placing the communications equipment in order to not depreciate the performance of the A/C system. Significant improvements in A/C effectiveness have been made in recent years including performance in compact cars equivalent to full size models (example, Plymouth Volare). It would be extremely difficult and time consuming, if not impossible, to duplicate the current level of performance in a modified or reworked system. This proposal therefore provides for the availability of a top performance A/C system with no sacrifice in performance due to selection of a compact car for the base vehicle.

- Heavy Duty Suspension. The performance level desired by many police departments (i.e., Los Angeles County Sheriff's Department and City of Los Angeles) requires both a heavy duty and a performance tuned suspension. The manufacturers of two compact size cars (Chevrolet and Dodge) recently demonstrated in the Los Angeles County Sheriff's Department evaluation tests (November 10, 1975) that they have developed an excellent handling compact size vehicle for police work. They also demonstrated that they were not inferior in handling to full or intermediate size vehicles. Therefore, the selection of a compact car for the base vehicle in this design will not result in any loss of desired handling performance. The amount of development work required to perfect this type of handling package is one of the reasons Pioneer chose a production base vehicle for this design. It is also a reason why a truck based, or other high c.g. vehicles, were not recommended.

- Built-In Crash Bars. The design includes provision of a roll bar as discussed in Section D, p. 60.

- Barrier Between Seats. Provision of a rear compartment shield is described in Section D, p. 60.

- Communications Console. Use of individual front seats provides room for several units of communications equipment. It is felt that this design provides room and convenience of access for the sophisticated communications equipment included in this project, plus provision for conventional controls...lights, siren, etc. A more detailed discussion of the provision for communications equipment will be found in Section C, page 56.

Other areas of interest or concern to police departments as revealed by the LEAA Survey are as follows:

- Control and Handling (Dynamic Handling). This area of performance was rated satisfactory or excellent (1972 models - 87½% full-size 4-door sedans) by a large majority of respondents except in the critical over 70 mph category. There 60% gave a satisfactory rating, 10% an excellent one, with 25% rating poor. It is obvious from the spread that the rating base varies, or vehicles differ in their performance levels. From various instrumented and therefore objective evaluations it would appear that most American built sedans can be equipped with steering/suspension systems which will give suitable dynamic handling performance levels. The key is that they be ordered and built with the proper components. In many instances this has not been done, either because the information was not available or other factors such as resale value influenced the vehicle purchase specifications. The Los Angeles County performance evaluation tests offer objective proof that acceptable handling can be obtained in production built 4-door sedans and that this level of performance is now also available in a compact size vehicle (see results of 1976 tests - Appendix B).

- Braking. Ratings for this performance factor were similar to handling. Again, objective tests demonstrate that brake systems are available to meet police performance requirements and this includes the compact size sedans. Brake system specifications (particularly lining material) must be selected for compatability with the performance desired.

The provision of acceptable high speed handling and braking could be a major development problem in a new and unique vehicle design and is another reason why Pioneer chose to make relatively minor modifications to a production base vehicle. As a result, the extensive background of the vehicle manufacturers in both performance development and compliance to Federal Safety Standards could be utilized. On the other hand, the specification of a particular vehicle for police use (as recommended in this report) should be extremely heldpful in assuring that the availability of optimum performance equipment is made known to all police departments.

It was mentioned in the first section of this report that the police departments interviewed all stressed the importance of:

- Performance
- Ease of Maintenance
- Reliability and Durability
- Operating Economy

Police departments stress performance as a deterent to high speed chases and stress avoiding them whenever possible. Fast acceleration and good handling will usually enable the police vehicle to apprehend suspects before a high speed chase develops. There are also instances when lives may depend on a high speed delivery of officers and equipment - when literally every second counts. For these reasons, this design provides a power/weight ratio and handling performance comparable to previously satisfactory police vehicles. However, it also offers the flexibility of using smaller

displacement engines if their level of performance is acceptable to the using department. It should be cautioned that smaller displacements do not necessarily provide better economy unless lower performance levels are recognized and the vehicle operated accordingly.

Ease of maintenance is recognized as an important factor in the operating cost of a vehicle. However, much of the maintenance complexity is due to the options specified by the user, air conditioning, power steering and brakes, etc., and the equipment required as a result of Government Standards and Regulations. Numerous developments in recent years have reduced the need for maintenance; electronic ignition, long life spark plugs and batteries, sealed cooling system, extended lubrication intervals, to name a few. The most important factor of all is probably a good maintenance program, however, it would seem that a well maintained production vehicle will be more likely to provide minimum maintenance costs than a specialized unique vehicle design. Another reason Pioneer favors the design approach recommended by this project. The importance of a well planned and executed maintenance schedule cannot be over-emphasized. It is recommended that the LEAA establish a project to educate police personnel on an optimum vehicle maintenance program. This could be carried out in conjunction with this vehicle program or conducted separately.

It also follows that a reliable and durable vehicle will minimize maintenance costs. Again, it would seem that a vehicle benefiting from the development experience of the large vehicle manufacturers would provide better reliability and durability than a low volume unique vehicle. To insure optimum reliability, it is critical that vehicles for police patrol car use be ordered with the specialized equipment designed and developed for the purpose. It would not be cost effective for the average car buyer to have this equipment on all cars sold. This program provides a unique opportunity to insure that the proper car is available to all departments regardless of size.

Reliability is also a function of the success of a good maintenance program previously discussed. The high cost of providing service parts for unique components would be another deterrent to that design direction.

Economy of operation is now generally recognized as a prime requirement of any police car of the future. To provide economy with performance - as required of a police car - means minimum weight. This is the primary reason for selecting a compact car as the base for this recommended design. The extent of modification depends on the cost effectiveness of the various possibilities, but the compact car will always provide the lowest base (among vehicles which have adequate room for the requirements).

H. Weight Summary

Base vehicle weight (Plymouth Volare 4-Door Sedan) - 3,550#

Less Modifications -

Roof	- 8#
Roof Interior Trim	- 3
Dome Light & Door Switches	- 2
Rear Window & Trim	-12
Rear Door Window (2)	-13
Rear Door Window Frame (2)	+ 1
Rear Door Window Operating Mechanisms (2)	- 5
Rear Seat	-12
Front Seat	+ 3
Rear Carpet Filler & Quarter Panel Trim	+ 2
Rear Deck Lid	-22
Hood	-42
Grille	-12
Front Bumper (including Supports & EA Units)	-52
Rear Bumper (including Supports & EA Units)	-44
Bumper Fillers	- 4

Recommended Vehicle Weight ---------- 3,325#

It is recognized that the above weight reduction of 225# is less than the earlier estimate of 350#. The above estimates are based on data obtained from supplier sources which admit to a conservative approach at this preliminary design concept stage. It is believed that much of the difference will be recovered during the prototype design and development program. It should be noted that the change in weight results in only a 0.1 change in fuel economy per EPA calculations.

I. Performance Summary

Because of the wide variation in fuel economy results obtained by different organizations under different conditions, it was decided to use typical results of the Los Angeles Sheriff's Department tests for a full-size car with maximum engine displacement as a base. Potential gains in fuel economy for this proposed design would then be:

Model	Wt.	Test Mileage	Operational Mileage *
Full-Size 4-Door Sedan	4,650#	10 MPG	6 MPG
Recommended Design Based on Compact 4-Door Sedan	3,325#	13.6 MPG**	8.2 MPG

* Los Angeles estimate 60% of test mileage.

** 36% better mileage based on EPA figures of 10% weight or displacement reduction = 3 to 6% saving in mileage (see Table VII-p. 33).

The value obtained appears conservative based on Los Angeles County tests of current compact cars.

Again using Los Angeles County figures of 70,000 miles/car the fuel usage per can would be:

Full-Size Car	-	11,667 gal.
Recommended Design	-	8,541 "
FUEL SAVING	-	3,126 "

The relative performance (acceleration and top speed) as a function of vehicle weight and engine size is:

	Wt.	Displacement	Wt. Per Displacement
Full-Size Car	4,650#	450	10.3
Recommended Design	3,325	315	10.5

Based on power output being proportional to displacement, the performance of both vehicles should be comparable. It should be noted that power output of two engines may not be in direct relationship to displacement. The L.A. tests are showing superior relative performance by the compacts. The effects of changes in emission controls from year to year also result in corresponding changes in output/cu. in. displacement. However, for purposes of this preliminary study, a constant relationship should be acceptable.

J. Car Cost Summary

Average Cost of Compact Base Car	-	$4,000*
Less Removed Parts	-	200
		$3,800
Added Parts	-	600
Assy. Labor		400
		$4,800
Minus Fuel Saving - 2 Year Car Life		
3,126 gal. @ .50/gal. (Sec. I)	-	1,572
Net Vehicle Cost	-	$3,228
Average Cost of Full-Size Car	-	$4,700*
Savings Per Car	-	$1,472

Assuming car is replaced at 2 year intervals - 70,000 miles (L.A. County program).

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* Includes high performance engine and chassis police package.

VI. Recommended Program

The design developed by this project clearly demonstrates that it is possible to modify a current compact size car to provide optimum interior space for personnel comfort and efficient functional operation as an urban police patrol car (superior to current full-size cars). Furthermore, this optimum space and utility is obtained with a significant improvement in fuel economy and no loss in performance levels desired for effective police work.

It is therefore recommended that a program to design, develop and promote the use of this design proposal should be initiated as soon as possible. A proposed prototype and production program is outlined on the following cost and timing charts.

Facility costs are difficult to determine at this point in the program since the sourcing pattern has not been established. One manufacturer has indicated tooling and facility costs to produce the vehicle in an existing assembly plant could involve a multi-million dollar expenditure. Assembly on an off-line rebuild operation could be more or less depending on facilities available at the time. A true cost picture cannot be established until design and development has proceeded to the point where firm quotes and commitments can be obtained. The preliminary estimates in the cost and timing charts are provided to give some idea of the magnitude of the expenditures involved in this proposal.

The tooling and facility costs, however, should be put in perspective. Assuming a $2,500,000 cost and 50,000 vehicles/year for 5 year tool life, the amortized cost per car would be only $10. Thus these costs should not be a determining factor.

All of the foregoing estimates are based on preliminary concept studies and do not represent firm quotes from Pioneer or any other contractor.

It is the conviction of this Contractor that this approach provides the lowest cost approach in both investment and unit costs. It also offers the most cost effective approach to providing all the space and performance required for optimum police operation.

PROGRAM COST ESTIMATE

Prototype - 4 Cars

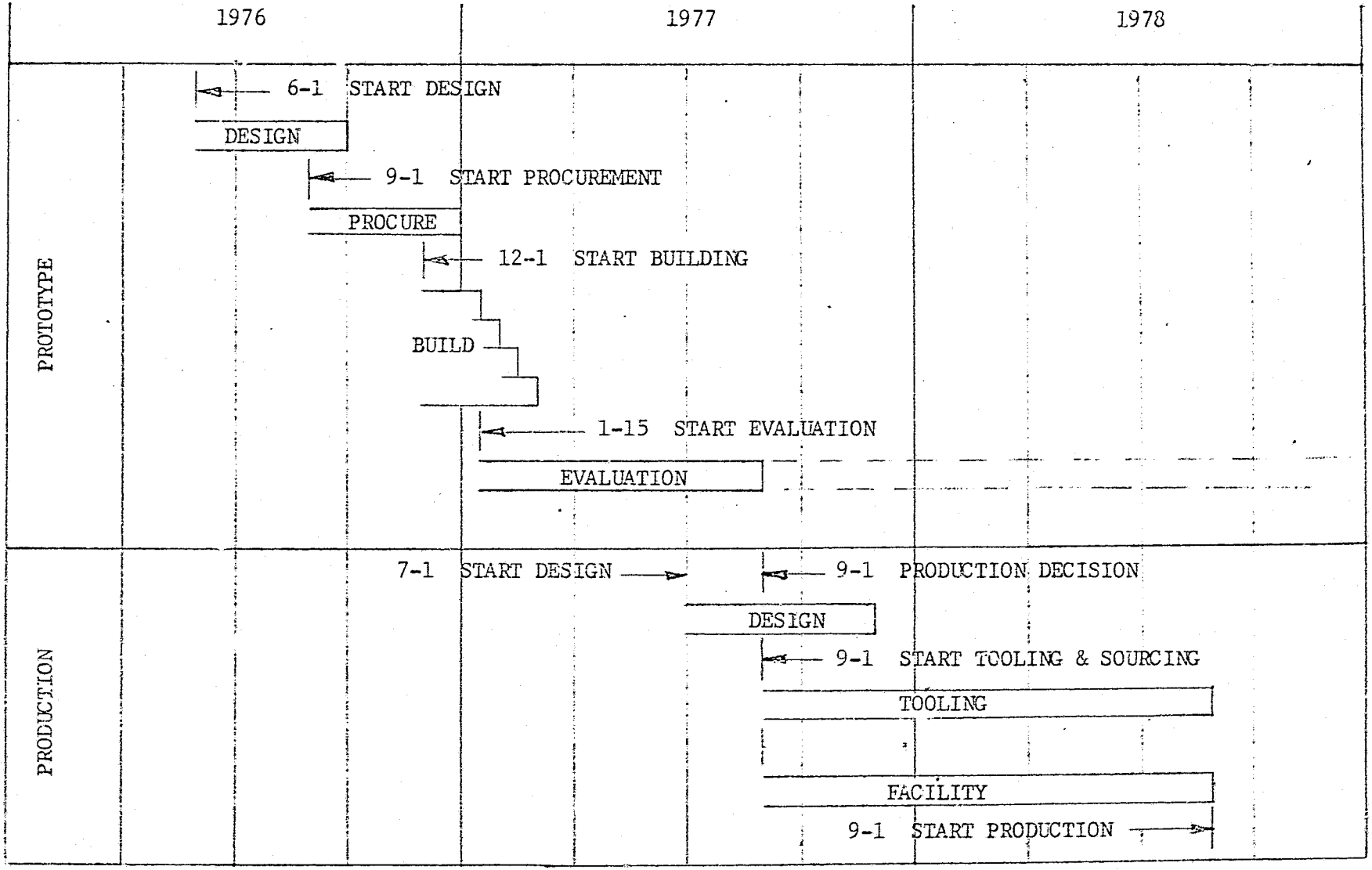
Design	-	$125 - $150,000 *
Tooling	-	$100 - $125,000
Build (4 cars)	-	$ 50 - $ 75,000
Test & Evaluation (by Builder)	-	$5,000
		$280 - $355,000
Timing	-	9 Months

Production

Design	-	$ 50 - $ 100,000 *
Tooling	-	$750 - $1,000,000
Facility (Indeterminate at this time - see text, p. 78)		
Timing	-	16 Months

The two manufacturers contacted were reluctant to give firm quotes on the vehicle at this stage of the program. However, they did indicate acceptance of the feasibility of the design approach and a strong desire to be a supplier of police vehicles in the time period specified.

* Division of total design time between prototype and production programs depends on character of prototype program. The above division is based on a comprehensive and complete prototype design program to ensure a meaningful evaluation in actual police activity.



PROPOSED PROGRAM TIMING CHART

In addition to developing and utilizing the improved vehicle concept, it is also apparent that considerable improvement in operational effectiveness can be achieved by improved dissemination of supportive information such as "Methods for Reducing Police Car Fuel Consumption"* and "Life Cycle Costing of Police Patrol Cars."**

Since two of the most effective ways of reducing operating costs are driving habits and an effective maintenance program, it is further recommended that concurrent programs be initiated to provide training programs on a national scale to instruct police personnel on driving procedures to reduce fuel consumption and to provide police departments with an optimum vehicle maintenance program.

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* Bibliography 10

** Bibliography 11

APPENDIX A

STATEMENT OF WORK

SUGGESTED GROUND RULES

CONCURRENCE ON CONCEPT

STATEMENT OF WORK

ALTERNATE POLICE PATROL CAR BODY DESIGN

May 12, 1975

Prepared by
Law Enforcement and Telecommunications Division
THE AEROSPACE CORPORATION
El Segundo, California

Prepared for
NATIONAL INSTITUTE OF LAW ENFORCEMENT
AND CRIMINAL JUSTICE
Law Enforcement Assistance Administration
U.S. Department of Justice
Washington, D.C.

Contract No. J-LEAA-025-73

Background

The Aerospace Corporation, under a prime contract covering work for the Law Enforcement Assistance Administration, U.S. Department of Justice, is engaged in a program to improve the police patrol car system. As a part of this program, vehicle improvements for reducing fuel consumption through alternate body configurations for weight reduction will be explored. With respect to lighter weight patrol cars, prior work by Aerospace has shown that the reduced vehicle weight attendant with smaller (compact size) cars offered significant potential improvement in fuel economy, up to 20% savings in fuel consumption compared to the standard, full-size, police car. It was further found that greater use of intermediate and compact size cars was practical although the extent of use was basically limited by their smaller size. Some of the past criticism about smaller police cars has been in regard to comfort, convenience, dependability, equipment interfaces and storage space, performance and safety.

Purpose

The effort defined by this statement of work is intended to result in a preliminary design concept for an alternate patrol car body configuration that provides significant weight reduction potential while enhancing human and equipment interfaces functionally. The developed concept is to reflect what could realistically be provided by the automotive industry at relatively low-volume production and competitively priced with current police car models in use.

Scope of Work

The following descriptions of general tasks to be performed define the scope of work:

1. Prepare Initial Concepts - A limited number of concepts shall be developed which illustrate innovative designs which range from a variation of current body designs to completely new body designs. Other considerations to be included consist of possible substitutions of materials and innovative passenger/prisoner compartment and equipment storage arrangements. The concepts shall be sketched out and defined to sufficient detail to allow an assessment as to their feasibility.

2. Assess Concept Feasibility - The initial concepts shall be assessed for feasibility based on engineering criteria which includes weight, volumes, producibility, and other factors mentioned under Task 3, below. The concepts will be reviewed by the contractor and The Aerospace Corporation within one month after the contract start date. Written concurrence on the initial concepts will be provided by The Aerospace Corporation one and one-half months after the contract start date.

3. Prepare Concept Design - The initial concept assessed as having greatest overall merit shall be used as the basis for preparation of scaled layouts, sketches and renderings as appropriate to illustrate the design concept. In addition to illustrative material, summary engineering and cost data shall be prepared which shows a comparison between the design concept and current police cars by class size. To the extent practical, the comparison should include such factors as body and total weights, overall dimensions and volumes, human interfaces and door sizes, visibility and window areas, equipment interfaces and storage space, load carrying capacity, crashworthiness, fuel economy, and durability/repairability.

4. Deliverables - A Design Concept Summary Final Report shall be prepared which includes the illustrative and comparative material prepared in Task 3. This Summary Report shall be suitable in format and content for distribution to such organizations as police departments and manufacturers. Twenty copies of the Design Concept Summary Final Report shall be provided.

Schedule

The work defined herein shall be completed and five copies of the Design Concept Summary Final Report first draft submitted within three months from contract start date. The Design Concept Summary Final Report copies are to be provided within one month after final draft copy approval by Aerospace.

CONTINUED

2 OF 3

SUGGESTED GROUND RULES FOR ALTERNATE BODY CONFIGURATION (ABC) STUDY

The kickoff meetings associated with the start of the ABC studies identified the need for basic ground rules. Such ground rules purposely constrain the design possibilities. The basic objective of these studies is to develop producible body design concepts that significantly reduce vehicle weight while enhancing the vehicle utility in police operations. The resultant lightweight is expected to improve vehicle economy.

Ground Rules

(1) The body shall be configured for use with chassis subsystems available in the 1977 to 1980 time frame.

(2) The body shall be configured to seat two officers and two prisoners.

(3) The resulting body configuration shall be cost competitive on a life-cycle basis with conventional police vehicles.

(4) Space shall be provided for electronic equipment in instrument panel and equipment bay locations. The approximate form factors of such equipment are provided in the attachment.

(5) Safety constraints of 1977 shall apply.

(6) Total vehicle performance shall be representative of urban and rural police use. The state highway patrol needs are not expected to apply.

(7) Annual production volume is expected to be approximately 48,000 units.

Note: These ground rules were established by L. Peterson, Contract Technical Manager, on November 5, 1975.

POLICE PATROL CAR SYSTEMS IMPROVEMENT PROGRAM

EQUIPMENT LIST

	Item	Dimensions (In.) Hght.	Wdth.	Lgth.	Location Constraints
	Main Display	7	9	2	Observable by driver and/or observe
2.	Main Display Electronics	5	8	4	Proximity of main display (i.e., beh dash)
3.	Heads-Up Display	2.5	7	4	Driver peripheral vision on road whe reading
	Keyboard	3	11	6	Operable by driver and/or observer
	Printer	6	5	14	Operable by driver and/or observer
	Peripheral Interface Box	2.5	15	4.5	Convenient for cabling to Items 1-5, 17, 23
	Voice Recorder	3	5	9	Convenient to rewind, load
	Digital Cassette	5	7	6	Convenient to rewind, load
	Control Panel (Radio, mike, speaker, lights, siren, etc.)	TBD	TBD	TBD	Operable by driver and/or observer
10.	Microprocessor	4	13	18	Equipment bay or trunk; Cabling interfaces as applicable
	Supplemental Memory	4	13	18	
12.	Digital Transceiver	4	13	18	
	Voice Transceiver	4	13	18	
14.	Power Supplies	6	15	21	
	Auxiliary Battery	8	12	6	
16.	Hand Held Terminal Transceiver	4	13	12	
17.	Sensor Interface Box	2	8	6	
	Siren Recorder	3	5	9	
19.	CO Monitor	6	12	6	Sample air in occupied compartment
	Inverter	8.5	18	11	Equipment bay or trunk
21.	Main Display Power Supply	7	6	13.5	Proximity to item 2
22.	Communications Controller	2.5	8	10	Cabling to items 10, 12, 13, 16.
	Sensor Signal Conditioner	3	8	5	Convenient to engine sensors
	Sensor A/O Converter	3	8	5	Cabling to items 6, 23
25.	Hand Held Terminal	8	6	5	Convenient to driver and/or observe

THE AEROSPACE CORPORATION

Post Office Box 92957, Los Angeles, California 90009, Telephone: (213) 648-5000

PLEASE REPLY TO:
SUITE 4040
955 L'ENFANT PLAZA, S.W.
WASHINGTON, D.C. 20024
TELE: (202) 484-5500

1710.C.2004
January 2, 1976

Pioneer Engineering and Mfg. Co.
2500 East Nine Mile Road
Warren, Michigan 48091

Attention: Mr. E. D. Jones
Vice President

Subject: Concept Selection
Subcontract No. 44373

Reference: Statement of Work, dated 12 May 1975

Gentlemen:

In accordance with the requirements of referenced document and your concept selection presented to Dr. L. Peterson, The Aerospace Corporation does by copy of this letter approve your concept selection.

If you have any questions, please do not hesitate to contact me at either (202) 484-7404 or (202) 484-5500.

Very truly yours,

THE AEROSPACE CORPORATION

G. A. Pierce
Subcontracts Administration

GAP:drc

APPENDIX B

LIST OF POLICE AGENCIES CONTACTED

- Los Angeles County Sheriff's Department
  Communications & Automotive Bureau
  1277 N. Eastern Avenue
  Los Angeles, California 90063

  Lt. J. A. Sullivan
  Sgt. H. Culelier

- Los Angeles Police Department
  Motor Transport Division
  151 N. San Pedro
  Los Angeles, California 90030

  Mr. G. R. Wynne
  Dir. Police Transportation

- Detroit Police Department
  Motor Transport Division
  2650 E. Jefferson Avenue
  Detroit, Michigan 48207

  Lt. C. Griffiths
  Sgt. P. J. Moroso
  Sgt. D. S. Sanderson

- Birmingham Police Department
  Municipal Building
  151 Martin Street
  Birmingham, Michigan 48009

  Chief R. G. Tobin

- Seattle Police Department
  610 3rd Avenue
  Seattle, Washington 98104

  Sgt. D. R. Harris
  Police Fleet Administration

S U M M A R Y

LOS ANGELES COUNTY SHERIFF'S DEPARTMENT

COMMUNICATIONS & AUTOMOTIVE BUREAU

AUTOMOTIVE SECTION

POLICE VEHICLE PERFORMANCE TEST & EVALUATION

1. Preliminary Evaluation

   Subjective rating of general handling and control characteristics of vehicle by four (4) experienced police drivers on established test course.

2. Instrumented Performance Characteristics

   Acceleration -

Standing Start	-	0 - 30, 45, 60, 1/4 mi.
Urban Speed	-	30 - 50, 65
Highway Speed	-	60 - 80, 95
Braking	-	30, 60 - 0
Emergency Handling	-	1, 2 & 3 lane change and recovery
Steady-State Handling	-	Left and right circle (200' dia.)

3. Fuel Economy Test

   Urban

   Suburban

   Freeway

4. Human Factors and Space Utilization (Ergonomics)

   Comparative evaluation of the suitability and efficiency of the vehicle for patrol car use. Rated are:

- Front Seat
- Wheel-Pedal-Seat Relationship
- Controls & Instrumentation
- Visibility
- Heater/A-C/Vents
- Windows and Doors
- Cockpit Stowage Space
- Special Equipment Location & Capability
- Rear Compartment
- Trunk

5. Mechanical Evaluation

Serviceability and projection of time, ease, and cost of maintenance and repairs.

6. Temperature Test

Radiator
Engine Oil
Transmission Fluid
Engine Compartment

7. Communications Evaluation

Ease of installation of communications equipment.

TEST RESULTS - GROUP I - 1976

	Dodge Dart	Plymouth Fury	Pontiac Le Mans	Mercury Montego	Chevrolet Nova	Ford Torino
Preliminary Handling Test	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable
Instrumented Performance (Time/Speed/g's)						
Acceleration						
0 - 30 mph	3.7 sec	3.9 sec	4.6 sec	3.6 sec	3.8 sec	3.8 sec
0 - 45 mph	6.7 sec	6.8 sec	7.8 sec	6.5 sec	6.3 sec	6.9 sec
0 - 60 mph	10.6 sec	11.0 sec	12.1 sec	10.8 sec	9.5 sec	11.2 sec
¼ mile standing start	78.9 mph	79.1 mph	73.0 mph	80.0 mph	82.9 mph	78.6 sec
Maximum force (g's)	.53 g	.48 g	.48 g	.51 g	.51 g	.48 g
30 - 50 mph	4.8 sec	5.1 sec	5.8 sec	4.7 sec	3.5 sec	4.1 sec
30 - 65 mph	9.3 sec	9.6 sec	11.8 sec	9.0 sec	7.2 sec	9.2 sec
60 - 80 mph	9.9 sec	8.8 sec	12.7 sec	8.2 sec	6.8 sec	8.1 sec
60 - 95 mph	21.0 sec	19.2 sec	24.0 sec	17.8 sec	16.1 sec	19.2 sec
Braking						
30 - 0 mph	.48 g	.97 g	.87 g	1.0 g	1.2 g	.95 g
60 - 0 mph	1.0 g	1.1 g	.87 g	.97 g	1.2 g	1.0 g
Handling & Recovery						
One lane change	.48 g	.58 g	.45 g	.47 g	.50 g	.55 g
Two lane changes	.825 g	.80 g	.74 g	.80 g	.82 g	.78 g
Three lane changes	.825 g	.78 g	.76 g	.70 g	.825 g	.73 g
Recovery	.87 g	.78 g	.87 g	.75 g	.80 g	.70 g
Left circle (200' DIA)	.782 g	.796 g	.76 g	.81 g	.815 g	.746 g
Right circle (200' DIA)	.76 g	.77 g	.712 g	.723 g	.782 g	.723 g
Total Score, Weighted 25%	14.69	14.76	12.83	14.97	16.83	14.62

TEST RESULTS - GROUP II - 1976

Heat Test Peak Temperatures Recorded	Dodge Dart °F/Score	Plymouth Fury °F/Score	Pontiac LeMans °F/Score	Mercury Montego °F/Score	Chevrolet Nova °F/Score	Ford Torino °F/Score
Radiator Coolant	240/2.36	217/5.55	227/4.16	235/3.05	227/4.16	250/.97
Engine Oil	276/4.25	277/4.23	290/3.96	295/3.85	285/4.06	315/3.44
Transmission Oil	255/4.69	200/5.83	244/4.92	235/5.10	251/4.77	245/4.90
Power Steering Fluid	255/4.69	270/4.38	314/3.46	290/3.96	275/4.27	300/3.75
Total Score, Weighted 25%	15.99	19.99	16.50	15.96	17.26	13.06

Fuel Economy						
Actual Miles Per Gallon	12.78	11.28	11.91	12.67	14.61	12.45
Total Score, Weighted 25%	15.98	14.10	14.89	15.84	18.26	15.56

Ergonomics (Human Factors)						
Averaged Score, Weighted 15%	8.65	8.86	10.45	9.12	8.99	N/A

Communications Evaluation						
Averaged Score, Weighted 5%	2.68	2.11	1.82	2.00	2.54	N/A

Mechanical Evaluation						
Averaged Score, Weighted 5%	2.87	2.65	2.50	2.60	2.79	N/A

TEST SCORE OVERVIEW - 1976

	Chevrolet Nova	Plymouth Fury	Dodge Dart	Mercury Montego	Pontiac LeMans
Instrumented Performance	16.83	14.76	14.69	14.97	12.83
Heat Test	17.26	19.99	15.99	15.96	16.50
Fuel Economy	18.26	14.10	15.98	15.84	14.89
Ergonomics	8.99	8.86	8.65	9.12	10.45
Mechanical Evaluation	2.79	2.65	2.87	2.60	2.50
Communications Evaluation	2.54	2.11	2.68	2.00	1.82
Total Score	66.67	62.47	60.86	60.49	58.99

APPENDIX C

SELECTED PASSENGER CAR DIMENSION DEFINITIONS
SAE J1100a - RECOMMENDED PRACTICE

2.1 Interior Dimensions -

All interior dimensions are defined with an adjustable front seat in its rearmost normal driving position...

3.2.1 Curb Weight -

The weight of a motor vehicle with standard equipment only; maximum capacity of engine fuel, oil, and coolant.

3.3.2 "X" Plane -

Vertical plane normal to vertical plane which passes through the longitudinal centerline of the vehicle.

3.11 H-Point -

The H-Point is the pivot center of the torso and thigh on the two- or three-dimensional devices used in defining and measuring vehicle seating accommodation (see SAE J826b).

3.16 Accelerator Heel Point -

Accelerator heel point is located at the intersection of the two- or three-dimensional device heel point and the depressed floor covering with the shoe on the undepressed acceleration pedal and the foot angle at a minimum of 87 degrees.

5.1 Front Seat Compartment Dimensions -

H30 H-Point-front to heel.
The dimension measured vertically from the H-Point-front to the accelerator heel point.

H61 Effective head room - front.

The dimension measured along a line 8 deg. rear of vertical from the H-Point-front to the headlining plus 4.0 in. (102mm).

L34 Maximum effective leg room - accelerator.

The dimension measured along a line from the ankle pivot center to the H-Point-front plus 10.0 in. (254mm) measured with right foot on the undepressed accelerator pedal.

W3 Shoulder room - front.

The minimum dimension measured laterally between the trimmed surfaces on the "X" plane through the H-Point-front within the belt line and 10.0 in. (254mm) above the H-Point-front.

W5 Hip room - front.

The minimum dimension measured laterally between the trimmed surfaces on the "X" plane through the H-Point-front within 1.0 in. (25mm) below and 3.0 in. (76mm) above the H-Point-front and 3.0 in. (76mm) fore and aft of the H-Point-front.

5.2 Second Seat Compartment Dimensions -

H63 Effective head room - second.

The dimension measured along a line 8 deg. rear of vertical from the H-Point-second to the headlining, plus 4.0 in. (102mm).

L51 Minimum effective leg room - second.

The dimension measured along a line from the ankle pivot center to the H-Point-second plus 10.0 in. (254mm).

W4 Shoulder room - second.

The minimum dimension measured laterally between trimmed surfaces on the "X" plane through the H-Point-second within 10.0-16.0 in. (254-406mm) above the H-Point-second.

W6 Hip room - second.

Measured in the same manner as W5.

5.4 Seat, Entrance and Exit Dimensions -

H74 Steering wheel to cushion.

The minimum dimension measured between the steering wheel, with the front wheels in the straight ahead position, and the undepressed seat cushion on the steering wheel center plane.

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   LEAA Police Equipment Survey of 1972

   Volume VII: Patrol Cars

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

2. S.A.E. J1100a - Recommended Practice

   Motor Vehicle Dimensions

   . Society of Automotive Engineers, Inc.
   400 Commonwealth Drive
   Warrendale, Pennsylvania 15096

3. S.A.E. J826b - Standard

   Devices for use in Defining and Measuring

   Vehicle Seat Accommodations

   . Society of Automotive Engineers, Inc.
   400 Commonwealth Drive
   Warrendale, Pennsylvania 15096

4. S.A.E. Paper 267A

   A 2-D Mannikin -- The Inside Story

   S.P. Geoffrey

   . Society of Automotive Engineers, Inc.
   400 Commonwealth Drive
   Warrendale, Pennsylvania 15096

5. 1976 MVMA Specifications - Passenger Car

   . American Motors Corporation
   Product Information Department
   14250 Plymouth Road
   Detroit, Michigan 48232

   . Chevrolet Motor Division
   General Motors Corporation
   Chevrolet Engineering Center
   30003 Van Dyke
   Warren, Michigan 48090

. Chrysler Corporation
Engineering Office
Technical Information Department
P.O. Box
Detroit, Michigan 48231

. Ford Motor Company
P.O. Box 2053
Dearborn, Michigan 48121

6. When to go to Foam - Leonard B. Ryder

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