SECTION 3
INDUSTRY STATUS REPORTS

A Status Report on the Calspan / Chrysler RSV

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ABSTRACT

The Research Safety Vehicle (RSV) program encompasses automobile safety, economy, resource conservation, and emissions appropriate for the U.S. economy in the late 1980's. The Calspan/Chrysler approach is based upon derivation of the RSV from a current, advanced, state-of-the-art production automobile. Adoption of a base vehicle approach provides a practical method for introducing incremental changes in vehicle design consistent with program goals and typical automotive production constraints.

The RSV is being developed within the framework of projections, specifications, and a preliminary concept developed in our phase I program. More salient aspects of that study are briefly reviewed in this report.

The Simca 1308, recently introduced to the European market, was selected as the base vehicle. In many respects, this automobile represents an advanced state-of-the-art engineering practice. Characteristics of the base vehicle that are pertinent to the study are discussed.

Design features of the RSV that distinguish it from the base vehicle are considered in detail. Major program development efforts have been expended in the areas of crash safety where extensive changes were made in the bumpers, body structures, and restraint systems. These features have been incorporated into a producible automotive design.

It is recognized that the RSV project includes four phases and the preliminary nature of the results obtained to date must be fully understood and appreciated. Nevertheless, these results seem highly encouraging in relation to performance characteristics that might eventually be incorporated into future motor vehicles.

INTRODUCTION

The objective of the RSV program, as defined by the National Highway Traffic Safety Administration (NHTSA), is to provide research and test data applicable to automobile safety requirements for the mid-1980's and to evaluate the compatibility of these requirements with environmental policies, efficient energy utilization, and consumer economic considerations. Accordingly, it is recognized that, in the performance of this program, factors extending well beyond a strict consideration of safety are to be investigated. Reduction of highway-accident losses, particularly human injuries and fatalities, remains the major concern in the study.

The overall program is being implemented in four distinct phases:

- Phase I: Program definition
- Phase II: Vehicle-design development
- Phase III: Vehicle-design optimization and final vehicle fabrication
- Phase IV: Test and evaluation

Phase I began in January 1974 and was completed in April 1975. This activity was followed by phase II which began in July 1975 and is scheduled for completion in November 1976. This report presents considerable information on the Calspan/Chrysler RSV; however, it is important that the reader appreciate the somewhat preliminary nature of the results. The basic design will undergo additional tests, redesign, and analyses before the overall program is completed. Although these preliminary results appear to us to be highly encouraging, a final assessment of the program significance cannot realistically be made until phase IV is completed.

To understand our approach to RSV development, it is necessary to review some of the pertinent background material. All RSV phase I contractors were given considerable freedom in the development of both the RSV specifications and the approach that would be undertaken in order to develop the vehicle. The only major program restriction was that the RSV not weigh more than 3,000 pounds. Early in phase I, Calspan decided that its recommended approach should stress current (or expected near future) automotive design practice and vehicle producibility. Consequently, Chrysler Corporation, an organization highly respected for its contributions to automotive engineering, was invited to participate in the program.

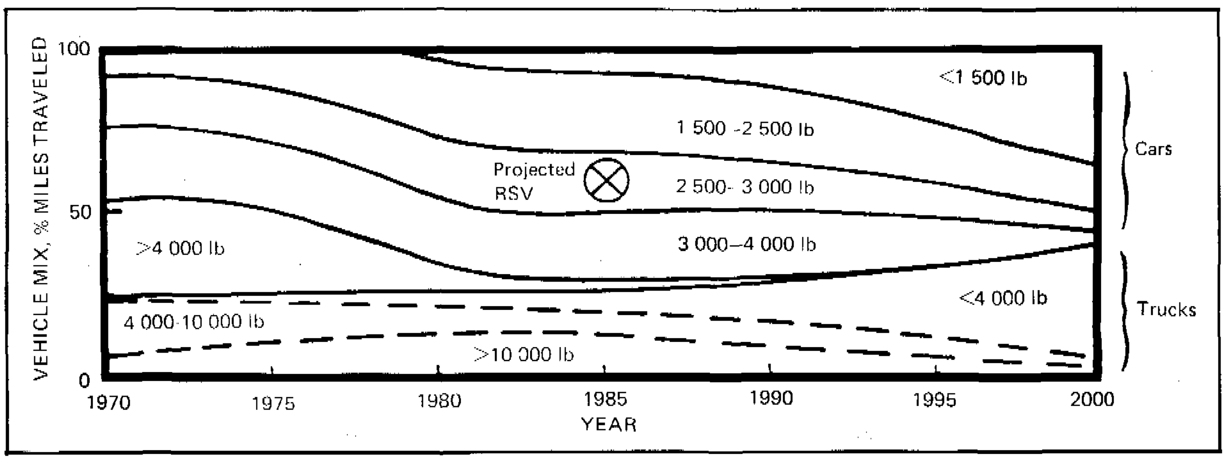
The results of our phase I study established the basic framework within which the RSV is being developed. For this reason, we provide a brief review of the more salient phase I results that greatly influenced our approach. The reader interested in specific details of the phase I study should consult the four-volume final report [1].

BACKGROUND

Because the RSV was directed toward the development of a vehicle suitable for the mid-1980's, it became necessary to analyze several trends that are expected to influence future U.S. automobile design practices. In general, we tended to focus attention on the time between now and the end of this century. Such a time period was felt to be realistic in relation to the program objectives. Certainly, the design of mid-1980 vehicles will be influenced by economic, social, and technical constraints operating between now and the time of introduction. Once introduced, the requirements that are suitable for the vehicle are dictated by the conditions operating during the vehicle lifetime—assuming a nominal 10-year vehicle lifetime extends the period of interest to the mid-1990's. Finally, it is our feeling that, because of material resources and other environmental factors, vehicle disposal constitutes an important part of the study. Thus, within this context, the study is influenced by several factors extending for an approximate 25-year period.

Results of our investigation strongly suggested that future automobile design practice, at least in the United States, would be importantly influenced by the availability of natural resources. The effect will be a notable and important downsizing in all automobiles. Figure 1 shows the projections for vehicle mix developed for the period between 1970 and 2000. It is important to note that, at least with this forecast, the median curb weight for automobiles operating on U.S. highways in 1985 is expected to be between 2,500 and 3,000 pounds. (Also note the projected RSV point on figure 1.) For the purposes of the

Figure 1. Projected vehicle mix.



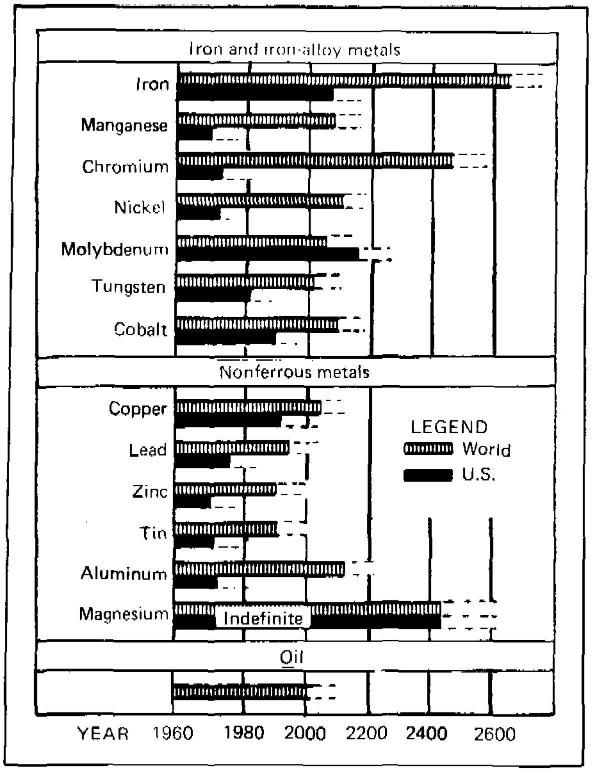


Figure 2. Depletion of resources.

study, we elected to pursue development of a car that would tend to approximate the median within the projected mix.

The basis for the projection of much lighter weight cars was based, for the most part, on the published estimates of both domestic and worldwide availability of natural resources. Recent projections for depletion of many vital resources are shown in figure 2, which is taken from reference [2]. The situation of petroleum is particularly alarming. Within the next 50 years, the world supply of oil may be depleted. As a consequence, fuel economy of future motor vehicles must take on increasing importance. The situation of other vital minerals, many of which are used in automobile production, is equally distressing. Thus, it is suggested that the combined influences of resource depletion of both petroleum and certain vital minerals will force public acceptance of smaller, lighter cars.

Of course, consumer expectations will also influence future designs. That is, perceived consumer expectations must be met in order for the automobile to be a viable product in the marketplace. For this program, it was assumed that the overriding factors in automobile-use expectations were related to passenger compartment accommodations and usable luggage capacity. It was our feeling that, although consumers would likely, even if reluctantly, accept smaller cars, they would not accept great reductions in what they perceive to be required capacity. Interior

Compartment	Vehicle		
	Valiant	Coronet	RSV
Front (inches):			
Effective head room	38.4	38.3	37-39
Maximum effective leg room—accelerator	41.7	41.9	42
Shoulder room	55.4	59.2	54-56
Rear (inches):			
H-point couple distance	33.3	33.2	32-34
Effective head room	37.2	37.3	37-39
Minimum effective leg room	35.9	36.7	37-38
Shoulder room	55.5	59.3	54-56
Usable luggage capacity (ft^3)	16.2	19.1	14-19

Table 1. Interior car and body dimensions

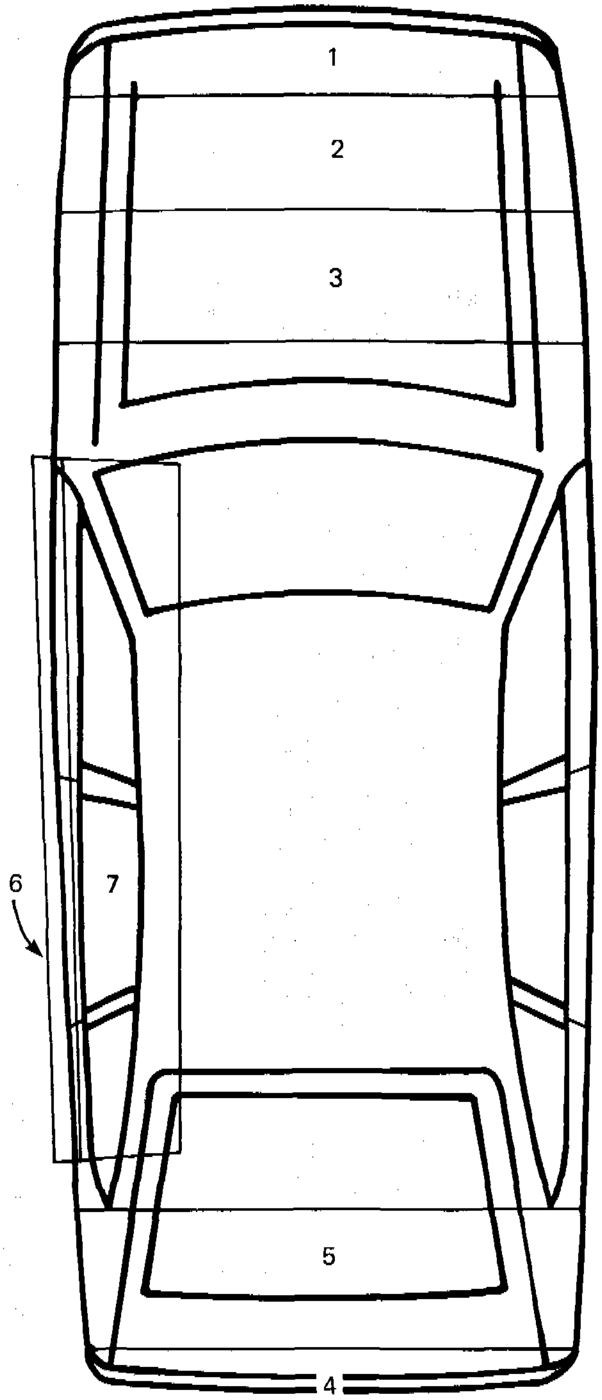
characteristics of a number of production cars were reviewed and RSV interior characteristics were then recommended to approximate those of cars which are felt to be nominally acceptable for family use. Table 1 shows the recommended ranges for various RSV interior dimensions, contrasted with those of the Plymouth Valiant and Dodge Coronet. It is evident in this chart that the RSV interior was expected to at least approximate current compact-car interiors.

In addition to the factors mentioned, it was felt that safety requirements would continue to have an increasing influence on vehicle design. Indeed, as the overall vehicle mix moves toward a greater proportion of smaller cars, the public's natural inclination to associate greater safety with increased vehicle weight (and size) is expected to accelerate demands for increased crash protection. Thus, it was suggested that the importance of safety (particularly crashworthiness) will increase significantly within the next decade.

When considering crashworthiness requirements for a mid-1980 vehicle, it is important to view the situation within the context of the expected vehicle mix (see figure 1). Within that projected vehicle mix, the RSV, representing a "median" weight vehicle, should be expected to have an almost equal likelihood of having accidents with cars that are significantly heavier and lighter. For example, in today's environment, a 2 500-pound car is most likely to encounter a heavier vehicle in an accident. In 1985, however, a 2 500-pound car would have an approxi-

Figure 3. RSV exterior crash characteristics.

Impact direction	Zone	Major consideration
Front	1	Pedestrian protection and minimum vehicle damage
	2	Side and rear compatibility with other vehicles
	3	Occupant protection frontal collisions
Rear	4	Minimum vehicle damage
	5	Occupant protection rear collisions
Side	6	Minimum vehicle damage and visibility
	7	Occupant protection side collisions
Rollover	–	Occupant protection



mately equal likelihood of encountering either a much heavier or a much lighter car. Hence, the demands on the RSV for crash compatibility with other cars are greater than those necessary for a car of similar weight operating in the present environment. Furthermore, it was our feeling that future requirements should give some consideration to pedestrian protection—a situation that is completely lacking in present automobiles. As a result of these considerations, a zonal concept was developed for the RSV.

The basic crash zone concept is illustrated in figure 3. As shown, there are three specific zones in the front structure and two for both the side and rear structures. It is, of course, recognized that a given zone may be involved in a number of different collisions. For example, zone 1 plays a part in all frontal collisions. Nevertheless, the controlling factors in the performance properties of this zone are pedestrian protection and minimization of vehicle change. Similarly, as shown in figure 3, basic crashworthiness-design motivation for all other parts of the vehicle structure were at least philosophically defined.

Finally, it is important to note the extent of demanding crash-performance specifications imposed on the RSV. These are summarized in table 2. Both a goal and minimum impact speed condition were specified for each collision mode. A strong effort is being made toward achieving the goals established for each impact type. However, it was felt that providing a range would allow systematic trade-offs to be made as the vehicle design was being developed. Such trade-offs are indeed being made as the program progresses.

Before leaving the topic of RSV impact specifications, the matter of vehicle intrusion and injury criteria should be briefly addressed. No specific intrusion requirements were imposed on the vehicle design. Intrusions that did not interfere with the function of providing occupant protection were deemed acceptable. Occupant protection systems are to be evaluated in relation to specified injury criteria. For the study, current Federal Motor Vehicle Safety Standard (FMVSS) 208 injury-criteria limits were selected.

Once the basic framework within which the program would operate was established, it became necessary to develop an approach for development of the RSV.

BASIC APPROACH

Because the RSV is intended to reflect automotive technology in the mid-1980 time

Table 2. RSV crash-performance specifications

Direction	Impact object	Configuration	Impact speed (mi/h)		Comments
			Goal	Minimum	
Front	Fixed flat barrier	0° to 45°	50	40	Injury criteria front-seat occupants
	Fixed pole barrier	Center impact	50	40	Injury criteria front-seat occupants
	Fixed flat barrier	0°	35	30	Injury criteria all positions, egress doors
	Fixed flat barrier	0°	25	20	Maximum barrier force 60,000 lb
	RSV	50% offset	[a]50	[a]40	Injury criteria front-seat occupants
	RSV	Center impact	[a]50	[a]40	Injury criteria front-seat occupants
Side	RSV	0° to 45°	45	40	Injury criteria side-struck occupants
Rear	RSV	0°	50	45	Injury criteria all occupants

[a]Speed for each car.

frame, the program must be viewed as having rather short-term objectives in relation to automotive transportation. Typical leadtimes for implementation of feasible concepts into production automobiles require 3-5 years. Furthermore, commitment to such implementation (at about 1980 for a 1985 car) must be based upon existing demonstrated and feasible production methods. Thus, automobiles that are likely to be produced and marketed in the mid-1980's are expected to be based upon advanced automotive technology representative of the late 1970's and early 1980's.

As a result of our particular concern for producibility and the limited available program resources, it was decided that the RSV should be derived from a production automobile. With this approach, producibility questions could be evaluated on an incremental rather than a global basis. That is, because the base vehicle is currently being produced, only the incremental design changes between the base vehicle and the RSV need to be investigated in order to establish the production feasibility of the resulting design.

Although this approach provides a rational basis for assessing vehicle producibility, it also results in a number of constraints on the subsequent vehicle design because the RSV must then reflect, for the most part, the basic geometrical design, drive system, chassis, and other properties of the base vehicle. Such constraints are not considered overly demanding, but they certainly do provide important restrictions. For example, with this approach, it is not feasible to relocate the engine in order to provide increased crush distance during frontal collisions.

It was essential that appropriate concern be exercised in the selection of the base vehicle. This selection constituted a significant part of the phase I effort. It was important that candidate base vehicles be ones which were suitable for expansion into a future vehicle design. Thus, such a vehicle must represent many aspects of the latest automotive state-of-the-art technology. Yet, it is equally important that the vehicle be reasonably representative of a wider class of automobiles. Clearly, if the base vehicle represented a "unique" design, then the eventual generalization of the RSV results to the automobile industry would be in serious question.

The base vehicle selected for the RSV is the Simca 1308, recently introduced by Chrysler France to the European market. This automobile, shown in figure 4, has interior occupant/cargo room equal to that of typical American compact cars (that is, a four-door Plymouth

Figure 4. Base vehicle—Simca 1308.

Valiant). Design features of the car include transverse front engine, front drive propulsion system, four-cylinder engine, unitized construction, and five-door (hatchback) layout. All of these features are expected to become increasingly popular in future American family cars.

A major factor in the selection of the Simca 1308 as the base vehicle was its transverse front-engine/chassis layout shown in figure 5. This arrangement allows excellent passenger-compartment space characteristics. Furthermore, the transverse engine allows one to maximize front crush distance in relation to overall hood length. The front drive, coupled with independent rear suspension, permits the fuel tank to be placed between the rear wheels providing excellent fuel system protection in the event of rear collisions. Finally, the absence of a drive shaft tunnel in the passenger compartment floor permits straight, constant section cross members to be placed in the underbody structure. Structural reinforcements may be internally contained within the various underbody cross members. This design results in greater passenger compartment structural integrity in both longitudinal and lateral loading directions.

Passenger compartment space, cargo capacity, and curb weight were generally important in the selection of the Simca 1308. These data for the Simca are summarized in the third column of table 3. The recommended ranges for these parameters for the RSV (see fourth column) are also shown. In general, the values for the Simca are reasonably close to those required for the RSV; yet, its curb weight of 2,317 pounds is well below the 3,000-pound RSV contract specified limit.[1] Thus, some expansion in vehicle dimensions as well as major crashworthiness improvements would be possible without exceeding weight requirements.

To illustrate the more advanced nature of the Simca design, similar data for the Pinto and Vega are provided in table 3. These two vehicles were introduced to the public in the late 1960's and must by now be considered rather mature designs. Certainly, comparing Pinto and Vega data to the RSV range suggests that development of the RSV from this type of vehicle would be extremely difficult. Thus, it was clear that, in order to develop the kind of car required, it would be necessary to select a small, lightweight, base vehicle unlike those traditionally produced in the United States.

Because the base vehicle had the various features noted above, it was then possible to concentrate RSV design efforts on crash-safety considerations. That is, such characteristics as compartment cargo space, and fuel economy were assured because these features would generally carry over from the base vehicle. The first step in the RSV development process was naturally a valid establishment of the base vehicle performance characteristics.

BASE VEHICLE EVALUATION

Extensive safety tests were performed with the base vehicle. These tests indicated the base vehicle active safety characteristics (braking, handling, and so forth) met or exceeded the respective RSV requirements in nearly all instances. The only major exception appeared to be the case of braking where a front-brake system failure condition was simulated. In this instance, the specified stopping distance was exceeded. It was found through subsequent testing that changing to a diagonal split brake system (rather than the base vehicle front/rear split) corrected this problem. Because of the excellent performance of the base vehicle active safety system, it was possible to direct a major program effort toward crash safety.

Both dynamic crash and static crush tests were performed with the base vehicle. The tests that were performed are schematically illustrated in figure 6. Static crush tests were performed on the front, rear, and side of the vehicle. These data were necessary in order to establish an initial condition for the structural modeling effort (see later discussion) and to provide some guidance in selecting impact

[1] Because the Simca 1308 is not marketed in the United States, it does not meet all Federal safety standards. It is estimated that using current automotive practice to upgrade the vehicle to U.S. requirements would likely add about 150 pounds to its curb weight.

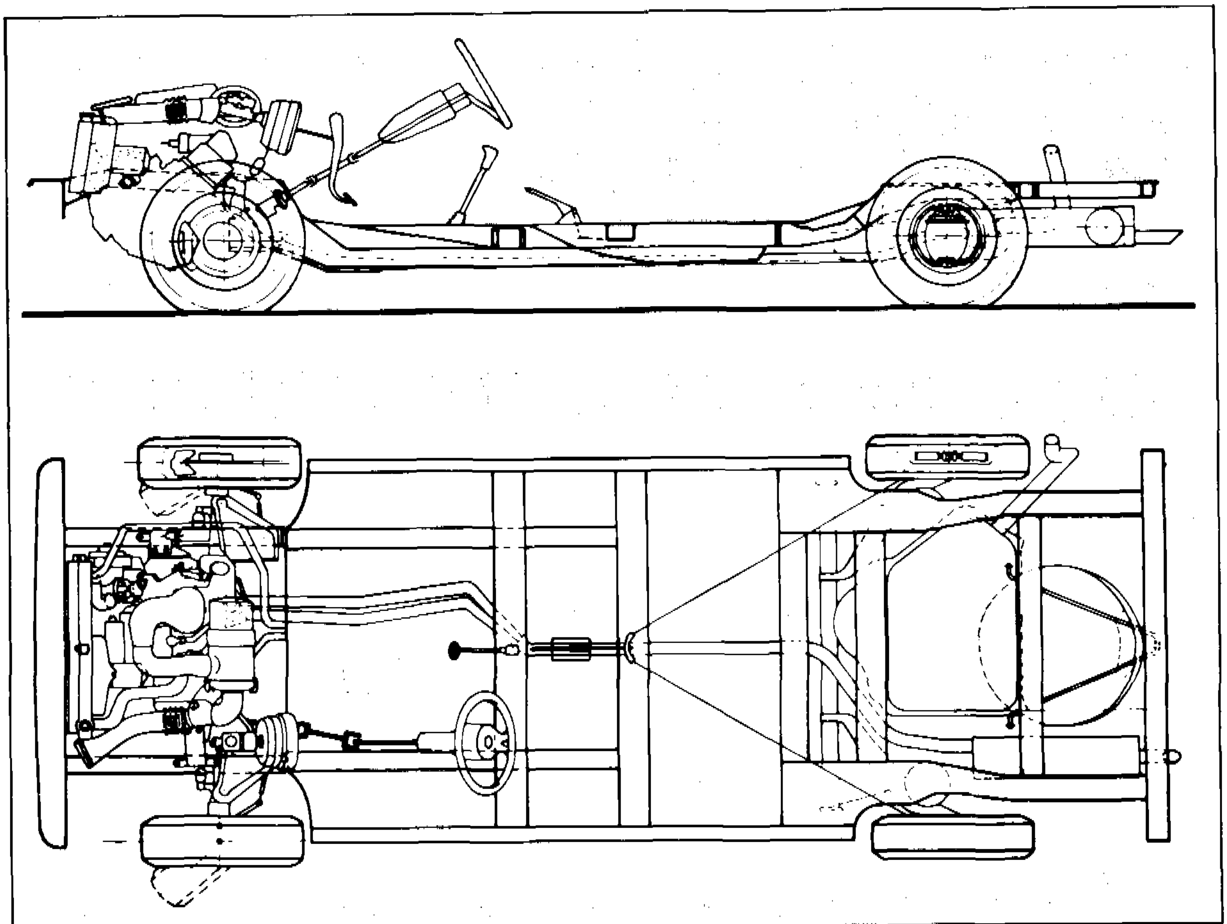


Figure 5. Schematic illustration of the Simca running gear components.

Table 3. Car and body characteristics

Item	Vehicle			
	1975 Pinto	1975 Vega	Simca	RSV range
Front compartment (inches):				
Effective headroom	37.3	37.1	37.2	36-39
Maximum effective leg room—accelerator	40.8	43.5	41.1	40-42
Shoulder room	52.5	51.3	54.7	54-60
Hip room	51.8	47.2	–	54-60
Rear compartment (inches):				
H-point couple distance	28.7	27.4	31.2	
Effective headroom	35.8	35.3	36.4	37-39
Minimum effective leg room	30.4	29.6	36.1	35-38
Shoulder room	51.0	49.2	53.5	54-60
Hip room	42.0	42.5	–	54-60
Luggage compartment:				
Usable luggage capacity (ft^3)	6.3	8.7	11.6	14-19
Curb weight (lb)	2 613	2 558	2 317	2 500-3 000

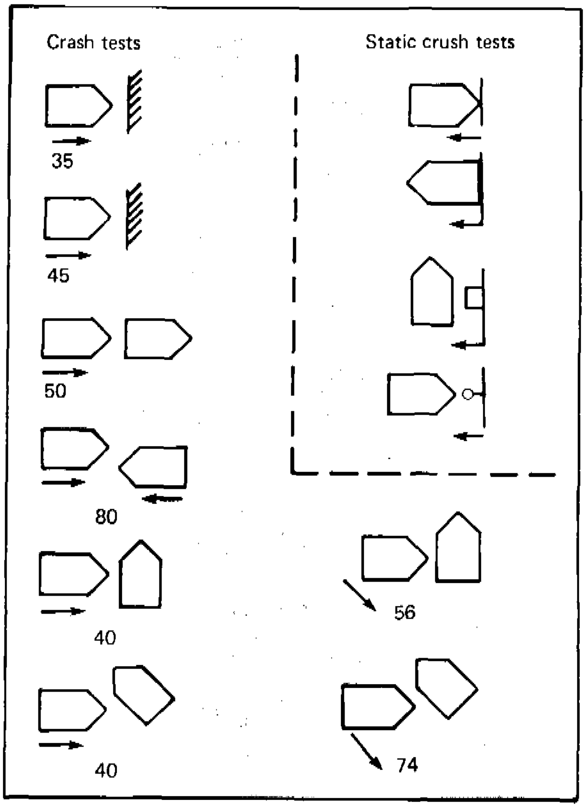


Figure 6. Base vehicle tests (mi/h).

conditions for the dynamic-crash-test series. In general, impact speeds for the various crash tests were within the ranges stipulated in the RSV specifications (refer to table 2).

Although the base vehicle exhibits satisfactory performance during 35-mi/h barrier and other low-speed impacts, its performance is far from satisfactory during impact within the RSV crash performance ranges. Figure 7 shows photographs of the base vehicle after some of these more severe crash tests. The major deficiencies of the base-car structure in relation to passenger compartment intrusion and basic integrity are apparent in all photographs except for the 35-mi/h barrier car. At this point in the study, it was clear that RSV development would have a substantial impact on the base-vehicle structure.

The development of the RSV was divided into three major categories: styling, crash safety, and vehicle systems. Of these, principal effort was expended in the area of crash safety. Each, however, is described briefly in the following sections.

STYLING

Both exterior and interior styling were deemed to be an important part of the RSV development. Because of limited program resources, it was decided that an attempt would be made to have the RSV carry over a maximum number of the base vehicle exterior body panels. Yet, it was also considered important that the RSV exhibit a distinctly different appearance than the base car and, if possible, improve aerodynamic drag. Finally, in view of the pedestrian impact requirements, it was recognized that a completely different front facia would be necessary.

A number of different front- and rear-styling themes were considered and developed into full-scale clay models. These were reviewed and an RSV exterior design was selected. The selected design led to the RSV illustrated in figure 8, where photographs of the front and rear views are provided. The contrast between the RSV and the base vehicle (refer to figure 4) clearly illustrates the carryover of body parts from the base car; yet, the RSV provides a fresh upgrading of the already attractive appearance of the base car. Although aerodynamic drag characteristics were not investigated, the RSV appears, at least from a subjective viewpoint, to provide improvement in drag properties.

A similar styling effort was directed towards the RSV interior. Again, an effort was made to maximize carryover parts. The areas of the vehicle that provided the greatest challenge were the door-trim panels, lower instrument panel (knee restraints), and rollbar structure. Each of these appears to have been resolved into attractive, functional components.

CRASH SAFETY

The RSV crash-safety activity is schematically illustrated in figure 9. As noted in the illustration, base vehicle crash properties as discussed previously constituted an initial input to this scheme. The crash-safety activity was divided into three principal categories: bumper, structure, and restraints/interior. In each case, engineering, design, and test activi-