RESEARCH SAFETY VEHICLE PHASE
VOLUME I

MINICARS, INC.
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APRIL 1975

FINAL REPORT PHASE I
CONTRACT NO. DOT-HS-4-00844

PREPARED FOR:
U.S. DEPARTMENT OF TRANSPORTATION
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION
WASHINGTON, D.C. 20590

REF-000876

Property of Liability Research

1. Report No.

2. Government Accession No.

4. Title and Subtitle

Research Safety Vehicle Phase I
Volume I

5. Report Date
April 1975

6. Performing Organization Code

7. Author(s)
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8. Performing Organization Report No.
DOT-HS-4-00844

9. Performing Organization Name and Address
Minicars, Inc.
35 La Patera Lane
Goleta, California 93017

10. Work Unit No. (TRAIS)

11. Contract or Grant No.

12. Sponsoring Agency Name and Address

13. Type of Report and Period Covered
Final Report
1/74 - 4/75

14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

Volume I summarizes the results of the Minicars Research Safety Vehicle Phase I program, as detailed in Volumes II and III. Accident analysis shows that small cars are producing a large and growing part of the accident costs, toward 60+ percent in 1985. The Minicars RSV characterization provides occupant protection in frontal modes to 50 mph and side modes to 30 mph, at low weight. The analysis identifies accident costs by increments of velocity in each of 13 crash modes. It also shows aggregate benefit for safety systems by requiring subsystems to compete with each other for shares of the available benefit.

17. Key Words

18. Distribution Statement

19. Security Classif. (of this report)

20. Security Classif. (of this page)

21. No. of Pages

22. Price

Form DOT F 1700.7 (8-72)

Reproduction of page authorized

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FINAL REPORT
RESEARCH SAFETY VEHICLE - PHASE I

1.0 INTRODUCTION

The work done by Minicars, Inc. for the National Highway Traffic Safety Administration in fulfillment of the Research Safety Vehicle Phase I procurement has led to these conclusions:

1) Analysis of existing data reveals large and growing accident costs in the smaller car classes, to more than 60 percent of all accident costs by 1985.

2) For that reason, the RSV program must aim at the small car -- 2,000 lb.

3) Though increased safety has always been associated with increased weight, our studies indicate that techniques already identified in other NHTSA programs can now be brought together to protect occupants to speeds of 50 mph in frontal impact modes and 30 mph in side modes, thus eliminating most of the accident casualty costs, with substantially reduced weight.

4) Because the RSV can be light, it can be inexpensive to build and operate, with 30+ mpg fuel economy.

5) A prototype car can now be built with all the above features and with emissions meeting 1977 standards in all categories.

6) Pedestrian injury and property damage costs make up half of the current societal cost of accidents; these costs must and can be reduced cost-effectively.

These conclusions are based on analysis of accident data that quantifies accident costs in detail in terms of societal costs versus accident modes and impact velocities. The analysis, methodology, and results are given in detail in Volume II: Program Definition Foundation.

The performance identified in the analysis as desirable, and a car that would provide the desired performance, are shown in Volume III: Vehicle Characterization and Performance Specification.

Volume I summarizes the contents of Volumes II and III.

2.0 EXECUTIVE SUMMARY

Commentators on the subject of auto safety sometimes give the impression that almost any change in cars would probably make a bad situation better. They point out that as many Americans die in traffic each year as died in Vietnam throughout our involvement there; that the cost to society is many billions annually (how much is a subject of controversy); etc. But, in fact, the American traffic situation could more easily be changed for the worse than the better, and any change not made on the basis of thoughtful interpretation of the results of careful analysis would probably change it for the worse.

The reason for this great need for care is that almost all of America's 210 or so millions of inhabitants drive or ride in cars or at least are pedestrians, yet only about one percent are significantly injured annually, and two hundredths of one percent are killed. So developing the basis of future traffic safety regulations means focusing a very narrow beam of attention on the highly specific area that will produce the bulk of the future auto accident costs.

This is not to say that there is little benefit to be gained in the area of traffic safety. On the contrary, our analysis shows that the cost to society of traffic accidents today is about $40 billion annually, and that over the next ten years, the cost will soar unless something is done -- something like the RSV program, which turns out to be, potentially, one of the government's wisest and most beneficial programs.

The first step in doing something about this problem is to determine where the present cost of accidents is coming from. Then we can propose regulations that will influence the evolution of the car so that the societal cost will trend downward rather than up. The key to this is an orderly methodology that anatomizes the present situation and describes it quantitatively. For that purpose we divide up the present cost of accidents into mode/velocity cells -- that is, how much cost arises from an accident in terms of <u>how</u> the car crashes and <u>how</u> <u>fast</u> it crashes.

The <u>how</u> of crashes is best defined according to the area of damage, a variable that is readily available from the data sources. Thus we divide up collisions according to where the impact force was applied: squarely on the front, on the front but offset to one side or obliquely, on the side, and on the rear. Rollover is treated as an additional category.

The <u>how</u> <u>fast</u> is rather more complicated. If a car runs into a wall at 30 mph, it experiences a change in velocity of 30 mph, obviously. And the crash mode is frontal. And, also, if a parked car gets hit from the front such that it winds up going backward at 30 mph, it has experienced exactly the same accident from a Newtonian point of view. To aid in comparing accidents, investigators use the concept of Barrier Equivalent Velocity or BEV, which is essentially the <u>change</u> in velocity, or the velocity of the car just before the accident vs. its velocity just after the accident. For instance, a car that enters a crash event forwards at 10 mph and departs from the event at 10 mph in the opposite direction is said to have seen a BEV of 20 mph.

Given these definitions, we find that in terms of mode the largest part of the societal cost of accidents is coming from frontal crashes -- and that frontal offset and frontal oblique crashes are generating even more cost than square-on frontal crashes. These high costs are the result not only of the higher BEV of these crashes (a problem we will return to) but of their great frequency. Side crashes, which typically mean a car struck on the door by the front of another car, are also producing great cost.

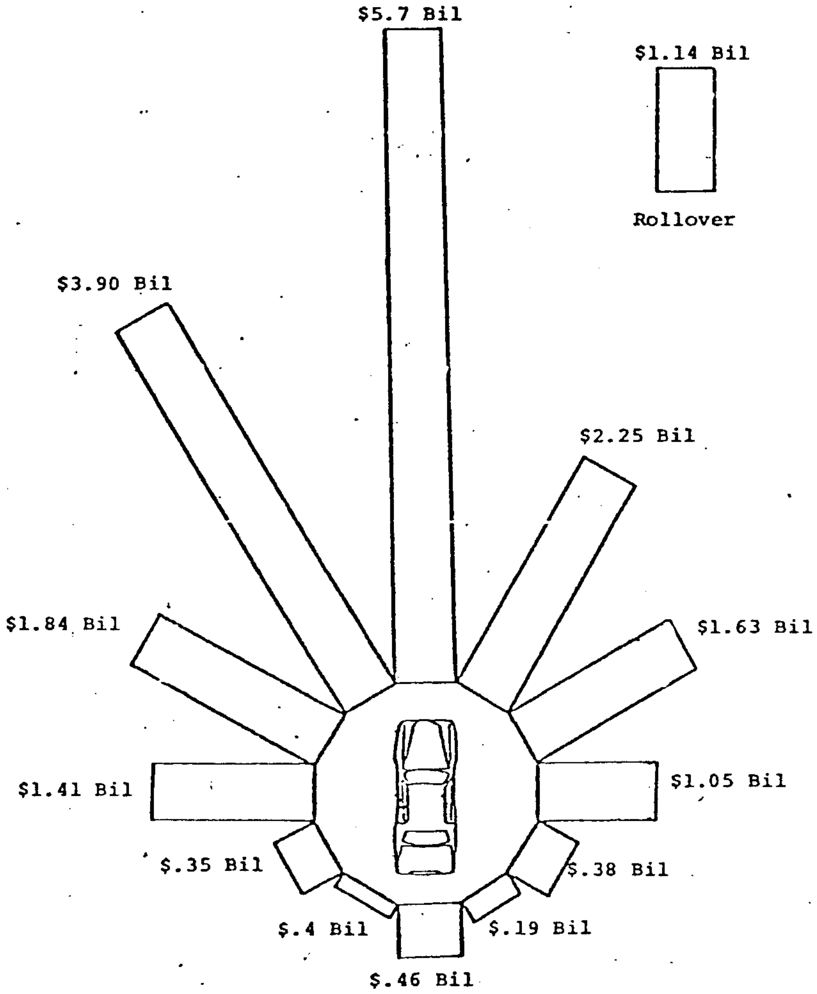


FIGURE 1. SOCIETAL COST OF INJURIES IN ACCIDENTS BY CRASH MODE, 1975

The fact that the bulk of the societal cost is coming from frontal crashes shows that crash protection must be very great in the front of the car. And the fact that frontal crashes other than square-on lined-up front-to-front crashes (or square-on crashes into barriers) are generating so much cost shows that this crash protection must not be sensitive to the direction in which the crash force is applied. In other words, since very high cost is coming from crashes distributed all over the front of the car, the safety performance for the frontal modes must be not only very high but equally high for all directions of crash force. So we can now lay down the first basic principle of safety performance: frontal crash performance must be all-directional. In fact, the two observations together -- that the largest part of the cost of collisions comes from frontal crashes, and that the frontal offset and frontal oblique are generating the most cost of all -- lead to the conclusion that the first priority must go to all-directional frontal safety performance.

The second major principle emerges from consideration of the speed or BEV at which accident costs are incurred. Obviously, crashes tend to be more expensive at higher speeds. But high BEV's are so much less frequent than low BEV's -- that is, so many more accidents happen at low speeds than high -- that we expected to find the bulk of the costs arising from lower-speed accidents. And though we found more cost associated with the higher velocities than we expected, that was essentially what we did find.

Nevertheless, we find that costs arising from high-BEV crashes are substantial, despite their relative rarity. And it is here that we discover the problem that will cause accident costs to soar if nothing is done. Each high-BEV accident is so much more expensive than each low-BEV accident that anything that tends to increase the frequency of high BEV's will substantially increase the costs of accidents. And we can expect high-BEV crashes to increase rapidly over the next ten years.

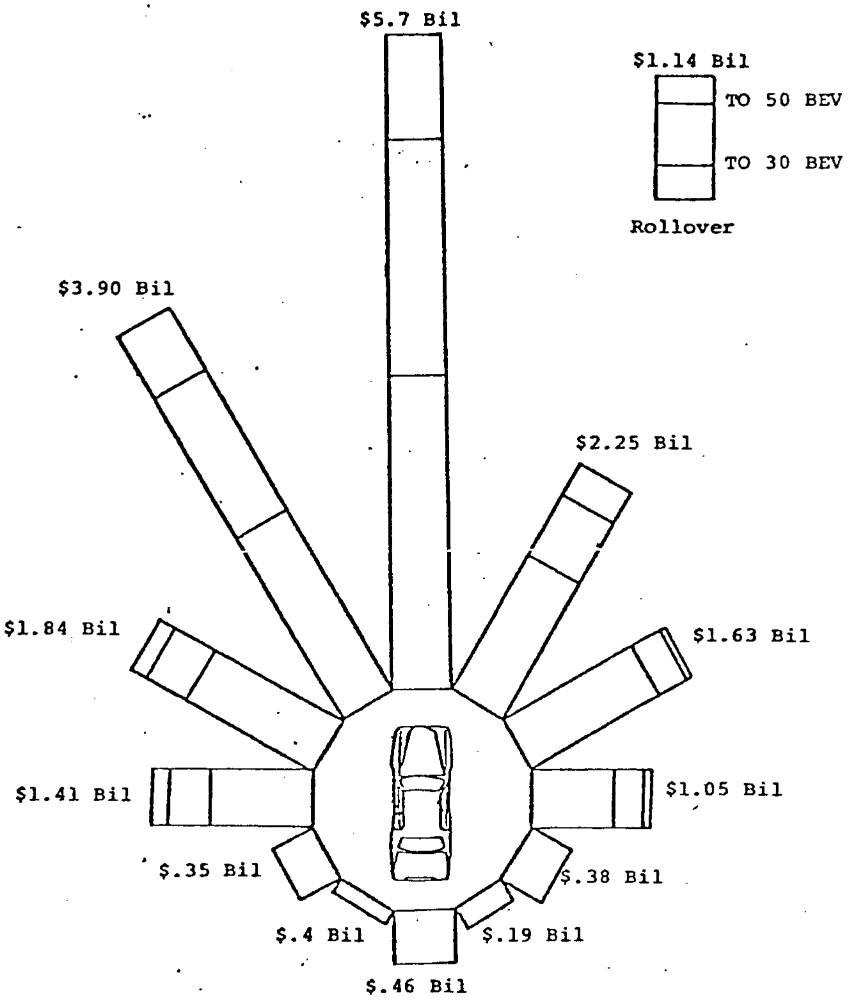


FIGURE 2. SOCIETAL COST OF INJURIES VS. VELOCITY, 1975

The reason for this is that "small" (light) cars are becoming more and more common in the vehicle mix, and that in car-to-car crashes (which are much more common than one-car crashes) a lighter car always sees a higher BEV than a heavier car. In fact, as presently designed, the smaller car in any given crash exposes its occupants to more danger than a heavier car would.

The higher BEV's in lighter cars come from the unequal-mass problem. For instance, in a crash between a 4,000 lb car and a 2,000 lb car, the lighter car sees a BEV twice that of the heavier car. If the cars approach each other at a closing speed of 60 mph, the change in velocity of the large car will be 20 mph, of the small car 40 mph.

Other factors also operate against the smaller car. As presently designed, it offers less frontal crush length than larger cars, and less interior distance over which a restraint can work to safely decelerate an occupant.

Even though the smaller cars at this time make up only about 25 percent of the vehicle population, they are generating about 32 percent of the societal cost of accidents.

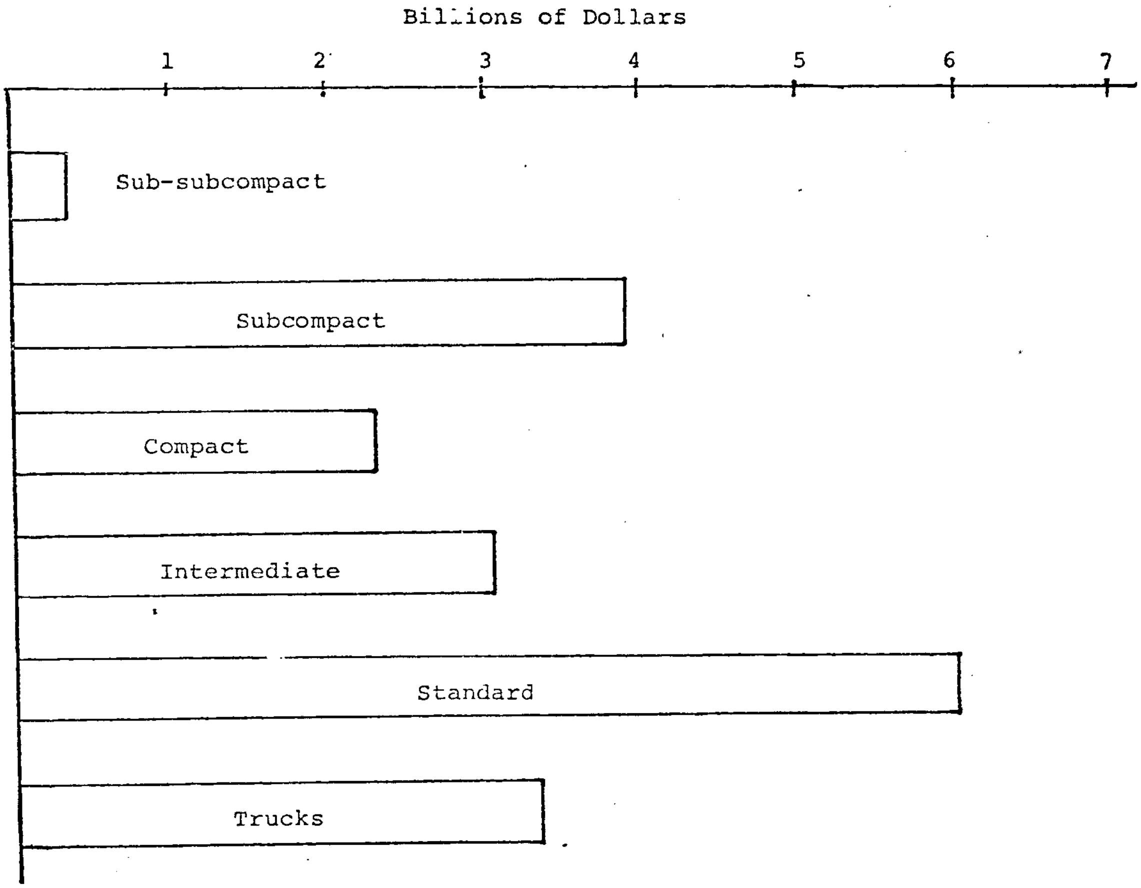


FIGURE 3. SOCIETAL COST OF ACCIDENT INJURIES BY CAR CLASS, 1975

By the mid-1980's, the smaller cars will make up more than half of the vehicle population, and will be responsible for more than 60 percent of the societal cost of accidents.

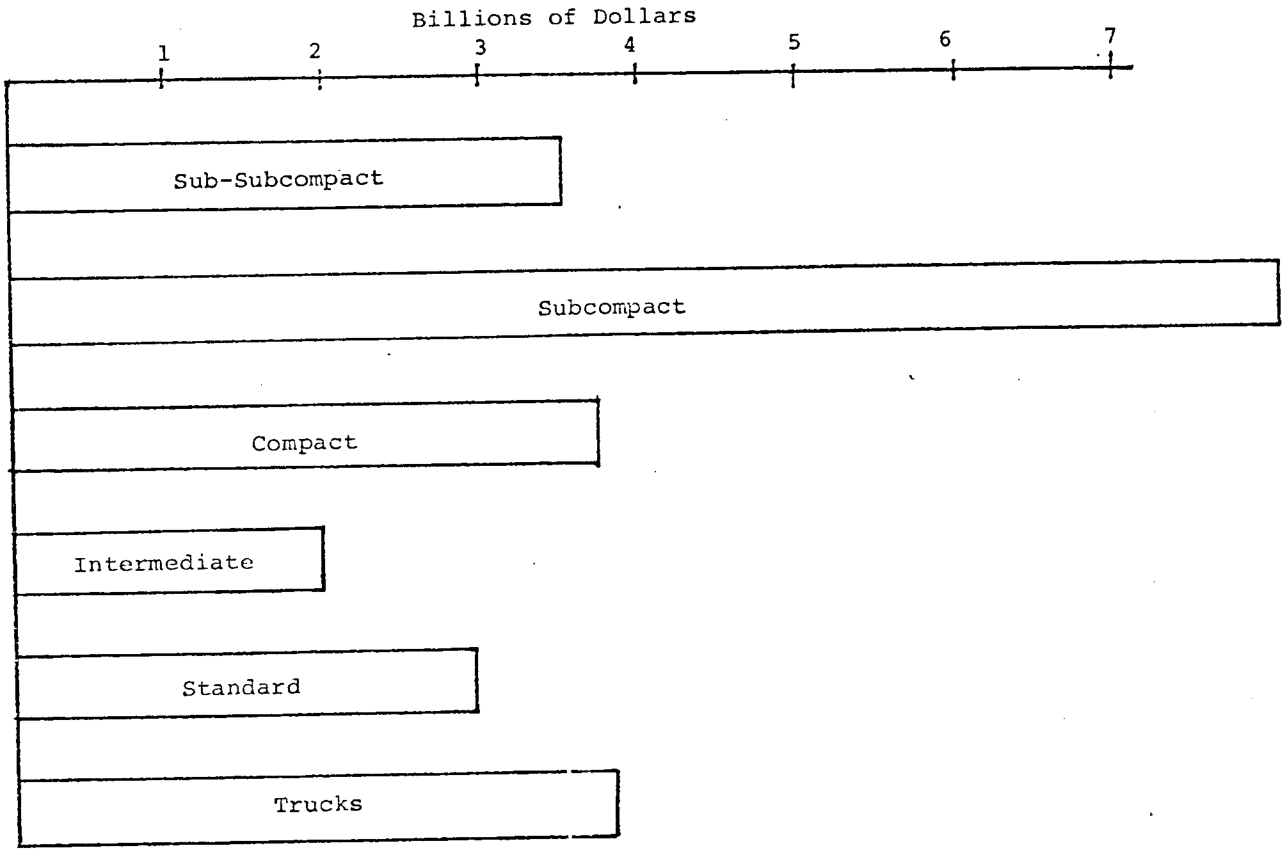


FIGURE 4. SOCIETAL COST OF ACCIDENT INJURIES BY CAR CLASS, 1985

So these two observations -- that smaller cars generate higher costs, and that smaller cars will dominate the accident statistics of the mid-1980's -- lead us to the second major principle: <u>The RSV must be a small car.</u> To put it more exactly, the RSV program must concentrate on improving safety performance in the 2,000 lb car class.

The two crucial principles identified to date, then, are that frontal safety performance must be all-directional and that the car characterized in the study must be a light car, and from these two principles much follows.

- Though other structural techniques might provide the kind of safety performance required, the only one that can provide all-directional performance at low weight is a bulk structure -- foam (enclosed in sheet metal). No matter how effective such techniques as hydraulics might be, their weight penalty, especially the higher weight associated with making them all-directional, rules them out.

- The high BEV's in smaller cars demand the use of a restraint that has high effectiveness at the higher velocities. This means the fast-deploying small-volume air bag and force limiter developed by Minicars for subcompact car drivers, and probably a similar system for the front passenger.

The selection of restraint actually differs with the different occupant positions in the car. The higher the occupancy rate of the positions, the higher the societal cost associated with that position and the more important it becomes to provide high performance in the restraint. Since the driver's position is always occupied, the driver's restraint must be of a kind that always works and works well. If the restraint were "active" -- voluntarily applied by the driver -- then we could not hope for it to be in use often enough to be highly effective. So we put in this position a "passive" or automatically applied restraint of the highest performance, which is the air bag mentioned above. Much the same argument applies to the right front passenger position, though making an air bag work in that position is somewhat harder, and we may find the inflating passive belt, as developed by Minicars in another program, preferable here.

The small car's limited frontal crush stroke also leads us to characterize the RSV as a light car with long frontal crush. This can be done either by lengthening the hood or by locating the engine in the rear, so that essentially all the front is available for crushing. The need to minimize weight presses upon us the rear engine location.

Costs arising from side collisions are also high, and here the problems are rather different. Lack of side crush stroke and occupant stroke, plus lack of structural strength in the doors, make it hard to protect occupants in cars that are struck on the side by the front of another car. In side collisions, the door is generally punched in and the occupant volume intruded upon, so that the occupant experiences something like a high-velocity collision even at low velocity. In the Minicars RSV, the door sill is raised to bumper level, so the striking car bears on this hard structural part of the car rather than on the door. The door itself is greatly improved structurally as well. Also, the front crush characteristic of the RSV is designed to limit the cost of injuries it causes in other cars when striking them on the side.

At some point it becomes unprofitable to continue increasing the safety performance of the structure-restraint combination while neglecting other areas of potential improvement. One of the most important features of the Minicars analysis is that different subsystems are in competition with each other for a share of the available benefit. Thus, so to speak, optimization of restraint and structure stops when improvement in some other subsystem would win a larger part of the available benefit. Furthermore, the benefit considered won by a subsystem is the benefit it wins over and above the benefit already won by other subsystems. This may sound too obvious to mention, but in fact, two different subsystems are sometimes given credit for the full benefit they would win if each were used alone, ignoring the fact that the benefits of the two systems may greatly overlap. Our methodology is to assemble the various subsystems into many different combinations and determine the real aggregate benefit for each system, then rank them according to net benefit, which is the benefit the system earns minus the cost of the system.

In other words, examination of data sources, no matter how sophisticated, can only take you as far as identifying the potential benefit or promise of a subsystem. The degree to which that promise is realized depends on the complex interrelationship of subsystem performances. Thus benefit is realized by whole-system performance and not by the performance of individual subsystems.

Because examination of the data suggests that improved braking has great promise, we next consider what it would contribute to the system. We find that improved braking could be very beneficial not only in preventing collisions but in reducing the impact velocity of collisions that do occur. There are several areas of improvement available in braking, by far the most important being percent of application and level of deceleration. Brakes are now applied in about 62 percent of all collisions -- a large fraction, but still a fraction, so that possibilities of improvement exist both in increasing the effectiveness of the brakes when they are applied and increasing the frequency with which they are applied toward 100 percent.

Raising the deceleration level of braking carries with it the danger of increasing rear-end collisions, so the brakes could have two modes: one "regular" mode such as that produced by four-wheel disc brakes with anti-skid features, and one high-g "panic" mode that would only be used when a collision is unavoidable. Determining when a collision cannot be avoided may be too much to ask of the driver, so an additional possibility is a radar subsystem to make that determination. If radar is used, then we can also have the possibility of automatic application of the brakes, so as to raise the frequency of application.

Note that at this point we do not need to say that the RSV will have high-g brakes or radar braking, only that it could have. These various possibilities will eventually be forced to compete with each other in various combinations to find the combination with the greatest net benefit.

The next highest share of the available benefit, according to our analysis, could be earned by detection of impaired driver performance. Impaired performance, caused by a great number of things but most often by drinking, is known to be associated with a large part of the accidents producing significant injury -- 21 percent, according to our survey of the data. And the average velocity of these collisions is higher than the average velocity of all significant-injury collisions. So mitigating these collisions could earn substantial benefit. Probably the most acceptable approach is to limit the top speed of a car being driven by an impaired driver to some speed at which no injuries could occur in either the driver's own car or in any car he might hit.

To find out what structural characteristics, restraint characteristics, braking, etc. can actually earn a place in the RSV, we must first assign each subsystem a cost. This can be done in a straightforward way by taking as a baseline a comparable American car as it exists today. Then each subsystem can be characterized as a modification of some already-existing subsystem or as an addition.

The primary source of cost in a car is weight. The cost of manufacturing an auto subsystem is directly related to its weight. More important, the largest single item in the total cost of a conventional car is fuel, and the use of fuel depends far more upon weight than upon any other factor. So the cost of each subsystem is almost entirely a function of its weight. Of course, electronics costs much more per pound than steel structure; but within a given category of item--within the category of conventional car structures, for instance--there is quite a direct relationship between weight and cost.

This leads to an interesting observation about the RSV bulk structure. Since it is considerably lighter than the structure of today's cars, it actually costs less both to build and to "operate" than today's structure. In fact, the foam/sheet metal structure saves more weight than is added by all the other subsystems combined. The net result is that the RSV ends up lighter than today's subcompact, and actually less expensive to build, to buy, and to own, even ignoring the benefit gained by improved safety performance.

The "added lightness" of the RSV structure would have some odd effects on our benefit/cost analysis if we included it -- a saving in accident costs achieved at a saving in production and operating costs would produce negative or infinite benefit/cost ratios. So we tacitly assume its use in all examined systems, and neglect the "negative cost" of its reduction in weight.

Ultimately all the possible combinations of subsystems are allowed to fight it out with each other. A computer comparison of the 5040 possible combinations allows us to rank the systems according to their net benefit or safety payoff. A selected sample of these systems in this ranking are depicted on the next page.

Also identified in this computer comparison are the cost of the safety subsystems per car, the total benefit in 1985, the total cost for all affected cars, and the benefit/cost ratio. The car population, in general, is assumed to meet FMVSS208.

SYSTEMS ORDERED BY GREATEST SAFETY PAYOFF
(FMVSS208 INCLUDED IN ALL NON-RSV AUTOS)

	SYSTEM DESCRIPTION										
RUN NO.	A.AVOID SYS	DRIV REST	R.PASS REST	REAR REST	STRUC MOD	IMP DRIVER	SYS COST ($)	SYS BEN (BILS)	TSYS COST (BILS)	BEN/ COST RATIO	SAFETY PAYOFF (BILS)
11	DRIV-.9G	AIRBAG	AIRBAG	LAP	RSV1	IPD-50%	271.	6.29	1.59	3.97	4.71
34	DRIV-.9G	AIRBAG	AIRBAG	FL 3-PT	RSV1	IPD-50%	295.	6.40	1.73	3.70	4.67
32	DRIV-.9G	AIRBAG	AIRBAG	FL ABLT	RSV1	IPD-50%	303.	6.44	1.78	3.63	4.67
33	DRIV-.9G	AIRBAG	AIRBAG	PL 3-PT	RSV1	IPD-50%	306.	6.41	1.79	3.57	4.61
25	DRIV-.9G	AIRBAG	FL ABLT	LAP	RSV1	IPD-50%	246.	6.06	1.44	4.20	4.61
6	NO SYS	AIRBAG	AIRBAG	LAP	RSV1	IPD-50%	221.	5.84	1.29	4.51	4.54
24	DRIV-.9G	AIRBAG	AIRBAG	AIRBAG	RSV1	IPD-50%	352.	6.58	2.06	3.19	4.51
7	DRIV-.9G	AIRBAG	AIRBAG	LAP	RSV1	NO SYS	191.	5.62	1.12	5.03	4.50
27	DRIV-1.2G	AIRBAG	FL ABLT	3-PT	RSV1	IPD-50%	294.	6.15	1.72	3.56	4.42
21	DRIV-1.2G	AIRBAG	AIRBAG	AIRBAG	RSV1	IPD-50%	382.	6.63	2.24	2.96	4.39
10	DRIV-1.2G	AIRBAG	AIRBAG	LAP	RSV1	NO SYS	221.	5.67	1.29	4.39	4.38
15	NO SYS	AIRBAG	AIRBAG	FL ABLT	RSV1	NO SYS	173.	5.36	1.02	5.28	4.35
13	NO SYS	AIRBAG	AIRBAG	FL 3-PT	RSV1	NO SYS	165.	5.30	0.97	5.48	4.33
22	RADAR-1.2G	AIRBAG	AIRBAG	LAP	RSV1	IPD-50%	371.	6.50	2.17	2.99	4.33
1	NO SYS	AIRBAG	AIRBAG	LAP	RSV1	NO SYS	141.	5.12	0.83	6.20	4.29
26	RADAR-1.2G	AIRBAG	AIRBAG	FL 3-PT	RSV1	IPD-50%	395.	6.60	2.31	2.85	4.29
12	NO SYS	AIRBAG	AIRBAG	3-PT	RSV1	NO SYS	159.	5.21	0.93	5.60	4.28
29	RADAR-1.2G	AIRBAG	AIRBAG	3-PT	RSV1	IPD-50%	389.	6.56	2.28	2.88	4.28
14	NO SYS	AIRBAG	AIRBAG	PL 3-PT	RSV1	NO SYS	176.	5.30	1.03	5.14	4.27
30	RADAR-1.2G	AIRBAG	AIRBAG	FL ABLT	RSV1	IPD-50%	403.	6.63	2.36	2.81	4.27
16	NO SYS	AIRBAG	AIRBAG	AIRBAG	RSV1	NO SYS	222.	5.56	1.30	4.27	4.26
28	RADAR-1.2G	AIRBAG	FL ABLT	3-PT	RSV1	IPD-50%	364.	6.32	2.13	2.96	4.19
31	RADAR-1.2G	AIRBAG	FL ABLT	FL ABLT	RSV1	IPD-50%	379.	6.39	2.22	2.88	4.17
8	RADAR-1.2G	AIRBAG	AIRBAG	LAP	RSV1	NO SYS	291.	5.87	1.70	3.44	4.17
23	RADAR-1.2G	AIRBAG	AIRBAG	AIRBAG	RSV1	IPD-50%	452.	6.77	2.65	2.55	4.12
9	DRIV-1.5G	AIRBAG	AIRBAG	LAP	RSV1	NO SYS	291.	5.80	1.70	3.40	4.09
2	NO SYS	AIRBAG	FL ABLT	LAP	RSV1	NO SYS	116.	4.77	0.68	7.00	4.09
3	NO SYS	AIRBAG	PL 3-PT	LAP	RSV1	NO SYS	117.	4.66	0.69	6.79	3.98
4	NO SYS	AIRBAG	FL 3-PT	LAP	RSV1	NO SYS	112.	4.63	0.66	7.05	3.98
5	NO SYS	AIRBAG	3-PT	LAP	RSV1	NO SYS	109.	4.50	0.64	7.04	3.86
17	NO SYS	FL ABLT	FL ABLT	LAP	RSV1	NO SYS	65.	3.78	0.38	9.98	3.41
18	NO SYS	PL 3-PT	PL 3-PT	LAP	RSV1	NO SYS	46.	3.42	0.27	12.64	3.15
19	NO SYS	FL,3-PT	FL 3-PT	LAP	RSV1	NO SYS	36.	3.31	0.21	15.63	3.10
20	NO SYS	3-PT	3-PT	LAP	RSV1	NO SYS	30.	2.86	0.18	16.28	2.69

FIGURE 5. SYSTEMS RANKED BY SAFETY PAYOFF

Also identified in this computer comparison are the cost of the safety subsystems per car, the total benefit in 1985, the total cost for all affected cars, and the benefit/cost ratio.

System #20, the lowest rated system here, we believe is just adequate to meet the requirements of FMVSS 208. It has no special high-g brakes or radar braking ("A-AVOID SYS" column, "NO SYS"). It uses active three-point harnesses for the driver and the front passenger, and ordinary active lap belts in back. The RSV structure, which adds no cost, is assumed, which grants the restraints their full benefit. The structure maximizes the effectiveness of the harnesses and adds considerable benefit in side impacts, where the restraints are ineffective. Even though the restraints are active--and therefore cheap--we grant them 60 percent usage, which is generous.

At the top of the scale, System #11 has driver-actuated high-g brakes, i.e., brakes with a "panic" mode generating 0.9 g, but without radar activation. The high-occupancy positions have the best restraint available, the force-limited air bag. The rarely-occupied rear seats have lap belts. Included is an impaired performance detector ("IMP DRIVER"). The system costs $271 per car, the net safety payoff is highest of all possible combinations, and the benefit/cost ratio is attractive.

The systems with the greatest benefit and, therefore, those that achieve the greatest reduction in suffering and death, are Systems 21 and 30. They have 1.2-g brakes and advanced restraints in all positions, including the rear. These systems also provide the greatest possible research payoff -- they will allow us to learn the greatest possible amount from the RSV program -- so we believe that the RSV itself should be chosen from one of these two systems. Since system 30 uses different restraints in front and rear -- a force-limited passively-applied air belt in the rear -- and radar-activated brakes, it has the greatest research payoff of all systems and is the system that should be chosen for the Research Safety Vehicle.

Not quantified in this figure are pedestrian/cyclist protection and property damage. These two areas represent a very large part of the cost of accidents -- about $11 billion and $9 billion respectively. The remainder of the RSV program should devote considerable attention to the pedestrian problem, even though it cannot be well quantified yet -- money spent on improvement cannot be clearly related to savings achieved. Savings in property damage can be quantified to some extent, and it is clear that improved braking contributes to savings in property damage by preventing some otherwise unavoidable accidents. This graph of a few of the top-rated systems takes property damage into consideration:

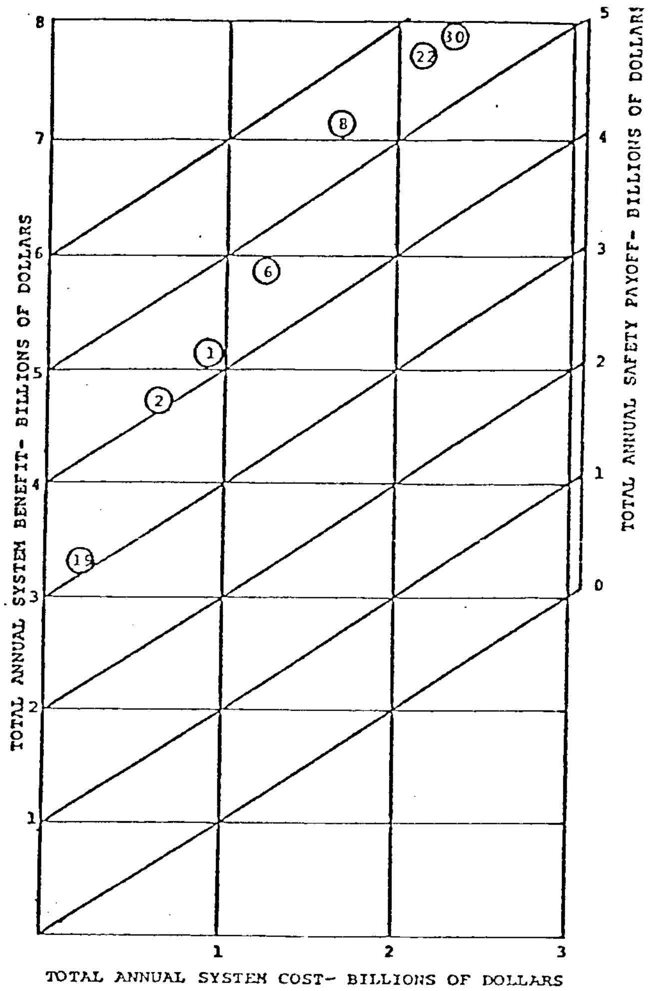


FIGURE 6. TOP-RATED SAFETY/DAMAGE SYSTEMS

If the performance of the RSV in all the areas discussed above were to achieved in all small cars of 1985, the effect on accident costs would be at least as shown here:

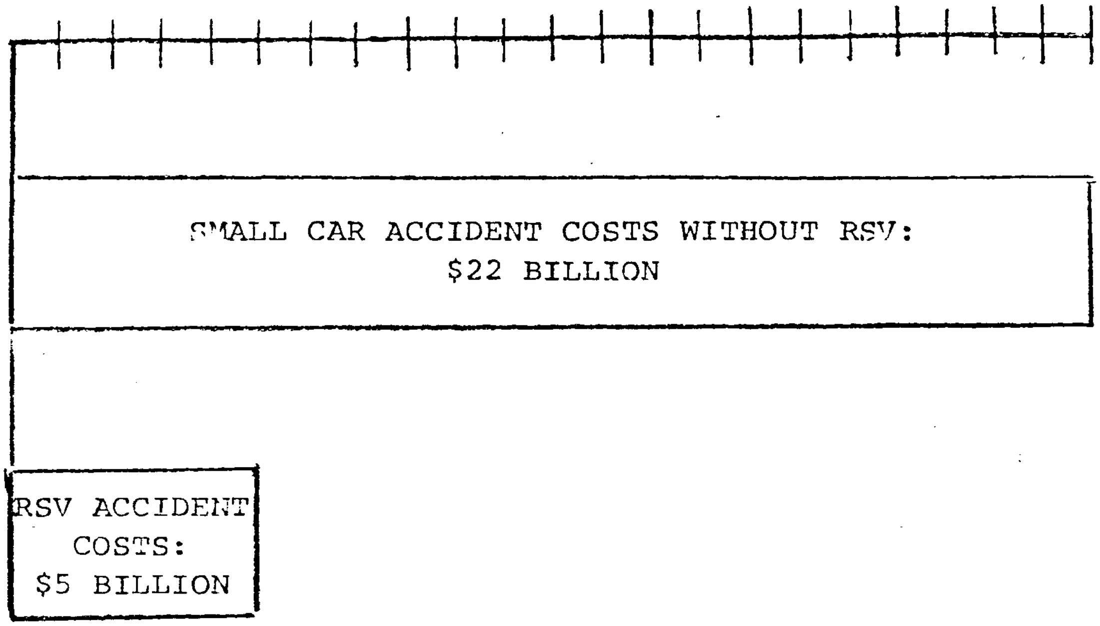


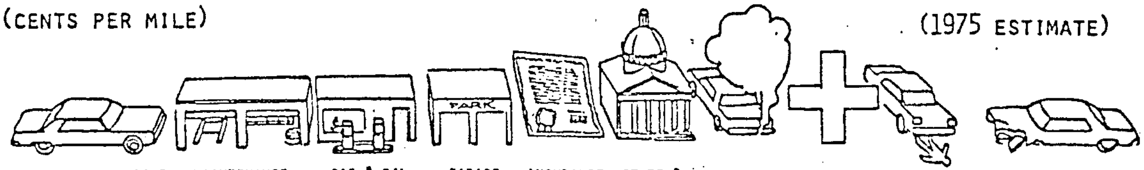
FIGURE 7. TOTAL SAVINGS IN 1985

Actually, large additional cost in pedestrian injuries and some additional cost in property damage would also be saved.

Safety is not the only area of concern in the RSV program. There are considerations of energy, economy, and environment to be met as well. In the area of energy, the RSV actually costs less in energy both to build and to operate than comparable present-day cars. The prototype will get better than 30 mph.

Its excellent fuel mileage and low energy cost to build also make it outstanding in the area of economy. This is especially true when including its savings in occupant injuries, but it would still be true even without that consideration. Here is how it compares in total cost to other cars.

(CENTS PER MILE) (1975 ESTIMATE)



	ORIGINAL VEHICLE COST DEPRECIATED	MAINTENANCE, ACCESSORIES, PARTS & TIRES	GAS & OIL (EXCLUDING TAXES)	GARAGE, PARKING, & TOLLS	INSURANCE	STATE & FEDERAL TAXES	EMISSIONS	OCCUPANT CASUALTIES	PEDESTRIAN CASUALTIES	PROPERTY DAMAGE	TOTAL
STANDARD	4.8	3.4	3.3	2.0	1.8	1.7	.8	1.6	.5	.8	20.7
COMPACT	3.8	2.9	2.8	2.0	1.7	1.3	.6	1.8	.5	.8	18.2
SUBCOMPACT	3.1	2.7	2.2	2.0	1.6	1.0	.4	2.1	.5	.8	16.4
RSV	2.7	2.5	1.6	2.0	1.0	.9	.1	.7	.3	.3	12.1

FIGURE 8. TOTAL COST FOR CARS

As for environment, the RSV, if it were to replace conventional subcompact cars, would use less of our natural resources and so have less impact on the environment in that way. The prototype will meet 1977 emissions standards in every category, and since this performance in all cars would make the car a minor source of air pollution, we expect that standards will not go beyond this.

A car must also have many other qualities, that we do not usually think of as societally beneficial, to attract buyers and find its way into the traffic mix. In the RSV Phase I program we have taken every opportunity to show that outstanding performance in safety, energy, economy, and environment is perfectly compatible with attractive styling, roomy interior, comfort, etc.

The buyer is not the only one whose approval the RSV must win. Analysis shows that the requisite performance can be achieved in a car as characterized above, with good producibility, profitability, and salability. It now remains to build a good enough case to convince the manufacturer of this. He is understandably reluctant to do anything he is not already doing, and any change presents itself to him as so many problems. Can production line workers produce millions of foam-filled structures each year, at reasonable cost? Will electronics pay their way? Will drivers accept automatic aids? Can the reliability of electronics be maintained in millions of cars? Why should he make any significant change in a car that sells in the millions every year?

The primary goals of Phase II should be to build a convincing case in the areas of producibility and marketability. Actually, the RSV shows the way out of the manufacturers' current dilemma. It will show for the first time that a car with improved safety performance can actually weigh less and, therefore, be more economical than current cars. The techniques of the RSV will allow the manufacturer to solve the apparent paradox of being required to improve safety and fuel economy at the same time.