Karthy
Red identifies changes to both versions -

THE MINICARS RESEARCH SAFETY VEHICLE STATUS

D. Friedman

Eighth International Experimental Safety Vehicle Conference

October 20-24, 1980 - Wolfsburg, Germany

Property of Liability Research
~~REF-000570~~ #32

The Minicars Research Safety Vehicle was characterized by a Phase I analytical effort in 1974 to predict and quantify the societal costs of the automobile in 1985.[1] These costs included occupant and pedestrian casualties, property damage, maintenance and repairability, emissions, fuel economy, etc. Systems were conceived to deal with and reduce all the costs and were quantified themselves regarding their eventual consumer price. These systems were analytically combined and their payoff assessed. A combination was selected which in essence maximized the benefits at the least consumer cost.

The Phase II effort developed the structure and restraint subsystems to meet the performance goals and established their compatibility for integration with all remaining systems into a prototype vehicle.[2] A number of important considerations were incorporated into the Phase II design effort, such as:

A) Omnidirectional high-speed impact energy absorption and occupant protection in real world collisions
B) Compatibility - that is, the design of a crashworthy structure which not only works in conjunction with the restraints to mitigate the consequences of a crash to its own occupants, but which minimizes the consequences to the occupants of the other car
C) Damageability with 10 mph no-damage front and rear bumpers and soft fenders
D) Repairability, with a replaceable nose section, confining damage to only the main structure when impact velocities exceed 20 mph
E) Pedestrian impact protection, reducing the levels of injury and the numbers of fatalities by contouring the front end and establishing its surface compliance at appropriate levels
F) Collision avoidance driver aids developed through the use of radar and microcomputer electronics.

DAMAGING THE MAIN
STRUCTURE ONLY WHEN

The Phase III effort may be thought of as having been divided into two parts.[3] The first was the development of the integrated Research Safety Vehicle to the prototype stage incorporating all of the currently practical and cost effective subsystems. The second was a research activity to demonstrate the performance of other subsystems which held promise for the future, as well as demonstrating the applicability of some subsystems to production cars.

LIGHTS DOWN

SLIDE 1

The vehicle effort has resulted in a prototype (Figure 1), built from the ground up, which has a configuration designed to maximize safety while maintaining relatively high fuel economy, low emissions and stylish appeal to the public at a reasonable cost. The result is not a production car. The objective was to demonstrate the feasibility and practicality of the subsystems for integration by the industry into vehicles the public could buy (Figure 2). The design effort was organized to minimize the fabrication, development, and testing cost associated with the structural crashworthiness effort. It was understood that to mass produce the vehicle in quantities of hundreds of thousands of units per year would require a production engineering effort and a 400 million dollar capital investment. #1 #2

The research effort resulted in two prototype vehicles. The High Technology Research Safety Vehicle (Figure 3) incorporates a variety of electronic systems including radar target detection, anti-skid braking, automatically shifted five-speed manual transmission, and a computer controlled collision mitigation system. The Large Research Safety Vehicle (Figure 4) which illustrates how to incorporate the structure/restraint concept into a production car to reduce weight and increase fuel economy while improving impact energy absorption and protecting the occupants to 40 mph. #3 #4

Results Obtained – Vehicle Effort

A. Occupant Protection Crash Tests

CHANGE FORMAT ON BOTH BUT NOT FIGURE/SLIDE ETC.

1. Frontal Barrier

NO NEW PARAGRAPH.

THIS SLIDE

Figure 5 summarizes the tests which have been conducted in the frontal barrier mode. The test conditions and injury measures for each test are correspondingly labeled in the following figures. With the exception of the Japanese barrier test discussed later, the results of Figure 5D are representative of the final configuration and show a substantial margin between nominal 50 mph injury measures and the NHTSA injury criteria. #5

2. Car-to-Car Frontal

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Figure 6 summarizes the significant car-to-car frontal and frontal offset tests conducted. Figure 6F, a Phase IV evaluation test at Dynamic Science involving a head-on impact with a Dodge Challenger at 80 mph, is representative and again shows substantial injury measure margins. The development test of Figure 6B with the Impala, as will be discussed later, used the same underpowered inflators as in the Japanese test mentioned previously and allowed us to "recall" and replace the remaining defective inflator units. Development tests showed that it was possible at least against frame structured vehicles like the #6 #6F

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DCOST 1980

Impala to adjust RSV frontal structural stiffness so as to override or underride.

← INSERT [illegible] HERE.

3. Car-to-Car Side

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Figure 7 summarizes the car-to-car side impact crash tests. In all of these tests the RSV side structure and padding does an effective job of protecting the near side front seat occupant. Although the Part 572 dummy was used, we are convinced that with padding density modifications, any dummy can be protected to delta velocities up to about 32 kph (20 mph). Fortunately, there aren't many rear seat occupants because the crash dynamics maximize intrusion in that area, and the velocity of dummy interior impact limits rear seat survival to somewhat lower delta velocities. #7

4. Car-to-Car Compatibility tests

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Last two

The tests ~~of Figures 7G and 7H~~ were run for compatibility purposes. ~~and~~ involve side impacts on a Datsun 510 target car by both an RSV and a Datsun 510, in which both the target and bullet cars are traveling at 56.4 kph (35 mph). Figure 8 shows a comparison of the injury measures received by the Datsun front and rear near side dummy occupants in these impacts. Clearly, the forgiving front end design of the RSV has a substantial favorable effect on the observed injury measures. #8

This slide

5. Rear Impact

The only rear impact conducted here. the program thus far was in Phase II, as shown in Figure 9. The injury measures were acceptable in the 40 mile per hour Volvo impact. #9

15

6. Rollover

Similarly, the only rollover test was conducted in Phase II and clearly demonstrated the capability of the structure and padding to protect both front and rear seat occupants without seat belts, as shown in Figure 10. #10

this slide.

B. Fuel Economy and Emissions

Figure 11 shows the results of the RSV fuel economy and emissions testing at Western Washington University are detailed ~~[illegible]~~ in this slide. #11

C. Collision Avoidance Capabilities

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Although the main focus of the RSV program has been on crashworthiness, the collision avoidance capabilities of the vehicle were not ignored. Figure 12 illustrates the tests conducted at Jari in Japan and Daimler-Benz in West Germany during this past summer. In both sets of tests, the RSV met the IESV goals except for lateral deviation on pavement irregularity, and hill holding with the parking brake. At Jari only, the stopping distance with a front brake system failure and returnability at 40 kph in a clockwise direction exceeded specifications. 12

D. Pedestrian Impact Capabilities

Here we see

Pedestrian impact tests were conducted at Battelle. Figure 13 illustrates the difference in performance achieved with the front fascia positioned directly on the foam bumper, as in the nominal configuration, and moved 5 inches forward of the bumper. Clearly, the knee impact accelerations and other injury measures are significantly reduced. Our conclusion is that providing about 3 inches of low force deformation space between the fascia and the bumper will reduce the already favorable pedestrian impact injury measures, without significantly affecting any other performance aspect of the vehicle. 13

E. Damageability Tests

this slide,

Low-speed damageability tests were conducted at Dynamic Science in August. As indicated in Figure 14, the tests confirmed the design intention to minimize impact damage in circumstances where, by comparison, a conventional car such as the Citation would have incurred substantial costs of repair. I have personally taken a baseball bat to the RSV soft fenders without damage, although no objective tests have been defined.

14 LISTS OF TESTS ~~[illegible]~~

CITATION

UNFORTUNATELY NO SUCH COMPARISON WAS MADE WITH THE CITATION.

F. Accommodations

This

Figure 15 illustrates the front seat accommodations of the RSV viewed with the doors open. The interior volume (calculated by EPA criteria) is equivalent to that of a compact car, and the easy of entry and exit, seating comfort, and driver instrumentation are rated "good" in subjective judgments. Obviously, each car manufacturer judges interior accommodations by his own criteria, so it is only our intention to illustrate that the safety features incorporated in the car need not interfere with or preclude an acceptable interior configuration. Note, in particular, the high mounted instrumentation, the transparent headrest, the lack of front seat belts and the rear seat leg room. *15 are shown here.

G. Cost

Figure 16 illustrates the typical expenses and capital costs for an all new car program of one car line to produce vehicles in quantities of several hundred thousand per year using an existing production drivetrain. The estimates were prepared by the Transportation Systems Center of the Department of Transportation and indicate that ~~for on the order of~~ 400 million dollars, the vehicle could have been produced and sold to consumers in these quantities for about $7000 ~~during the 1980 model year~~. #16

with a

INVESTMENT

RSV

BE

each, in 1980 dollars.

Results Obtained – Research Effort

A. High Technology RSV

this slide.

The High Technology RSV incorporates the electronic control features illustrated in Figure 17. Since it is a research vehicle, involving first and second generation development electronics, no extensive evaluation tests have been conducted. Development testing has indicated that collision mitigation braking can reduce the velocity of the vehicle by 10 to 30 mph after being triggered by a computer which processes the radar system signal. The combination virtually precludes false alarms. The car-following-cruise-control works substantially better than a human driver in controlling engine power to maintain steady following distances. The anti-skid braking system works well on a variety of skid-producing surfaces. The automated electronically ~~operated~~ 5-speed manual transmission provides excellent fuel economy with the smoothness of a good manual shift driver. The electronic display is shown in ~~Figure 18~~ and, in our opinion is likely to be the forerunner of more production-oriented displays of a comparable level of sophistication. I would like to encourage you to see the short film of the High Technology RSV being shown adjacent to the car in the exhibit hall. #17 #18

15 to 30

HIGHWAY

CONTROLLED

THESE SLIDES

GET THE SLIDES BACK FROM THE LAB. TO SUBSTITUTE IF NECESSARY.

B. Large Research Safety Vehicle

1. Crashworthiness

here

The Large Research Safety Vehicle has now completed a number of tests in the crashworthiness area, as shown in Figure 19. We have demonstrated low injury measures relative to injury criteria for all three front seat passenger positions in frontal and angled barrier tests. A marked improvement in side impact protection is observed through the addition of RSV type padding as compared to the original Impala padding as shown by the injury measures of the last two tests. #19

ALTHOUGH NOT AT THE SAME VELOCITY

To 65 KPH (40mph).

2. Fuel Economy and Emissions

here.

The fuel economy and emissions performance tests conducted by Volvo of America are shown in Figure 20. The results indicate #20 that a full size car can be designed to exhibit significantly higher crashworthiness, while at the same time achieving significantly improved fuel economy and reduced emissions through weight reduction and available technology.

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Any Divider Type Symbol

With a few exceptions, Minicars is reasonably satisfied with our efforts and the results obtained. Our impression is that the Congress of the United States and the public are interested and impressed with the program's results, but somewhat disappointed with the rate and timing of the industry's incorporation of the technology. Through the project, NHTSA foresaw in 1975 America's need for lightweight, safe, fuel economical vehicles, but was unable to pressure the industry to produce such cars through rulemaking (or public information). Apparently only after the American marketplace imposes severe economic penalties on corporate management, stockholders and workers does implementation begin and then, only in the direction of current concern. The huge investments now being committed to retool automotive production could also have included substantially improved occupant protection, damageability and repairability, etc., but instead they focus primarily on fuel economy. Apparently the highway damage ~~slaughter~~ will have to get bad enough, or some other factor significant enough, to reflect itself in an economic marketplace reaction before RSV-type safety can be justified for most cars.

To last paragraph of paper

Through the insight of the management of the National Highway Traffic Safety Administration and the able direction of their Contract Technical Manager, Mr. Jerome Kossar, there are many things about the car that are just right. There have been some disappointments, however, and some concepts which, while they work well in tests, need real world evaluation.

A major problem disappointment has been the weight growth of the car (Figure 21). We had hoped that in the one iteration of the design #21 from the Phase II subsystem efforts to the Phase III integrated car efforts we could maintain the weight budgets without complete redesign. It turned out that, in order to accommodate all of the requirements for all of the subsystems simultaneously, the weight increased about 15 percent more than expected. Investigation has convinced us that the weight growth can be removed with #22 iteration. Nevertheless, the car as tested at 2560 pounds is approximately 300 pounds over our target weight. This weight growth is not overly surprising, nor is there any reason to doubt the ability to eliminate it in production. For instance, General Motors modified a B-body sedan to meet ESV specifications in 1973, with a resulting increase in weight of more than 20 percent. When required by the fuel economy pressures of the marketplace in 1977, GM reduced the B-body weight by 20 percent, but at nominal safety performance levels.

leave in STAT

Minicars has been able to show with the LRSV that the next generation of full-size six-passenger cars can weigh 20 percent less than the 1977 Impala and protect its occupants to 40 mph. At its current weight, 50 mph occupant protection is possible. Later in the session VW will conduct a crash test of a Minicars prepared front seat airbag equipped Citation at between 35 and 40 mph. This vehicle weighs 400 pounds less than the LRSV. These points remind me that in several previous conferences the opinion has been expressed that improved occupant safety involves substantial weight and cost penalties, yet as time goes on, we ourselves prove that performance can be increased while weight can be significantly reduced.

? LRSV weight

POSSIBLY LEAVE

CITATION PICTU

Another disappointment in building the prototypes was the need to follow up and inspect components for quality and performance on repeat development orders. In development we assume that a specially tailored component will continue to be delivered as specified unless changed. Much to our dismay, we noticed that the injury measures were substantially higher in the first of the Phase IV evaluation tests in Japan, than those that had been obtained a year earlier during development. A Phase III two-car head-on frontal development test with full airbag instrumentation was scheduled soon thereafter and produced similarly disappointing results.

The instrumentation led us to suspect, in our first "defects" investigation, that the passenger restraint was not performing correctly. We then conducted some component tests and found that the inflators used in these two tests and installed in all vehicles for Phase IV evaluation were significantly different from the earlier development test units, as shown in Figure 22. In other words, the most recently delivered inflators filled the bags significantly slower than the earlier development units perhaps because Thiokol had used a different lot of production grain. This led to a revision of our inflator specification and our first, but completely successful, "recall" campaign.

#22

here.

There are also a variety of other problems which were not considered important enough to be completely resolved for prototype use, such as adequately counterbalancing and sealing the door. For performance tests these factors are not important, although the gull-wing doors of the show car have been effectively sealed and counterbalanced through most of the range of motion. Further, it isn't clear that a gull-wing door of this configuration is appropriate to a production vehicle.

LIGHTS UP

Similarly, the A-posts were not designed to incorporate a recess for the glass windshield as in stamped production posts so there is some occlusion of vision in the frontal area. We had no doubt that it could be done, but it seemed inappropriate to invest the necessary funds in dies to produce the right configuration.

When the car grew in weight, changes should have been made to the suspension, steering, braking, engine and transmission systems. To adequately optimize the results, these changes would have added another 50 pounds to 100 pounds since those systems were designed for a target weight vehicle of about 2200 pounds. On the other hand, when the car was tested at 2550 pounds, only a few items required adjustment and modification. In most cases the adjustments were not what was desired, nor what would be required, but what was necessary to make the vehicle perform as close to the program goals as possible without the iteration of design necessary to reduce the non-running gear weight. In only a few tests, such as passenger/luggage capacity ~~fuel economy~~ and hill holding, did the vehicle not achieve the performance goals we had hoped for. We believe that with an additional design iteration and a production engineering effort, a commercial version will weigh 2200 pounds, and achieve these goals.

Lastly, the possible production of a commercial version of the RSV with airbags raises some significant product liability problems. Because there are 40 times as many injury as fatality accidents in the U.S., many American manufacturing companies would prefer to face the relatively few product liability claims that involve fatalities than the large number that involve injuries.

Most American auto manufacturing companies are self insured for the first one million dollars of product liability coverage, so their out-of-pocket costs are likely to be much higher if there is any possibility that the bags could have aggravated injuries, whether they do or not. Considering the probable range of impact conditions, anthropometric sizes, age and health differences, etc., it would seem a legitimate business risk decision to design a low performance system to mitigate the possibility of any injury in any impact in which the bags are triggered, even though such a system may not have much effect on the fatalities and the 10 percent of the injuries which are severe.

NHTSA, on the other hand, has focused on, and we have designed for the RSV a system which, in our opinion, will significantly mitigate the probability of serious injury and fatality and which is not likely to aggravate minor injuries under most accident circumstances.

A careful analysis of the real world situation conducted by Minicars confirms the reasonableness of both the business risk management decision and the government's desire to reduce societal cost. So making airbags available isn't a question of who is right, or how much more this system costs than that, but how can experts from both sides in liability law, insurance, cost effectiveness, and technology resolve the situation in favor of

benefit-cost analysis

the public. As technologists, we believe that the RSV system, with its forgiving structure, air bags and padding, is the right system. But, if necessary, one could install a somewhat more expensive dual-level inflation system to satisfy both points of view.

If Minicars can raise 20 million dollars of equity capital through a private placement, we may find out. PRODUCTION F A company has been formed called "Response Motors" to produce and market commercial versions of the car. With Federal loan guarantees from the U.S. Government through the Departments of Commerce, Agriculture and Labor, the cooperation of the Government of the Commonwealth of Puerto Rico, and with the production design assistance of our associates from Renault and Chausson in France, Response Motors will be able to market, in limited quantity, two commercial versions of the RSV. The first to be produced would be a luxury version, virtually hand built, but production engineered by LIGHTS DOWN Chausson, with powertrain and running gear by Renault Motors, and marketed through Rolls Royce Motors International. The Luxury version is shown in Figure 23. here It would be elongated some 23 10 inches, configured with a flatter roof and a Lunke sliding door system, but it would still incorporate the RSV foam-filled sheet metal structure, dual-chambered airbags and some of the special electronics features researched during the program.

The luggage capacity of the luxury vehicle is almost doubled by raising the hood and making the center floor of the luggage compartment substantially thinner (and lower) than the foam-filled 12-inch section in the existing configuration (Figure 24). 24 Reducing this section is the result of analyzing a variety of frontal impact tests including underride, override, offset and head-on modes. This analysis indicated that, when impacting both frame and integrated structure vehicles, impact energy is primarily absorbed in the RSV by the foam-filled wheel well panel, the outside volume and sheer strength of the luggage compartment floor and the upper fender boxes. This also leads us to believe that, by sacrificing compatibility, a front engine configuration is perfectly possible, with little degradation of occupant protection and pedestrian impact capability.

The Standard version, which would be first here produced in 1985 in quantities of up to 30,000 per year, is shown in Figure 25. 25 It would have conventional opening doors, a Renault 1.6 liter engine with 5-speed manual transmission, and would be expected to weigh about 2200 pounds.

Both cars would use have the RSV prototype structural concept with little change and 60 percent fabricated parts commonality. Since the RSV program was only to produce prototypes, it was clear that stamped and formed parts would limit the ability to iterate the design of the structure from a crashworthiness point of view. The configuration that evolved then was one suitable for very short-run production activities; that is, using brake formed parts. This technique also saves many millions of investment dollars for presses and dies and is ideal for limited production runs by semi-skilled workers.

The resulting energy absorbing structure cannot be expected to have style and smooth contours. To provide these features, the exterior of the vehicle (which makes little or no structural contribution) is a polyurethane plastic with a relatively high flex-modulus to reduce minor damage and to style the energy absorbing structure (Figure 26). 26

Response Motors is now at the stage of soliciting financial participation in raising the 20 million dollars in equity capital necessary to finance this 85 million dollar project. A private placement memorandum has been released by our investment consultant, A. David Silver & Company in New York. (Figure 27) summarizes the pertinent financial information. ~~and Figure 28~~ summarizes the use of investment capital. 27 28

FINANCIAL INVESTMENT 28 USE

LIGHTS UP.

[illegible]

At this point, I have no way of knowing whether we will be successful in raising the necessary equity capital, or whether consumer demand for an available vehicle providing a substantially higher level of safety will be limited. I believe those answers are important to the future planning of government and industry, and I solicit your support in obtaining it in the real world. I urge you to ~~join~~ sponsor Renault, Chausson, Rolls and Minicars in this venture to ~~by~~, voluntarily respond~~ing~~ to, and assess~~ing~~ the level of, consumer demand for auto safety without governmental intervention.

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1. Minicars, Inc., "Research Safety Vehicle, Final Report," Contract DOT-HS-4-00844, April 1975.

   D.E. Struble, R. Petersen, B. Wilcox, D. Friedman, "Societal Costs, and Their Reduction by Safety Systems," Fourth International Congress on Automotive Safety, July 1975.

2. Minicars, Inc., "Research Safety Vehicle, Final Report," Contract DOT-HS-5-01215, November 1977.

3. "The Research Safety Vehicle: Present Status and Future Prospects," SAE No. 780603, June 1978.

   Did Struble give a paper at the Paris RSV 7th Conference? ADD REF HERE.

   see other version

4. "The Near-Term Prospect for Automotive Electronics: Minicars' Research Safety Vehicle," SAE No. 780858, September 1978.

5. ~~Title of paper at SAE in June in Detroit???~~ ADD REF HERE.

   ~~the feasibility of producing the RSV~~
   the ~~production~~ feasibility of the RSV - D. FRIEDMAN SAE PASSENGER CAR MEETING, HYATT REGENCY DEARBORN, MICH JUNE 1980.

THE MINICARS RESEARCH SAFETY VEHICLE STATUS

D. Friedman

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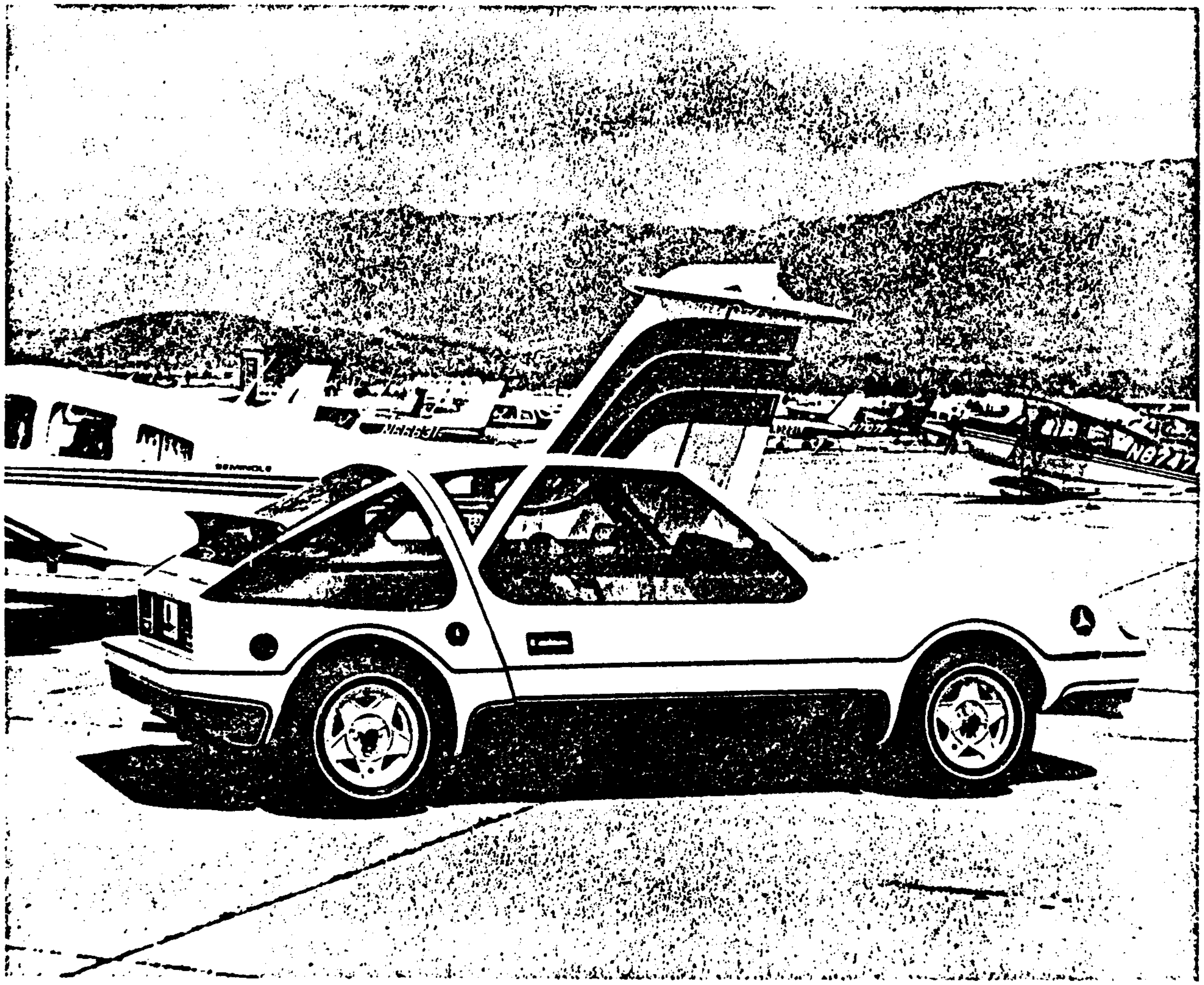

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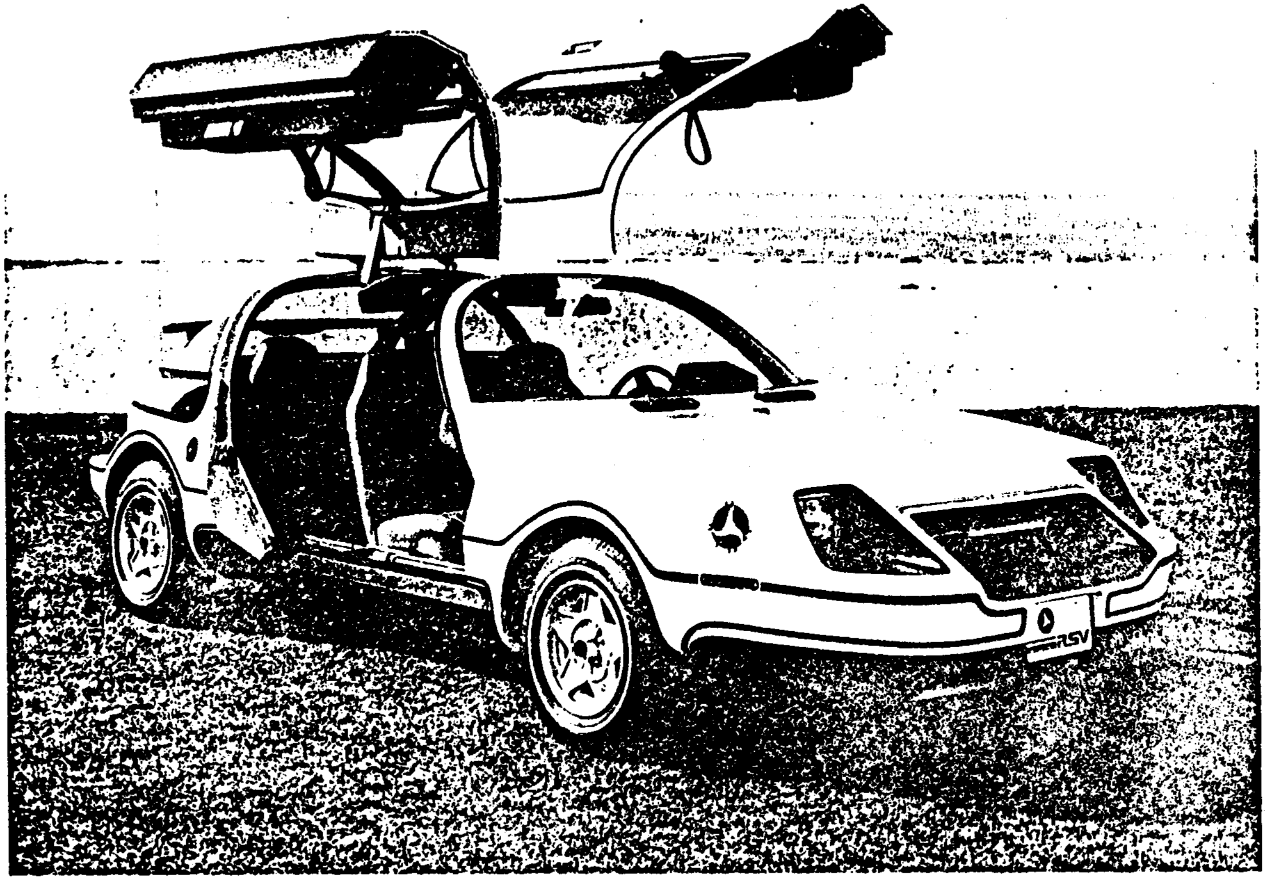

#3


MINICARS, INC.
LRSV

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1. Frontal Barrier

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FIGURE 5A
RSV PHASE II - RSV FRONT INTO BARRIER

DATE: 5/12/76

RSV SPEED: 81.79 KPH (50.8 MPH)

	DRIVER	RIGHT FRONT PASSENGER
HIC	753	722
CHEST G's (3 MSEC)	50	46
L. FEMUR, KG (LBS)	668 (1470)	1456 (3200)
R. FEMUR, KG (LBS)	591 (1300)	818 (1800)

FIGURE 5B

RSV PHASE II - RIGHT OFFSET RSV FRONT INTO BARRIER

DATE: 7/9/76

RSV SPEED: 78.9 KPH (49.0 MPH)

	DRIVER	RIGHT FRONT PASSENGER
HIC	474	189
CHEST G's (3 MSEC)	55	30
L. FEMUR, KG (LBS)	591 (1300)	445 (980)
R. FEMUR, KG (LBS)	545 (1200)	314 (690)

FIGURE 5C
RSV PHASE III - RSV FRONTAL BARRIER IMPACT

DATE: 10/7/78

RSV SPEED: 80.77 KPH (50.17 MPH)

	DRIVER	RIGHT FRONT PASSENGER
HIC	375	497
CHEST G's (3 MSEC)	52	87
L. FEMUR, KG (LBS)	N/A	523 (1150)
R. FEMUR, KG (LBS)	545 (1200)	886 (1950)

FIGURE 5E

RSV PHASE IV - RSV FRONTAL BARRIER IMPACT (QUICK LOOK DATA RESULTS)

LOCATION: TSUKUBA, JAPAN

DATE: 6/10/80

RSV SPEED : 79.7 KPH (49.5 MPH)

	DRIVER	RIGHT FRONT PASSENGER
HIC	494	994
CHEST G's (3 MSEC)	51	46
L. FEMUR, KG (LBS)	497 (1085)	581 (1278)
R. FEMUR, KG (LBS)	607 (1335)	525 (1155)

FIGURE 6A

RSV PHASE II- LEFT OFFSET RSV FRONT INTO VOLVO

DATE: 12/7/76

RSV SPEED: 65.9 KPH (40.9 MPH)

VOLVO SPEED: 65.9 KPH (40.9 MPH)

	RSV DRIVER	RSV RIGHT FRONT PASSENGER
HIC	230	215
CHEST G's (3 MSEC)	42	59
L. FEMUR, KG (LBS)	1364 (3000)	545 (1200)
R. FEMUR, KG (LBS)	636 (1400)	818 (1800)

FIGURE 6B

RSV PHASE III - RSV- IMPALA FRONTAL IMPACT

DATE: 8/7/79

RSV SPEED: 58.8 KPH (36.5 MPH)

IMPALA SPEED : 58.8 KPH (36.5 MPH)

	RSV DRIVER	RSV RIGHT FRONT PASSENGER	IMPALA DRIVER
HIC	183	261	963
CHEST G's (3 MSEC)	36	29	40
L. FEMUR, KG (LBS)	591 (1300)	364 (800)	136 (300)
R. FEMUR, KG (LBS)	727 (1600)	273 (600)	500 (1100)

FIGURE 6C

RSV PHASE III - RSV-IMPALA FRONTAL IMPACT (RSV UNDERRIDE)

DATE: 11/14/79

RSV SPEED: 57.2 KPH (35.5 MPH)

IMPALA SPEED: 44.0 KPH (27.3 MPH)

	RSV DRIVER	IMPALA DRIVER
HIC	514	342
CHEST G's (3 MSEC)	55	70
L. FEMUR, KG (LBS)	519 (1300)	455 (1000)
R. FEMUR, KG (LBS)	727 (1600)	409 (900)

FIGURE 6D

RSV PHASE III - RSV- IMPALA ALIGNED FRONTAL IMPACT (RSV OVERRIDE)

DATE: 12/19/79
RSV SPEED:
IMPALA SPEED:

	RSV DRIVER	RSV RIGHT FRONT PASSENGER	IMPALA DRIVER	IMPALA RIGHT FRONT PASSENGER
HIC	813	2243	484	390
CHEST G's (3 MSEC)	74	70	21	30
L. FEMUR, KG (LBS)	409 (900)	273 (600)	136 (300)	227 (500)
R. FEMUR, KG (LBS)	409 (900)	364 (800)	91 (200)	182 (400)

FIGURE 6F

RSV PHASE IV - RSV AND DODGE CHALLENGER ALIGNED FRONTAL CRASH (QUICK LOOK DATA RESULTS)

LOCATION: DYNAMIC SCIENCE

DATE: 9/10/80

RSV SPEED: 69.7 KPH (42.26 MPH)

DODGE CHALLENGER SPEED: 69.7 KPH (43.26 MPH)

	RSV LEFT FRONT	RSV RIGHT FRONT	DODGE LEFT FRONT	DODGE RIGHT FRONT
HIC	690	690	1690	3630
CHEST G's (3 MSEC)	41	42	92	77
L. FEMUR, KG (LBS)	665 (1462)	483 (1062)	446 (982)	362 (796)
R. FEMUR, KG (LBS)	666 (1465)	434 (955)	417 (917)	652 (1434)

Impala to adjust RSV frontal structural stiffness so as to override or underride.

3. Car-to-Car Side

Figure 7 summarizes the car-to-car side impact crash tests. In all of these tests the RSV side structure and padding does an effective job of protecting the near side front seat occupant. Although the Part 572 dummy was used, we are convinced that with padding density modifications, any dummy can be protected to delta velocities up to about 32 kph (20 mph). Fortunately, there aren't many rear seat occupants because the crash dynamics maximize intrusion in that area, and the velocity of dummy interior impact limits rear seat survival to somewhat lower delta velocities.

4. Car-to-Car Compatibility

The tests of Figures 7G and 7H were run for compatibility purposes and involve side impacts on a Datsun 510 target car by both an RSV and a Datsun 510, in which both the target and bullet cars are traveling at 56.4 kph (35 mph). Figure 8 shows a comparison of the injury measures received by the Datsun front and rear near side dummy occupants in these impacts. Clearly, the

FIGURE 7A

RSV PHASE II - MOVING RSV STRUCK AT 270° IMPACT ANGLE, FORWARD OF A-POST BY A VOLVO MOVING AT THE SAME SPEED

DATE: 11/19/76

RSV SPEED: 63.1 KPH (39.2 MPH)

VOLVO SPEED: 63.1 KPH (39.2 MPH)

	RSV DRIVER	RSV RIGHT FRONT PASSENGER
HIC	66	39
CHEST G's (3 MSEC)	40	40
PELVIC G's (3 MSEC)	35	26

FIGURE 7B

RSV PHASE III - MOVING RSV STRUCK AT A 90° IMPACT ANGLE FORWARD OF A-POST, BY A CHEVROLET IMPALA MOVING AT THE SAME SPEED

DATE: 6/8/79

RSV SPEED: 56.4 KPH (35.0 MPH)

CHEVROLET IMPALA SPEED: 56.4 KPH (35.0 MPH)

	RSV RIGHT FRONT PASSENGER	RSV RIGHT REAR PASSENGER
HIC	540	244
CHEST G's (3 MSEC)	32	65
PELVIC G's (3 MSEC)	32	50

FIGURE 7C

RSV PHASE IV - RENAULT 20 INTO RSV DRIVER SIDE AT 90° (QUICK LOOK DATA RESULTS)

LOCATION: LARDY, FRANCE

DATE: 5/28/80

RSV SPEED: 0

RENAULT 20 SPEED: 50 KPH (31 MPH)

	RSV DRIVER	RSV RIGHT FRONT PASSENGER	RSV LEFT REAR PASSENGER
HIC	46	57	42
CHEST G's (3 MSEC)	50	43	47
PELVIS G's (3 MSEC)	42	15	40

FIGURE 7D

RSV PHASE IV - RENAULT 20 INTO RSV PASSENGER SIDE AT 90° (QUICK LOOK DATA RESULTS)

LOCATION: LARDY, FRANCE

DATE: 6/17/80

RSV SPEED: 0

RENAULT 20 SPEED: 65.7 KPH (40.8 MPH)

	RSV DRIVER	RSV RIGHT FRONT PASSENGER	RSV LEFT REAR PASSENGER
HIC	175	172	310
CHEST G's (3 MSEC)	80	50	80
PELVIC G's (3 MSEC)	20	70	80

FIGURE 7H

RSV PHASE IV - DATSUN 510 IMPACTING RSV AT 90° FROM RIGHT SIDE (QUICK LOOK DATA RESULTS)

LOCATION: TSUKUBA, JAPAN

DATE: 7/10/80

RSV SPEED: 64.4 KPH (40 MPH)

DATSUN 510 SPEED: 64.1 KPH (39.8 MPH)

	RSV RIGHT FRONT	RSV RIGHT REAR	DATSUN LEFT FRONT	DATSUN RIGHT FRONT
HIC	30	87	187	191
CHEST G's (3 MSEC)	56	84	24	23
PELVIC G's (3 MSEC)	38	69	29	27

forgiving front end design of the RSV has a substantial favorable effect on the observed injury measures.

5. Rear Impact

The only rear impact conducted in the program thus far was in Phase II, as shown in Figure 9. The injury measures were acceptable in the 40 mile per hour Volvo impact.

6. Rollover

Similarly, the only rollover test was conducted in Phase II and clearly demonstrated the capability of the structure and padding to protect both front and rear seat occupants without seat belts, as shown in Figure 10.

B. Fuel Economy and Emissions

Figure 11 shows the results of the RSV fuel economy and emissions testing at Western Washington University.

C. Collision Avoidance Capabilities

Although the main focus of the RSV program has been on crashworthiness, the collision avoidance capabilities of the vehicle were not ignored. Figure 12 illustrates the tests conducted at Jari in Japan and Daimler-Benz in West Germany during this past summer. In both sets of tests, the RSV met the IESV goals except for lateral deviation on pavement irregularity, and hill holding with the parking brake. At Jari only, the stopping distance with a front brake system failure and returnability at 40 kph in a clockwise direction exceeded specifications.

D. Pedestrian Impact Capabilities

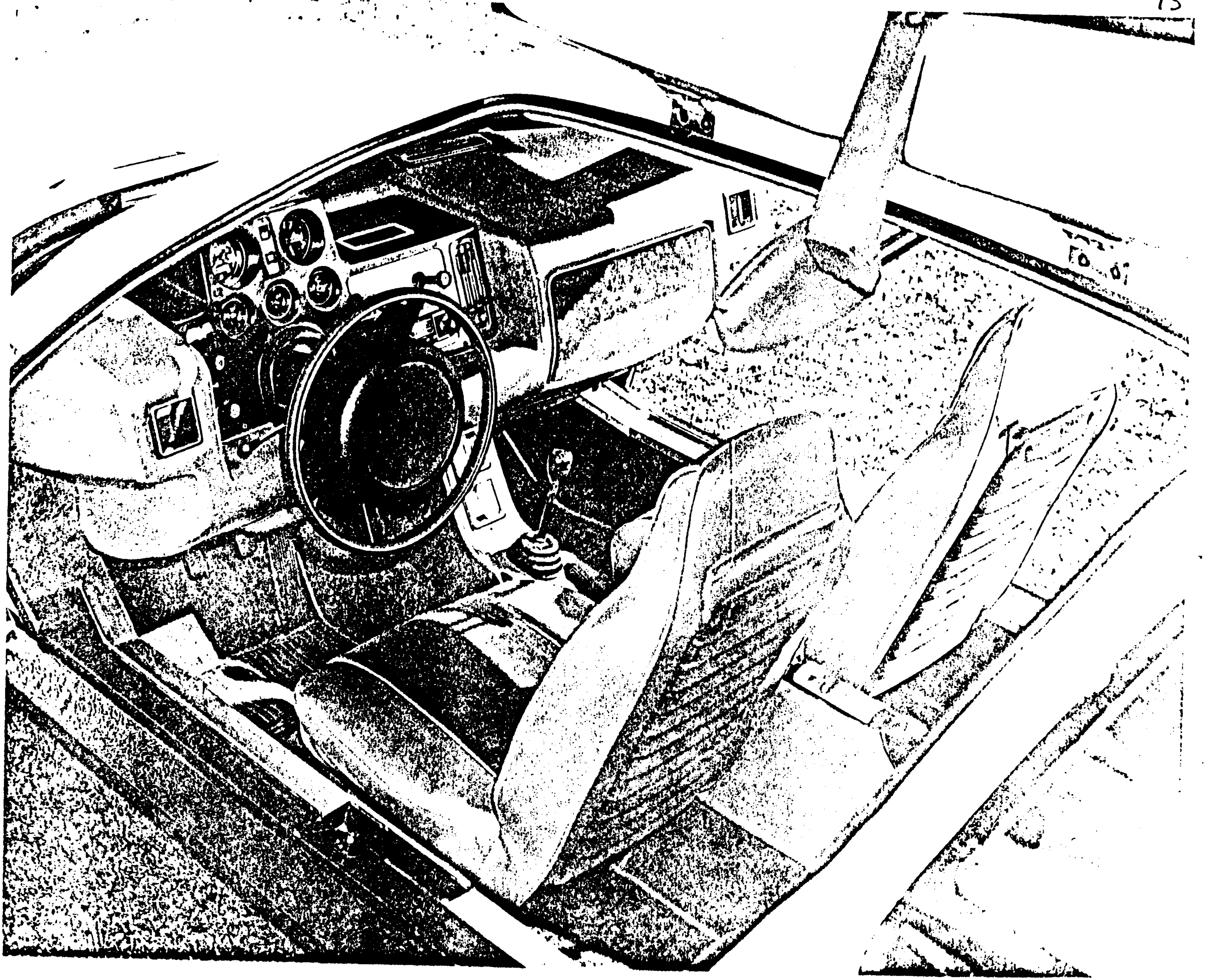
Pedestrian impact tests were conducted at Battelle. Figure 13 illustrates the difference in performance achieved with the front fascia positioned directly on the foam bumper, as in the nominal configuration, and moved 5 inches forward of the bumper. Clearly, the knee impact accelerations and other injury measures are significantly reduced. Our conclusion is that providing about 3 inches of low force deformation space between the fascia and the bumper will reduce the already favorable pedestrian impact injury measures, without significantly affecting any other performance aspect of the vehicle.

E. Damageability Tests

Low-speed damageability tests were conducted at Dynamic Science in August. As indicated in Figure 14, the tests confirmed the design intention to minimize impact damage in circumstances where, by comparison, a conventional car would have incurred substantial costs of repair. I have personally taken a baseball bat to the soft fenders without damage, although no objective tests have been defined.

F. Accommodations

Figure 15 illustrates the front seat accommodations of the RSV viewed with the doors open. The interior volume (calculated by EPA criteria) is equivalent to that of a compact car, and the easy of entry and exit, seating comfort, and driver instrumentation are rated "good" in subjective judgments. Obviously, each car manufacturer judges interior accommodations by his own criteria, so it is only our intention to illustrate that the safety features incorporated in the car need not interfere with or preclude an acceptable interior configuration. Note, in particular, the high mounted instrumentation, the transparent headrest, the lack of front seat belts and the rear seat leg room.



G. Cost

Figure 16 illustrates the typical expenses and capital costs for an all new car program of one car line to produce vehicles in quantities of several hundred thousand per year using an existing production drivetrain. The estimates were prepared by the Transportation Systems Center of the Department of Transportation and indicate that for on the order of 400 million dollars, the vehicle could have been produced and sold to consumers in these quantities for about $7000 during the 1980 model year.

Results Obtained - Research Effort

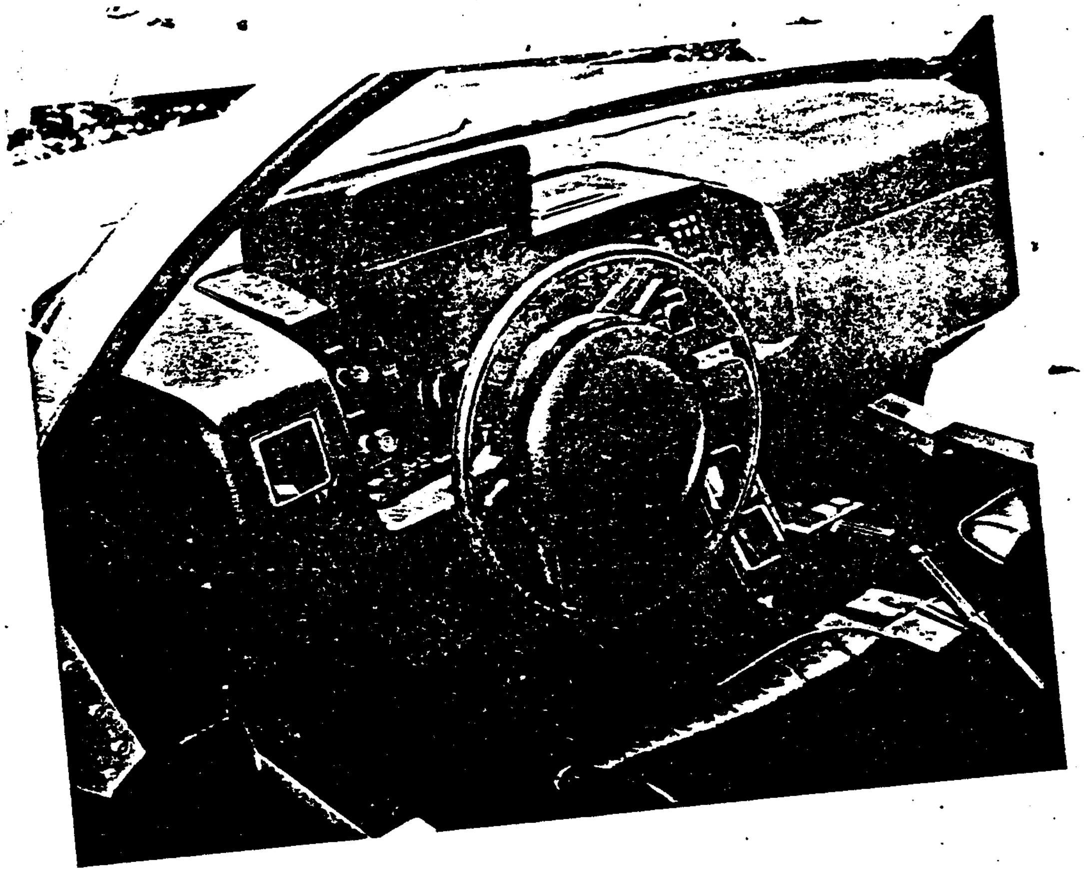
A. High Technology RSV

The High Technology RSV incorporates the electronic control features illustrated in Figure 17. Since it is a research vehicle, involving first and second generation development electronics, no extensive evaluation tests have been conducted. Development testing has indicated that collision mitigation braking can reduce the velocity of the vehicle by 15 to 20 mph after being triggered by a computer which processes the radar system signal. The combination virtually precludes false alarms. The car following cruise control works substantially better than a human driver in controlling engine power to maintain steady following distances. The anti-skid braking system works well on a variety of skid-producing surfaces. The automated electronically operated 5-speed manual transmission provides excellent fuel economy with the smoothness of a good manual shift driver. The electronic display is shown in Figure 18, and, in our opinion, is likely to be the forerunner of more production-oriented displays of a comparable level of sophistication. I would like to encourage you to see the short film of the High Technology RSV being shown adjacent to the car in the exhibit hall.

B. Large Research Safety Vehicle

1. Crashworthiness

The Large Research Safety Vehicle has now completed a number of tests in the crashworthiness area, as shown in Figure 19. We have demonstrated low injury measures relative to injury criteria for all three front seat jpassenger positions in frontal and angled barrier tests. A marked improvement in side impact protection is observed through the addition of RSV type padding as compared to the original Impala padding as shown by the injury measures of the last two tests.



18

FIGURE 20A

RSV PHASE III - LRSV FRONTAL BARRIER IMPACT

DATE: 5/9/79

LRSV SPEED: 62.8 KPH (39.0 MPH)

	DRIVER	MIDDLE FRONT PASSENGER	RIGHT FRONT PASSENGER
HIC	174	169	178
CHEST G's (3 MSEC)	37	30	30
L. FEMUR, KG (LBS)	523 (1150)	364 (800)	364 (800)
R. FEMUR, KG (LBS)	500 (1100)	500 (1100)	455 (1000)

FIGURE 20B

RSV PHASE III - LRSV 30 OBLIQUE BARRIER IMPACT

DATE: 7/20/79

LRSV SPEED: 54.4 KPH (40 MPH)

	DRIVER	MIDDLE FRONT PASSENGER	RIGHT FRONT PASSENGER
HIC	248	74	130
CHEST G's (3 MSEC)	32	25	35
L. FEMUR, KG (LBS)	591 (1300)	273 (600)	568 (1250)
R. FEMUR, KG (LBS)	455 (1000)	545 (1200)	273 (600)

FIGURE 20C

RSV PHASE III - SAE 1818 KG (4000 LBS) BOEGY INTO LRSV RIGHT SIDE

DATE: 10/4/79

BOGEY SPEED: 48.3 KPH (30 MPH)

	RIGHT FRONT PASSENGER	RIGHT REAR PASSENGER
HIC	182	627
CHEST G's (3 MSEC)	90	150
PELVIC G's (3 MSEC)	100	105

FIGURE 20D

RSV PHASE III - SAE 1818 KG (4000 LBS) BOGEY INTO LRSV LEFT SIDE

DATE: 2/7/80

BOGEY SPEED: 41.2 KPH (25.6 MPH)

	DRIVER
HIC	132
CHEST G's (3 MSEC)	55
PELVIC G's (3 MSEC)	55

2. Fuel Economy and Emissions

The fuel economy and emissions performance tests conducted by Volvo of America are shown in Figure 20. The results indicate that a full size car can be designed to exhibit significantly higher crashworthiness, while at the same time achieving significantly improved fuel economy and reduced emissions through weight reduction and available technology.

With a few exceptions, Minicars is reasonably satisfied with our efforts and the results obtained. Our impression is that the Congress of the United States and the public are interested and impressed with the program's results, but somewhat disappointed with the rate and timing of the industry's incorporation of the technology. Through the project, NHTSA foresaw in 1975 America's need for lightweight, safe, fuel economical vehicles, but was unable to pressure the industry to produce such cars through rulemaking (or public information). Apparently only after the American marketplace imposes severe economic penalties on corporate management, stockholders and workers does implementation begin and then, only in the direction of current concern. The huge investments now being committed to retool automotive production could also have included substantially improved occupant protection, damageability and repairability, etc., but instead they focus primarily on fuel economy. Apparently the highway slaughter will have to get bad enough, or some other factor significant enough, to reflect itself in an economic marketplace reaction before RSV-type safety can be justified.

Through the insight of the management of the National Highway Traffic Safety Administration and the able direction of their Contract Technical Manager, Mr. Jerome Kossar, there are many things about the car that are just right. There have been some disappointments, however, and some concepts which, while they work well in tests, need real world evaluation.

A major disappointment has been the weight growth of the car (Figure 21). We had hoped that in the one iteration of the design from the Phase II subsystem efforts to the Phase III integrated car efforts we could maintain the weight budgets without complete redesign. It turned out that, in order to accommodate all of the requirements for all of the subsystems simultaneously, the weight increased about 15 percent more than expected. Investigation has convinced us that the weight growth can be removed with iteration. Nevertheless, the car as tested at 2560 pounds is approximately 300 pounds over our target weight. This weight growth is not overly surprising, nor is there any reason to doubt the ability to eliminate it in production. For instance, General Motors modified a B-body sedan to meet ESV specifications in 1973, with a resulting increase in weight of more than 20 percent. When required by the fuel economy pressures of the marketplace in 1977, GM reduced the B-body weight by 20 percent, but at nominal safety performance levels.

Minicars has been able to show with the LRSV that the next generation of full-size six-passenger cars can weigh 20 percent less than the 1977 Impala and protect its occupants to 40 mph. At its current weight, 50 mph occupant protection is possible. Later in the session VW will conduct a crash test of a Minicars prepared front seat airbag equipped Citation at between 35 and 40 mph. This vehicle weighs 400 pounds less than the LRSV. These points remind me that in several previous conferences the opinion has been expressed that improved occupant safety involves substantial weight and cost penalties, yet as time goes on, we ourselves prove that performance can be increased while weight can be significantly reduced.

Another disappointment in building the prototypes was the need to follow up and inspect components for quality and performance on repeat development orders. In development we assume that a specially tailored component will continue to be delivered as specified unless changed. Much to our dismay, we noticed that the injury measures were substantially higher in the first of the Phase IV evaluation tests in Japan, than those that had been obtained a year earlier during development. A Phase III two-car head-on frontal development test with full airbag instrumentation was scheduled soon thereafter and produced similarly disappointing results.

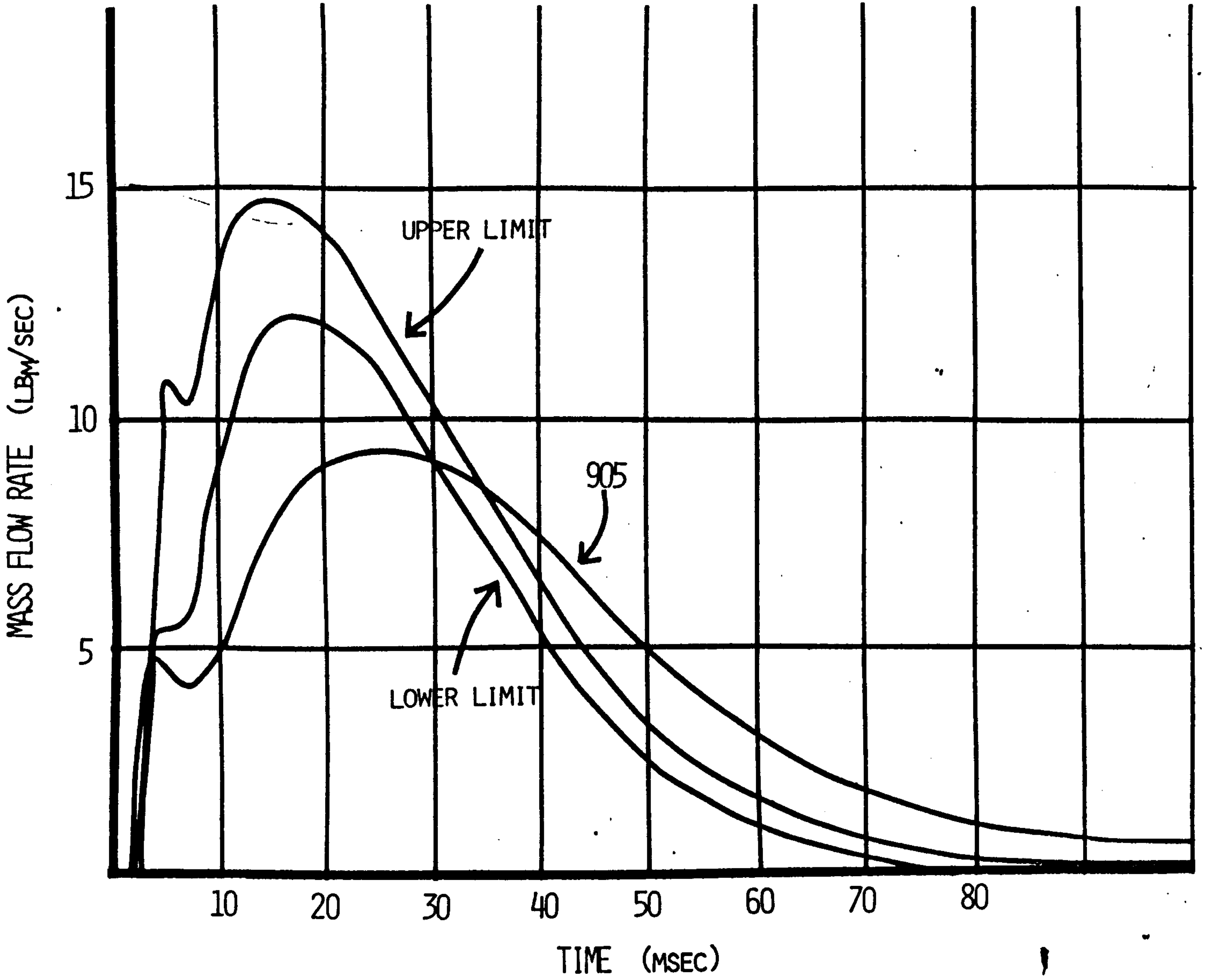
The instrumentation led us to suspect, in our first "defects" investigation, that the passenger restraint was not performing correctly. We then conducted some component tests and found that the inflators used in these two tests and installed in all vehicles for Phase IV evaluation were significantly different from the earlier development test units, as shown in Figure 22. In other words, the most recently delivered inflators filled the bags significantly slower than the earlier development units perhaps because Thiokol had used a different lot of production grain. This led to a revision of our inflator specification and our first, but completely successful, recall campaign.

There are also a variety of other problems which were not considered important enough to be completely resolved for prototype use, such as adequately counterbalancing and sealing the door. For performance tests these factors are not important, although the gull-wing doors of the show car have been effectively sealed and counterbalanced through most of the range of motion. Further, it isn't clear that a gull-wing door of this configuration is appropriate to a production vehicle.

Similarly, the A-posts were not designed to incorporate a recess for the glass windshield as in stamped production posts so there is some occlusion of vision in the frontal area. We had no doubt that it could be done, but it seemed inappropriate to invest the necessary funds in dies to produce the right configuration.

When the car grew in weight, changes should have been made to the suspension, steering, braking, engine and transmission systems.

FIGURE 22



MASS FLOW RATE (LBM/SEC)
15
10
5
UPPER LIMIT
905
LOWER LIMIT
10
20
30
40
50
60
70
80
TIME (MSEC)

To adequately optimize the results, these changes would have added another 50 pounds to 100 pounds since those systems were designed for a target weight vehicle of about 2200 pounds. On the other hand, when the car was tested at 2550 pounds, only a few items required adjustment and modification. In most cases the adjustments were not what was desired, nor what would be required, but what was necessary to make the vehicle perform as close to the program goals as possible without the iteration of design necessary to reduce the non-running gear weight. In only a few tests, such as fuel economy and hill holding, did the vehicle not achieve the performance goals we had hoped for. We believe that with an additional design iteration and a production engineering effort, a commercial version will weigh 2200 pounds, and achieve these goals.

Lastly, the possible production of a commercial version of the RSV with airbags raises some significant product liability problems. Because there are 40 times as many injury as fatality accidents in the U.S., many American manufacturing companies would prefer to face the relatively few product liability claims that involve fatalities than the large number that involve injuries.

Most American auto manufacturing companies are self insured for the first one million dollars of product liability coverage, so their out-of-pocket costs are likely to be much higher if there is any possibility that the bags <u>could</u> have aggravated injuries, whether they do or not. Considering the probable range of impact conditions, anthropometric sizes, age and health differences, etc., it would seem a legitimate business risk decision to design a low performance system to mitigate the possibility of <u>any</u> injury in <u>any</u> impact in which the bags are triggered, even though such a system may not have much effect on the fatalities and the 10 percent of the injuries which are severe.

NHTSA, on the other hand, has focused on, and we have designed for the RSV a system which, in our opinion, will significantly mitigate the probability of serious injury and fatality and which is not likely to aggravate minor injuries under most accident circumstances.

A careful analysis of the real world situation conducted by Minicars confirms the reasonableness of both the business risk management decision and the government's desire to reduce societal cost. So making airbags available isn't a question of who is right, or how much more this system costs than that, but how can experts from both sides in liability law, insurance, cost effectiveness, and technology resolve the situation in favor of the public. As technologists, we believe that the RSV system, with its forgiving structure and padding, is the right system. But, if necessary, one could install a somewhat more expensive dual-level inflation system to satisfy both points of view.

If Minicars can raise 20 million dollars of equity capital through a private placement, we may find out. A company has been formed called "Response Motors" to produce and market commercial versions of the car.[5] With Federal loan guarantees from the U.S. Government through the Departments of Commerce, Agriculture and Labor, the cooperation of the Government of the Commonwealth of Puerto Rico, and with the production design assistance of our associates from Renault and Chausson in France, Response Motors will be able to market, in limited quantity, two commercial versions of the RSV. The first to be produced would be a luxury version, virtually hand built, but production engineered by Chausson, with powertrain and running gear by Renault Motors, and marketed through Rolls Royce Motors International. The Luxury version is shown in Figure 23. It would be elongated some 10 inches, configured with a flatter roof and a Lunke sliding door system, but it would still incorporate the RSV foam-filled sheet metal structure, dual-chambered airbags and some of the special electronics features researched during the program.

The luggage capacity of the luxury vehicle is almost doubled by raising the hood and making the center floor of the luggage compartment substantially thinner (and lower) than the foam-filled 12-inch section in the existing configuration (Figure 24). Reducing this section is the result of analyzing a variety of frontal impact tests including underride, override, offset and head-on modes. This analysis indicated that, when impacting both frame and integrated structure vehicles, impact energy is

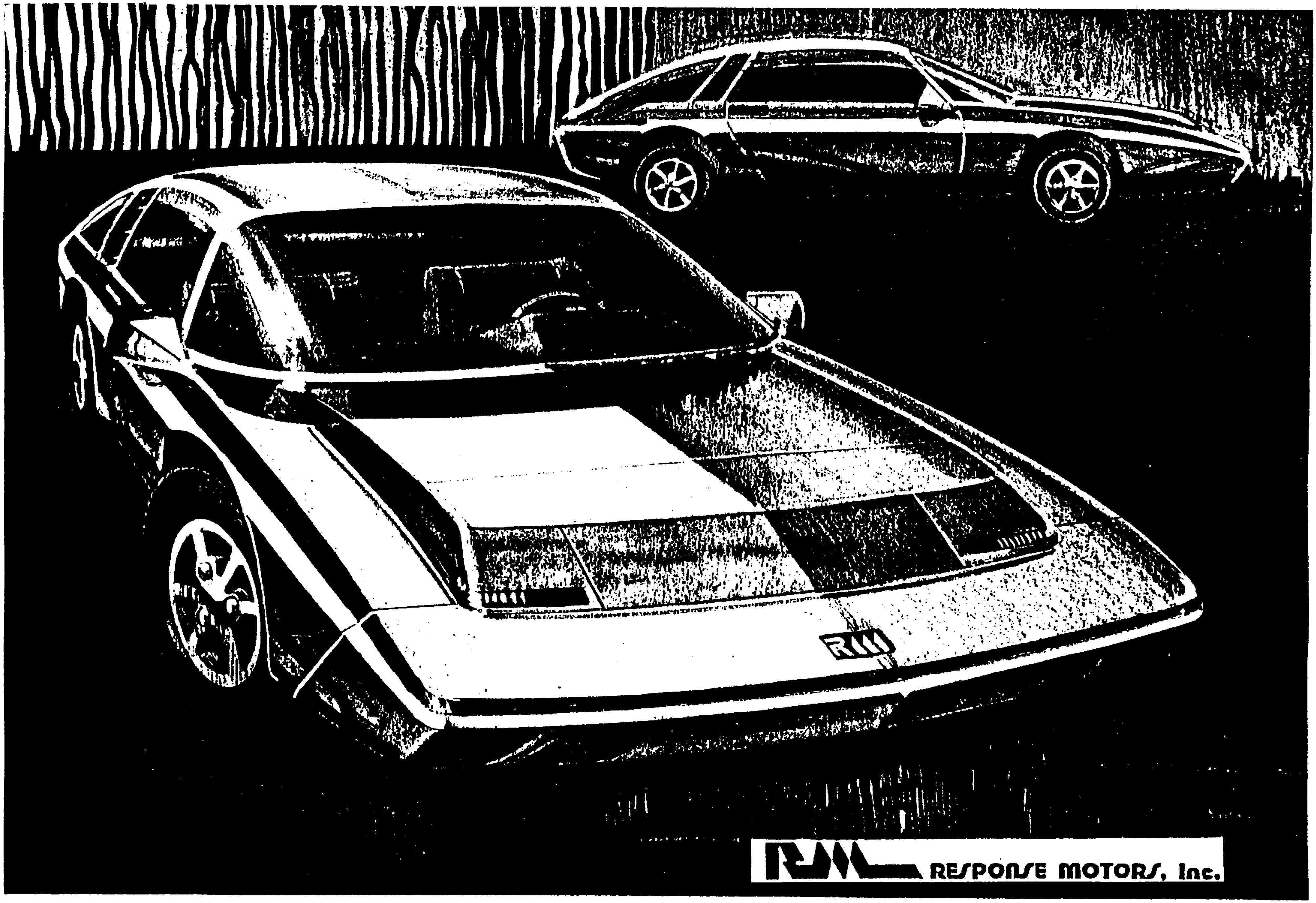


FIGURE 24 THE "LUXURY" RSV

primarily absorbed in the RSV by the foam-filled wheel well panel, the outside volume and sheer strength of the luggage compartment floor and the upper fender boxes. This also leads us to believe that, by sacrificing compatibility, a front engine configuration is perfectly possible, with little degradation of occupant protection and pedestrian impact capability.

The Standard version, which would be first produced in 1985 in quantities of up to 30,000 per year, is shown in Figure 25. It would have conventional opening doors, a Renault 1.6 liter engine with 5-speed manual transmission, and would be expected to weigh about 2200 pounds.

Both cars would use the RSV prototype structural concept with little change and 60 percent fabricated parts commonality. Since the RSV program was only to produce prototypes, it was clear that stamped and formed parts would limit the ability to iterate the design of the structure from a crashworthiness point of view. The configuration that evolved then was one suitable for very short-run production activities; that is, using brake formed parts. This technique also saves many millions of investment dollars for presses and dies.

The resulting energy absorbing structure cannot be expected to have style and smooth contours. To provide these features, the exterior of the vehicle (which makes little or no structural contribution) is a polyurethane plastic with a relatively high flex-modulus to reduce minor damage and to style the energy absorbing structure (Figure 26).

Response Motors is now at the stage of soliciting financial participation in raising the 20 million dollars in equity capital necessary to finance this 85 million dollar project. A private placement memorandum has been released by our investment consultant, A. David Silver & Company in New York. Figure 27 summarizes the pertinent financial information, and Figure 28 summarizes the use of investment capital.

At this point, I have no way of knowing whether we will be successful in raising the necessary equity capital, or whether consumer demand for an available vehicle providing a substantially higher level of safety will be limited. I believe those answers are important to the future planning of government and industry, and I solicit your support in obtaining it in the real world. I urge you to join Renault, Chausson, Rolls and Minicars in this venture by voluntarily responding to, and assessing the level of, consumer demand for auto safety without governmental intervention.

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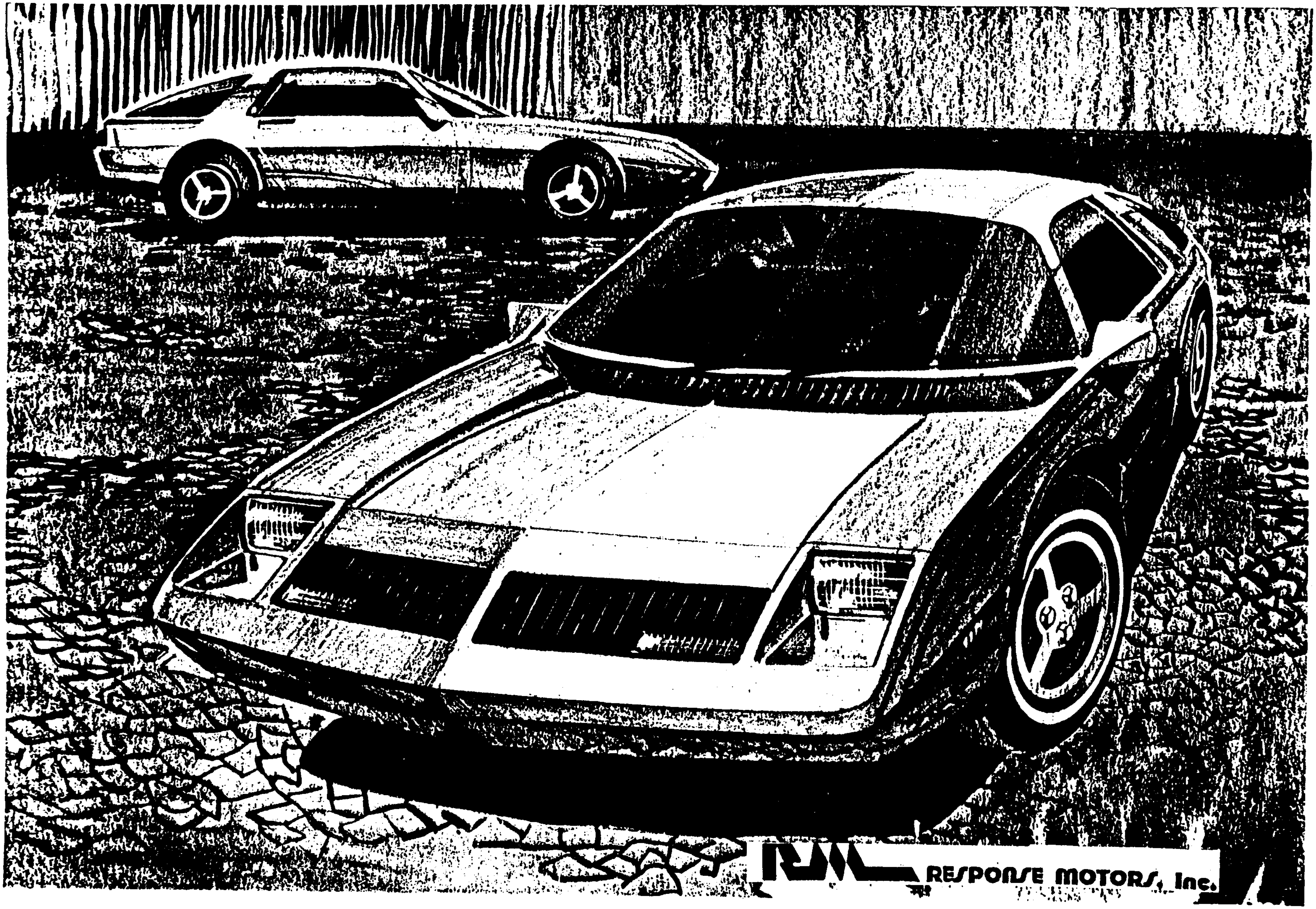

FIGURE 26 THE "STANDARD" RSV

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STATUS REPORT of Minicars' Research Safety Vehicle

Did Struble give a paper at the Paris RSV 7th Conference? ADD REF HERE.

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