U.S. Department
of Transportation
**National Highway
Traffic Safety
Administration**

Final Regulatory Impact Analysis

Amendment to Federal Motor Vehicle Safety Standard 208 Passenger Car Front Seat Occupant Protection

FINAL REGULATORY IMPACT ANALYSIS

AMENDMENT TO FMVSS NO. 208

PASSENGER CAR FRONT SEAT
OCCUPANT PROTECTION

NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION
PLANS AND PROGRAMS
OFFICE OF PLANNING AND ANALYSIS

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SUMMARY

In October 1983, the Department of Transportation published a Notice of Proposed Rulemaking (NPRM) which proposed several alternative amendments to FMVSS No. 208, Occupant Crash Protection. The Preliminary Regulatory Impact Analysis (PRIA) accompanying the NPRM discussed the uncertainty involved in determining the effectiveness of restraint systems, safety benefits, insurance savings/costs, as well as consumer and other costs that could be anticipated under various alternatives and solicited comments on this subject. In response to the NPRM, over 7,800 commenters offered their views about various aspects of the proposed rulemaking, including the automobile manufacturers, insurance companies, consumer groups, and other interested parties. In May 1984, the Department published a Supplemental Notice of Proposed Rulemaking (SNPRM) asking for comments on four additional alternatives, as well as other issues. There were over 130 comments to the SNPRM. In preparation for this rulemaking, the Department of Transportation conducted comprehensive analyses of pertinent comments and of all accident data and other material available in its files. On the basis of these analyses, the agency sought to determine the effects on benefits and costs of the proposed alternatives to improve passenger car occupant protection.

While many of the uncertainties still remain, notably the uncertainty surrounding the precise level of potential usage of automatic belts, the summary data below are based on the best currently available estimates.

Effectiveness

Effectiveness of an occupant restraint system is defined as the percentage reduction in fatalities or injuries for restrained occupants as compared to unrestrained occupants. In this analysis, the agency reviewed all pertinent accident data in order to develop a range of estimates of the effectiveness for air bags without belts, with lap belts, and with three point belts; manual lap belts, manual lap and shoulder belts; and automatic belts. The results of the effectiveness evaluation are as follows:

TABLE 1
PERCENT EFFECTIVENESS

	Manual Lap Belt	Manual Lap/ Shoulder Belt	Automatic Belt	Air Bag Alone	Air Bag With Lap Belt	Air Bag With Lap/ Shoulder Belt
Fatalities	30-40	40-50	35-50	20-40	40-50	45-55
AIS 2-5 Injuries	25-35	45-55	40-55	25-45	45-55	50-60
AIS 1 Injuries	10	10	10	10	10	10

According to these estimates, there is no single system more effective than the manual lap/shoulder belt when used; but using this system with an air bag as a supplement provides the most effective system for both fatalities and AIS 2-5 injuries.

Throughout the analysis, the safety benefits and insurance premium changes will be presented as a range of values. These ranges reflect the low and high effectiveness estimates.

Safety Benefits

Based on projected fatalities and injuries and using the range of effectiveness estimates and a range of automatic and manual seat belt usage, estimates were made of the incremental reductions in fatalities, AIS 2-5 injuries, and AIS 1 injuries for all automatic restraint systems (air bags without seat belts, air bags with lap belts, air bags with lap/shoulder belts and automatic belts) and for mandatory use laws if they are effective in all states. Estimates are provided across a broad range of usage (20-70 percent) for automatic belts and a narrower range (40-70 percent) for mandatory use laws because the precise level of future usage is uncertain. Below are the results of this analysis:

TABLE 2
INCREMENTAL REDUCTION IN

	Fatalities	AIS 2-5 Injuries	AIS 1 Injury
Air Bags Only (No Lap Belt Usage)	3,780-8,630	73,660-147,560	255,770
Air Bags With Lap Belt (12.5% Usage)	4,410-8,960	83,480-152,550	255,770
Air Bags With Lap Shoulder Belt (12.5% Usage)	4,570-9,110	85,930-155,030	255,770
Automatic Belts			
20% Usage	520-980	8,740-15,650	22,760
30%	1,420-2,280	24,370-37,440	52,640
40%	2,320-3,590	39,990-59,220	82,510
50%	3,230-4,900	55,610-81,000	112,380
60%	4,130-6,200	71,240-102,790	142,250
70%	5,030-7,510	86,860-124,570	172,120
Mandatory Belt Use Laws (in all states)			
40% Usage	2,830-3,590	47,740-59,220	82,510
50%	3,860-4,900	65,300-81,000	112,380
60%	4,890-6,200	82,860-102,790	142,250
70%	5,920-7,510	100,430-124,570	172,120

Insurance Premium Changes

Based on the projected loss experience of the insurance industry resulting from an automatic occupant protection requirement, insurance premiums should change for various automobile insurance coverages, as well as for health insurance and life insurance. These results are summarized below:

TABLE 3
SUMMARY OF POTENTIAL EFFECTS
ON INSURANCE PREMIUMS FROM
AUTOMATIC RESTRAINT REQUIREMENTS

Air Bags	Per Vehicle Annual Savings ($)	Per Vehicle Lifetime Savings ($)	Total Annual Savings 1990 Fleet Equivalent ($M)
Automobile Insurance			
Savings-Safety	9-17	62-115	1,108-2,046
Loss-Deployment	(3)	(18)	(312)
Health Insurance	4-8	29-54	521-962
Life Insurance	0-1	3-7	62-136
Total	10-23	76-158	1,379-2,832
Automatic Belts (For 20 Percent Assumed Usage)			
Automobile Insurance	1-2	5-14	89-243
Health Insurance	0-1	2-7	42-114
Life Insurance	0	0-1	7-14
Total	1-3	7-22	138-371
Automatic Belts (For 70 Percent Assumed Usage)			
Automobile Insurance	10-14	65-94	1,146-1,676
Health Insurance	5-7	31-44	539-788
Life Insurance	1	4-6	71-106
Total	16-22	100-144	1,756-2,570

Consumer Cost

The following table presents current estimates of the consumer cost of different automatic restraints (air bags and automatic belts) as well as the incremental fuel cost over the lifetime of the vehicle resulting from the additional weight of such restraints.

TABLE 4
PER VEHICLE COST IMPACTS

	Incremental Cost	Lifetime Energy Costs	Total Incremental Cost Increase
Automatic Belt System (2-pt. or 3-pt. Non-Power, High Volume, Driver and Front Right)	$40	$11	$51
Air Bag - Driver Only (High Volume)	$220	$12	$232
Air Bag - Full Front (High Volume)	$320	$44	$364

Net Dollar Costs

The results of a lifetime net dollar cost analysis for air bags and automatic belts are shown in the following table. The analysis considers only the costs related to motor vehicle ownership; it does not include economic costs to society, or values for the pain and suffering experienced by the victims of motor vehicle accidents. Thus, lifetime dollar costs include retail price increases and fuel cost increases and lifetime dollar benefits include only insurance premium reductions. The range of lifetime net dollar costs is $206-$288 per car for air bags at 12.5 percent lap belt usage. For automatic

TABLE 5

SUMMARY OF SAFETY BENEFITS AND NET DOLLAR
COSTS OR BENEFITS FOR AIR BAGS AND AUTOMATIC BELTS
(COSTS ON A PER CAR BASIS)

	----SAFETY BENEFITS----				
	FATALS	AIS 2-5 INJURIES	INCREMENTAL LIFETIME COSTS	LIFETIME INSURANCE PREMIUM REDUCTIONS	LIFETIME NET DOLLAR COST OR (BENEFITS)
Full Front Air Bag With Lap Belt					
No Usage of Lap Belt	3,780-8,630	73,660-147,560	$364	$66-154	$210-298
12.5% Usage of Lap Belt	4,410-8,960	83,480-152,550	364	76-158	206-288
Driver and Front Right Air Bag with Lap Belt (Center Seat Exempt)					
No Usage of Lap Belt	3,710-8,490	72,480-145,408	354	64-151	203-290
12.5% Usage of Lap Belt	4,340-8,810	82,260-150,370	354	74-155	199-280
Driver Air Bag with Lap Belt					
No Usage of Lap Belt	2,680-6,250	56,330-114,370	232	36-100	132-196
14.0% Usage of Lap Belt	3,200-6,520	64,820-118,680	232	44-104	128-188
Driver and Right Front Automatic Belt (Center Seat Exempt)					
20% Usage	520-980	8,740-15,650	51	7-22	29-44
70% Usage	5,030-7,510	86,860-124,570	51	100-144	(49)-(93)
Driver Automatic Belt					
20% Usage	270-580	5,260-10,370	26	0-8	18-26
70% Usage	3,610-5,440	67,160-96,770	26	65-99	(39)-(73)

Note: ( ) means dollar benefits (insurance premium reductions) exceed dollar costs.

belts, net dollar costs vary by belt usage rates because the insurance benefits vary by belt usage rates. At 20 percent usage, lifetime insurance benefits range between $7-$22 per car resulting in a lifetime net cost per car of $29-$44, while at 70 percent usage lifetime insurance benefits are $100-$144 per car, resulting in a net dollar savings of $49-$93 per car.

Breakeven Points

Several breakeven points were calculated throughout the analysis. The breakeven points indicate where benefits of one alternative equal another, or where costs equal benefits, etc.

Figure I shows the fatality reduction breakeven points between automatic belts and air bags for a variety of combinations within the ranges of usage and effectiveness as they apply to these two restraint systems.

For example, the combination of the high level of effectiveness for automatic belts (50 percent) and the low effectiveness for air bags (20 percent) result in a breakeven point at a usage level of 44 percent. That is, with 44 percent automatic belt usage, the safety benefits provided by these two systems are equal.

Figure 2 shows breakeven points for costs related to automatic belts using low and high effectiveness estimates. The breakeven point occurs when lifetime costs (retail price increases and additional fuel costs) equal lifetime insurance premium reductions. At the high effectiveness level, the breakeven point occurs at the 32 percent usage level. At the low effectiveness level, the breakeven point occurs at the 44 percent usage level.

Air bag systems do not attain similar breakeven points. The estimated lifetime cost of a full front air bag system is $364, while lifetime insurance premium reductions range from $76-$158 at 12.5 percent lap belt usage for low and high estimates of effectiveness respectively. Based on these estimates, there is no point at which air bag insurance savings would equal air bag costs. This is true for all air bag configurations--full front, driver only, and driver and front right seats (center seat exempt). It should be noted, however, that these are not "societal" breakeven points as they do not include lost productivity and other costs to society.

Figure 1

ANNUAL FATALITY REDUCTION

BREAKEVEN ANALYSIS

ASSUMING EFFECTIVENESS RANGE

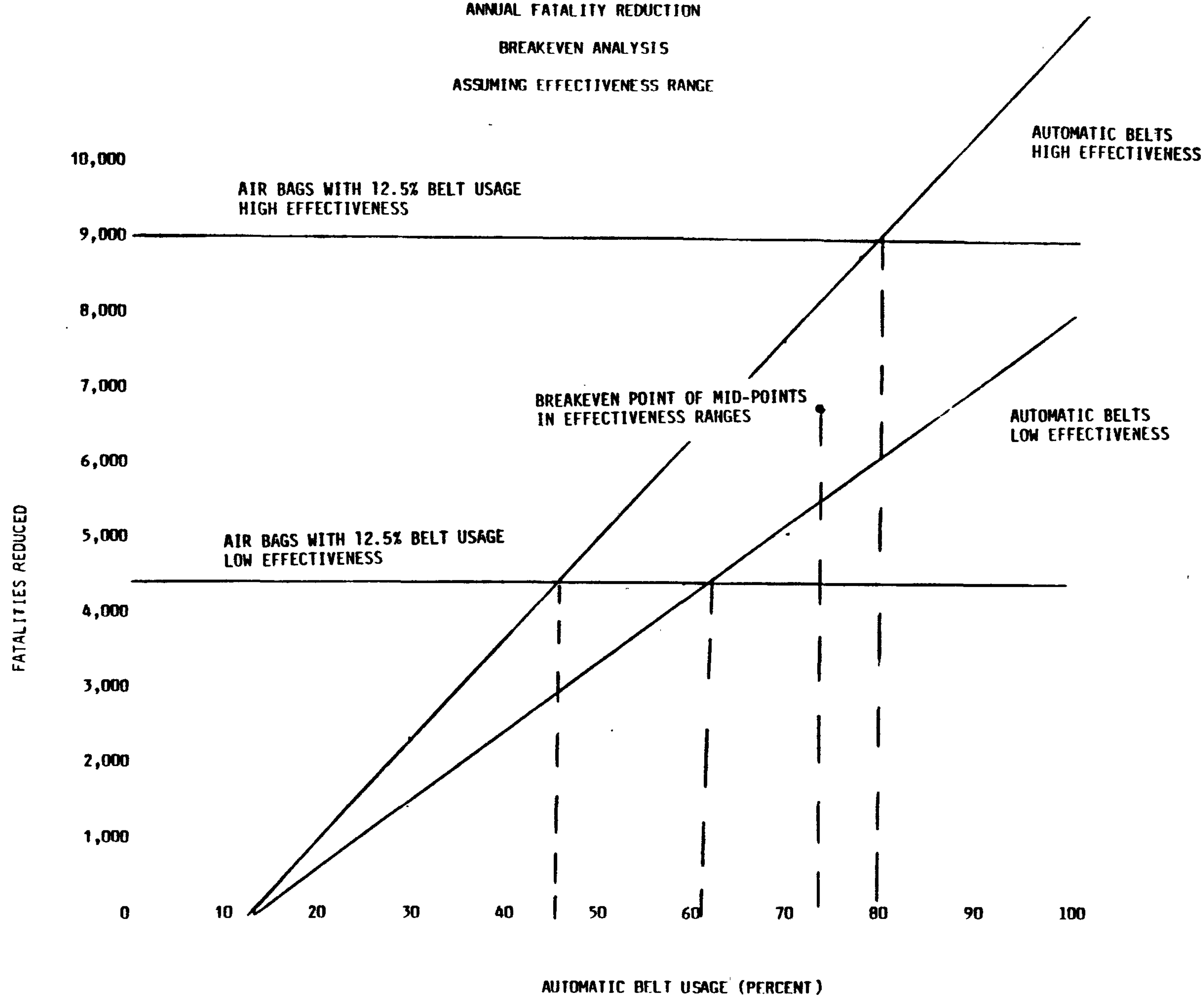
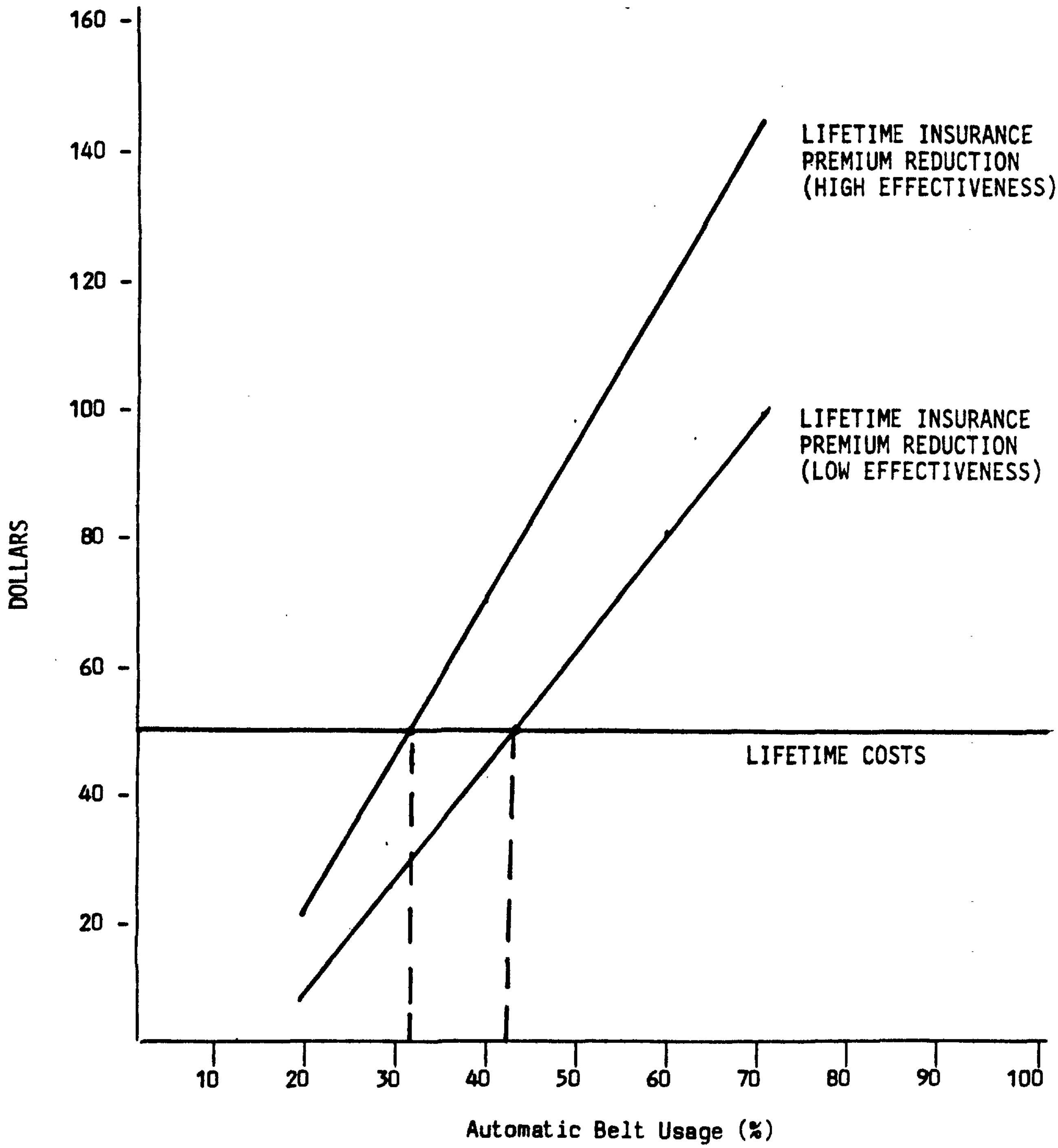


Figure 2

BREAKEVEN POINT ANALYS'S FOR AUTOMATIC BELTS
LIFETIME COSTS VERSUS LIFETIME INSURANCE PREMIUM REDUCTIONS



Benefits of the Final Rule

The Final Rule calls for a gradual introduction of automatic restraints during model years 1987-89 and a full implementation of the automatic occupant protection requirement of FMVSS 208 effective September 1, 1989, unless two-thirds of the U.S. population are covered by mandatory safety belt use laws. Tables 6 and 7 show the reductions in fatalities and AIS 2-5 injuries, respectively, over the life of cars sold during model years 1987-89. Reductions are shown for two possible scenarios that satisfy the Final Rule's implementation schedule: under the first scenario automatic belts would be used in 10, 25 and 40 percent of the fleet, respectively, for the first, second and third year; under the second scenario air bags would be used in 6.67, 16.67 and 26.67 percent of the fleet, respectively (the Final Rule allows an extra credit of 1.5 for each car that provides automatic protection with a system other than seat belts for the purpose of meeting the percentage requirements of the Final Rule). These benefits should be added to those that accrue under full implementation (see Table 2) which begins in model year 1990.

TABLE 6
INCREMENTAL REDUCTION IN FATALITES
OVER THE LIFETIME OF THE MODEL YEAR FLEET
CENTER SEAT EXEMPT
BASED ON LOW-HIGH EFFECTIVENESS ESTIMATES

	MY 1987 10% Automatic Belts, 6.67% Air Bags	MY 1988 25% Automatic Belts; 16.67% Air Bags	MY 1989 40% Automatic Belts; 26.67% Air Bags
Air Bags Only	250-570	620-1,420	990-2,260
Air Bags with Lap Belt (12.5% Usage)	290-590	720-1,470	1,160-2,350
Air Bags with Lap/ Shoulder Belts (12.5% Usage)	300-600	750-1,500	1,200-2,390
Automatic Belts (20% Usage to	50-100	130-250	210-390
70% Usage)	500-750	1,260-1,880	2,010-3,000

TABLE 7
INCREMENTAL REDUCTION IN AIS 2-5 INJURIES
OVER THE LIFETIME OF THE MODEL YEAR FLEET
CENTER SEAT EXEMPT
BASED ON LOW-HIGH EFFECTIVENESS ESTIMATES

	MY 1987 10% Automatic Belts, 6.67% Air Bags	MY 1988 25% Automatic Belts; 16.67% Air Bags	MY 1989 40% Automatic Belts; 26.67% Air Bags
Air Bags Only	4,830-9,700	12,080-24,240	19,330-38,780
Air Bags with Lap Belt (12.5% Usage)	5,490-10,030	13,710-25,070	21,940-40,100
Air Bags with Lap/ Shoulder Belts (12.5% Usage)	5,650-10,200	14,120-25,480	22,590-40,770
Automatic Belts (20% Usage to	870-1,570	2,190-3,910	3,500-6,260
70% Usage)	8,690-12,460	21,720-31,140	34,740-49,830

Table 8 shows the reductions of fatalities and AIS 2-5 injuries that would occur if states containing a total of 67 percent of the Nation's population enacted mandatory use laws, without the implementation of the automatic restraint requirements of Standard 208. Of course, benefits would be higher if additional states passed mandatory use laws.

TABLE 8
ANNUAL SAFETY BENEFITS OF
MANDATORY USE LAWS
AFFECTING 67% OF THE POPULATION

INCREMENTAL FATALITY REDUCTION

USAGE	LOW (40%)	EFFECTIVENESS MID-POINT (45%)	HIGH (50%)
40%	1,900	2,160	2,410
70%	3,970	4,500	5,030

INCREMENTAL AIS 2-5 INJURY REDUCTION

	LOW (45%)	MID-POINT (50%)	HIGH (55%)
40%	31,990	35,800	39,680
70%	67,290	75,310	83,460

I. INTRODUCTION

This Final Regulatory Impact Analysis (FRIA) represents the Department of Transportation's assessment of the benefits and costs of various alternative approaches to automatic occupant protection. It addresses issues that were raised in the PRIA and the subsequent rulemaking hearings and docket comments.

In October 1983, the Department published a Notice of Proposed Rulemaking (NPRM) as part of the further review of the occupant crash protection standard required by the Supreme Court decision. Accordingly, the agency outlined a range of regulatory actions (amend, retain, or rescind FMVSS 208) and potential alternative proposals if the decision was to amend the current standard; e.g. air bags only, air bags or non-detachable automatic belts, etc. The NPRM sought public response on 91 specific questions on various aspects of the occupant protection issue.[1] In addition, it called for three public meetings to gather nationwide response to the issues and questions raised in the NPRM. These public meetings were held in Los Angeles, California, on November 28-29, 1983, in Kansas City, Kansas on December 1-2, and in Washington, D.C. on December 5, 6, and 7. The public docket for this NPRM (Docket No. 74-14, Notice 32) formally closed on December 19, 1983, but the Department accepted comments received after that date and considered more than 7,800 docket comments.

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1 For the reader interested in the specific questions outlined in the NPRM, see 48 FR 48622-41.

Subsequently, the Department issued a Supplemental Notice of Proposed Rulemaking (SNPRM) on May 10, 1984, seeking additional comment on several issues and proposing four other alternatives. Over 130 comments were received. All timely comments have been considered in preparing this FRIA.

After a brief review of the background of FMVSS 208, the FRIA outlines the significant issues raised by the Supreme Court in its June 1983 decision -an all air bag requirement and usage of non-detachable automatic safety belts, as well as other issues resulting from agency analyses and docket comments. The following sections contain the main body of the analysis, including estimates of effectiveness, usage rates, safety benefits, insurance premium changes, cost and leadtime of the various restraint systems, impacts of increased costs on vehicle manufacturers, and possible small business impacts. Also included is an analysis of recent major public opinion surveys. Each of the alternatives considered in this analysis -- amend, retain, rescind the standard, as well as demonstration programs and mandatory seat belt use laws -- is discussed in the alternatives section of the analysis.

The Conclusions section draws all the information within the FRIA and its referenced material into a concise statement. The Conclusions section reflects the intense review conducted on a subject that has been controversial for over a decade and highlights the significant findings of the FRIA. Additional material relevant to the analysis has been included in appropriate Appendices.

II. BACKGROUND

FMVSS 208 was one of the initial standards of the agency, issued in 1967 as a standard for seat belt installation in passenger cars. Since that time, there have been a number of actions relative to automatic occupant restraints. From 1970 (rule establishing automatic restraint systems for passenger cars) to 1983 (temporary suspension of the 1977 automatic restraint requirements) issuance of an automatic occupant protection rule has been debated, proposed, revised, promulgated, and rescinded. Alternatives such as starter interlock options were proposed (1971), established (1972), and eventually overturned by congressional legislation (1974). Test criteria and demonstration programs were established and changed (1971 and 1977). The courts were also involved in the process, rendering decisions in 1972, 1979, and 1982. (These events are summarized in Table II-1 of the October 1983 Preliminary Regulatory Impact Analysis. They are also described in detail in the October 1981 Final Regulatory Impact Analysis concerning the rescission of the automatic occupant protection requirements of the standard.) The most recent actions concerning FMVSS 208 follow.

In January 1977, Secretary William Coleman negotiated agreements which would have resulted in an air bag and passive seat belt demonstration program, the purpose of which was to show the effectiveness of these devices, and thereby counter possible public resistance to this new technology and familiarize the public with the overall benefits of occupant restraints.

Ford, General Motors, Mercedes-Benz, and Volkswagen agreed to participate in the voluntary program. Ford agreed to manufacture 140,000 air bag equipped cars, GM 300,000, and Mercedes 900 driver only air bag cars. VW agreed to manufacture no fewer than 125,000 cars equipped with a passive belt system in both front seating positions between model years 1975 and 1980, with at least 60,000 of these cars manufactured between model years 1978 and 1980. The anticipated incremental consumer price to be negotiated was $100 for full front air bags and $50 for a driver only air bag.

In addition to the agreements by the automobile manufacturers, three insurance companies (Allstate, Nationwide, and Volkswagen Insurance Company) agreed to provide 30 percent discounts on medical coverage premiums for those consumers purchasing passive restraint cars.

The demonstration program was subsequently voided and abandoned by the manufacturers in June 1977, when, as a result of a reassessment of Secretary Coleman's decision, his successor, Secretary Brock Adams, issued a rule requiring automatic restraints in all front seating positions on a phased-in schedule depending on vehicle size: large cars to small cars with all cars having to comply in Model Year 1984.

Although the 1977 demonstration program contained a provision which released the automobile companies from their responsibilities if automatic restraints were to be mandated, the manufacturers were asked by Secretary Adams to continue their voluntary agreements to produce automobiles with automatic crash protection in Model Year 1980. Volkswagen continued to offer automatic belts in the U.S. and does so to this date. GM offered two-point automatic belts in Model Years 1978 and 1979 and three-point automatic belts in Model Year 1980 on all Chevettes. A small number of Cadillacs were offered with three-point detachable automatic belts and, over the last few years, Toyota Cressidas have come equipped with a motorized automatic belt. In Europe, approximately 25,000 Mercedes Benz cars have been sold with a supplemental (i.e., in addition to the three-point manual belt) driver side air bag coupled with a pyrotechnic pre-tensioning reel for the right front passenger 3-point belt, which in the case of the S-class cars sold in Germany, represents 17 percent of sales (9.6 percent worldwide.)[1] Mercedes Benz began to offer such a system in the U.S. on certain 1984 models. No other manufacturer has offered air bags to the U.S. public since GM discontinued the air bag as an option on some cars in 1976.

In February 1981, the Department issued an NPRM which proposed a 1-year postponement of the effective date of the automatic restraint requirement. This permitted further study of that requirement in light of changed circumstances since the standard's promulgation, such as the decision by virtually all major manufacturers to elect to use automatic belts rather

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1 Daimler-Benz Docket Comment No. 74-14-N32-5886, p. 3.

than air bags as the means of compliance and the dramatic shift in the market toward small cars resulting from changes in fuel price and availability. In April 1981, the agency issued a final rule delaying from September 1, 1981 to September 1, 1982, the date on which large cars had to begin complying with the requirement, and also issued an NPRM setting forth three alternative amendments to the automatic restraint requirement: (1) reversal of the phase-in sequence to require compliance by small cars first; (2) simultaneous compliance by all cars; (3) rescission of the requirement; and in addition, a sub-alternative proposed the deletion of the requirement for automatic restraints in the front center seating position for the first two alternatives.

On October 23, 1981, the agency issued a final rule rescinding the provisions which would have required front seating positions in all new cars to be equipped with automatic restraints.

The rationale for this decision was based on the belief that compliance would be by detachable automatic belt, that such belts might only result in a marginal increase in belt usage and resultant safety benefits, that the compliance costs associated with the standard were high, and that the public might have an adverse reaction to these belts, which could have an adverse effect on overall motor vehicle safety efforts.

In June 1983, the Supreme Court held that the agency's rescission of the automatic restraint requirement was arbitrary and capricious, that the agency had failed to present an adequate basis and explanation for rescinding the requirement, and that the agency must either consider the matter further or adhere to or amend the standard along the lines which its analysis supports.

The Supreme Court remanded the case to the Court of Appeals with directions to remand the matter to the Department for further consideration consistent with the Supreme Court's opinion.

On August 31, 1983, the Department issued an interim final rule which suspended the passive restraint requirement while it re-examined the issue as required by the court. The 1-year suspension was issued to preclude any possibility that manufacturers might be in technical violation of a requirement that, as a practical matter, could not be met.

In October 1983, the Department published an NPRM and a Preliminary Regulatory Impact Analysis. The analysis presented the Department's assessment of the benefits and costs of various approaches to automatic occupant protection and examined the overall safety and economic effects of these approaches. The NPRM invited comment on the proposed automatic protection requirements. Comments were received in the docket from a wide variety of individuals and organizations, ranging from automobile manufacturers and insurance companies to private citizens. More than 7,800 comments have been received to date.

Public meetings were held in Los Angeles, Kansas City, and Washington, D.C. during the period November 28 to December 7, 1983. More than 155 individuals presented testimony. The testimony in these meetings and the comments to the docket raised complex issues or led to the identification of other alternatives that were not specifically addressed in the NPRM. For these reasons, the Department issued a Supplemental Notice of Proposed Rulemaking (SNPRM) on May 10, 1984. The Notice solicited comments on the above issues and proposed four additional alternatives. More than 130 comments were received, primarily from automobile manufacturers, the insurance industry, public interest groups, and several states.

III. ISSUES

This section examines several issues raised in testimony at the public hearings and in comments to the docket. A number of these concern air bags, including the applicability of air bags to small cars, the use of sodium azide, product liability concerns associated with air bag use and repair, and the introduction of new technology which could lower the cost of air bags. Other issues discussed include the potential use of passive interiors to provide automatic occupant protection and test procedures repeatability.

A. Air Bag Issues

1. Provision for Air Bags in Small Cars

Air bags have been designed and installed in 12,000 production vehicles in the early and middle 1970's. Mercedes-Benz has sold more than 20,000 air bag equipped vehicles in Europe over the past two years and plans to sell 5,000 in the U. S. this year. However, these vehicles were all large and intermediate sized cars. Small cars present particular problems in the near term for designers of air bag systems. In the most general terms, the smaller the car, the shorter the "crush distance" and the greater the collision severity. For smaller cars, the time available for crash sensing and bag inflation is shorter. This necessitates an air bag system that uses greater force and inflation speed to produce adequate and timely occupant protection.

Several issues have been raised concerning air bag use in small cars. The issues fall into two basic categories--technical feasibility and out-of-position occupants. Specifically, is it technically feasible to design small car air bags? If it is feasible, what are the cost and leadtime implications? Are there significant differences due to car size in driver versus passenger systems? Do air bags cause injuries to out of position occupants, especially children?

a. Technical Feasibility

While most of the real world air bag experience has involved large and intermediate sized cars, laboratory tests on small cars indicate that air bags are technically feasible of being applied to small cars. Ford, in a response to Representative Dingell's questions on air bags in small cars (Docket response 74-14-N32-3115) stated that air bag technology is safe for use as a supplement to manual three-point belt systems for drivers in all sizes of cars. The Motor Vehicle Manufacturers Association's (MVMA) technical report on air bag use in small cars provided a summary of frontal barrier crash test results with air bags installed in small cars.[1] Those test results (see Table III-1A) indicate that driver and front passenger occupant protection as defined by FMVSS 208 is possible with air bags in small cars based on laboratory experiments. The report concludes that "the use of air bags in small cars shows promise in providing occupant

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1 "Air Bag Use in Small Cars-Literature Review", Technical Report by David J. Segal, November 1983. Prepared for Motor Vehicle Manufacturers Association by MGA Research Corporation, Buffalo, N.Y., p.27. (Docket 74-14-N32-1674).

Table III-1A

SUMMARY OF "SMALL" CAR AIRBAG CRASH TEST RESULTS

Vehicle	Bibliography Item	Seat Position*	Crash Speed (MPH)	HIC	Chest G	Femur Loads-LBS
Pinto	1	D	34.9	474	61	2060
Pinto	1	P	34.9	702	53	1590
Pinto	1	D	30	320-510	49-68	570-2000
Pinto	1	P	30	277-357	46-65	810-1560
Pinto	81	D	31.2	617	43	1039-1343
Pinto	82	P**	31.2	278	44	
Chevette	65	D	30	443	50	1550
Chevette	66	P	30	189	27	600
Omni	66	D	30	279	42	1300
Omni	66	P	30	492	45	700
Vega	65	D	31.9	353	45	1520
Honda Accord	53	D	35	264-859	47-59	1416-1854
Datsun 260Z	76	D	30	424-558	44-52	568-870
Datsun 260Z	76	P	30	284-540	33-44	356-687
Citation	67	D	36.9	398	40	1760
Citation	67	P	36.9	554	44	1150
DeLorean	35	D	40.6	336	46	1220
DeLorean	35	P	40.6	684	53	2110
Volvo	69	D	40.0	440	58	2100
Volvo	69	P	40.3	204	50	1580

* D - Driver, P - Passenger

**95th Male dummy

protection levels consistent with FMVSS 208." However, it was pointed out that more developmental work was necessary prior to mass production. Thus, the issue appears to be one of leadtime rather than technical feasibility.

The agency has also previously looked at the small car-air bag situation. Agency data from a computer simulated crash test of a typical small car showing the movement of the 5th, 50th and 95th percentile dummies and air bag over time in a 30 mph crash are shown in Table III-1. These data show that the bag is fully inflated before the dummy has any substantial movement in a vehicle substantially smaller than the 1974 model GM vehicles equipped with air bags. Before the dummy has moved, the sensor has detected the crash and initiated bag deployment. The bag begins to inflate at about 14ms[2] and it is at 10ms that the dummy's H point[3] begins to move from the rest position at the back of the seat. H point movement is still less than 1 inch after 30ms, and by 35ms the bag is fully inflated. By 40ms, the dummy movement is just over 2 inches. The dummy's first contact area is the femur, which contacts the small car dash at 50ms for all dummy sizes. H-point movement at this time is nearly 5 inches. Maximum H-point movement of around 8 to 10 inches occurs in the range of 70-80ms.

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[2] ms=milliseconds.

[3] H point means the mechanically hinged hip point of a manikin which simulates the actual point center of the human torso and thigh, described in SAE Recommended Practice J826, Manikins for Use in Defining Vehicle Seating Accomodation," November, 1962.

TABLE III-1
DUMMY MOVEMENT AND AIR BAG INFLATION
IN 30 MPH CRASH

Time From Onset of Initial Crash (MS)	H-Point Movement 5th Percentile Dummy (in.)	H-Point Movement 50th Percentile Dummy (in.)	H-Point Movement 95th Percentile Dummy (in.)	Bag Movement
0	0	0	0	*
10	.01	.01	.01	**
20	.17	.17	.17	
30	.81	.81	.81	
35				***
40	2.29	2.29	2.29	
45				
50	4.08****	4.72****	4.83****	
60	6.99	7.32	7.79	
70	7.88 (Max)	8.95	10.04	
75		9.21 (Max)		
80			10.90 (Max)	

* Sensor detects impact
** Bag starts to inflate (14 ms)
***Bag fully inflated (35 ms)
**** (Femurs hit)

Note: Data taken from simulated crash test of a typical small car.

NHTSA has also evaluated the performance of current air bag systems and conducted lab tests to demonstrate that air bags could meet FMVSS 208 requirements at speeds up to 40 mph in small cars. Vehicles in which air bags have been evaluated include the Chevrolet Chevette, Dodge Omni, Chevrolet Citation, Volvo 244, and the Delorean. Each of these vehicles is smaller than the previous and current production vehicles which were equipped with air bags.

The results[4] of the NHTSA sled tests and bar ier crash tests of the above vehicles lead to the conclusion that there is no technical reason why air bags meeting the injury prevention criteria of FMVSS 208 cannot be used in small cars. In addition, NHTSA has developed research safety vehicles which have provided occupant protection below the FMVSS 208 criteria at speeds up to 50 mph. For example, the Minicars RSV is a small car which has demonstrated this level of performance.

However, the agency recognizes that a manufaturer's concerns extend far beyond the test requirements of a Federal Motor Vehicle Safety Standard. Manufacturers need be concerned about air bag performance in other situations, such as in pole crashes,.and with out-of-position occupants, as discussed in the next section. Thus, developmental work, to fine-tune sthe air bag system to account for the above type situations in specific vehicles, still needs to be done. Since little work has been done by manufacturers in developing and producing air bags for small cars, the development time must necessarily be longer than for large cars.

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[4] DOT-HS-805-943 "Small Car Front Seat Passenger Inflatable Restraint Systems," April 1981.

DOT-HS-805-944 "Small Car Front Seat Passenger Inflatable Restraint Systems, Volume II-Citation Air Bag System," April 1981.

DOT-HS-805-960 "Upgrade Volvo Production Restraint Systems," April 1981.

DOT-HS-806-312 "Systems Analysis Approach to Integrating Air Bags into a Production Ready Small Car," November 1981.

In summary, based on a review of the docket comments, manufacturers' tests, and agency evaluations of small car air bag installation, it is believed that there is no technical reason why air bags cannot be installed in any car, regardless of the size although all manufacturers who commented on the small car issue stated that technical issues remain. GM, in comments to the NPRM, also stated that challenges remain in developing air bags for small cars and that additional leadtime is required for such development. However, GM concluded by saying that "It should not be inferred . . . that General Motors does not believe that air bag technology can be developed for small cars. "The agency has determined that additional leadtime is required to field test and final design air bag systems for current and future small production vehicles. It is expected that up to 5 years may be needed to design and gain experience with small car air bags.[5]

b. Out-of-Position Occupant

While it appears technically feasible to install air bags in small cars, the issue of occupant interaction with the air bag system in small cars merits review. GM, in particular, has addressed the two fold problem of designing air bags for small cars to 1) meet the FMVSS 208 30 mph criteria, and 2) at the same time avoid potential hazards from air bag induced injury to out-of-position occupants.[6]

[5] Docket Comment 74-14-N32-5299, AMC, P.4-5; Docket Comment 74-14-N32-1666, GM, Appendix A, p.7; and others.

[6] Docket comment 74-14-N32-1666, Appendix D, p.2.

The problem described by the manufacturers is that small cars have less available front end crush space and less occupant spacing from injury producing sources in the passenger compartment (such as the steering column, instrument panel or A pillar) than larger cars. In effect, this reduces the permissible time to sense and inflate the air bag to safely cushion the occupant. The small car air bag must therefore inflate quicker and utilize a thicker bag to withstand the greater inflation pressures. The effect of the necessarily more "aggressive" small car air bags on out of position occupants, particularly passengers, continues to pose a problem for vehicle manufacturers. (Drivers tend to have about the same amount of space behind the steering column independent of car size).

Most danger to out of position occupants occurs when they are located near the instrument panel at the time of bag inflation and, therefore, contact the bag when it is rapidly expanding. The agency has analyzed the effect of air bag systems on various ages and sizes of occupants, with a particular emphasis on the small child.[7] The result of that analysis indicates children would only be at the instrument panel relatively infrequently at the time of air bag deployment. Further, the fact that these small children are near the instrument panel does not necessarily mean that they would be injured. In order to be injured by a deploying air bag the child would likely not only have to be near the instrument panel but would have to be struck in such a manner as to produce injury or be thrown into another component of the vehicle interior which would produce

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7 "Protection of Children and Adults in Crashes with Automatic Restraints," Ralph Hitchcock and Carl Nash, NHTSA, October 1980, presented at the Eighth International Technical Conference on Experimental Safety Vehicles, Wolfsburg, Germany, p. 317-325.

injury. Another point to be considered is whether the child would have been injured in the absence of an air bag. Nevertheless, a small number of children could in fact be at greater risk from the air bag induced trauma than that from the effects of the crash itself.

A large part of the research and development effort on air bags through the years has focused on designing an air bag system that has location, size, and deployment characteristics (e.g., pressure, time, etc.) such that vehicle occupants are protected in as high a crash speed as possible without creating an unreasonable risk to an occupant who is out-of-position (i.e., near the stored bag at the time of deployment). The automobile industry, the research community, and NHTSA have done a tremendous amount of work over the years in trying to assess the air bag's potential for injury to out-of-position occupants, and to assess the probability of those injuries occurring in the real world.[8] [9]

At this time, air bag technology could be likened to a drug with great potential lifesaving and injury reducing capability, but with some limited adverse side effects for some (out-of-position children). In the past few years child restraint legislation has been enacted in nearly all of the states. This has the effect of reducing the probability that a child would be out-of-position to levels below that used in previous studies.

8 GM comments to 74-14-N32-1666.
9 Hitchcock/Nash Paper referenced in footnote 7.

Nontheless, any air bag design should attempt to minimize the probability of a child being injured, regardless of position, while maintaining the large potential lifesaving benefits for children and other occupants.

In summary , the agency concludes that although air bags, on isolated occasions, may cause injuries that may not have otherwise occurred, their overall safety benefits far outweigh this chance occurrence. Air bags are no different from other safety devices in this regard.

c. Cost of Out-of-Position Technical Features

In many of the NHTSA studies, concepts have been evaluated that address the concern over out-of-position occupants. One method of addressing the out-of position occupant problem is the use of a dual level inflation system. The dual level system has two inflators; the main inflator is fired at any speed above the threshold of 12 mph; the booster inflator only at speeds above 30 mph. Another possibility is to sense an out-of-position occupant with a switch in the seat or elsewhere that measures occupant size or weight. If the seat is unoccupied or a child is out of position, then the low level system will fire; if the seat is occupied, then the high level system will actuate. It has been estimated that a seat switch would add less than $10 to the total cost of an air bag system. Similarly, a simple electronic device in the instrument panel can sense if an occupant is close and deploy the low inflation mode, etc. Further, many other techniques are available to address this problem such as bag shape and size, instrument panel contour, aspiration, inflation technique, etc.

d. Summary and Conclusions

It is technically feasible to produce small car air bag systems, however, these systems will require additional lead time to design and test to assure a reduction in the potential for injury to out-of-position children. The agency has already proposed several designs that appear to reduce the out-of-position occupant problem. These techniques, if adopted, will require 2 to 5 years leadtime to bring to production feasibility and will result in some increase in air bag costs. The out-of-position child problem would affect a small number that should become smaller as the usage rates of child restraints continues to climb.

2. Sodium Azide - The Air Bag Solid Propellant

One of the main ingredients of the solid propellant used in the gas generators of air bag systems is a compound primarily based on the inorganic chemical sodium azide, NaN_3. Sodium azide in its natural state is a poisonous, colorless crystal, soluble in water and liquid ammonia, which decomposes at 300 degrees centigrade. It is used in the pharmaceutical industry, in herbicides and wood preservatives, and in the intermediate manufacture of lead azide for the explosives industry.

The use of sodium azide as a solid propellant gas generant must not be confused with its explosive applications. In the air bag system, sodium azide, as a solid propellant hermetically sealed inside a steel or aluminum cartridge, is ignited by the pressure and high temperature created by the igniter charge. What occurs then is not an explosion, but a programmed expansion of a predetermined amount of generated gases. Instead of exploding, the pelletized solid propellant begins a relatively slow (approximately 50 ms) burning process, generating non-toxic nitrogen gas which in turn inflates the air bag. These characteristics are what makes sodium azide ideally suited as an air bag gas generant.

a. Background

Since the Environmental Impact Statement for FMVSS No. 208 was issued in 1977, a number of questions have been raised regarding the use of sodium azide based gas generants in air bag systems. The issues of concern which relate to the toxicity, including carcinogenicity, flammability and disposition of the gas generants have been investigated by both the industry and Federal government agencies. The primary industry investigators include Ford, General Motors (GM), the Motor Vehicle Manufacturers Association (MVMA), Pittsburgh Plate Glass Industries, Inc. (PPG), Thiokol, Battelle, Arthur D. Little, Automobile Dismantlers and Recyclers of America (ADRA), and the Institute of Scrap Iron and Steel (ISIS). Government agencies include the National Highway Traffic Safety Administration (NHTSA), the Environmental Protection Agency (EPA), the Occupantional Safety & Health Administration (OSHA) and the National Institute of Health (NIH). The investigations have resulted in the resolution of most of the initial concerns.[10] However, some issues related to the final disposal of non-deployed air bags remain to be resolved.

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[10] For a better understanding of the issues, investigations, research, and conclusions reached by the various industries and government agencies, the reader is referred to the following sources of information:

a. Talley Industries of Arizona, Inc., "The Facts About the Use of Sodium Azide in Air Bag Inflators,: Sept. 1977.

b. Buckheit, B. and Fan, W., "Sodium Azide in Automotive Air Bags," NHTSA report, draft March 1978, update Feb. 1981, by Milleron, M. and Stucki, S.L.

c. Thiokol, "Sodium Azide Investigation Program -- Ford Motor Company," P.O. No. 47-2-594035-GM, May 1978.

d. Battelle Columbus Laboratories, "Gas Generants Research," report to MVMA, Nov. 1978.

e. Arthur D. Little, Inc., "An Investigation of the Potential Human and Environment Impacts Associated with Motor Vehicle Air Bag Restraint Systems," report to MVMA, Dec. 1978.

f. Buckheit, B. and Fan, W., "Sodium Aizde -- The Federal Responsibility," SAE paper, June 1979.

g. Gratch, S. and McConnell, C. C., "The MVMA Gas Generants Investigation," SAE paper, June 1979.

h. Herridge, J. T., "Selected Aspects of Gas Generants Research," SAE paper, June 1979.

i. Partridge. L. J. and Young, S., "An Investigation of the Potential Human Environment Impact Associated with Motor Vehicle Air Bag Restraint Systems," SAE paper, June 1979.

j. Arthur D. Little, Inc., "Identification of Approaches for the Control of Health, Environmental, and Safety Hazards Associated with Air Bag Use and Disposal," August 1979, DOT HS-805-184.

b. Toxicity

Sodium azide is classified as a Class B poison by the Materials Transportation Bureau under Title 49, CFR, Parts 100-199. The chemical is a broad-spectrum, metabolic poison that interferes with oxidation enzymes and inhibits nuclear phosphorylation. Phosphorylation is the process by which chemical compounds are converted to phosphates. Although the effects of these systems are complex, there is general agreement that the major effect of exposure to this chemical is a profound reduction in blood pressure. An oral dose of 0.014 mg/kg has a rapid hypotensive effect (i.e., it lowers blood pressure) that persists for 10 to 15 minutes. When this dose was administered to a group of patients with high blood pressure for a period of up to two years, it produced a substantial lowering of blood pressure to normal levels, without a noticeable side effect.[11]

The toxicity of sodium azide has long been a controversial issue. In the recent Public Hearings on FMVSS No. 208, a number of commentors raised the toxicity argument. A brief discussion on the subject follows.

c. Acute Exposure

Data on humans are limited and are mainly from accident records. Considerable information is available on acute toxicity of sodium azide in animals. According to the Registry of Toxic Effects of Chemical Substance

[11] Dodge, C. H., "The Toxicity of Sodium Azide," Congressional Research Service, unpublished report, 1977.

(RTECS) published by NIOSH, the oral TDLo for sodium azide is 0.71 mg/kg.[12] The definition for TDLo is the lowest dose of substance introduced by any route, other than inhalation, over any period of time and reported to produce any toxic effect in humans. According to the Registry, it takes at least 70 mg of sodium azide for a 220 pound person, by oral administration, to produce any serious toxic effect. However, when a researcher accidently swallowed a 5 to 10 mg sodium azide tablet, it resulted in a substantial lowering of blood pressure for 15 minutes, violent heart stimulation for 5 minutes, loss of consciousness for 10 minutes, followed by rapid recovery.[13] In another instance, a woman accidently drank 1.5 cc of 10 percent sodium azide solution (150 mg). This 150 mg dose is three times the TDLo for an average adult. In five minutes, she experienced nausea, diarrhea, violent headache and other symptoms. Ten days later, she continued to feel weak and dizzy.[14]

Based on the incidents cited above, the agency believes that toxic symptoms can be expected for an oral dose lower than that noted in the Registry. The agency believes such symptoms will occur at doses greater than 0.05 mg/kg (3 mg for an average person).

The lethal dose of sodium azide has not been established officially for humans. Based on actual experience, at least one person has survived a one time dose of up to 150 mg. This figure is probably the maximum non-lethal

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[12] NIOSH, "Registry of Toxic Effects of Chemical Substances," Volume 3, 1981 -- 1982 issue.

[13] Buckheit, B., and Fan, W., "Sodium Azide in Automotive Air Bags," NHTSA report, draft March 1978, update Feb. 1981, by Milleron, M., and Stucki, S.L.

[14] Canadian Industries Limited, "Toxicity of Azides," report prepared for companies using sodium azide in lumber industry, unpublished.

dose that has been recorded. Based on the available information, the low lethal dose for an adult human is estimated to be 5 mg/kg.[15] This implies that sodium azide is probably not as toxic as some substances found in common household materials, such as nicotine concentrate for use in insecticides.

d. Long Term Exposure

Long term effects of sodium azide are not nearly as well known. However, very mild toxic symptoms first appear when repeated exposure is in the range of 0.01 mg/kg, and it appears that it would be desirable to limit long term exposure to levels substantially less than 0.01 mg/kg. In acid solution, sodium azide will hydrolyze to form hydrazoic acid which will vaporize into air. Therefore, the hydrazoic acid concentration in air is another problem of concern in the chemical or inflation manufacturing facility or vehicle shredding facility. It is noted that RTECS recommends a TCLo level of 0.3 ppm.[16] The definition for TCLo is the lowest concentration of a substance in air which, having been exposed for any given period of time, has introduced any toxic effect in humans. Although there is no specific TCLo for sodium azide, this 0.3 ppm limit appears appropriate for sodium azide dust concentration in air. Canadian Industries Limited, a large manufacturer of sodium azide, suggests a soduim azide concentration below 0.1 ppm for persons who perform heavy work because

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15 "An Investigation of the Potential Human and Environmental Impacts Associated with Motor Vehicle Air Bag Restraint Systems," prepared by Arthur D. Little, Inc., for the MVMA, Dec. 1978, p.4-11, and Table 4-1.

16 NIOSH, "Registry of Toxic Effects of Chemical Substances," Volume 3, 1981 - 1982 issue.

those people breathe three times more air than an ordinary person.[17] Although OSHA does not have specific standards or requirements for sodium azide, the American Conference of Governmental Industrial Hygienists[18] has published a Threshold Limit Value (TLV) of 0.1 ppm. The TLV refers to airborne concentrations of substances and represents conditions to which nearly all workers may repeatedly be exposed day after day without adverse effect.

The gas generant used in air bag inflators is pressed into various pellet forms. Typically, a driver bag requires approximately 0.2 pounds (0.09kg) of pellets, while a passenger bag needs two to four times that amount depending upon the size of the vehicle.

Since the gas generant is hermetically sealed, the potential for motorists being exposed to a critical dose of sodium azide is remote. It has been noted that extremely low dosage exposure would be expected if the hermetic seal failed. However, there does not appear to be a real concern on the basis of the toxicity level because the results of the air bag effluent analysis (see footnotes 10b and 10c) indicate that, with the advanced filtering techniques, the concentration of sodium azide can be controlled below the 0.1 ppm level.

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17 Canadian Industries Limited, "Toxicity of Azides", report prepared for companies using sodium azide in lumber industry, unpublished.

18 ACGIH, "Threshold Limit Values for Chemical Substances and Physical Agents in the Workroom Environment with Intended Changes for 1979."

Sodium azide is known to be a potent mutagen in a number of plant species and bacteria. However, the mutagenic effects on animal species and cellular cultures are considerably less.[19 20 21 22 23 24 25] No mutagenic effects have been detected in tests of sodium azide and hydrogen azide on cultures of human cells. Since the vast majority of mutagens are carcinogens, of particular concern is the suggestion that sodium azide may be carcinogenic. In the past, several studies on carcinogenicity of sodium azide in vivo were conducted. In each study, the results were negative or at least inconclusive.[26 27] The most recent investigation at NIH by Dr. Weisburger, shows that there is no indication that sodium azide is a potent carcinogen.[28] Dr. Weisburger's belief is that it is doubtful that the chemical is carcinogenic at all in vivo because sodium azide is

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19 Owais, W. M., Kleinhofs, A. and Nilan, R. A., "Effects of L-Cysteine and O-Acetyl-L-Serine in the Synthesis and Mutagenicity of Azide metabolite," Mutation Research, 1980.

20 Kleinhofs, A., Owais, W. M. and Nilan, R. A., "Azide Mutation Research, 55, 165-195, 1978.

21 Nilan, R. A., Klienhofs, A. and Konzak, R. A., "Nature and Mechanism of Induction of Mutations," Annual Progress Report, Department of Energy, DOE/EV/72002-5, October 1, 1981.

22 De Flora, A. and Boido, V., "Effect of Human Gastric Juice on the Mutagenicity of Chemicals," Mutation Res., 77, 307-315, 1980.

23 Kamura, O. P.1 and Gollapudi, B., "Mutagenic Effects of Sodium Azide in Drosophila Melanogaster," Mutation Res., 66, 381-384, 1979.

24 Kleinhofs, A. et al," "Induction and Selection of Specific Gene Mutations in Hordeum and Pisum," Mutation Research, 51, 29-53, 1978.

25 Jones, J. A. et al, "Toxicity and Mutagenicity of Sodium Azide in Mammalian Cell Cultures," Mutation Research, 77, 293-299, 1980.

26 See footnote 10b for discussion of Carcinogenicity of sodium azide.

27 See the "Final Report on Gas Generants Research," by Battelle, Columbus Laboratory, for the MVMA, November 30, 1978, p I-41, for discussion of Carcinogenicity of sodium azide.

28 Weisburger, E. K., et al, "Carcinogenicity Tests of Certain Environmental and Industrial Chemicals," NCI, Vol. 67, No. 1, July 1981.

rapidly inactivated by the liver. This agrees with the results of Professor Nilan's work that sodium azide is weakly mutagenic and is not carcinogenic in mammalian systems due to the absence of metabolites in humans.

e. Flammability

Sodium azide is technically not an explosive since it will not detonate. It is a low energy pyrotechnic propellant possessing only one third the energy of rifle powder and 1/30 that of gasoline. Moreover, sodium azide produces nearly pure nitrogen gas (which is inert) when burned. The gas generant, when properly formulated and hermetically sealed in air bag inflators, is safe and stable.

The gas generants to be used in air bag inflators consist mainly of sodium azide and oxidizers. Other chemicals are used as binders, coolants and stabilizers. This chemical mixture is not explosive and cannot be detonated even by a blasting cap. Therefore, the air bag inflators cannot produce highly explosive results because the burning rate is controlled and the sodium azide based gas generant has a low energy content. Therefore, it is not likely that vandals and terrorists would choose the sodium azide based gas generant as a weapon because powerful gun powder is available in sporting goods stores. In addition, a simple Molotov cocktail made of a bottle of gasoline and a rag is a much more powerful bomb.

Possible abuses of air bag inflators were investigated by both Thiokol and Battelle. The air bag inflator units have been tested for resistance to shock by dropping them from a height of 12 feet and 40 feet onto a steel plate and by impacting them with a bullet fired from a 30.06 rifle. While the drop had no effect at all, the shock of the bullet was sufficient to ignite the gas generant. In addition to these tests, the inflator units were subjected to bonfire tests. The units would not ignite until the temperature exceeded 700 degrees Fahrenheit. The units were also subjected to drill and saw tests. The units would not ignite when the tests were conducted at ambient temperature. In the tests at 212 degrees Fahrenheit, one of the passenger units ignited when the saw cut into the squib initiator (i.e., firing mechanism). During product development, an inflator was placed in a burning bed of sawdust soaked with diesel fuel. Ignition occurred after 11 minutes but no explosion occurred and the unit did not fragment. The inflators are designed to produce a non-directional thrust and remain intact when the gas generant burns.[29] Therefore, the air bag inflators are classified by DOT for transport purposes as a Class-C explosive which makes them equivalent to such items as highway flares.

In acidic water, sodium azide will hydrolyze to form hydrazoic acid. Many people think that hydrazoic acid, like hydrogen azide, is very unstable and highly explosive. It must be pointed out that although both hydrogen azide and hydrazoic acid have the same chemical formula-HN_3, they have different

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[29] See the following three reports for a description of shock and burn tests: Thiokol/Wasatch Division, "Sodium Azide Investigation Program -- Ford Motor Company -- P.O. No. 47-2-594035 -- GM, "Final Report, Publication No. 7844, May 26, 1978, and Battelle Columbus Laboratory, "Final Report on Gas Generants Research," prepared for the Motor Vehicle Manufacturers Association of the U.S., Inc., November 30, 1978, 2 vols.

properties. Hydrogen azide is very unstable and highly explosive. When this chemical dissolves in water, the aqueous solution is hydrazoic acid. Hydrazoic acid is quite safe in dilute solution, but it may become explosive in aqueous solution in concentrations from about 17-50% and above. However, it requires more than two pounds of sodium azide per gallon of water to make a 17 percent hydrazoic acid solution. Therefore, hydrazoic acid, formed from sodium azide under the expected condition, is not explosive.

f. Disposal of Sodium Azide

The use of the sodium azide based gas generant in air bag inflators has aroused many controversial arguments over the final disposal phase. In 1978, the automotive industry sponsored three studies (Ford-Thiokol, MVMA-Battelle and Arthur D. Little, Inc.) to investigate these problems.[30] NHTSA reviewed these studies and with the help of comments from the public, industry and other Federal agencies, concluded that abandoned vehicles should not present a long term environmental problem, but that potential problems associated with the disposal of air bag equipped cars could surface in the auto recycling process. Basic concerns to auto dismantlers and shredders are the potential hazardous exposure to workers and toxic waste in land fills. The scrap melting industry fears that a large amount of nitrogen emission during the melting process would affect the steel quality and could damage melting furnaces. However, the general consensus is that sodium azide should not pose any problems to a facility and its surrounding environment when the working conditions are

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[30] See footnotes 10c, 10d, and 10e.

properly controlled. For instance, steel scraps can be pre-heated to burn out sodium azide before feeding them into furnaces. This can be done by directing the exhaust heat from furnaces to scrap loads.

In 1979, the agency contracted with Arthur D. Little, Inc., to study possible solutions for these potential problems.[31] A practical solution to the recycling problem recommended by the study is to discharge air bags at the beginning of the recycling process. Simple and safe means do exist to dispose of the sodium azide. The problem is to assure that the automotive salvage industry becomes aware of these methods just as they pay special attention to the disposal of gasoline tanks and batteries.

The agency has worked with the members of ADRA (Automobile Dismantlers and Recyclers of America) and ISIS (Institute of Scrap Iron and Steel). They have frequently expressed their concern about areas that have not been fully explored regarding the disposal of sodium azide. They have stated that they would support any practical means by which the safety of their workers can be guaranteed. In 1979, ADRA urged that a remote triggering device, such as a unique electric plug, be required on all vehicles equipped with air bag restraints. This would enable the auto recycling industry to discharge the air bag from a remote location rendering it nontoxic and harmless both to the workers and to the environment. In November 1979, a remote triggering method was demonstrated by NHTSA at the ADRA annual convention. The ADRA

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[31] "Identification of Approaches for the Control of Health, Environmental, and Safety Hazards Associated with Air Bag Use and Disposal," prepared for NHTSA by Arthur D. Little, Inc., August 1979, DOT HS-805 184.

Safety Committee agreed that the remote triggering device would alleviate all but a small percentage of non-deployed inflators entering a shredder or baler.[32]

Once again, both ADRA and ISIS expressed their concerns in the recent Public Hearing on FMVSS No. 208. The ISIS indicates that the shredder is the main consumer of auto hulks and thus the major generator of potential sodium azide related problems. Shredders insist that non-deployed air bag inflators be discharged early in the recycling process because they have no way to conduct visual inspections for non-deployed inflators in flattened auto hulks. Several approaches can be employed to solve this problem. One approach is to utilize the Tagged Material Detector (Piezoelectric resonator) techniques which enable the shredders to detect non-deployed inflator modules in flattened auto hulks prior to the shredding process. An alternative is to build in a self-ignition mechanism that will deploy automatically during the shredding operation. Several self-ignition techniques are available; however, this approach may require additional research on hardware modifications. The ADRA wants to make sure that passive restraint regulations do not compromise the safety of their workers. Consequently, the ADRA recommends that the following items be provided to auto dismantlers.

1. A positive, discernible identification for air bag cars.
2. A unique device for remote triggering of air bag inflators.

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[32] Parsons, B., Safety Committee Chairman, ADRA, Letters dated 11/13/79 and 12/4/79 to NHTSA Administrator Claybrook.

3. Some financial incentives for discharging inflators prior to the dismantling and recycling process.

The Breed Corporation is developing a retrofit driver air bag system. The system consists of a modified inflator which includes a mechanical sensing and actuation device. Therefore, the remote, electric triggering method cannot be applied to this system. However, the application of heat, mechanical impacts, or magnetic impulses to this system can cause the deployment of the inflator module. Fortunately, many effective approaches are available which involve the application of physical, mechanical, chemical and electrical stimuli to deploy the retired air bag inflators (see footnote 10). Furthermore, the recycling industry may want to retrieve the air bag units since they can be easily installed and removed and should have a reasonably high salvage value due to their self-contained design. The proposed Breed units do not appear to pose any particular problems in final disposal.

The sodium azide disposal problem can be better understood by analyzing the magnitude of the problem. Let us assume that 50 percent of the cars scrapped in the year 2000 would have air bag restraints using sodium azide based gas generants, and a total of 10,000,000 cars would be scrapped annually. Up to 93 percent of the cars originally equipped with air bags would have non-deployed units when scrapped or abandoned. This 93 percent rate includes cars scrapped immediately after accidents and cars retired after normal use. The number of scrapped vehicles after air bag deployment is 550,000 to 700,000, as shown and derived in Chapter VII (see p. VII-31). This estimate is mainly for cost evaluation purposes and is based on the assumption that in the late 1990's, all cars will have air bag restraints. Also, we assume that at least 97 percent of the air bag systems in scrapped cars would be discharged by auto dismantlers prior to final disposal process. This 97 percent rate is actually lower than the rate at which batteries, radiators and gasoline tanks are routinely removed prior to shredding (See footnote 10b). A tagged material detector or financial incentives could reduce this even further.

On average, each pair of air bag restraints will contain 0.8 pounds of gas generant which is approximately half sodium azide. Based on the above assumptions, about 139,500 cars (5,000,000 * 0.93 * 0.03) delivered to shredders in 2000 would have non-deployed air bag inflators, and about 230 pounds of sodium azide would be released nationally each working day. This amounts to less than one pound of sodium azide, or about two pairs of undeployed inflators per shredder per working day. Although some big shredders may have to handle as much as three times the average load, it is still a very small quantity that can be controlled with proper management. The above analysis is based on the assumption that half of cars have air bags using sodium azide based gas generants, which is neither being required nor is likely to occur in the near future voluntarily.

The distribution and the fate of sodium azide in shredder facilities were studied by both Thiokol and Battelle (see footnotes 10c and 10d). Thiokol shredded three cars consecutively with live air bag inflators which contained a total of 2.3 pounds of sodium azide. The important results were: (1) 60 percent of the sodium azide was burned or dispersed during the shredding operation, (2) 30 percent was trapped in wholly or partially intact inflators, (3) the remaining was found in fluff, nonferrous scraps, and scrubber water, and (4) sodium azide concentration in the air in some areas exceeded the TCLo limit of 0.3 ppm. In the Battelle study, three pairs of readily frangible, thin walled air bag inflators were shredded. The results were: (1) about 60 percent of the sodium azide was burned or dispersed, (2) only 1 percent was found in ferrous products, (3) the remaining sodium azide was found in fluff, nonferrous concentrate and scrubber water, and (4) no measureable amount of sodium azide was ejected to the environment via the air discharge stack. However, the Battelle study indicates that the test conducted by Thiokol is more realistic because the production inflator hardwares were used for the test. Therefore, the 10% distribution in the fluff and nonferrous concentrate and the airborne sodium azide should be acknowledged.

Based on the above results, we can estimate that, since, on average, a shredder would handle one pound of sodium azide per working day and 10 percent of this amount might be passed through the shredder, a shredder in the year 2000 would dispose approximately 0.1 pound of sodium azide in land fills per working day. Again, these values are based on the assumption that half of cars have air bags using sodium azide based gas generants. Sodium azide concentration in the air would not be a problem except for some big shredders that should closely monitor locations near the scrubber exhaust and the nonferrous product discharge areas. However, the concentration in the air should not exceed the 0.3 ppm limit because it is not likely that three consecutive cars with non-deployed inflators would be shredded as simulated in the Thiokol and the Battelle tests. Although sodium azide in nonferrous concentrate and in scrubber water could be exposed to lead, copper and other metal and in theory could form explosive materials, this is unlikely to happen. For instance, cuprous azide can be formed if copper metal is exposed to hydrazoic acid with the presence of water and carbon dioxide. Also, sodium azide will form copper azide with copper salts to the extent of the copper salts' solubility in water. However, these chemical reactions occur in a controlled laboratory condition and it is unlikely that metallic azides would form in significant quantities in scrubber water or in nonferrous concentrate under an unattended, natural condition. The agency believes there is no danger in this regard because the pH value of scrubber water may inhibit the formation of metallic azides, even if they do form concentrations they are likely to be weak because the water is constantly circulated, and impacts necessary to cause difficulties are unlikely in such a system. In addition, copper azide is very unstable and must be concentrated to detonate. Dilution with sodium azide-copper salts inhibits the detonation.[33]

Given the above disposal rate, high concentrations of sodium azide in land fills are not likely because the chemical will decompose completely within several weeks when exposed to the natural environment. In addition, in acid solution, sodium azide will hydrolyze to form hydrazoic acid, which will then either vaporize, auto-oxidize, or be broken down organically into harmless substances if the condition exists.

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[33] Talley Industries of Arizona, Inc., "Use of Sodium Azide for Air Cushion Inflators," unpublished report.

In summary, some concerns may be associated with the disposal of sodium azide, but these concerns appear resolvable and manageable. Control strategies for disposal of vehicles should recognize that sodium azide is not the only toxic chemical that may be present in vehicles. Efforts must be made to protect workers and the environment from hazardous exposure to other chemicals as well. It should be pointed out that the potential hazards pertinent to the disposal of air bag inflators are similar to the general problems that industrial workers must deal with daily and the problem should be viewed in this larger context. Nevertheless, additional work is now underway to further mitigate any potential hazards.

g. Conclusions

After reviewing all available information, the agency concludes that the manufacture of sodium azide and the normal use of air bag restraints would not pose any particular problems to motorists or the community. The only areas of concern with the use of sodium azide based gas generants are in the final disposal phase of cars with non-deployed air bag inflators. The primary potential hazards associated with the disposal of these cars are manifested within the automobile recycling operations. Many controversial arguments were raised on the disposal issue. These issues have been studied extensively and all indications are that the magnitude of the potential problems is manageable. Importantly, both Ford and GM indicated in the recent Public Hearings on FMVSS No. 208 that the potential risks associated with the use of soduim azide based gas generants in air bag inflators are manageable. In reviewing the NHTSA's draft

Environmental Impact statement on "Alternative Proposals Concerning Occupant Crash Protection," EPA has not identified any problems related to their areas of expertise and jurisdiction.

With the help from the public, industry and other Federal agencies, the agency (NHTSA) has drawn the following conclusions:

1. Several approaches could be employed to ensure that the non-deployed inflator modules will deploy automatically during operations such as shredding, shearing or baling. However, these approaches require additional research on hardware modifications because current air bag systems are designed to prevent inadvertent deployment. According to estimates of A. D. Little, based on typical times needed for development of automotive equipment, a minimum time of 2 years is required to assess various new designs in order to ensure that the retired air bag systems can be safely deployed during the shredding process without compromising the reliability of the systems in normal use.

2. The results of a countermeasure analysis indicate that the risks associated with air bag systems can be minimized by employing a series of options at the beginning of recycling operations. The effective approaches involve the application of physical, chemical, mechanical and electrical stimuli to deploy the retired air bag systems. However, the use of a 12-volt dc source to deploy the system is the only approach that is immediately available for application. NHTSA demonstrated this method at the 1979 ADRA annual convention.

3. It is recognized that the most effective approach for the safe disposal of air bag inflators is to deploy those non-deployed inflator modules at the beginning of the recycling phase. An optimal result can be anticipated if the following items would be provided to auto dismantlers in cars equipped with air bag restraints:

- A positive, discernible identification for air bag cars.

- Tagged Material Detectors.

- A unique device, such as special electric plugs, for remote triggering mechanisms.

- Some financial incentives for discharging inflators prior to the dismantling and recycling process. Recently, ADRA is suggesting $15.00 per car. ADRA is the one to discharge air bag restraints before the auto recycling process.

4. The recently developed Breed retrofit driver air bag system does not pose any particular problems in the final disposal process.

5. The agency will continue, in consultation with EPA and OHSA, to work with ADRA and ISIS to resolve the issues.

3. Automatic Restraint Product Liability

a. Sources of Potential Manufacturer Liability

A manufacturer's liability for product related injuries may arise from instances in which the product failed to meet the manufacturer's own specifications (manufacturing defects), from instances where the product met all the manufacturer's specifications, but the design still did not provide sufficient protection (design defects), and from instances where a manufacturer did not warn purchasers of the dangers associated with the product (failure to warn). Regardless of which theory of recovery (negligence, warranty, or strict liability in tort) is used, the nature of a manufacturer's liability for automatic restraint-related injuries is no different from its current liability for injuries caused by manufacturing or design defects in such existing vehicle features as fuel systems, batteries, energy-absorbing steering assemblies, manual seat belts (most of which have many of the same mechanisms as automatic belts), and braking systems.

Several questions have been raised about a manufacturer's liability for automatic restraint-related product liability claims. One basis for possible liability involves the failure of the automatic restraint to perform properly in a crash. In the case of an air bag, the alleged defect could be the failure of the bag to deploy, or the premature, late or improper deployment of the bag. In the case of an automatic belt, a defective retractor could fail to lock up in a crash, or the belt could break. However, the limited field experience of the current automatic restraint equipped fleet and laboratory tests have shown those systems to be very reliable. Manufacturer statements to the docket also indicate that their automatic restraints systems have performed as designed.

Another argument is that even if an automatic restraint functions as intended, manufacturers and/or dealers may still be held liable for any injuries that occur in the crash because of "unreasonable expectations" about the performance of automatic restraints.[34] However, a manufacturer is not absolutely liable for any crash related injuries associated with its product. Thus, manufacturers have not been held liable in instances where current manual belts have performed as intended, but an occupant still was injured.[35] However, manufacturers have been found liable when it can be demonstrated that a manufacturing or design defect caused a belt to break during a crash, allowing the driver to be thrown from the car and killed.[36]

Another potential source of liability arises from a manufacturer's decision, in the absence of a Federal mandate, not to install an automatic restraint. During the public hearings, Mr. Stephen Teret, representing the National Association for Public Health Policy, argued that:

> If a reasonable means of protection is being denied to the motoring public, that denial should lead to liability, even if the liability can be imposed on each and every car manufacturer. People whose

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[34] Submission of General Motors, December 19, 1983, p. 3. Docket 74-14-N32-1664.

[35] Hurt v. General Motors Corporation, 553 F.2d 1181 (8th Cir. 1977).

[36] Engberg v. Ford Motor Co., 205 NW 2d 104 (S.D. 1973).

> crash injury would have been averted had the car been equipped with an air bag can sue the car manufacturer to recover the dollar value of that injury. [37]

Although, according to Teret, such product liability suits have been or are about to be brought, the agency is not aware of any court that has adopted this theory of liability as yet.

Another potential liability concern involves providing automatic restraints for the driver and not for front seat passengers. The issue is whether those passengers could bring suit against the manufacturer if they were injured in a crash in which the driver was uninjured because of the automatic restraints. If driver only automatic restraints were mandated by Standard No. 208, manufacturers do not have an absolute defense against such claims because section 108(c) of the National Traffic and Motor Vehicle Safety Act provides, in effect, that compliance with a Federal standard is not a defense to a civil liability suit. However, while compliance with a Federal standard is not a defense, it is usually given substantial weight by a court in determining whether a manufacturer has acted reasonably. Therefore, the agency believes that the risk of liability would be minimal.

Finally, one commenter raised the issue of spurious suits being filed. He said that General Motors' experience with its 1973-1974 Air Cushion Restraint System program was that there was a "tendency for those involved in accidents in these ACRS cars to sue in any situation."[38] The

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[37] Transcript of Public Hearing on Federal Motor Vehicle Safety Standard No. 208, Washington, D.C., December 5, 1983, p. 154.

[38] Jack Ridenour, letter of June 4, 1984, Docket 74-14-N35-069.

introduction of automatic restraints, as with the introduction of many new products may be initially accompanied by a number of spurious suits. However, because of the extensive crash testing and research done by manufacturers on automatic restraints, compared to the testing done on most new automotive products, manufacturers will be in a better than usual position to defend against such suits.

b. Manufacturer Product Liability Costs

The most recent comprehensive review of product liability costs and experiences of manufacturers available to the agency was conducted by the interagency task force on Product Liability chaired by the Department of Commerce. The final report of the task force shows that the automotive industry, in comparison to the other industries studied, is in a good position with regard to product liability costs. The task force found that between 1975 and 1976, the absolute number of automotive personal injury product liability cases in Federal District Courts decreased and the percentage of automotive personal injury product liability cases to all personal injury product liability cases dropped from 18 percent to 13 percent.[39] The interagency study also found that the average settlement and judgment for product liability claims not only declined for the automotive industry between 1972 and 1976, but declined at a much greater rate than the average of all industries studied.[40]

39 Interagency Task Force on Product Liability, Final Report of the Legal Study, Volume III, Table A, p. 10.

40 Interagency Task Force, Final Report of the Industry Study, Volume I, Table IV-29, p. IV-56.

An important finding of the task force was that the average product liability insurance cost for companies represents somewhat less than one percent of their gross sales.[41] The report found that for the automotive industry, the average cost per $1,000 of sales for comprehensive general liability insurance (which provides coverage for a number of different types of liability including product liability) is well below the average for most industries and is at the average for industries with gross sales exceeding $100 million. Where companies were able to report the proportion of their insurance costs directly related to product liability coverage, the report found that the average cost per $1,000 of sales for product liability insurance for automotive firms is far below average.[42]

c. Availability of Product Liability Insurance

During prior rulemaking on Standard No. 208, insurance companies have consistently stated that automatic restraints should decrease, not increase, product liability claims and that insurance is available to cover possible automatic restraint-related product liability claims.[43] During the current proceeding, insurers reiterated that position. For example, at the Los Angeles public hearing, Allstate Insurance Group addressed the potential of automatic restraints to reduce product liability claims and

41 Interagency Task Force, Final Report, p. III-3.

42 Interagency Task Force, Final Report of the Industry Study, Volume I, Table IV-II, p. IV-31, and Table IV-13, p. IV-34.

43 American Mutual Insurance Alliance letter of May 25, 1978, to Secretary Adams, Docket 74-14-N8-188; American Insurance Association letter of June 27, 1977, to Secretary Adams, Docket 74-14-N8-231.

the availability and cost of manufacturer product liability insurance. Mr. Donald Schaffer, Senior Vice President, Secretary, and General Counsel of Allstate, testified that:

> Our product liability people believe that the air bag equipped cars, if you insure the total vehicle, will produce better experience than the non air bag cars because the air bag reliability factors are much higher than anything on the car. They are much higher than the brake failure rates or anything else.[44]

Mr. Schaffer also testified that, at the time of Secretary Coleman's proposed demonstration program, Allstate was Ford Motor Company's product liability insurer and had informed Ford that there would be no increase in its product liability insurance costs if Ford built an air bag fleet. He also testified that Allstate entered into a written agreement with General Motors that "we would write all of their product liability cars in the Coleman demonstration fleet at the same price they were getting from their regular product liability insurer per unit for non air bag cars of the same make and model year."[45]

The National Association of Independent Insurers (NAII) also addressed the product liability concerns raised by manufacturers and dealers. NAII said that:

> The potential for product liability suits is always present for any manufacturer or seller of consumer goods. That threat is present at the current time for anyone in the distribution chain. We in the insurance industry expect that savings (not increased costs) would accrue to manufacturers and dealers, as a result of

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[44] Transcript of the Public Hearing on Federal Motor Vehicle Safety Standard No. 208, Los Angeles, CA, November 28, 1983, p. 60.

[45] Los Angeles Public Hearing Transcript, p. 59-60.

automatic crash protection systems being installed in all cars, as lives are saved and injuries are reduced, thus reducing potential litigation over safety deficiencies.[46]

d. Sources of Potential Dealer and Repair Shop Liability

During the public hearings and in written comments submitted to the docket, individual dealers[47] and the National Automobile Dealers Association (NADA) raised the issue of whether the use of automatic restraints will increase a dealer's product liability costs. Likewise, the Automotive Service Council of Michigan raised the issue of of the potential liability of independent repair shops that would service automatic restraint equipped vehicles.[48] William C. Turnbull, President of NADA, testified that:

> The reliability of passive restraint systems, particularly air bags, has been a matter of grave concern to dealers and consumers alike. No mass-produced product can ever be "fail-safe." Components deteriorate due to passage of time, usage and climate. There are reports of inadvertent air bag deployments in the past. We fear that, with any widespread usage of air bags, incidences of inadvertent deployments and system failure will occur, with perhaps tragic consequences to vehicle occupants. In such cases, dealers may be the innocent victims of product liability lawsuits.[49]

The primary source of potential liability for both dealers and repair shops arises from the servicing of a vehicle. If the vehicle is subsequently involved in a crash and the automatic restraint system does not perform,

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46 Docket submission of National Association of Independent Insurers, December 19, 1983, Docket 74-14-N32-1672, answer to question three.

47 E.g., Statement of John J. Pohanka before the Public Hearing on Federal Motor Vehicle Safety Standard No. 208, Washington, DC, December 7, 1983, Docket 74-14-N33-131.

48 Transcript of Public Hearing on Federal Motor Vehicle Safety Standard No. 208, Overland Park, Kansas, December 2, 1983, pp. 334-340.

49 Statement of William C. Turnbull before the Public Hearing on Federal Motor Vehicle Safety Standard No. 208, Washington, DC, December 5, 1983, p. 5, Docket 74-14-N33-100.

the dealer or the repair shop is potentially liable if it can be shown that the cause of the failure is the result of the dealer's or repair shop's negligent servicing of the vehicle. To minimize such problems, dealers and repair shops will have to make sure that their service personnel are adequately trained and institute appropriate quality control measures in their service operations. Those training and quality control measures are no different from actions a dealer or repair shop owner would have to take any time a new device is installed on a vehicle. For example, if dealers or repair shops do not properly train their service personnel about the new computer control systems on vehicle engines, the faulty repair of the system could lead to engine stalling and a possible accident.

If a dealer or repair shop is involved in a suit alleging both a design defect and dealer or repair shop negligence, the dealer or repair shop has the right to indemnification from the manufacturer for design or manufacturing related defects. Chrysler, Ford, and General Motors currently have a program to indemnify their dealers in suits based on defects in the design, and manufacture of their vehicles. According to NADA, at least eight other vehicle manufacturers (Datsun, Fiat, Peugeot, Porsche-Audi, Saab, Toyota, Volkswagen, and Volvo) also have similar product liability indemnification programs for their dealers.[50] Dr. Willi Reidelbach of Mercedes-Benz, which is currently marketing an air bag-equipped vehicle in Europe and in the U.S., testified that he was not aware of any product liability concerns expressed by Mercedes dealers over the system.[51]

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[50] Cars & Trucks, July 1978, p. 29.
[51] Transcript of Public Hearing on Federal Motor Vehicle Safety Standard No. 208, Washington, DC, December 7, 1983, p. 45.

e. Conclusions

Based on its review of the product liability issues, the agency has concluded that manufacturers and dealers do not face an increased risk of liability because of the use of automatic restraints. In fact, the installation of automatic restraints should decrease the number of product liability claims. Many people previously injured or killed in crashes allegedly caused by vehicle manufacturing or design problems, such as stalling engines, locking brakes, collapsing wheels, blown out tires and jamming throttles, will be protected by automatic restraints.

In addition, information provided by insurers indicates that product liability insurance is available to cover the automatic restraint related claims experienced by vehicle manufacturers. Also, the indemnification programs offered by vehicle manufacturers may eliminate many of the product liability problems faced by vehicle dealers as a result of factors beyond their control. Both dealers and independent garages will have to ensure that their repair personnel are adequately trained on servicing automatic restraints and follow appropriate quality control measures in their service operations to minimize product liability problems.

4. Breed All Mechanical Air Bag System

The Breed Corporation of Lincoln Park, New Jersey, is developing an all-mechanical air bag system in which the sensor is integral with the gas generator. If this system proves to have production feasibility and performs according to its design, it holds promise for increased reliability, simplicity and most importantly, substantially reduced cost. The all mechanical modular Breed concept would potentially eliminate the multiple up-front electric switch sensors, all wiring leading from the sensors to both the diagnostic package and the gas generator, the steering wheel slip ring, the electric squib, the auxiliary capacitor power supply and the electronic diagnostic module of a conventional air bag system; (a complete description of the system is included in Chapter VIII). Since the entire unit, including sensors is located completely within the occupant compartment, it should not be affected directly by the elements and other hostile aspects of the automotive environment such as road salt, high underhood temperatures, etc.

Breed currently estimates the cost to consumer of a driver air bag system to be $47 and one for the driver and passenger to be $141 installed, based upon an initial production rate of one million units annually. Other annual production rate estimates submitted by Breed for the driver and one passenger system were $199 for 100,000 production, $170 for 300 thousand production, and $130 for 2.5 million production. Breed states that their cost estimates have been independently verified by technical experts familiar with auto industry practices, procedures and pricing mechanisms. If this cost proves out through development, then this is a rather dramatic reduction from the air bag system cost of $320, as currently estimated by the agency. It should be pointed out, however, that the Breed estimate does not include necessary vehicle modifications such as the knee bolster. A preliminary agency cost estimate of a Breed system for driver only is $95 and one for the driver and one passenger is $206 at the million unit level, (see Chapter VIII). Other agency annual production rate estimates of a

Breed system for the driver and one passenger are $225 and $198 for production volumes of 300 thousand and 2.5 million, respectively. These estimates include vehicle modification costs and manufacturers' overhead appropriate for purchased components.

While the Breed concept appears to be fundamentally sound, David Breed, the company's research director, admits that the system still requires "a good year" of research before it can be put into production.[52] Allen Breed, the company president, speaking at the December 6, 1983 public hearing in Washington, stated that an accelerated program lasting 1 year and costing an estimated $5 million, including equipping 10,000 vehicles with a driver air bag, is necessary to prove and make ready for production the design of the Breed Air Bag Module.[53] General Motors, Ford, and Mercedes-Benz are all interested in the concept and each company is independently evaluating the system in their labs. Mercedes-Benz has ordered two of the units for testing but no test results have been released yet. Ford considers the Breed concept "not yet fully developed . . . but worth exploring." GM is interested in the concept, but has doubts about its ability to perform as quickly as needed on pole impacts, such as a light pole or tree or some other narrow, immovable object. GM is still evaluating the Breed system.

NHTSA is also interested in evaluating the Breed system. The agency recently awarded a contract for a two phase study of a driver only all-mechanical air bag system. The first phase of this contract involves

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52 "Fuse Firm Offers Idea on Air Bags" John E. Peterson, Detroit, Michigan News, December 3, 1983. Company comments are taken from this article.

53 FMVSS No. 208 Occupant Crash Protection Public Hearing, December 6, 1983, p. 208.

crash testing of three Ford LTD's at various impact speeds. The crash testing is being supplemented with computer simulation. The object of this first phase of the study is determination of product feasibility -- can the all-mechanical system detect and actuate in sufficient time to protect the driver while not being overly sensitive in low speed collisions? If the limited crash testing and computer simulation confirm timely air bag deployment and reveal no other problems, phase two will be implemented. Two vehicles of different makes will be selected for air bag retrofit and will be subjected to a series of fifty sled tests and eight full scale crash tests. After completion of this development, Breed will be expected to fabricate approximately 500 kits for retrofit on selected police fleets. A complete evaluation of this test fleet is expected to answer some of the questions concerning real world operation of these all-mechanical retrofit type air bag systems. However, this effort is directed toward answering the question of the practicability of the system for large cars. A separate study would be required to determine the practicability of the system for other classes of cars, especially small cars. Honda stated that they had concluded that the all-mechanical system cannot be used in a small car; however, no data were supplied in support of this conclusion.

Allen Breed recommended at the December 6 public meeting that the Government require auto makers to design air bag cavities in steering wheels and dashboards. According to Breed, if auto manufacturers agreed to this design change, it would put air bags on the same par as radios that are purchased separately for automobiles and placed in the cavity left for them by the manufacturer. Thus, car owners who prefer the additional crash protection afforded by air bags could purchase a conforming Breed unit at auto supply stores and install them in pre-designed cavities.

In summary, an alternative to the conventional electro-mechanical air bag system is under development and test results from industry and government programs should be available at some future date. The most significant feature of this new system is its projected lower cost compared to other systems. Its most important drawback at this time is its lack of full scale test and field data. Specifically, can the system detect a crash early enough to actuate the system properly? Is the crash pulse sensed on the steering column so different in various crash modes that the sensor cannot be tuned properly? Will it be possible to design a passenger side system and when could it be done? Can a steering wheel assembly be made to accept and structurally maintain a retrofit air bag system but also provide adequate occupant protection if no air bag is fitted in the cavity by the owner? In addition to these technical questions is the question of manufacturers' liability and willingness or desire to design into vehicles a cavity for a retrofit air bag that could be manufactured by other vendors.

These and other questions on the all-mechanical air bag system may be answered by Breed research, GM, Ford, and Mercedes testing, and the agency testing program. At this point, however, many questions remain. Until these questions can be answered, the agency can not base its 208 decision on this technology.

B. Other Issues

1. Passive Interiors

a. Comments to the Docket

Modifying the design of vehicle interiors to offer increased occupant protection through passive interiors was addressed by two commenters to the docket. GM (Docket Comment No. 74-14-N32-1666 and 74-14-N35-068A) cited its Vehicle Safety Improvement Program (VSIP) results as an example of an alternative technology that should be investigated. According to GM, the accelerated use of the computer in the design of GM vehicles has allowed them to "build in" safety. The VSIP process has accelerated design changes to improve vehicle structural integrity, the energy absorption of vehicle interiors, steering columns, windshields, door structures and latch mechanisms. GM proposed an additional compliance option for Standard 208, namely, that unrestrained Hybrid III dummies not exceed the existing injury criteria in a 25 mph frontal test, while dummies using manual restraints pass a 30 mph test. This would allow for passive interiors in combination with existing manual belt systems.

MCR Technology, Inc. (Docket Comment No. 74-14-N32-583) stated that "recent research has shown that it is now possible to automatically protect occupants by making minor modifications to vehicle interiors and pass the FMVSS 208 injury criteria in compact or larger vehicles without the use of restraints at all." MCR Technology suggests that the agency emphasize public information, discovered through crash testing, about the degree of real world protection afforded unrestrained occupants so that people would have some appreciation of the relative merit of unrestrained versus restrained occupant protection.

Thus, these two docket comments intimate that passive interior design can provide occupant protection without restraints, protection possibly equivalent to that indicated by passing the 30 mph perpendicular barrier test requirements of the current FMVSS 208 standard. GM provided data showing that two of their production vehicles - the 1982 X-Car and the new 1984 Pontiac Fiero - when tested in the 30 mph barrier crash using the GM Hybrid III test dummy and without the use of seat belts or air bags, showed very favorable test results compared to the current standard's injury criteria limits.[54] However, GM also stated that even using its dummy and assuming no test variability, it could not certify to the 30 mph requirement. But they felt that a 25 mph requirement for unrestrained dummies in combination with a 30 mph requirement for dummies using manual restraints would be within their near term capabilities and could result in safety benefits as great or greater than those projected for the existing 208 standard.

b. <u>GM Presentation on the Vehicle Safety Improvement Program</u>

GM presented an overview and some detailed discussions of its Vehicle Safety Improvement Program to the agency on January 26, 1984 and June 8, 1984, and supplemented them with their June 13, 1984, submission (Docket

[54] GM Docket Comment 74-14-N32-1666, Appendix C, Figure 1 and Figure 2, p. 3-4.

74-14-N35-068A). GM stated that originally they had set a goal to reduce total harm[55] to occupants by a factor of 2 with various passive interior projects. However, upon a closer review by GM's project managers involved with the VSIP program, it was determined that 50 percent effectiveness was not possible with vehicle changes alone because over 50 percent of the accidents were not affected by these changes. A long-term goal of 25 percent total harm reduction in crashes was therefore established, with a near term goal of approximately 12 percent. GM claims that the latter would achieve benefits as great as a 35-40 percent level of automatic restraint usage.

The VSIP strategy consists of making improvements to vehicle structures and interior design and evaluating their effect. Improvements are contemplated for the steering assembly, windshield, instrument panel, etc. Their net effect is evaluated by performing frontal crash tests with unrestrained Hybrid III dummies at speeds such as 25 or 30 mph. Crash test results are then equated to injury risk in highway accidents as follows: injuries reported in the National Crash Severity Study which are due to occupant contacts with frontal components are tabulated by Delta V and AIS severity level. Next, GM hypothesizes that if the cars in NCSS were replaced with a fleet that could meet the Standard 208 criteria, with unrestrained dummies in 25 mph crash tests, then all of the AIS 2-6 frontal contact injuries in the sub-25 mph crashes would be reduced in severity by one AIS level. This, in turn, would reduce harm by 12.6 percent.

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[55] Harm is a concept put forth in SAE 820242, "A Search for Priorities in Occupant Crash Protection," as the sum of injuries from vehicle points contacted by injured body regions, weighted by societal costs per AIS level.

The agency can not accept GM's proposal for unrestrained occupant protection at 25 mph as it could be a diminution of the potential benefits expected with 30 mph automatic protection. However, the GM approach, which is also the subject of agency research (see "Planning For Safety Priorities, 1983 Safety Priorities Plan," NHTSA, April 1983, pgs. 129-140), is to be encouraged. The agency believes that with adequate leadtime GM, as well as other manufacturers, can develop 30 mph passive interiors. It is also believed that such an approach is likely to be less costly than air bags as well as less obtrusive than automatic belts, resulting in perhaps greater public acceptability than those means of compliance. The Department has structured its decision to help foster this, as well as other, innovative technologies.

2. <u>Test Procedures Repeatability</u>

a. <u>Background</u>

Recently, the agency conducted the 35 mph frontal barrier crash Repeatability Test Program (RTP). The RTP resulted from concerns over the significance of New Car Assessment Program (NCAP) data derived from a single crash test. The fundamental question to be addressed in the RTP was the repeatability of crash test data, especially the dummy injury measurements. The program consisted of four frontal barrier impacts of 1982 Chevrolet Citations at each of three different test sites. The Citations were manufactured consecutively, on the same production line, in the same assembly plant, in an attempt to achieve maximum possible vehicle uniformity. The agency test sites were Calspan Corporation, Buffalo, New York; Dynamic Science, Inc., Phoenix, Arizona; and the Transportation Research Center, East Liberty, Ohio.

The RTP was designed to assess the repeatability (can crash test results be replicated at the same test site?) and reproducibility (can different test sites produce the same crash test results?) of the dummy injury measures. It was recognized that the RTP would not be able to identify and quantify the sources of any repeatability or reproducibility variances.

Substantial engineering and statistical analysis of the RTP data has been performed. These analyses provided information which led to changes in the NCAP test procedure. The analyses also identified a number of research programs to reduce crash test variability.

b. Docket Comments--Notice of Proposed Rulemaking Docket 74-14, Notice 32

Three automobile manufacturers and the Automobile Importers of America (AIA) submitted comments to the docket referencing the RTP and/or repeatability tests they have conducted. AIA questioned the adequacy of the test dummies, specifically the alleged imprecision with which the dummy will record when compared to a real-world human response to the same trauma. They also claimed that the limitations of the dummy are more apparent when used with a belt restraint system, as compared to an air bag restraint system.

Ford Motor Company (Ford) stated that repeatability crash testing provides sound data which demonstrates that the results obtained from a single crash test are influenced by the large variability which remains undefinable and uncontrollable. Ford also reported the conclusions from its repeatability testing of thirty-three 1972 Mercury air bag equipped vehicles, which underwent 30 mph frontal barrier impacts. The objective of their program was to determine variability among Part 572 test dummies, test sites and crash tests themselves. Ford concluded that: (1) there was a great amount of variability in the test results; (2) the largest source of differences in the test results was due to test-to-test variability; (3) the variability in the results due to the dummy is small for HIC measurements, and nil for chest g's and femur load measurements; and (4) the considerable variation in test results suggests that there may be limited confidence in meeting the performance criteria of a standard.

General Motors Corporation (GM) stated that the Safety Act requires that standards issued by NHTSA should be practicable, i.e., capable of being used, and therefore a standard which is based on test procedures which do not assure repeatable results is not practicable. Furthermore, to be practicable, repeatable test results must be attainable from test methods which are identical, or which differ only in minor detail. GM also mentioned the Paccar decision on FMVSS No. 121, wherein the Court concluded that "Manufacturers are entitled to testing criteria that they can rely upon with certainty." GM cited the Repeatability Test Program's results which indicated a significant coefficient of variation (COV) of 21 percent and noted that the testing was based on FMVSS No. 208 criteria. They also referenced the Uniform Tire Quality Grading Standard (UTQGS), in which the treadwear grading was suspended, and pointed out that it had a COV of only 5 percent. GM's conclusion was that the FMVSS No. 208 compliance tests are subject to significantly more variation than the UTQGS treadwear tests, and therefore, would appear to be even more unacceptable. (The suspension of the treadwear grading requirements were subsequently overturned by a court decision, in which the court stated that the variability in UTQGS was insufficient to rescind the standard). GM stated that the need to consider experimental data in establishing safety standards is specifically set forth in the Safety Act. Finally, GM stated that vehicle (crash) testing can be instructional in establishing directional correctness of design changes under consideration.

Volkswagen of American (VWOA) stated that the current test procedure is simply not appropriate, particularly for the testing of vehicles equipped with seat belts.

In their comments, GM and VWOA reflected the belief that the test procedures are the cause for much of the variability which exists in the RTP results. AIA questions the adequacy of the test dummy. Ford stated that the variability due to the test dummy is small; however, they believe the reasons for the variability are undefinable and uncontrollable. In summary, the industry suggested different reasons for test result variability, those being the test dummy, the test procedure, or unknown.

It is important to note that in their comments to the NPRM, the industry, except for GM, Ford, and Volvo, provided little data to demonstrate that the test vehicle was not a significant cause of the variability of the results.

c. Docket Comments -- Supplementary Notice of Proposed Rulemaking (SNPRM) 74-14, Notice 35

In the SNPRM, repeatability was included in the general topic of "Test Procedures." Fourteen automobile manufacturers and four private organizations referenced the RTP and/or repeatability testing. Specifically, the SNPRM requested comments on: a) the relevance of the RTP results (35 mph) to FMVSS 208 compliance tests (30 mph); and (b) the applicability of the RTP Citation results to all other vehicles.

Ford Motor Company (Ford)

Ford stated that the variability observed in the RTP would be expected in all vehicle models. They based this statement on driver HIC data from three repeatability test programs; Citation (RTP), Volvo, and Mercury. In discussing test procedures, Ford questioned the repeatability of the test dummy. They believe that NHTSA has not incorporated results of the proposed repeatability research programs and are projecting conclusions prior to the completion of research it initiated to resolve the variability issues. They know of no data which prove that changes in the NCAP test procedure will reduce the variability of the test results. Ford believes that the test dummy and test procedure contribute to the high level of variability, and, in fact, stated that it is irreducible. They stated that the current coefficient of variation in the barrier crash test measurement is 21 percent. They also referred to the Part 572 dummy as the "rubber yardstick" that can be stretched or compressed at the whim of the measurer. Ford concluded, based on calculation of Mercury, Citation and Volvo repeatability results, that there is a large and unacceptable amount of variability no matter what type of vehicle is crash tested.

In discussing test procedures, other commenters mentioned the subject of repeatability.

American Motors Corporation (AMC)

AMC believes "the agency must modify the test procedure to increase repeatability before any automatic restraint portion of FMVSS 208 is adopted". Because the proposed modifications to the test procedure were minor, AMC does not expect them to reduce the variability. They stated that tests have shown that a slight change in the placement of the passenger right foot or a slight revision in the method of applying the force used in positioning the upper torso of the dummy in the seat produces significant differences in HIC as shown in the RTP data.

They stated that it is "unrealistic to believe that dummy placement procedures will have any significant affect in eliminating test variability" since there are other variables (belt tension and actual dummy position just prior to impact) that are not controlled.

AMC finds that the test procedures for the automatic restraint portion of the standard do not meet the criteria of "practicable" and "objective", which is supported by NHTSA's and GM's repeatability crash test results. If the agency continues to use the revised test procedure then, AMC would have to "overdesign" to a level that approximates half the specified injury criteria values.

Chrysler Corporation

Chrysler stated that the range of the results of the RTP demonstrate that the procedures are not "capable of producing identical results" and are not "practicable" within the meaning of two previous court decisions. They stated that "the test procedures measure the ability of the manufacturer to conduct the test and not the restraint system performance".

Chrysler stated that "a major source of non-repeatability is the inherent crash variability of the vehicle itself" and, therefore, "NHTSA must design a test which, when vehicle crash-to-crash variability is considered, will produce repeatable results".

General Motors Corporation (GM)

GM does not agree that the proposed test procedure modification will provide a reasonable range of test variability. They cite that the changes were used in NHTSA's RTP with little improvement in variability. GM stated that, based on sled tests, a major portion of the variability in the RTP was test related, not vehicle related. GM states that "vehicle variability is a fact of life and cannot be dismissed as a manufacturer's concern". GM argues that vehicle variability impacts the practicality of any safety standard. Additionally, "design compensations to overcome the effects of variability can be contrary to the need for safety".

BL Technology Ltd.(BL)

BL does not believe the subject of test procedures is "supremely important" for discussion and, since it is so involved, it would require a period of longer than 30 days to comment.

BMW of North America, Inc. (BMW)

BMW states only that there are a "number of reproducibility problems regarding HIC". BMW also states that "our experience is that impacts of 30 degrees impose less severe forces on dummies and increase testing variables."

Honda

Honda believes the test procedure for NCAP is "inadequate and many things need to be improved with regard to repeatability". Details will be supplied later (by Honda).

Mazda North America, Inc. (Mazda)

Mazda recommended conducting a repeatability program testing a subcompact vehicle to examine the variability of the test results. They recommended performing an analysis of the impact of the proposed modifications of the test procedure to examine the variability issue.

Mercedes-Benz (M-B)

M-B stated that neither the Hybrid II nor Hybrid III permit repeatable compliance test results. They believe that the "design to conform" as practiced in FMVSS 108 is a solution to this problem and should be adopted.

Nissan Motor Company, Ltd. (Nissan)

Nissan believes that "the ability to demonstrate repeatability of the injury criteria is the key point in NHTSA's vehicle assessment testing program". They stated that the NCAP test result variability from the 1982 and 1984 Nissan Stanza was due to varied dummy positioning. Maintaining the same relative dummy position is difficult and Nissan recommends using the same dummy-to-vehicle interior dimensions for the same car models tested. They also proposed positioning the shoulder belt to design measurements submitted by the manufacturers. They recommended positioning the seat in a track position which accurately represents real world usage as opposed to the specified mid-seat track position in the procedure. If a car model has limited interior size, then the seat should be placed in the "rearmost position".

Peugeot/U.S. Technical Research Company (Peugeot)

Peugeot states that "a manufacturer can but reluctantly accept as valid a test procedure which produces a coefficient of variation of 21 percent with substantially similar vehicles. Vehicle likeness will remain what it is and as long as the variability of parameters (test procedures, dummy, measuring method) which are responsible for such variations are not mastered, the requested level of performance should be raised by the amount of variations".

Peugeot further states that "the current Hybrid II dummy is one cause of variability, and consequently it cannot be said to meet the statutory criteria. Nevertheless, in the present situation and considering that it is absolutely necessary for manufacturers to dispose of a reference, even questionable, it must be maintained and imposed".

Renault USA, Inc. (Renault)

Renault believes the coefficient of variation "must not exceed a maximum of 10%" for crash test results. If the coefficient remains at 21%, "the admissible limits for HIC should be increased by 63% or else the manufacturer is to anticipate an overdesign of 63%".

Toyota Motor Corporation (Toyota)

Toyota believes that major problems exist in the test procedure, such as, influence of the Part 572 dummy on crash results, unresolved electronic measurement problems, incompleteness of the proposed modified test procedures, and exclusion of data points from the statistical analysis of the RTP without an explanation.

Volkswagen of America, Inc. (VW)

VW stated that the RTP demonstrated variability "was much too high to yield an acceptable certification procedure". VW stated that they have "no confidence that the changes in the modified test procedure will cause a significant reduction in the test variability" or that "those changes will solve the problem." VW alleged that the manufacturers must "overdesign" the system only for the purpose of compensating for deficiencies in the compliance test procedure.

Volvo North American Car Operations (Volvo)

Volvo disagreed that after certain modifications to the NCAP test procedures, the "remaining test variability would be due largely to vehicle-to-vehicle differences". They agreed that the modifications to the procedure were a step in the right direction. They stated that the total random error in a crash test includes: (a) vehicle-to-vehicle parameters; (b) test procedure related parameters; (c) dummy related parameters; (d) electronic parameters; and (e) data processing.

They believe that the modifications to the NCAP procedures only address some of the parameters which influence that procedure. The parameters which influence the dummy, electronic data gathering and data processing have not been addressed at all.

They stated that the present procedure allows a large degree of subjectivity in attaching and routing seat belts, knowing that the seat belt geometry is of great importance to the variability of the test results. Volvo recommended checking the placement and installation of the same dummy in the same vehicle at various laboratories to determine differences in seating locations.

They also questioned the unreliability in the signals obtained from accelerometers and believe that there are cases where disturbed signals are not discovered because they do not appear as "obviously abnormal". In addition, data filtering can cause variability. Volvo also provided data from 10 sled tests which demonstrated a scatter of data about the mean HIC of 466. The coefficient of variation for the sled tests was 12.5%.

Allstate Insurance Company (Allstate)

Allstate questioned the great concern about minute details of the test procedure for automatic restraints, when there are no dynamic crash test requirements or injury prevention criteria for present manual belts. They believe the answer is to move to automatic crash data protection with test procedures based on present knowledge and data, and update them as more data and experience become available. They stated that in the case of Public Citizen vs. Steed, the D.C. Court of Appeals cited the case of Goodrich vs DOT for the proposition that "no test procedures...are going to approach perfection".

The D.C. Court went on to say "NHTSA's approach to fulfilling an undisputed statutory mandate is to withhold any regulation until every i is dotted and t is crossed. That is not what Congress commanded the agency to do, nor is it reasonable behavior by an agency established to execute policy, rather than achieve quantitative perfection in its execution". Allstate claimed "it would be the height of absurdity to refuse to implement a passive restraint standard because of concern over minor test details, when such action would leave us with a manual belt system and no test procedure whatsoever."

Motor Vehicle Manufacturers Association (MVMA)

MVMA stated that before action is taken to incorporate the modified NCAP procedure into FMVSS 208, NHTSA must provide additional technical data supporting variability reduction for improved test procedure practicability and objectivity. They stated that proposed changes to the test procedure were used in the RTP, and that the variability in the test results was unacceptably high.

Insurance Institute for Highway Safety (IIHS)

IIHS discussed the need to retain the 1000 HIC number. They state that all regulations which specify a value which can not be exceeded involve overdesign. Thus, overdesign is not only reasonable, but is a standard industry practice. They also stated that the degree of vehicle overdesign needed to meet a HIC of 1000 is "easily achievable."

State Farm Mutual Automobile Insurance Co. (State Farm)

State Farm stated that NCAP tests at 35 mph involve 36% more force than crash tests at 30 mph, the speed required under FMVSS 208. The reduced speed "should result in less variability and fewer cars with HIC levels over 1000". They cited a recent decision by the Court of Appeals for the District of Columbia in Public Citizen v. Steed which held that "the variability in the tire quality grading program was insufficient to justify the recisson of that standard". Also, they believe that nothing in the NCAP should alter rulemaking in FMVSS 208.

d. Discussion

With respect to repeatability, the comments to the SNPRM provided little new information or analyses beyond what was submitted to the NPRM. It should be noted, however, that in Ford's analysis of the Citation, Volvo, and Mercury repeatability crash test results, Ford provided no data to support their claim that the variability in dummy injury criteria for each data set was essentially the same. The agency does not agree with Ford's approach of combining two different data sets of Volvo crash test results. In discussions with the agency, Volvo said they could not confirm that MIRA, the other conductor of Volvo crash tests, had followed the NCAP test procedures. Thus, without this assurance, treating the two data sets as one is unfounded. Additionally, the agency is not aware of any rationale whereby statistical measures of variability (be they standard deviations or coefficients of variation) derived from a single model vehicle at a single test speed can be assumed to be directly applicable to all other model vehicles and at a different test speed. Ford, in its comments to the SNPRM, used a "scaling" factor to change the standard deviation obtained in 30 mph crash tests to one for 35 mph tests. Although Ford did not explain what its "scaling" factor was nor how it was derived, it supports the agency's argument that statistical variations of injury prevention/measurements can not be made across test speeds.

The agency recognizes that a certain level of variability exists in dummy test results and has acknowledged its efforts to identify, quantify, and, where possible, reduce the amount of variability. It should be noted that some variability would exist in all areas of testing performed by the agency or by the manufacturers, from research and development tests to NCAP tests, and from component tests to full-scale vehicle tests.

Engineering analysis of the RTP data identified four components of variability in dummy injury measurements -- the test site, the test dummy, the test procedures, and the test vehicle.

The results of previous studies of both dummy testing and test site instrumentation provide an indication of the amount of variability which may be due to each of these components. A test site instrumentation study indicated that, at some test sites, instrumentation differences could produce as much as 10 percent variation in HIC values. Regarding dummy testing, GM and Ford differ in their NPRM submittals. Ford stated that, based on their 33 air bag car crash program, the variability in results due to dummies is small for HIC measurements, and nil for chest g's and femur load measurements. Renault, in comments to the SNPRM, agreed that the dummy is "not the major cause of dispersion in the results." GM observed variability when they conducted sled tests utilizing belted dummies. However, they were not able to isolate the dummy variables from system variables. They also claimed that the dummy is inappropriately sensitive to belt testing and they are not confident that current dummies can accurately demonstrate belt restraint effectiveness.

As a result of the RTP, the agency has instituted a number of improvements to the NCAP test procedures. Additionally, a research program has been defined which will attempt to identify and reduce causes of variation in crash testing.

The RTP analysis indicates that the vehicle is a major contributor[56] to variability, as evidenced by the significant differences observed in the structural/occupant compartment behavior in the RTP crash tests.

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56 See "Analysis of NHTSA's Crash Test Repeatability Program," John M. Machey, October 12, 1983.

Engineering analyses of the RTP indicate that these differences in vehicle behavior have a significant effect on the dummy measurements, particularly the driver dummy. There are many vehicle components that varied when comparing all the vehicles in the RTP; e.g., steering column movement, belt spoolout, structural member bending, and passenger compartment floor pan buckling, all of which can contribute to varied dummy response results.

Specific examples are:

o The steering column angles were measured and varied from 21.5 degrees to 23.5 degrees.

o The dynamic crush ranged from 27.5 inches to 32.0 inches and the permanent crush varied from 22.7 inches to 24.5 inches.

o An examination of a structural component, the engine cradle member, revealed that different load paths developed during the crash event. In 10 out of 12 vehicles, the left member buckled at the engine cradle member cutout, whereas, on the right side, only 6 out of 12 buckled at the cutout.

o Because of the range of driver HIC's that were recorded, and realizing the importance of the steering column location at the time of driver contact, the steering column assembly motion was analyzed photographically and its motion recorded in the X-Z plan. Figures 1 through 3 graphically demonstrate the movement of the steering column from the onset of the crash (barrier contact) to the time of dummy contact with either the steering wheel hub or rim.

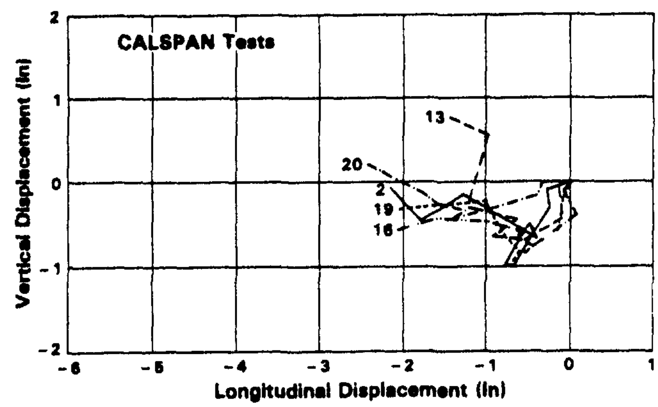


Figure 1.

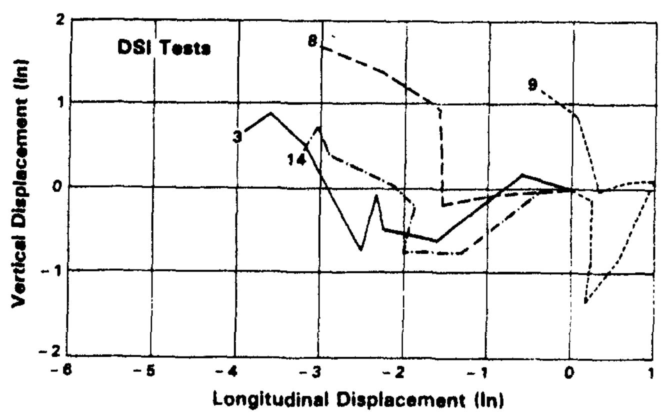


Figure 2.

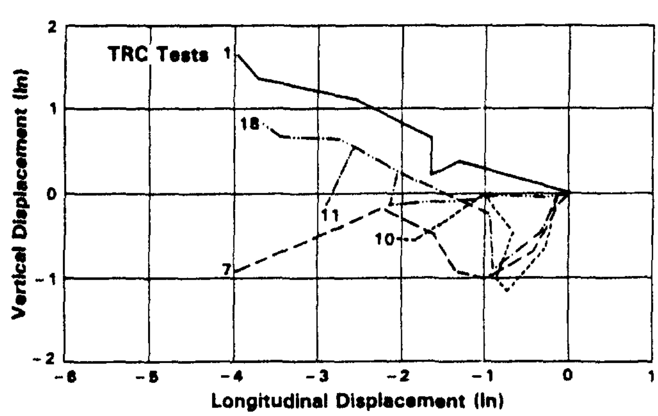


Figure 3.

o The driver and passenger HIC were examined separately. For the passenger, less variability could be expected because no steering column is present to influence dummy injury measurements. The pooled standard deviation for the passenger HIC was 77 and the coefficient of variation (CV) was 11%; approximately 50% less than the CV of 21% for the driver HIC. The average passenger HIC ranged from 659 to 704 between laboratories and the average driver HIC ranged from 596 to 699.

The irregular motion of the steering column and its location at the time of dummy impact vastly affects the point and duration of contact of the driver dummy's head with the steering wheel hub or rim and the velocity at which the driver is moving forward. Obviously, this affects the resultant HIC. The agency is conducting research on methods of reducing test variability due to test site, test dummy, and test procedures. Clearly, however, it is the manufacturers' responsibility to account for any test variability which may be attributable to the test vehicle, and provide accordingly for adequate allowances in the test criteria through design of the vehicle.

In comparing the Volvo (4 tests of the 1983 Volvo 760 GLE) and Citation data, (Table III-6) it is evident that the Volvo data is a data set with lower standard deviation than the Citation data.

Table III-6

	1982 Chevrolet Citation		1983 Volvo 760 GLE	
	Driver	Passenger	Driver	Passenger
Mean HIC	655	694	898	731
Standard Deviation	137	77	71	27

The agency tested a 1983 Volvo 760 in the 1983 NCAP and the driver and passenger HIC's were 791 and 778, respectively. It should be noted that the Volvo is a front engine, rear wheel drive vehicle, and the Citation is a front engine, front wheel drive vehicle. The Citation experienced floor deformation in the passenger compartment, whereas the Volvo's floor pan was not buckled.

Another issue concerns the variation in test results at various crash speeds. The above discussion concerns 35 mph frontal tests, whereas FMVSS No. 208 would utilize a 30 mph test speed. An analysis of some 30 mph frontal barrier crash data shown in Table III-7 illustrates means and standard.

Table III-7

	Driver HIC		Passenger HIC		
Vehicle	Mean	Standard Deviation	Mean	Standard Deviation	Number of Cars Tested
1972 Mercury, Air Bags	478	84	451	72	15
1974-75 General Motors Air Bags	418	98	362	101	9
1975 VW Rabbit, Passive Belts	917	218	503	177	6

deviations greater and less than the Citation data. The large standard deviation in the 1975 VW Rabbit tests for driver HIC appears due to the fact that the vehicles were not identical (four had non-collapsible steering columns);the ambient temperature of the dummies varied by 40°; and two of the vehicles were purchased as used cars, whose previous damage history was unknown. Although these results do not demonstrate that test speed has a more significant effect on variability than the other components mentioned previously, one would expect greater variability at higher speeds due to exceeding the strength of certain structural members. More importantly, regardless of variability, if the mean is sufficiently low then no problem or burden exists. For instance, if the mean is 500 for HIC, then a ±20 percent COV is irrelevant to a manufacturer for assuring compliance, as its vehicle will clearly always be below the 1000 threshold.

The important statistical factor to compare is the standard deviation, which represents the variation in the data. The results for HIC obviously demonstrate greater variation from one vehicle to another. The test procedures, dummies, and instrumentation were similar in all tests; however, the major difference in each series is the test vehicle. It is not possible, however, to quantify the vehicle variability.

The claims made in a number of NPRM docket submissions concerning the coefficient of variation in the RTP/NCAP and the Uniform Tire Quality Grading System (UTQGS) are not relevant to FMVSS No. 208. (Since the closing of the docket for the NPRM the courts have overturned the suspension of the treadwear part of UTQGS.)[57] The NCAP and UTQGS are consumer information programs which provide relative performance data to the public to aid in their purchasing decision. As a result, the amount of variations among vehicles in the published data provide information to those interested in determining the usefulness of comparing one vehicle's data to another.

FMVSS No. 208, on the other hand, is a minimum performance standard, and as such, it entails the design of a vehicle which will satisfy the test criterion. In other words, it is a measure of compliance, not a continuous rating scale. Thus, if a manufacturer knows that the variability of a particular make/model is "X" percent, then that manufacturer must design the vehicle to meet the FMVSS' performance criterion by making appropriate allowance for such variances.

Several commenters to the SNPRM state that there is inherent variability in vehicle crash test behavior, dummy behavior, and the test procedures. However, they claim it inappropriate to require the manufacturer to overdesign to all sources of variability. It is the agency's view that it is normal design practice (i.e., it is not "overdesign") for a manufacturer to account, in the vehicle's design, for variation in any case where a specific test value must be met. The question is whether the cost and difficulty of the design make it "practicable."

[57] Public Citizen vs. Steed, District of Columbia Circuit, Case No. 83-1327 (April 24, 1984).

Figures III-4 and 5 summarize the trend of driver and passenger HIC values from NCAP tests of passenger cars from 1979 through 1984 to date. For 1983 and 1984, the mean HIC values are below 1000. It should be noted that these mean values include a number of vehicles with HIC values of 2000 or greater. This is quite remarkable considering that the NCAP tests are approximately 36% more severe[58] than the 30 mph FMVSS 208 tests injury criteria. Further, these vehicles are equipped with conventional manual belts. Trends in NCAP test results for chest g's (See Figure III-6) and femur loads have also been downward. Since the program's inception, the mean chest g's have been below 60. Also since 1981, over 90% of the dummies in NCAP test vehicles have had chest measurements under 60 g's. In the entire NCAP, only five femur measurements have exceeded 2,250 pounds. Tests run with air bags show much lower absolute HIC values (generally about 400-500) and the levels of variation shown, even in the higher speed NCAP program, appear to generally pose no compliance problem (compliance is based on a HIC of 1000). That is, extraordinary quality control or overdesign (and subsequent higher costs of production) are unnecessary to assure compliance. It thus appears that manufacturers have considerable flexibility for insuring that a vehicle would comply with a mandated 30 mph requirement.

[58] Crash severity is related to energy which a crashing vehicle is forced to absorb. Since energy is a function of the square of velocity, the 35 mph NCAP test is approximately 36% more severe than the 30 mph FMVSS 208 test: $[(35)^2-(30)^2]/(30)^2=.36$.

FIGURE III-4

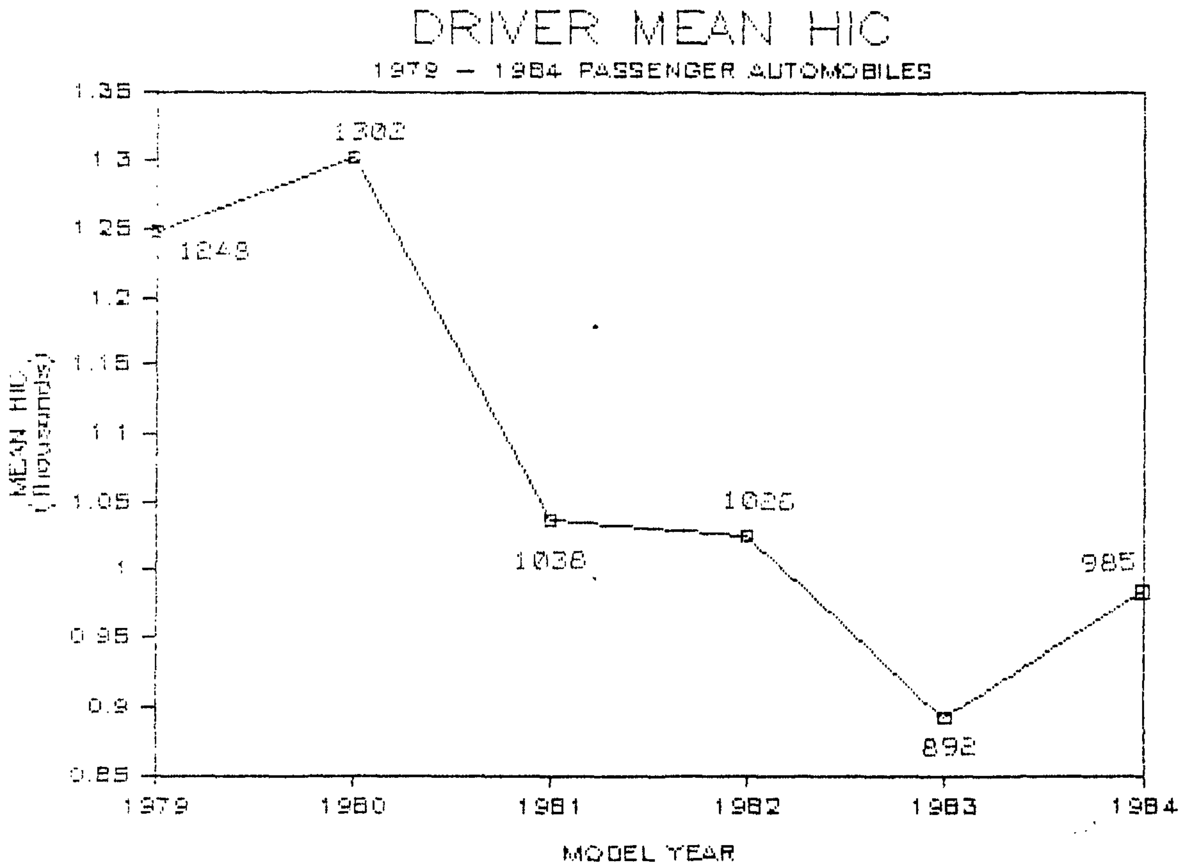


FIGURE III-5

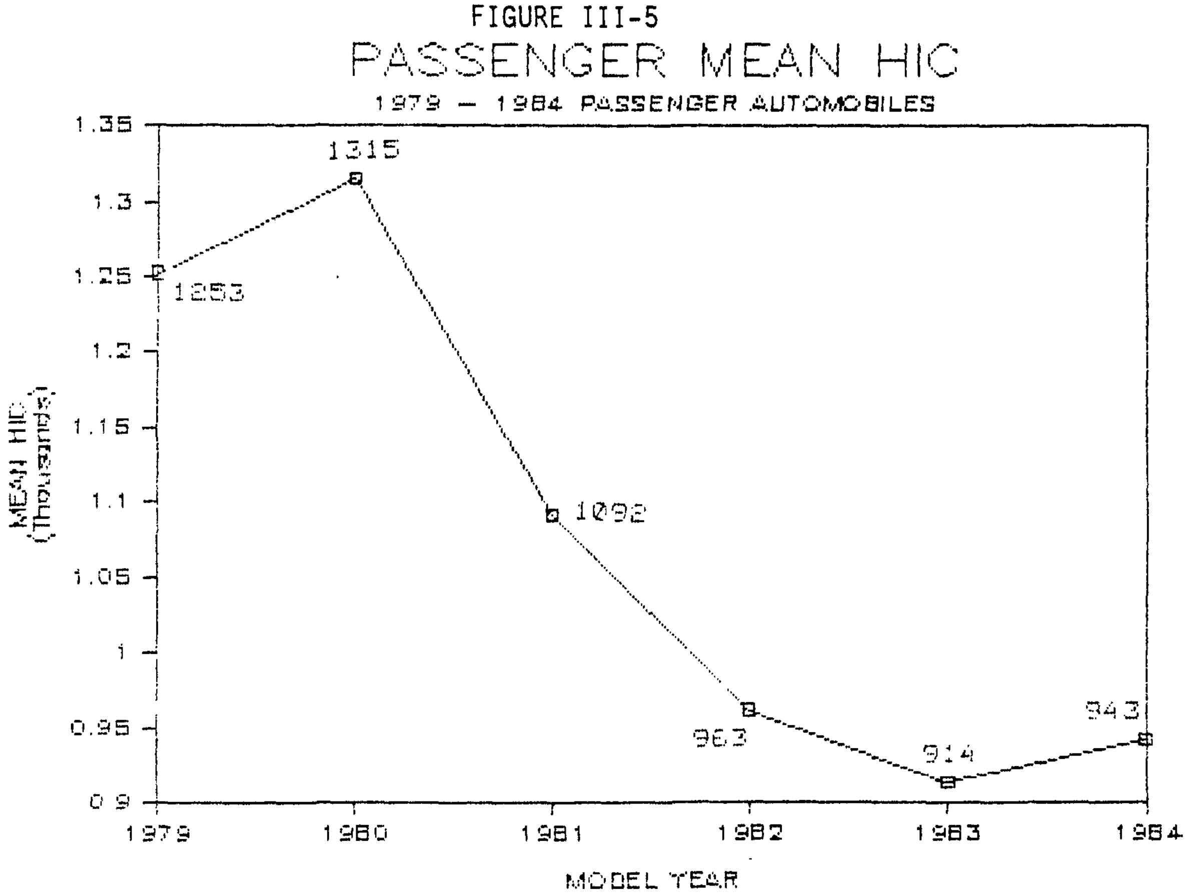
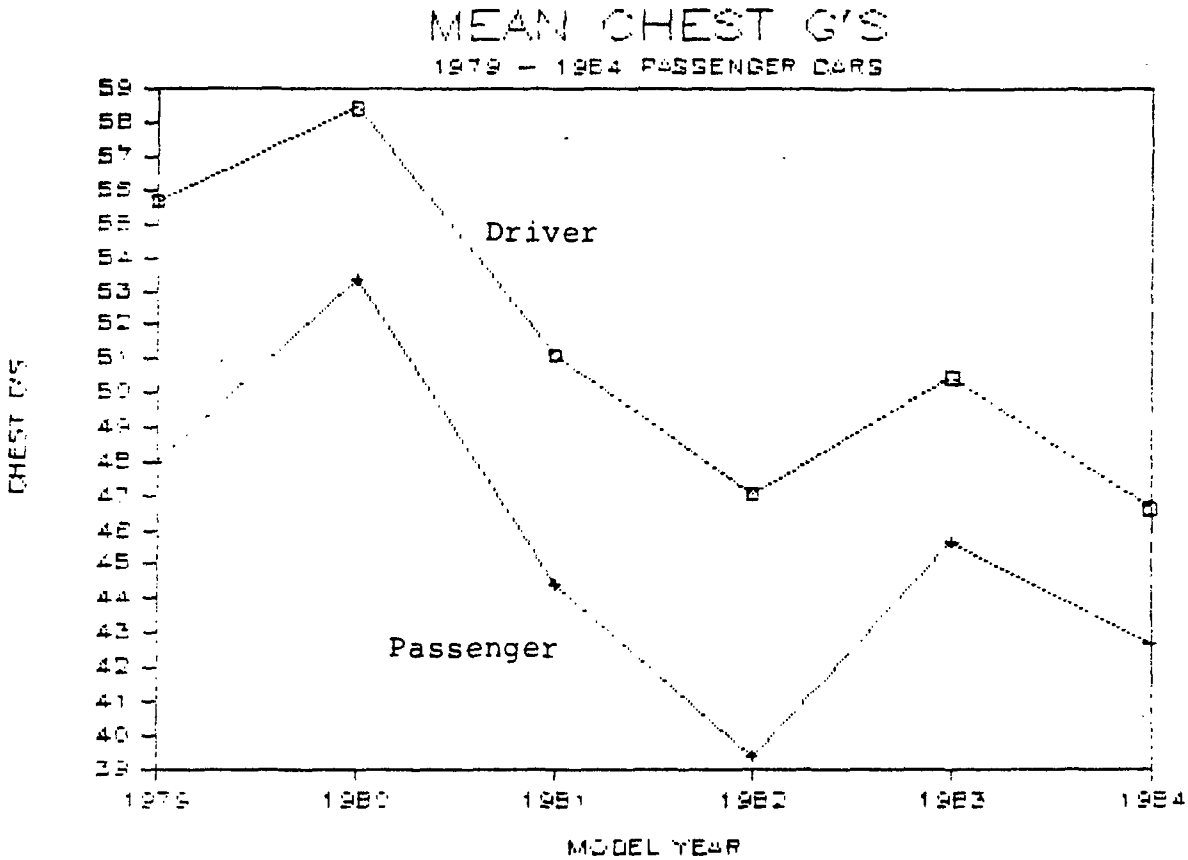


Figure III-6


MEAN CHEST G'S
1979 – 1984 PASSENGER CARS
Driver
Passenger
CHEST G'S
MODEL YEAR
59
58
57
53
52
41
40
1980
1983

IV. EFFECTIVENESS

Safety benefits are a function of both the usage of a restraint system and the effectiveness of the system when used. Effectiveness of an occupant restraint system is expressed as a percentage reduction in injuries or deaths for a restrained occupant when compared to the situation when an occupant is unrestrained. This section of the analysis considers the fatality and injury reduction potential of occupant restraint systems used in the front seating positions of passenger automobiles. The systems considered are present manual belts (both lap belts and lap/shoulder belts), automatic belts, (both two-point and three-point), air bags alone, air bags with lap belts, and air bags with lap/shoulder belts.

After issuance of the NPRM (October 19, 1983), the agency assembled a task force of NHTSA experts to analyze the available system effectiveness data for the various restraint systems and to develop estimates of effectiveness to be used in this FRIA. Table IV-1 shows the results of the work of this task force; the rationale behind each of these estimates is presented subsequently.

TABLE IV-1

SUMMARY OF EFFECTIVENESS ESTIMATES

	Manual Lap Belt	Manual Lap/ Shoulder Belt	Automatic Belt	Air Bag Alone	Air Bag With Lap Belt	Air Bag With Lap/ Shoulder Belt
Fatalities	30-40	40-50	35-50	20-40	40-50	45-55
AIS 2-5 Injuries	25-35	45-55	40-55	25-45	45-55	50-60
AIS 1 Injuries	10	10	10	10	10	10

NOTE: A knee restraint is assumed to be an integral part of all air bag systems and some automatic belt systems.

Abbreviated Injury Scale

The severity of injuries is expressed in terms of the Abbreviated Injury Scale (AIS). The scale used in this analysis is based on the following AIS 1976 definitions:

AIS INJURY LEVEL

0	No injury
1	Minor (e.g., simple cuts or bruises)
2	Moderate (e.g., simple fracture)
3	Serious (e.g., compound fracture or dislocated major joints)
4	Severe (e.g., amputated limbs, depressed skull fracture, survivable organ injuries)
5	Critical (e.g., major spinal cord injury, critical organ injuries)
6	Maximum, currently untreatable

While virtually all AIS 6 injuries and over 50% of all AIS 5 injuries result in fatalities, it is not unusual for an AIS 3-4 injury to result in a fatality to an elderly person or a person with special medical problems. Throughout this report, fatalities will be considered separately from the non-fatal AIS 1-5 injuries.

A. Manual Lap and Lap/Shoulder Belts

Table IV-2 presents an analysis of data available in the National Crash Severity Study (NCSS), the 1979 to 1982 National Accident Sampling System (NASS), and a study called NCSS-NASS. NCSS-NASS was a special study by the NCSS teams using the NASS forms; it was collected between April 1979 and March 1980. These three sources of data are combined and shown in the table as

NCSS/NASS. Table IV-2 also presents data from an earlier study, the Restraint System Evaluation Project (RSEP)[1]. Combining these data results in a reasonably large sample of accidents from which effectiveness estimates can be determined.[2]

The effectiveness estimates from the two sets of data are relatively close, with the exception being lap belt fatalities, which is probably the result of small sample size in RSEP. The results of the raw data in Table IV-2 are that lap/shoulder belts are more effective than lap belts in reducing moderate to fatal injuries; again, the exception is RSEP fatalities. These data are considered "raw" data because they have not been "controlled" for various factors. For example, an examination of the data shows that occupants wearing lap or lap/shoulder belts were generally involved in less severe accidents, in terms of damage extent zones and Delta V, than unrestrained occupants. Delta V is the instantaneous velocity change during the impact. Delta V data are shown in Table IV-3.

---

1 RSEP data in Table IV-2 include 783 more cars than were available when the following reports were completed, and when the controlled estimates which appear on page IV-7 were made, thus, the effectiveness estimates for the raw data are slightly different between the two tables for lap/shoulder belts (59% vs. 61%). "Fact Book: A Summary of Information About Towaway Accidents Involving 1973-1975 Model Cars," Robert G. Hall, Highway Safety Research Center, University of North Carolina, May 1976. "A Statistical Analysis of Seat Belt Effectiveness in 1973-75 Model Cars Involved in Towaway Crashes" Highway Safety Research Center, University of North Carolina, May 1976.

2 Data from the Fatal Accident Reporting System (FARS) are not utilized here for two reasons: 1) FARS only includes fatal accidents, thus the number of accidents which did not result in a fatality due to seat belt usage would have to be estimated. 2) Restraint system usage in FARS is not considered as reliable as in NCSS or NASS. In comments to the SNPRM, Volkswagen (74-14-N35-046) disagreed with 1) above and provided a formula to calculate effectiveness from FARS. However, the formula is sensitive to belt usage in a potentially fatal accident. Given the Department's findings that belted occupants are included in less serious accidents, one can not use a general indication of belt usage (e.g. observed usage) as a proxy measure for belt usage in potentially fatal accidents.

TABLE IV-2
FRONT SEAT OCCUPANTS OF TOWED PASSENGER CARS
COMBINED RAW DATA OF
NCSS, NCSS-NASS, AND 1979-82 NASS
PLUS RAW DATA OF RSEP
WEIGHTED -- UNKNOWNS DISTRIBUTED

	UNRESTRAINED		MANUAL LAP BELT		MANUAL LAP/SHOULDER BELT	
	NCSS/NASS	RSEP	NCSS/NASS	RSEP	NCSS/NASS	RSEP
NO INJURY	68,696	4,232	2,577	1,345	5,026	2,307
NON FATAL						
AIS 1	57,952	4,371	1,654	1,107	3,133	1,684
AIS 2	8,624	840	155	152	187	153
AIS 3	3,602	202	70	23	95	32
AIS 4	858	34	7	9	18	4
AIS 5	276	7	2	2	8	2
FATALITIES	1,290	75	22	6	32	14
Total	141,298	9,761	4,487	2,644	8,499	4,196
INJURY RATES IN TOWAWAY ACCIDENTS						
AIS 1	41.0%	44.8%	36.9%	41.9%	36.9%	40.1%
AIS 2-5	9.5%	11.1%	5.2%	7.0%	3.6%	4.6%
FATALITIES	0.91%	0.77%	0.49%	0.23%	0.38%	0.33%
CALCULATED EFFECTIVENESS COMPARED TO UNRESTRAINED OCCUPANTS						
AIS 1	-	-	10%	6.5%	10%	10%
AIS 2-5	-	-	45%	37%	62%	59%
FATALITIES	-	-	46%	70%	59%	57%

TABLE IV-3

RESTRAINT USAGE RATES IN CRASHES OF GIVEN SEVERITY[3]

DELTA V (MPH)	NASS	NCSS
1-10	9.5%	10.2%
11-20	7.1	6.4
21-30	5.6	5.0
31-40	4.8	2.7
41-99	3.2	3.2

[3] "Restraint Use and Effectiveness as Estimated From U.S. Accident Files and Observational Survey" Van Dyke and Springer, NHTSA, November 1982.

Another way to examine Delta V by restraint usage is shown below using NCSS data.[4]

DELTA V (MPH)	PERCENT OF UNRESTRAINED OCCUPANTS	PERCENT OF RESTRAINED OCCUPANTS
1-10	50.5%	64.2%
11-20	39.6	30.6
21-30	7.5	4.4
31-40	1.7	0.5
41-99	0.7	0.3
TOTAL	100%	100%

Since the effectiveness of belts is believed to be higher in the lower severity crashes, the effectiveness estimates from the raw data would be overestimated. One theory is that present belt wearers are a special set of drivers who are more cautious and less prone to severe accidents. These factors must be controlled for, since a mandatory seat belt use law or an automatic belt requirement would result in a new set of belt wearers with driving characteristics more like the average driver.

In the Restraint System Evaluation Project considerable statistical analyses were performed by the contractor to control for four factors which could bias the effectiveness estimates taken from the raw data. These four factors were: age of occupant, accident severity, impact mode (front, side, etc.), and size of car. The results were as follows for AIS 2 or greater injuries, including fatalities.

4 "Effects Of Different Crash Severities for Restrained vs. Unrestrained Occupants," Conrad Cooke, Engineering Systems Staff, NHTSA, 12/1/83.

	EFFECTIVENESS	
	LAP BELT	LAP/SHOULDER BELT
RSEP Raw Data	39%	61%
RSEP Controlled Estimate	31%	57%

While the agency did not control for all four of the variables in its in-house analysis of NCSS/NASS as was done by the contractor with the RSEP data, a substantial effort went into assessing the impact of damage type and accident severity on overall effectiveness. Accident severity by impact mode was found to be significantly different between restrained and unrestrained occupants.

Initially, the agency examined the impact that Delta V has on effectiveness. Using the NCSS file, it was found that restrained occupants were involved in less severe accidents to such an extent that the severity of the accident by itself could explain most of the apparent fatality effectiveness of restraints and nearly half of the apparent injury effectiveness (see footnote 4 on page IV-6). Due to the large number of cases of unknown Delta V in the file (55 percent of the cases have unknown Delta V), it was realized that Delta V, by itself, was not a good control factor. This is especially true since Delta V is unknown in most rollover accidents, where seat belts are particularly effective.

The agency then examined two other methodologies to control for accident severity. The first methodology examined Delta V, when known, and the collision deformation classification (CDC) or damage extent zone, when Delta V was unknown, by crash mode using the NCSS data. The results of this analysis are adjustment factors for lap/shoulder belts of 28.4 percent for fatalities and 18.0 percent for AIS 2-5 injuries. By breaking up the accidents into 21 categories, this methodology has a problem with sample size in the severe accident groups (Delta V > 30 mph and CDC > 5); thus the results are somewhat tenuous. Using the formula: (1-Real Effectiveness) = (1-Observed Effectiveness)/(1-The Adjustment Factor), and applying this formula to the NCSS/NASS data in Table IV-2, results in the following controlled effectiveness estimates:

	Manual Lap Belts	Manual Lap/ Shoulder Belts
AIS 2-5 Injuries	37%	54
Fatalities	27%	43

The second methodology examines only the collision deformation classification by crash mode and damage extent.[5] Three separate analyses were performed using this methodology on the combined NCSS, NCSS/NASS, and NASS files. First, unrestrained occupants were adjusted to match the frequency of damage area and extent that were observed for restrained occupants. This is the same methodology used in the two previous analyses discussed and probably best represents the effectiveness for current belt users. Second, the restrained occupants were adjusted to match the unrestrained occupants. Third, the restrained and unrestrained occupants were each adjusted to match the entire population of occupants, restrained and unrestrained. These last two analyses were performed to see how effectiveness might change if a mandatory belt use law turned a large proportion of current non-users into belt users. The results are shown in Table IV-4. This

5 "Seat Belt Effectiveness Estimates Using Data Adjusted for Damage Type," Susan C. Partyka, Mathematical Analysis Division, NHTSA, January 1984.

third analysis (restrained adjusted to all occupants) may best represent the seat belt effectiveness for a group of current non-users who would accept wearing belts.

Comparing the two right columns shows very little difference between these two analyses. However, comparing the left column to the two right columns indicates that restraints are more effective for current users than they would be for current non-users since the current non-users tend to be in more severe accidents, where belts are not as effective.

TABLE IV-4
EFFECTIVENESS AFTER ADJUSTMENT FOR CRASH SEVERITY
(NCSS, NCSS-NASS AND NASS)

	Unrestrained Adjusted to Restrained	Restrained Adjusted to Unrestrained	Restrained and Unrestrained Adjusted to All Occupants
Lap Belts			
AIS 2-5 Injuries	39%	30%	30%
Fatalities	21%	22%	22%
Lap/Shoulder Belts			
AIS 2-5 Injuries	53%	47%	48%
Fatalities	52%	38%	39%

Finally, the third analysis - where restrained and unrestrained occupant counts are both adjusted to reflect the damage distribution of the entire population - was performed on RSEP alone, RSEP adjusted to NCSS/NASS, and a combination of all of the previous files: RSEP, NCSS, NCSS-NASS and NASS.[6] Moreover, 90 percent confidence bounds were calculated for the effectiveness estimates (by a technique that generates asymmetric bounds).

6 "Addendum to Seat Belt Effectiveness Estimates Using Data Adjusted for Damage Type," Charles J. Kahane, Office of Program Evaluation, NHTSA, February 1984.

The results, which are shown in Table IV-4a, employ the largest available probability sample of accident data collected by the agency. Moreover, the adjustment procedure, as explained in the report, makes RSEP data comparable with the other files.

TABLE IV-4a

MANUAL BELT EFFECTIVENESS AFTER ADJUSTING FOR CRASH CONDITIONS
RESULTS OF COMBINING DATA FILES

BELT EFFECTIVENESS (%)

	LAP BELTS ONLY		LAP/SHOULDER BELTS	
	BEST ESTIMATE	90% CONFIDENCE BOUNDS	BEST ESTIMATE	90% CONFIDENCE BOUNDS
AIS 2-5 INJURIES				
NCSS/NASS ONLY	30	20-50	48	38-61
RSEP ONLY	30	16-37	53	45-61
RSEP ADJUSTED TO NCSS/NASS/RSEP	26	16-46	50	42-58
NCSS/NASS/RSEP	22	13-42	46	40-54
TASK FORCE FINAL ESTIMATE	25-35		45-55	
FATALITIES				
NCSS/NASS ONLY	22	-14 to +100	39	24-67
RSEP ONLY	75	+50 to +93	55	30-77
RSEP ADJUSTED TO NCSS/NASS/RSEP	72	+47 to +90	48	23-70
NCSS/NASS/RSEP	37	-39 to +100	49	37-68
TASK FORCE FINAL ESTIMATE	30-40		40-50	

Having examined all of the results of the above analyses, the agency believes that it is appropriate to rely on the controlled data more heavily than the raw data in deriving an effectiveness range. The controlled data give an indication of the direction and possible magnitude of the adjustment, but the agency does not believe that the controlled data can be used to pinpoint an exact effectiveness estimate. Instead, an effectiveness range is seen as the best approach to estimating uncertain variables. The final estimates of the agency are as follows: lap and shoulder belts are estimated to reduce fatalities by 40-50 percent and AIS 2-5 injuries by 45-55 percent, with fairly narrow confidence bounds. Lap belts are estimated to reduce fatalities by 30-40 percent and AIS 2-5 injuries by 25-35 percent, with substantially greater statistical uncertainty. (See the 90% confidence bounds in Table IV-4a; lap belts have a wider confidence bound than lap/shoulder belts mainly due to a smaller sample size, see Table IV-2.)

Several SNPRM commenters, notably Ford (74-14-N35-065), Chrysler (74-14-N35-036), Renault (74-14-N35-050), the American Seat Belt Council (74-14-N35-044), and Professor Nordhaus (74-14-N35-079), argued that the Department's effectiveness estimates for manual belts were too low. Chrysler stated that the correct range should be 50-70 percent. Renault stated that according to an analysis of accidents in France, effectiveness is around 60 percent. Renault supplied a graph showing that Delta V for unbelted occupants was only slightly higher than Delta V for belted occupants and stated that belted drivers may feel better protected and therefore drive faster. However, France has a much higher belt usage rate than the U.S. (see Table IV-4b; data used in the Delta V graph implied 39 percent belt usage). Professor Nordhaus stated that the Department adjusted the effectiveness estimates too low. He apparently believes the Department determined the level of adjustment by assuming that all of the more severe accidents will involve restrained occupants, when no analysis in the record predicts 100 percent usage. The Department considered this very point raised by Professor Nordhaus and for that reason Table IV-4 includes the third column -- restrained and unrestrained adjusted to all occupants. This is one of the reasons the Department chose a range of values for effectiveness.

Ford believes that the Department should rely on the combined NCSS/NASS/RSEP data that indicate a confidence interval of 37-68 percent for fatality effectiveness of manual lap/shoulder belts. Ford believes this indicates a range of 50-60 percent effectiveness rather than 40-50 percent. The Department based its estimates on several analyses, rather than just the one combined analysis cited by Ford, and took into account the best estimates and confidence bounds derived from these analyses.

Ford further justified a 50-60 percent range by quoting B. J. Campbell's analysis of North Carolina State accident data (Safety Belt Reduction Related to Crash Severity in Front Seated Position, HSRC-PR129, March 1984, Docket No. 74-14-N35-065) which found a 62 percent fatality reduction for belts even after the data had been controlled for differences in TAD Crash Severity and other factors. Based on NHTSA's extensive experience in statistically analyzing State data, as for example in the evaluation of several existing standards, the control variables available in state data are inadequate for adjusting the populations for differences in crash severity. In other words, analyses of State data using control variables yield exaggerated effectiveness estimates. In particular, the 62 percent estimate in Campbell's study appears to be overstated. Another reason for selecting the 40-50 percent range for manual lap/shoulder belt effectiveness was because C. J. Kahane's study of the potential effectiveness of air bags and seat belts (Estimates of Fatality Reduction for Air Bags and Lap/Shoulder Belts, February 1984), examined the unrestrained front-seat occupant fatalities in NCSS and concluded that 51 percent of those fatalities were likely to have been prevented by belts. Many of the other fatalities involved circumstances that would have rendered any restraint system of little value.

Ford further stated that the actual data presented, historical literature and the Campbell study, indicate lap/shoulder belts are more effective in preventing fatalities than injuries, not the other way around as estimated by the Department. The Department's conclusion that injury effectiveness is 5 percentage points higher than fatality effectiveness for lap/shoulder belts, was largely based on the NCSS/NASS adjusted data -- the latest data source -- which show that AIS 2-5 injury effectiveness is 48 percent while fatality effectiveness is 39 percent. The RSEP adjusted data indicate the effectiveness is about the same. While it is true that many historical estimates and the Campbell study indicate higher fatality effectiveness than injury effectiveness, these studies are not typically comparable with this analysis because of the AIS 2-5 injury criteria used here. If AIS 1 injuries were included, fatality effectiveness for lap/shoulder belts would be much higher than injury effectiveness.

The agency also examined the effectiveness of belts as derived from a review of the experiences in a number of countries after implementation of mandatory usage laws. Sufficient data are available to compute effectiveness in 11 locations. The fatality effectiveness of belts ranged from a low of 20 percent in Quebec, Canada, to a high of 77 percent in Sweden. The 11 location average effectiveness was 47.1 percent. This includes some unknown combination of lap belts and lap/shoulder belts, although most of these countries required lap/shoulder belts as of the early 1970's. While this appears to confirm the results of the NCSS, NASS and RSEP studies, the agency did not consider these results in its final determination of belt effectiveness. The agency has no way of verifying the validity of the data or the statistical techniques employed in the various locations. The details of the effectiveness computations for each location are contained in Table IV-4b.

TABLE IV-4b
SUMMARY OF MANDATORILY INCREASED SAFETY BELT USAGE EXPERIENCE

Location	Use Rate (%) Before	After	Fatality Reduction (%)	Belt Effectiveness[8] (%)
Australia[1,4]	30	80	22.5	39.6
France[1,4]	26	75	22	40.6
Belgium[4]	17	92	39	47.8
Great Britain[6]	40	90	24.5	41.0
Israel[5]	6	70	43	64.6
Sweden[4,7]	36	79	46	77
Switzerland[1]	32	81	12	22.7
Canada, Ontario[3]	24	58	13.7	36.7
Quebec[3]	20	37	3.5	19.8
Saskatchewan[3]	13	50	21.7	54.4
British Columbia[3]	23	50	24.2	74.3
Average all locations				47.1%

Ref.

1. "Effectiveness of Safety Belt Usage Laws," Dr. Franklin B. Fisher, May 1980 (Peat, Marwick, Mitchell & Co.).

2. "Seat Belts: Effectiveness of Mandatory Use Requirements," Roger L. McCarthy, et al., SAE 840329, Failure Analysis Associates.

3. "The Effectiveness of the Canadian Mandatory Seat Belt Use Laws," Brian A. Jonah, Transport Canada.

4. "Task Force Report on Safety Belt Usage Laws," Livingston, et al, NHTSA, June 1978.

5. "Patterns of Safety Belt Usage Following Introduction of Safety Belt Wearing Law", Hakkart, A., Ziedel, D., Technion, Israeli Inst. Tech, June 1983.

6. "Legislation for Seat Belt Use in Britain," Murray Mackay, University of Birmingham, SAE 840328.

7. "Seat Belt Use in Sweden and Its Injury Reducing Effect," Hans Norin et al, SAE 840194. Data on Volvo cars alone indicates a belt effectiveness of 74.5%.

8. Calculated as follows: $E = \dfrac{F_R}{U_a - (1-F_R)(U_B)}$

Where E = Effectiveness
F_R = Fatality Reduction
U_a = Usage After the Law
U_B = Usage Before the Law

For minor injuries (AIS 1), the NCSS/NASS data for towed cars in Table IV-2 indicate an effectiveness estimate of 10% for both lap and lap/shoulder belts. An analysis of non-towed cars in the 1979-1981 NASS files indicates about the same effectiveness for lap/shoulder belts (11%) as in towed cars (10%). However, the effectiveness of lap belts in non-towed cars is -27%. This is a rather implausible result since all other data indicate one is safer with a belt than without one. Other sources of data indicate that lap belts provide roughly the same effectiveness as lap/shoulder belts for AIS 1 injuries. The RSEP (raw) data indicate lap belts are 6.5 percent effective and lap/shoulder belts are 10 percent effective in reducing AIS 1 injuries. The combined NCSS/NASS/RSEP data adjusted for crash conditions indicate both lap and lap/shoulder belts are 4 percent effective in reducing AIS 1 injuries. A 1974 study of rural accidents in Pennsylvania indicates for police reported B and C injuries (mostly minor injuries) that lap belts are 23% effective and lap/shoulder belts are 21% effective.[7]

In general, the agency has less confidence in effectiveness estimates for AIS 1 injuries than for more severe injuries due to reporting problems. Many people don't report minor injuries or don't know they are injured until the next day. While these reporting problems should not impact the relative effectiveness of lap and lap/shoulder belts, there is some doubt about whether the overall level of effectiveness is accurate.

Based on the data presented above, the agency estimates the effectiveness of lap and lap/shoulder belts to be 10 percent in reducing AIS 1 injuries.

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7 "Usage and Effectiveness of Seat and Shoulder Belts in Rural Pennsylvania Accidents," C. J. Kahane, NHTSA, 1974, DOT-HS-801,398.

B. Automatic Belts

The agency has five sets of data relating to automatic belt effectiveness. They are: a) an update of a North Carolina study of state accident data b) a NHTSA analysis of fatalities in the automatic and manual VW Rabbits; c) a NHTSA analysis of fatalities in the automatic and manual Toyota Cressidas; d) frontal crash tests of both automatic and manual belt systems; e) a Transport Canada report which suggests some reasons why automatic belts may not be as effective as manual belts.

a) The results of a study comparing the usage and effectiveness of VW Rabbit belt systems in accidents are presented in Tables IV-5, IV-5a and IV-6. These data are a further update of the material entered into the docket in the effectiveness report accompanying the SNPRM. Since that time, it was learned that there were some problems with the 1980-81 New York data; corrections have been made to these data and new data for 1982 have been included. In addition, 1975-1979 data from the previous study[8] for four states have been corrected using an updated vehicle identification number (VIN) tape. These new data are all combined in Table IV-5.

Table IV-5 presents the number of serious plus fatal injuries (coded A+K on the police reports) to front seat occupants of manual and automatic VW Rabbits. The designation of automatic or manual belt is determined via the VIN; belt usage is determined via the police report. One question

[8] "A Comparison of Automatic Shoulder Belt/Knee Bolster Restraint System with the Lap and Shoulder Belt Restraint System in VW Rabbits "Highway Safety Research Center, University of North Carolina, March 1981, DOT HS-805-856.

regarding the accuracy of the data is in the ability of the police to determine accurately whether a belt is used and whether crash victims, when asked, would provide accurate usage data.

Data are available on over 27,000 front seat occupants in police reported accidents in the four states, New York 1975-82, North Carolina 1975 to part of 1983, Maryland 1975-82, and Colorado 1975-1979.

Table IV-5a presents the serious to fatal injury rates for the four states. Three interesting points emerge from these data. One, the injury rates for unrestrained occupants in manual restraint system cars is higher than the unbelted injury rate in automatic restraint system cars in three of the four states, although this difference is not statistically significant. This could occur because a) the knee restraint in the automatic restraint cars may have some effectiveness for unrestrained occupants, or b) passengers of the higher priced automatic restraint cars (automatic restraints were standard equipment on deluxe models of the Rabbit) may be involved in less serious accidents. Two, when the restraint system is used, manual belt cars have a lower injury rate than automatic belt cars in all four states, but this difference is also not statistically significant at the 95 percent confidence level. Three, combining restrained and unrestrained occupants, automatic belt cars have a 17.3 percent lower injury rate than manual belt cars in all states, due to higher usage of automatic belts. Combining the four states, this 17.3 percent difference in overall injury rates is statistically significant.

The first point leads to a question concerning the appropriate basis for determining the effectiveness of automatic belts. Taking the combined results in Table IV-5a, for example, should the .0331 automatic belt restrained injury rate be compared to the .0582 automatic belt car unrestrained rate or to the .0629 manual belt car unrestrained rate? Because the agency believes that the knee bolster has some effectiveness, the latter comparison is valid and will be used in Table IV-6.

TABLE IV-5
NUMBER OF SERIOUS PLUS FATAL INJURIES (A+K) TO
VW RABBIT FRONT SEAT OCCUPANTS BY RESTRAINT USE BY STATE
WITH KNOWN INJURY LEVELS AND KNOWN RESTRAINT USAGE

	UNRESTRAINED			RESTRAINED		
RESTRAINT TYPE	A+K INJURED	NOT A+K INJURED	TOTAL	A+K INJURED	NOT A+K INJURED	TOTAL
			NEW YORK 1975-1982			
Manual	496	6,112	6,608	82	2,249	2,331
Automatic	108	1,414	1,522	64	1,576	1,640
			NORTH CAROLINA 1975 TO PART OF 1983			
Manual	169	3,751	3,920	14	811	825
Automatic	48	1,096	1,144	24	1,037	1,061
			MARYLAND 1975-1982			
Manual	156	2,832	2,988	29	1,296	1,325
Automatic	30	652	682	37	1,114	1,151
			COLORADO 1975-1979			
Manual	93	917	1,010	12	364	376
Automatic	22	206	228	10	219	229
			COMBINED RESULTS			
Manual	914	13,612	14,526	137	4,720	4,857
Automatic	208	3,368	3,576	135	3,946	4,081

TABLE IV-5a
A&K INJURY RATES
(SERIOUS PLUS FATAL INJURIES COMPARED TO TOTAL OCCUPANTS FOR
VW RABBIT FRONT SEAT OCCUPANTS BY RESTRAINT USE BY STATE)

RESTRAINT TYPE	UNRESTRAINED	RESTRAINED	OVERALL
	NEW YORK 1975-1982		
Manual	.0751	.0352	.0647
Automatic	.0710	.0390	.0544
	NORTH CAROLINA 1975 TO PART OF 1983		
Manual	.0431	.0170	.0386
Automatic	.0420	.0226	.0327
	MARYLAND 1975-1982		
Manual	.0522	.0219	.0429
Automatic	.0440	.0321	.0366
	COLORADO 1975-1979		
Manual	.0921	.0319	.0758
Automatic	.0965	.0437	.0700
	COMBINED RESULTS[9]		
Manual	.0629	.0282	.0542
Automatic	.0582	.0331	.0448

9 There is not a statistically significant difference between the unrestrained injury rates of manual and automatic belt systems, or between the restrained injury rates of the manual and automatic belt systems. There is a statistically significant difference in the overall injury rates, due to the higher usage of automatic restraints.

TABLE IV-6
EFFECTIVENESS OF VW RABBIT MANUAL AND
AUTOMATIC BELT SYSTEMS IN REDUCING SERIOUS
TO FATAL INJURIES (A+K) WHEN USED COMPARED
TO UNRESTRAINED MANUAL BELT OCCUPANTS[10]

	MANUAL BELT EFFECTIVENESS	AUTOMATIC BELT EFFECTIVENESS	PERCENTAGE POINT DIFFERENCE
New York 1975-1982	53%	48%	5
North Carolina 1975 to Part of 1983	61%	48%	13
Maryland 1975-1982	58%	39%	19
Colorado 1975-1979	65%	53%	12
Combined Result -- 4 States			
a) Aggregation of Injury Data	55%	47%	8[11]
b) Simple average of the 4 states	59%	47%	12[12]

Table IV-6 presents the effectiveness of the VW Rabbit automatic and manual belts, <u>when used</u>, in reducing serious to fatal injuries. Manual belt effectiveness is fairly consistent among the four states, ranging from 53 to 65 percent. Automatic belt effectiveness is also fairly consistent between the states, ranging from 39 to 53 percent. (None of these State data have been adjusted for differences in crash severity between the restrained and unrestrained occupants. Thus, all estimates, especially those for manual belts, are overstated.)

[10] Combining restrained and unrestrained occupants, automatic belts (as used) are 17% more effective than manual belts (as used) due to higher restraint usage of automatic belts.
[11] Not a statistically significant difference.
[12] Not a statistically significant difference.

Since the agency will estimate automatic belt effectiveness based on a comparison with manual belt effectiveness, it is important to note that the difference in effectiveness ranges from 5 to 19 percentage points and the combined results indicate a difference of 8 to 12 percentage points. The combined results are examined in two ways: 1) using an aggregation of all injuries from the four states, and 2) based on a simple average of the effectiveness estimates from the four states. However, the state data do not show statistically significant differences in effectiveness between automatic and manual VW Rabbit restraint systems.

b) An August 1983 NHTSA analysis of Volkswagen Rabbit fatality data by type of restraint system is presented in Table IV-7. Fatalities were categorized using Vehicle Identification Numbers (VIN) and the FARS system. Exposure data were developed from monthly sales data provided by Volkswagen and take into account scrappage rates.

Since VW automatic belt usage is significantly higher than VW manual belt usage, cars with automatic belts have a lower fatality rate than cars with manual belts, the exception being 1980. Combining 1975 through 1982, the fatality rates in cars with automatic belts (as used) compared to cars with manual belts (as used) was 19.3 percent lower. A 90 percent confidence interval, that is a 5 percent tail on either side, indicates the fatality rate reduction is in the range of 11.0 to 27.6 percent. These percent reductions reflect the combined effects of belt usage as well as "effectiveness" when used, the subject of this chapter. The yearly

TABLE IV-7

VW RABBIT FATALITY DATA BY TYPE OF RESTRAINT SYSTEM

(FRONT SEAT OCCUPANT)

	MANUAL RESTRAINT SYSTEM			AUTOMATIC RESTRAINT SYSTEM				
ACCIDENT YEAR	FATALS	EXPOSURE (MILLION CAR MONTHS)	FATALITY RATE	FATALS	EXPOSURE (MILLION CAR MONTHS)	FATALITY RATE	RESTRAINT SYSTEM UNKNOWN FATALS	AUTOMATIC BELT EFFECTIVENESS COMPARED TO MANUAL BELTS, AS USED, (%)
1975	16	0.4734	33.8	0	0.1786	0	0	100.0%
1976	29	1.457	19.9	4	0.4341	9.2	0	53.7
1977	70	2.659	26.3	5	0.8154	6.1	6	76.7
1978	82	3.905	21.0	25	1.361	18.4	4	12.4
1979	124	5.401	23.0	41	2.135	19.2	11	16.5
1980	116	6.587	17.6	64	3.173	20.2	10	-14.8
1981	153	7.797	19.6	67	3.942	17.0	12	13.3
1982	121	8.776	13.8	48	4.384	10.9	13	21.0
1975-82	711	37.055	19.2	254	16.423	15.5		19.3

SOURCE: Internal NHTSA Analysis

differences in fatality rates show the great variability and uncertainty in these types of accident statistics. For example, if this analysis had been done in 1978, using 1975-1977 data, cars with automatic belts would have been estimated to have an occupant fatality rate 75 percent lower than cars with manual belts, instead of the 19.3 percent for 1975-1982. However, taken together these data represent a large fleet of cars and the results are statistically reliable.

Table IV-8 shows the difference in automatic and manual belt usage from three separate sources; observations of belt usage in traffic (48 percentage points), state accident data (28 percentage points), and telephone surveys (42 percentage points). Observed data are believed to be more reliable than either telephone surveys or police reported state accident data. As discussed in Section V, one study documented that people overstate their actual belt usage in telephone surveys. Police reported usage data is based on after-the-fact police judgment, witness reports, or accident victim self reporting. None of these are as definitive as actual observations. However, restraint usage in accidents and effectiveness are the measures which impact safety benefits.

Table IV-8

AUTOMATIC VERSUS MANUAL BELT USAGE
FOR VW RABBITS

	Automatic Usage (%)	Number of Observations	Manual Usage (%)	Number of Observations	Percentage Point Difference in Usage
Observed Usage					
1977-79[13]	81	401	36	1,049	45
1980-82[14]	86	304	28	687	50
11/82-3/83	80	240	28	552	52
5/83-10/83[15]	75	398	31	1,092	44
1977-83 Average Observed Usage	80	1,343	32	3,380	48
Accident Data[16]					
1975-82 New York	52	3,162	26	8,939	26
1975-83 North Carolina	48	2,205	17	4,745	31
1975-82 Maryland	63	1,833	31	4,313	32
1975-79 Colorado	50	457	27	1,386	23
Average Accident Data	53	7,657	25	19,383	28
Telephone Surveys[17]					
MY's 1978-79	89	1,010	46	203	43
MY 1980	89	1,013	48	222	41
Average Telephone Survey	89	2,023	47	425	42

[13] Opinion Research Corporation, "Safety Belt Usage Among Drivers," May 1980, DOT-HS-805-398, pg.30.

[14] Opinion Research Corporation, "Restraint System Usage in the Traffic Population." May 1983, DOT-HS-806-424, collected November 1980 to October 1982.

[15] 1983 data collected by Goodell-Grivas, Inc.

[16] Collected for NHTSA by HSRC, see Table IV-5.

[17] Opinion Research Corporation, "Automatic Safety Belt System Owner Usage and Attitudes in GM Chevettes and VW Rabbits, May 1980 and February 1981, DOT-HS-7-01736.

Using the three different sources of automatic and manual VW restraint usage from Table IV-8, the fatality rate of automatic belts as used compared to manual belts as used, and the estimate that manual belts when used are 45 percent effective in reducing fatalities (the mid-point of the range shown in Table IV-1), then a formula for fatality effectiveness of the VW automatic belt system when used compared to unrestrained occupants can be determined.[18] In this instance, the VW Rabbit automatic belt effectiveness for fatalities, compared to unrestrained occupants, would be 39 percent if the usage rates found in observation surveys are inserted in the effectiveness formula, 41 percent if the usage rates obtained from the telephone survey are inserted, and 54 percent if the usage rates reported in the accident data are employed. Thus, the automatic VW Rabbit restraint system, when used, is estimated to be 39-54 percent effective in reducing fatalities compared to unrestrained occupants.

c) The agency examined the fatalities in Toyota Cressidas with automatic and manual belts. Between 1977 and 1980 over 37,000 manual belt Toyota Cressidas were sold. In 1981 and 1982, over 67,000 automatic belt Toyota Cressidas were sold. The following table presents the number of fatalities, estimated exposure, and fatality rate by system.

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[18] $$\frac{Fa}{Fm} = \frac{1 - Ua\ Ea}{1 - Um\ Em}$$

Where F = Fatality Rate, U = Usage Rate,
E = Effectiveness, a = Automatic Belts,
m = Manual Belts

Toyota Cressida

	Manual Belts	Automatic Belts
1977-1982 Fatalities	29	8
Estimated Car Months	1,609,286	560,766
Fatality Rate Per Million Car Months	18.0204	14.2662

The Toyota Cressida data indicate that automatic belt cars have a lower fatality rate (20.8% lower) than the manual belt cars. Automatic belt effectiveness compared to unrestrained occupants can be roughly estimated at 40 percent using these fatality rates and belt usage.[19] This is considered a rough estimate because there are few fatalities in the automatic and manual belt cars, due to limited exposure through 1982, making the estimates statistically suspect, and the usage estimates for comparable manual belts were not adequate. Observed usage of automatic Cressidas (96% usage) is based on 203 observations and agrees very well with a telephone survey[20] that found 92 percent usage. However, the agency has no specific data on manual Cressida belt usage. Observed data are available on all Toyota manual belt models (19% usage). This 19% may be a low estimate for Cressidas, because they are one of the highest priced Toyotas and belt usage has been shown to be related to income level. On the other hand, the telephone survey found 45 percent usage for Toyota Coronas (manual belt). The 40 percent effectiveness estimate is calculated based

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19 $\frac{14.2662}{18.0204} = \frac{1-(.92)(x)}{1-(.45)(.45)}$; x=40% Effectiveness. One reason that the Toyota Cressida automatic belt may not be as effective as the manual belt (when used) is that automatic belt users may not connect the manual lap belt that is provided with the automatic system.

20 "Automatic Safety Belt Usage in 1981 Toyotas," JWK International Corporation, February 1982, DOT-HS-806-146.

on the results of the telephone survey and is a high estimate if the 45 percent manual usage is overestimated. Because of these problems, the 40 percent effectiveness estimate must be considered a very rough estimate.

d) The agency examined the crash tests it has recently performed on automatic and manual VW Rabbits and Chevrolet Chevettes at 30 mph. These are shown in Table IV-9. In these frontal crash tests, the automatic restraints performed better than manual restraints, in terms of lower Head Injury Criterion (HIC) (HIC is an indicator of the possibility of head injury).

TABLE IV-9

VW RABBIT AUTOMATIC VS. MANUAL
30 MPH TEST RESULTS

SYSTEM	MODEL YEAR	CRASH SPEED	HIC VALUES DRIVER	HIC VALUES FRONT PASSENGER	CHEST G's DRIVER	CHEST G's FRONT PASSENGER
Automatic	1976	29.3	604	444	37	31
Automatic	1976	29.3	542	255	-	-
Automatic	1976	30	452	225	40	31
Manual	1976	30	1,433	518	42	43
Manual	1978	29.58	1,552	661	59	42

CHEVY CHEVETTE AUTOMATIC VS. MANUAL
30 MPH TEST RESULTS

SYSTEM	MODEL YEAR	CRASH SPEED	HIC VALUES DRIVER	HIC VALUES FRONT PASSENGER	CHEST G's DRIVER	CHEST G's FRONT PASSENGER
Automatic[21]	1978	30	475	450	47	43
Manual	1976	28.3	922	797	47	33
Manual	1976	30	1,024	936	43	43

e) Transport Canada released a paper,[22] which included a discussion which implies that automatic belts may not be as effective as manual 3-point belts. For the 2-point automatic belt system and knee bolster, the absence of a lap belt may result in the 2-point belt being less effective in preventing ejection. Also, it was claimed that the door mounted belt might have little capability of restraining an occupant in the event of accidental door opening during a collision. The agency has performed an analysis which examines passenger car occupant partial and total ejection

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21 Manual Lap Belt was not attached.
22 "Transport Canada's Policy on Occupant Restraints," G.D. Campbell and E.R. Weibourne, Transport Canada, June 1981.

fatalities through doors.[23] In the 1979 FARS file, there are 27,799 passenger car occupant fatalities, of which 6,190 (22 percent) involved ejection. The FARS files do not record the ejection route, however, the NCSS file does. There are 910 fatalities in NCSS of which 210 (23 percent) involved ejection. Thus, the NCSS file has about the same percent of ejection fatalities as the FARS file (23 percent vs. 22 percent). Of the 910 NCSS fatalities, 32 (3.5%) were drivers ejected through the left front door and 13 (1.4 percent) were right front passengers ejected through the right front door. The agency does not know how effective the 2-point shoulder belt might be in preventing ejections. If it is assumed that the 2-point system is not effective, then 1,390 ejected fatalities (27,799x4.9 percent) might have been saved if a 3 point manual belt had been used.[24] Of course, the 3-point manual belt would not have prevented all these fatalities since some fatalities occur as the result of impacting interior components (side door, armrest, pillars, etc.) before the ejection, while others occur as a result of occupant contact with objects outside the vehicle after partial ejection. It should also be pointed out that the door mounted belt may actually prevent door openings in many instances because the retractor will lock up on the belt, not allowing it to spool out, and thus help to hold the door closed. Further, some motorized automatic belts (e.g. Toyota Cressida) are not attached to the door but have anchorages on the B-pillar, the same as manual lap/shoulder belts.

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[23] "An Analysis of the Ejection Problem Using NCSA Automated Data Files," Nancy Bondy and Sharon Hart, NHTSA, June 1982.

[24] This calculation assumes all cars would have been equipped with 2-point automatic belts.

Transport Canada also suggested that the advantage of eliminating lap belt abdominal injuries by using a knee bolster instead of a lap belt may be offset by less control of occupant displacement in collisions involving a significant transverse component of acceleration. For 3-point automatic belts, Transport Canada concluded that there is little reason to believe the effectiveness should not be essentially the same as for 3-point manual belts, except in cases where the anchorage points on the door are outside the geometrical zones prescribed by FMVSS 210. It should be noted that NHTSA has provided a waiver from FMVSS 210 if manufacturers meet the barrier crash test criteria for automatic protection requirements of FMVSS 208. However, Transport Canada's testing indicated less effective control of the dummy and markedly higher chest loads with the automatic 3-point system.

There were several comments to the docket which compared automatic to manual belt effectiveness, or compared detachable to non-detachable belt effectiveness. British Leyland (74-14-N32-5296) and Renault (74-14-N32-1165) both stated that two-point automatic belts are less effective than manual lap/shoulder belts in side impacts and rollovers. Renault also stated that three-point automatic belts afford unsatisfactory protection in frontal impacts.

The Insurance Institute for Highway Safety (74-14-N35-022) stated that automatic belt effectiveness was downgraded because of the hypothetically possible increase in the chance of ejection, when no statistical or other evidence supports this assumption about ejection. Further, IIHS argues the Department ignores crash test data that indicate automatic belts might reduce head injuries more than manual belts. The Department based the lowering of automatic belt effectiveness on the state data that indicate automatic belts are probably less effective than manual belts and on the possibility that automatic restraint designs without the lap belt may not be as effective in side impacts and rollovers -- particularly when ejections are involved. The Department did consider the test data that indicate automatic belts are as effective or possibly more effective than manual belts in frontal impacts. However, the state data, which include all accident modes, still indicate that automatic belts may be less effective than manual belts. The Department cannot be precise about this issue until additional field data are available.

Professor Nordhaus argues that the only reliable data the Department should consider in determining automatic belt effectiveness is the analysis of VW fatalities and the crash tests. Together, these indicate automatic belt and manual belt effectiveness should be equivalent. He believes the usage figures and effectiveness values from the state data, which are dependent upon the accurate characterization of restraint usage, should be disregarded. However, the Department fails to see a convincing reason why automatic belt usage would be mischaracterized any more than manual belt usage. Thus, the Department believes that the comparison between automatic and manual belt effectiveness rates remains valid for the state data.

Nordhaus also claims that Transport Canada "concluded" that the effectiveness of 2-point automatic and 3-point manual belts were consistent. It is difficult to see how this <u>observation</u> by Transport Canada is a conclusion. Professor Nordhaus has omitted the first part of the quote, printed here in its complete form. "Although these data [recent VW Rabbit accident data] do not permit a direct comparison of the effectiveness of the two systems, the fatality rate in vehicles equipped with the automatic system is consistent with an effectiveness at least equal to that of the 3-point belt system" (emphasis added). Transport Canada's conclusions are evidenced by their statement preceding the referenced quotation that "the effectiveness of the 2-point automatic belt is lower overall than that of the conventional 3-point belt system." The agency does not believe that referencing partial quotes, taken out of context, can alter the clearly stated conclusions of Transport Canada.

Ford (74-14-N35-065) argued that there is the potential for lower effectiveness with automatic belts. Ford questions the premise that 3-point automatic belts will be as effective as manual belts, saying there is no adequate body of data to justify this conclusion; their comment pointed out also that manual belts can be more securely adjusted than 3-point automatic belts. In addition, Ford discussed the "danger of attempting to estimate system effectiveness solely from controlled crash data" by comparing the favorable automatic belt crash tests with the higher observed injury rates in the state data for the automatic restraint VW Rabbit versus the manual restraint VW Rabbit.

Volvo (74-14-N30-047) argued that non-detachable automatic belts may be less effective than detachable automatic belts due to a "film spool effect." This "film spool effect" may occur in 2-door models if the amount of webbing in the non-detachable automatic belt must be increased to allow entrance to the rear seat.

NADA (74-14-N32-1680) indicated its concern that a belt fastened to the door may possibly be less effective than manual lap/shoulder belts. VW (74-14-N32-1678) and State Farm (74-14-N32-5295), quoting the earlier North Carolina Study, stated that they believe automatic belts are as effective as manual lap/shoulder belts. However, none of the above commenters provided new data to substantiate their statements.

Another issue brought out in the docket comments distinguishing detachable belts from non-detachable belts is post-accident ease of getting injured, immobile, belted occupants out of a car. Volkswagen stated that they specifically designed their automatic belts to have the emergency release button near the window so that persons assisting an injured belted occupant could easily find and detach the belt and would not have to reach in, across the occupant, to release the belt as is the case in today's cars with manual belts. While the spool-out release mechanism on a non-detachable belt allows the belt to be elongated and pushed out of the way, there may be some cases where the belt needs to be cut in order to extract an injured occupant; also, the spool-out release may be confusing to those who are not familiar with it. However, the Department does not believe that this post-accident ease of detachability is a significant factor.

In conclusion, the effectiveness of automatic belts is less precisely known than is the effectiveness of manual belts. Most of the agency's data are on one type of automatic belt system (a two-point belt with a knee bolster). Some manufacturers may use a 3-point automatic lap-shoulder belt design or a 2-point automatic belt with a manual lap belt that will be worn by some occupants (based on prior data submitted to NHTSA). Given the uncertainty regarding actual restraint usage in accidents, the agency can not precisely estimate the effectiveness, when worn, of the VW Rabbit automatic belts, compared to unrestrained occupants. The North Carolina study indicates the VW automatic belt may be less effective than the manual belt for serious to fatal accidents, however, these differences are not statistically significant. Assuming manual lap/shoulder belts are 45 percent effective, the agency's analysis of VW Rabbit occupant fatalities, coupled with various estimates of automatic and manual belt usage, indicates a fatality effectiveness range of from 39 to 54 percent - i.e., about the same as manual belts. Based on these studies and the possibility that the two-point automatic belt may not be as effective as a manual lap/shoulder belt in side impacts and rollovers, the agency believes that two-point automatic belts may be 5 percentage points less effective than lap/shoulder belts. The agency has no data on 3-point automatic belts or the extent of manual lap belt usage with 2-point automatic belts. The agency believes that both the 3-point automatic belt and the 2-point automatic belt, when a manual lap belt is used, may be as effective as manual lap/shoulder belts. Thus, the agency's estimate of automatic belt effectiveness for fatalities is 35-50 percent, and for AIS 2-5 injuries is 40-55 percent. These are the same ranges as for manual lap/shoulder belts except that the low end of the range has been lowered by 5 percentage points.

The agency has no specific analyses on the effectiveness of the automatic belt system for AIS 1 injuries. The agency sees no reason why the effectiveness of automatic belts should not be equivalent to the effectiveness of the manual 3-point belt for AIS 1 injuries (10 percent).

C. Air Bag

As shown in Table IV-1 the agency is now estimating air bag alone (without belts) effectiveness as 20-40% for fatalities and 25-45% for AIS 2-5 injuries. Although the ranges are similar to those used in the Preliminary Regulatory Impact Analysis (PRIA), the current ranges are based principally on new analyses which the agency has conducted subsequent to the publication of the PRIA. The following sections will discuss these new analyses as well as previous estimates, new computation of effectiveness from ACRS field experience and other issues related to the effectiveness of air bags.

1. Historical Estimates of Effectiveness

In 1974, the agency estimated air bag effectiveness as follows:[25]

1974 AIR BAG EFFECTIVENESS ESTIMATES
(FULL FRONT SEAT)

IMPACT MODE	FATALITIES		INJURIES	
	AIR BAG WITH LAP BELT	AIR BAG ONLY	AIR BAG WITH LAP BELT	AIR BAG ONLY
Frontal	57%	57%	64%	64
Side	45	20	40	25
Rollover	50	15	50	15
Rear	0	0	0	0
Combined effectiveness weighted by probability of occurrence	45%	32%	39%	30%

The effectiveness estimates assumed that air bags would be effective in frontal impacts up to 35 mph. The effectiveness estimates for side, rollover, and rear end impacts were based on engineering judgment. It was also assumed that lap belt usage with air bags would be 60 percent -- the level observed for manual belts with interlocks in 1974.

The agency estimated that 12,000 lives would be saved annually by air bags. Since seat belts were already saving 3,000 lives a year at that time, the incremental life savings for air bags over seat belts was 9,000. This 9,000 estimate persisted in later work, even after the substantial reduction in fatalities brought about by the 1974 energy crisis and the 55 mph speed limit. It was argued by NHTSA that the 1974 national fatality decrease resulted mainly from a decrease in the number of most severe accidents, for which no air bag effectiveness was claimed; thus air bags

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25 "Analysis of Effects of Proposed Changes to Passenger Car Requirements of FMVSS 208," NHTSA, August 1974, Docket No. 74-14-N01-104.

would have a higher overall effectiveness for the remaining fatal accidents. However, fewer occupant fatalities also occurred on roads with lower speed limits and fewer pedestrians were killed, two categories for which high speed travel was irrelevant. Thus, some reduction, of undetermined magnitude, in air bag benefits would be expected.

Another factor that led to an increase in estimated air bag effectiveness after 1976 was the results of the Restraint System Evaluation Project. The high levels of effectiveness for seat belts, and the belief that air bags were yet more protective, led the agency to believe that a higher level of effectiveness should be ascribed to air bags. Further, the agency's research in air bags was producing systems capable of restraining occupants in 40 to 45 mph frontal crashes, even in some smaller car sizes.

Finally, given the overall number of passenger car occupant fatalities in 1975-76 and the reduction in seat belt usage, a 40 percent effectiveness, instead of the previous 32 percent, was attributed to air bags without lap belts. An estimated 9,000 incremental lives were still saved. In 1977, the following estimates of air bag effectiveness were published:[26]

1977 AIR BAG EFFECTIVENESS FOR
AIS 4-6 INJURIES

Impact Mode	Air Bag with Lap Belt	Air Bag Only
Frontal	77%	65%
Side	50	16
Rollover	65	5
Rear	15	10
Combined effectiveness weighted by probability of occurrence	66	40

[26] "Standard No. 208 -- Passive Restraint Amendment, Explanation of Rulemaking Action," NHTSA, July 1977, Docket No. 74-14-N10-011, DOT-HS-802-523.

Comparing the 1977 to the 1974 estimates, shows that 1) in 1974, frontal impact effectiveness was assumed to be the same for air bags with and without lap belts -- this assumption was changed significantly for 1977;[27] 2) the 1977 effectiveness for side impacts and rollovers went up for air bags with lap belts, but down for air bags only; 3) in 1977, an effectiveness level was assumed for rear impacts, where no estimate was made for rear impacts in 1974. Overall, effectiveness was assumed to be 25 percent higher ((40-32)/32) for air bags only and more than 40 percent higher ((66-45)/45) for air bags plus lap belts. All these estimates were based on accident data for belted and unbelted occupants, laboratory results, some favorable field accidents with air bags, and engineering judgment.

Table IV-10 shows the 1977 effectiveness estimates, average AIS 2-5 injury effectiveness estimates weighted by 1982 injuries,[28] and average overall air bag effectiveness, assuming 1983 driver belt usage of 14.0 percent would continue with air bag cars. Using the 1977 analysis, average air bag effectiveness for fatalities is 44 percent and for AIS 2-5 injuries is 26 percent for drivers. It is slightly less for the other front seat passengers.

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27 Economic Impact Assessment, Amendment to FMVSS No. 208, Occupant Crash Protection," NHTSA, July 1977, p. 43.

28 Calculated as follows -- for example for air bags only -- of all AIS 2-5 injuries, 76.7 percent are AIS 2, 19.6 percent are AIS 3, 2.5 percent are AIS 4, and 1.2 percent are AIS 5. Thus, (76.7%x22)+(19.6%x30)+(2.5%x40)+(1.2%x40)=24.2 rounded to 24 percent. This calculation weights air bag effectiveness by the percent of injuries.

TABLE IV-10
AIR BAG EFFECTIVENESS ESTIMATES[29]
FROM THE 1977 ASSESSMENT FOR INJURIES

AIS INJURY LEVEL	AIR BAG	AIR BAG WITH LAP BELT
1	0%	15%
2	22	33
3	30	45
4	40	66
5	40	66

AVERAGE AIR BAG EFFECTIVENESS
ASSUMING CURRENT LAP BELT USAGE

	Air Bag Only	Air Bag With Lap Belt	14.0 Percent (Driver)	5.0 Percent[30] (Front Cntr)	8.4 Percent (Front Right)
AIS 1			2%	1%	1%
AIS 2-5 Average effectiveness weighted by 1981 number of AIS 2-5 injuries	24%	37%	26%	26%	26%
Fatality effectiveness	40%	66%	44%	41%	42%

2. Field Data

Air bag cars in use consisted of manufacturers' test fleets of 831 1972 Mercurys, 1,000 1973 Chevrolets, and 75 1975 Volvos. In addition, 10,281 1974-76 Buicks, Oldsmobiles, and Cadillacs were sold to the public, for a total of 12,187 air bag cars in the fleet. The agency has attempted to keep track of fatalities and injuries in these vehicles and in a national population of approximately equivalent cars with manual belts. While early

29 Compared to unrestrained occupants.
30 Opinion Research Corporation "Restraint System Usage in the Traffic Population," May 1983, DOT-HS-806-424, and "Progress Report on Restraint System Usage in the Traffic Population," Goodel Grivas, Inc., January 1984.

estimates of effectiveness were developed in 1976-77 using field data, there were so few cars equipped with air bags and so few cases of serious or fatal injuries that the results were meaningless. Even today, there are so few cases that the results have little statistical meaning.

In 1979 and 1980, the agency published analyses of air bag effectiveness based on field data.[31] In the 1979 report, the agency compared air bag equipped car fatalities (five fatalities were known at that time) to a national population of equivalent cars. The results were that air bags were 41 percent effective in reducing fatalities compared to unrestrained occupants.

A second analysis performed in 1979 and updated in 1980 compared air bag fatalities and injuries to a sample of GM cars weighing more than 4,000 pounds found in NHTSA's National Crash Severity Study (NCSS) file. At that time, there were six known air bag fatalities. Air bag effectiveness compared to unrestrained occupants was 54 percent for fatalities, 56 percent for AIS 3-4 injuries, and 43 percent for AIS 2 injuries.

New data would necessitate a recalculation of these estimates. Based on a vehicle identification number (VIN) search of the FARS file, we now know there were seven fatalities in air bag equipped cars as of December 1978, rather than the five fatalities used in the 1979 analysis or the six fatalities used in the 1980 analysis. These additional fatalities would

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[31] "Occupant Protection Program Progress Report No. 2," NHTSA, April 1979, pp. 10-11.

"Automobile Occupant Crash Protection, Progress Report No. 3," NHTSA, July 1980, p. 85.

have lowered the previously stated effectiveness estimates for the air bag fleet cars. However, rather than present recalculations of past analyses, the agency will present its latest analysis, using the most up-to-date data available.

The Preliminary Regulatory Impact Analysis contained a table comparing the fatality rates for both the manufacturers' test fleets and the publicly purchased 1974-76 Buicks, Oldsmobiles, and Cadillacs (ACRS cars). The experience with the manufacturers' 1972 and 1973 model test fleets (which have experienced a total of four front-seat fatalities, including two since the publication of the Preliminary Regulatory Impact Analysis) is being discounted in this final regulatory impact analysis for several reasons:

1. Many of the air bag systems were prototypes and not representative of anticipated production systems.

2. Many of the air bag systems were removed during the lives of the vehicles, complicating exposure calculation.

3. Many vehicles were fleet vehicles and thus underwent an exposure very different from typical privately owned vehicles (e.g., some of the vehicles were police vehicles).

The agency has refined its estimates of exposure for the 1974-76 ACRS equipped cars by utilizing detailed R.L. Polk data to calculate precise scrappage rates for each of the equivalent make/model combinations in the ACRS fleet. The agency now knows of ten front seat fatalities which have occurred in the ACRS fleet (as well as four in the manufacturers' test fleets). Two additional fatalities have occurred since publication of the Preliminary Regulatory Impact Analysis. Using the refined estimates of exposure through 12/31/83 and the total front seat fatality count of ten, the computed air bag effectiveness over regular belt systems as used is now 0 percent as compared to 16 percent in the Preliminary Regulatory Impact Analysis. (If the test fleets had been included in the calculation, the effectiveness estimate would have been negative.)

It should be noted that the latest statistical analysis of air bag fatalities differs from other effectiveness estimates in the chapter in that it compared all fatalities in air bag cars (including some belt users) to all fatalities in the control group cars (including some belt users) - as opposed to "air bag only" versus "unrestrained only." The reason for this approach was analytic simplicity. It was considered appropriate given the sparse data on air bag fatalities and problems with unknown safety belt usage in FARS. It is recognized that the results are not identical to "air bag only" versus "unrestrained" but the bias should be negligible in comparison to the -70 to +46 percent confidence bounds due to sampling error. Further, the benefits of belt usage in the control group are offset by approximately equal benefits of belt usage in the air bag cars, so the bias is a second order effect.

TABLE IV-11[32]

	Front Seat Fatalities In All Accidents	Estimated Exposure In Car Years	Fatality Rate Per Thousand Car Years	Air Bag Effectiveness Over Regular Belt Systems As Used
ACRS Car[33]	10	84,008	0.119	0%
National Population[34] of Equivalent Cars with Regular Belts	1,527	12,784,000	0.119	

However, even today after 3 more years of exposure, this 0 percent effectiveness figure has little meaning for a number of reasons:

1. Because of the relatively small sample size, a 90 percent confidence interval indicates that the effectiveness could be anywhere in the range of -70 to +46 percent. Thus, the field data are not statistically meaningful except as supporting evidence for the studies described below which indicate that effectiveness is unlikely to be on the order of 50 percent or more.

2. Small changes in the number of air bag fatalities cause drastic changes in effectiveness estimates. This is further proof that there are too few air bag cars in the fleet to provide an effectiveness estimate which can be viewed with confidence:

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32 This analysis only includes front seat occupants. It should be noted that there have been cases where children have been thrown from the rear seat to the front seat and have been saved from serious injury by an air bag.

33 Fatalities and exposure through 12/31/83.

34 Fatalities based on FARS, 1975-81. Exposure based on Polk registration data July 1, 1975-81.

If Air Bag Fatalities Had Been:	Observed Air Bag Effectiveness Would Be:	90 Percent Confidence Bounds Would Be:
8	20	-43% to + 60%
9	10	-57% to + 52%
10 (currently known)	0	-70% to + 46%
11	-10	-82% to + 38%
12	-20	-94% to + 30%

3. The effectiveness estimate is "air bags as used" versus "manual belts as used," not "air bag only" versus "unrestrained." In the ACRS fleet, there was 17 percent usage of lap belts, while 83 percent of the occupants were protected by the air bag alone. In the control group of equivalent 1974-76 cars, there was exceptionally high seat belt usage during the first few years, because many of the cars were equipped with the starter interlock system. In order to estimate the effectiveness of "air bag only" versus "unrestrained" it would have been necessary to deduct the belt users from both the fatalities and the exposure totals, in both the ACRS and the control group. This would have led to even more imprecise estimates based on even sparser data. (Because all 10 of the ACRS fatalities did not use the lap belt, it would actually have led to a negative effectiveness estimate for "air bag only" versus "unrestrained" and a 100 percent estimate for "air bag plus lap belt" versus unrestrained.)

4. The air bag and equivalent cars were very large cars, and are not typical of cars being produced today. These cars had very low fatality rates to begin with; thus it is more difficult for a restraint device to show statistically significant effectiveness, with only a small sample, in these large cars. For example, the front seat fatality rates in the

equivalent large cars was 0.119. This was 40% lower than the 0.198 rate for all cars in 1982, the lowest rate in recent history (21,200 front seat fatals/106.9 million cars in use).[35]

The agency has conducted a new analysis of air bag injury effectiveness from field data. The injury rates in the air bag equipped cars were compared to the injury rates of occupants involved in frontal accidents of similar severity and similar sized vehicles on the NCSS file. The weighted air bag effectiveness in frontal collisions was 23.9 percent for AIS $\geq$ 2 and 38.2 percent for AIS $\geq$ 3. These results are in conflict with the fatality effectiveness, which was calculated to be zero. The details of this study are reported in the next section on new analyses.

The Pacific Legal Foundation argues (74-14-N32-1675) that the agency's position that the effectiveness of air bags is understated in the field data is incorrect. According to this commenter, the Department cannot know of all of the fatalities that have occurred in accidents in air bag equipped cars. The agency now has a tape listing all the vehicle identification numbers (VIN) of the ACRS cars. This tape was matched against the FARS file to check for ACRS cars involved in fatal accidents. All fatal accidents which were previously reported to the agency through normal reporting channels were found on FARS plus two previously unreported accidents. The agency thus feels reasonably confident that this system is yielding all fatal ACRS crashes, since FARS is a census, not a sample, of all fatal accidents. The agency does not have a VIN tape for the non-ACRS air bag cars and this along with the previously cited reasons is why

[35] In-Use data based on R. L. Polk Data.

analysis of the fatalities in this fleet have been dropped from this analysis. PLF also questions the premise that the large size of the air bag car models tends to hide the effectiveness of the air bag. However, in the PRIA, the Department merely acknowledged that it is more difficult to show statistically significant effectiveness because the control group cars already have a very low fatality rate.

Ford suggested that the Department update the fatality rate of the base population of equivalent cars with safety belt systems to include the 1983 FARS data to eliminate any bias which would be expected to result from the difference in reporting periods (the ACRS fleet exposure is through 1983, the control group exposure is through 1981). The Department did not update the control group exposure because fatality rates per 1000 car years are relatively stable if sample size is sufficient to minimize sampling error.

3. New Analyses of Air Bag Effectiveness

The best way to estimate the safety effectiveness of any new device is to analyze the accident experience of a large fleet of cars equipped with the device. However, since the existing fleet of cars equipped with air bags has been too small for statistically meaningful analyses of its accidents, as was discussed in the preceding section, NHTSA explored other methods.

The restraint effectiveness task force commissioned three separate in-house studies of air bag fatal effectiveness subsequent to the publication of the Preliminary Regulatory Impact Analysis. Each of the analyses used a distinctly different methodology; however, they have two fundamental similarities. First, they all utilize the National Crash Severity Study (NCSS) file as a fundamental source of accident data. The NCSS was a major accident data collection program of the agency which began on January 1, 1977 and terminated on March 31, 1979. The combined investigations represent 12,050 accidents, 25,237 vehicle occupants and 924 fatalities. The accidents were sampled according to a plan designed to result in a representative sample of accidents severe enough to require that the vehicles be towed from the scene. Second, each study arrives at an estimate of effectiveness inferentially rather than directly, since none of the fatal accidents in the NCSS file occurred in air bag equipped vehicles. The small number of actual crashes involving air bag equipped vehicles is analyzed in the preceding section of this document. Effectiveness is estimated by partitioning the NCSS accidents into various sub-groups by distinguishing characteristics and then making judgments about whether an air bag could prevent or mitigate injury or fatality in that sub-group. Overall effectiveness is then calculated from a weighted total of the individual judgments within the various sub-groups. A fourth study conducted subsequent to the PRIA estimates AIS 2-5 injury effectiveness from a file containing data on ACRS vehicle crashes by making comparisons to non-ACRS cars in the NCSS file. The following sections will summarize the methodology and findings of each of the studies; more detailed explanations can be found in the actual reports, which have been placed into the FMVSS 208 docket.

Study #1 - Assessment of the Potential of Air Bags to Prevent Car Occupant Fatalities Using NCSS Data, S. Partyka

The 846 front-seat occupant fatalities in passenger cars on the NCSS file were partitioned into subsets according to factors judged to be relevant to the life-saving potential of air bags. The subsetting process is detailed in figures IV-1 thru IV-4. The potential of air bags is computed from the diagram as follows:

1) Of the 924 fatalities, 92.80 percent of the known seating areas were front.

2) Of these, 84.00 percent of the known forces were horizontal.

3) Of these, 73.27 percent of the known longitudinal delta V's were 12 miles per hour or greater directed towards the back of the vehicle. A review of extent zone for missing versus completed delta V revealed no obvious bias among these non-rollover frontal crashes.

4) Of these, 92.30 percent of those with known ejection status were not totally ejected (or were ejected through the windshield).

FIGURE IV-1 - CATEGORIZATION OF NCSS FOR AN ASSESSMENT OF AIR BAG POTENTIAL

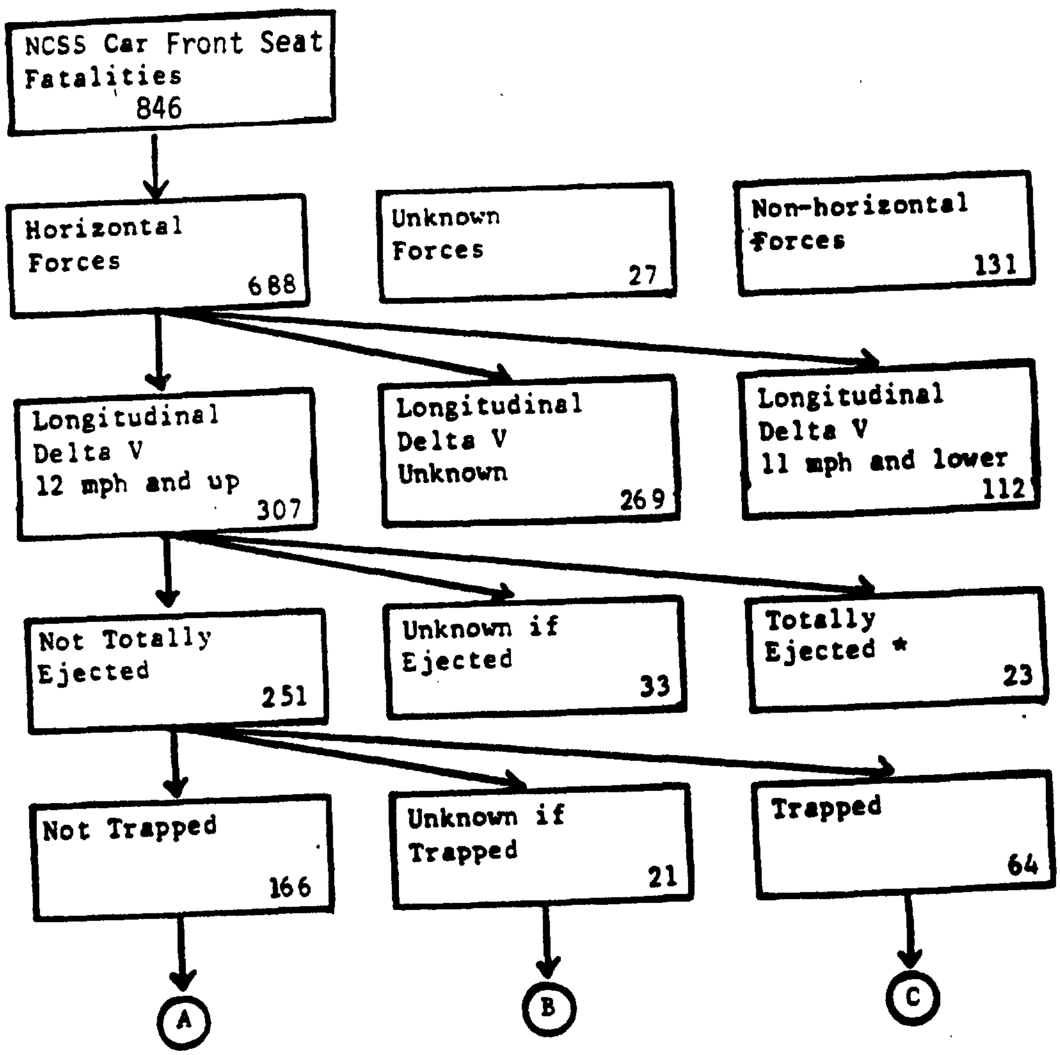


FIGURE IV-2

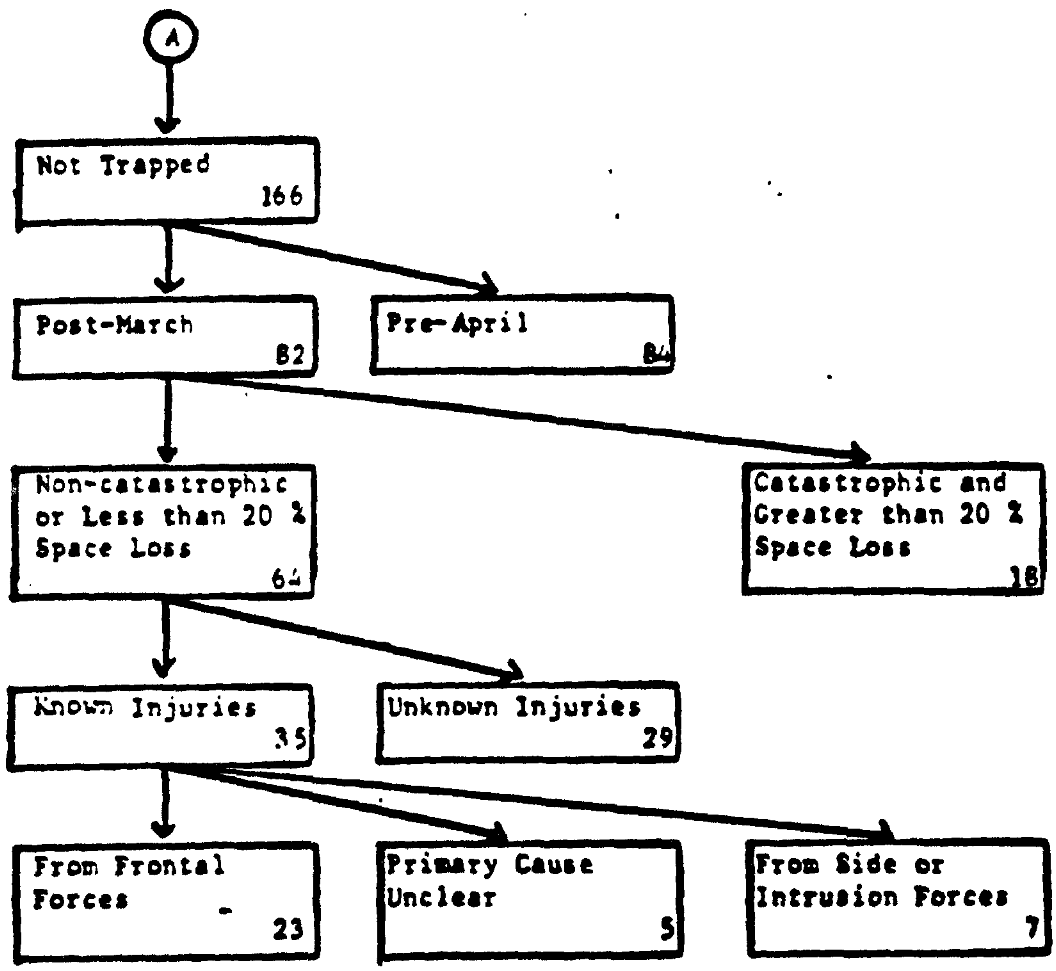

A
Not Trapped 166
Post-March 82
Pre-April 84
Non-catastrophic or Less than 20 % Space Loss 64
Catastrophic and Greater than 20 % Space Loss 18
Known Injuries 35
Unknown Injuries 29
From Frontal Forces 23
Primary Cause Unclear 5
From Side or Intrusion Forces 7

FIGURE IV-3

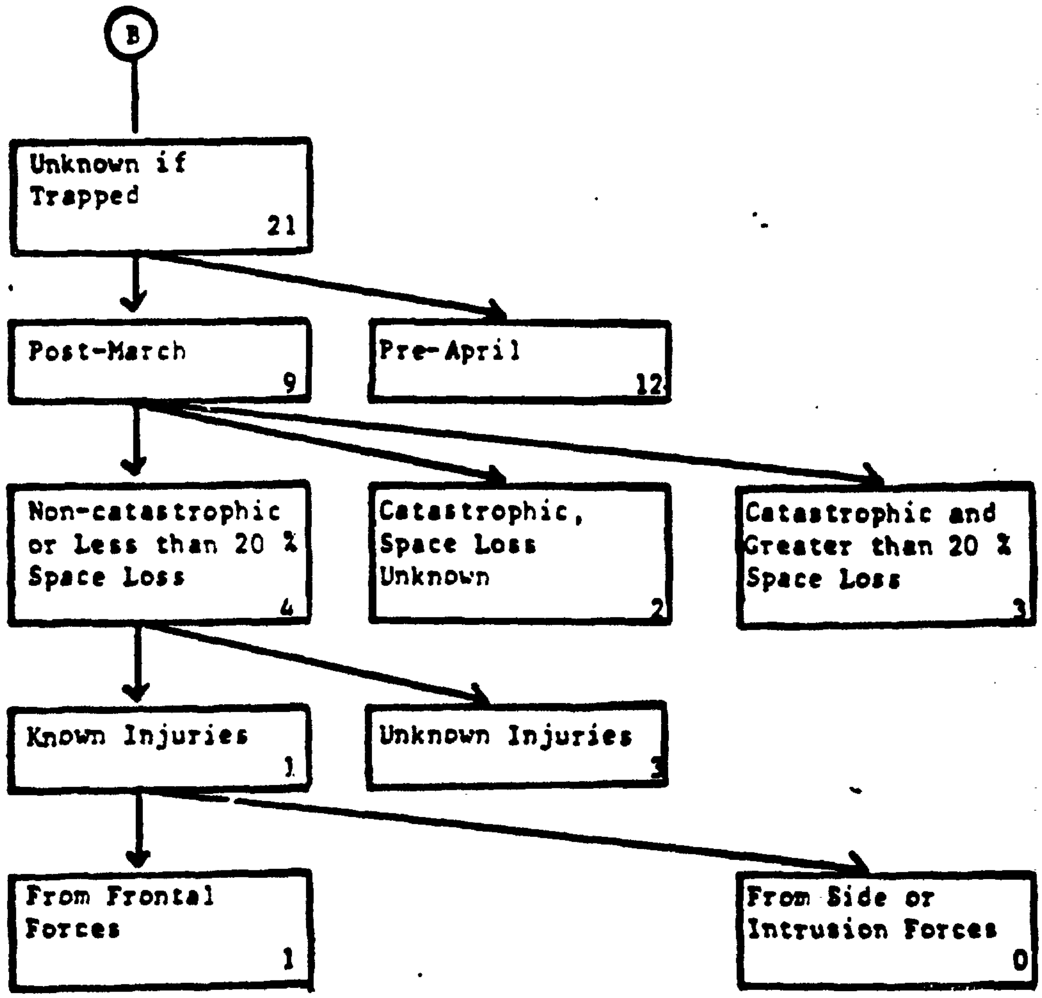
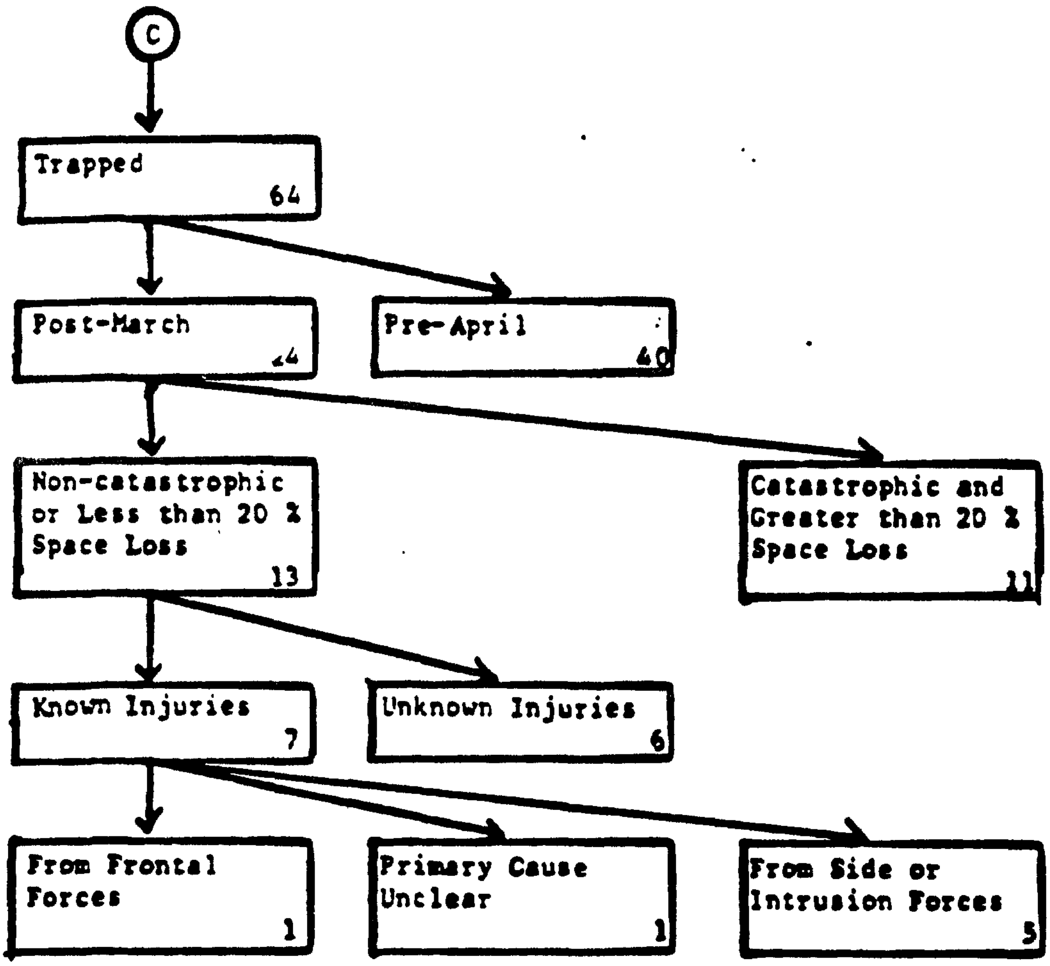

B
Unknown if Trapped 21
Post-March 9
Pre-April 12
Non-catastrophic or Less than 20 % Space Loss 4
Catastrophic, Space Loss Unknown 2
Catastrophic and Greater than 20 % Space Loss 3
Known Injuries 1
Unknown Injuries 3
From Frontal Forces 1
From Side or Intrusion Forces 0

FIGURE IV-4


C
Trapped
64
Post-March
24
Pre-April
40
Non-catastrophic or Less than 20 % Space Loss
13
Catastrophic and Greater than 20 % Space Loss
11
Known Injuries
7
Unknown Injuries
6
From Frontal Forces
1
Primary Cause Unclear
1
From Side or Intrusion Forces
5

5) Of these, 66.14 percent were not trapped, 8.37 percent were unknown if trapped, and 25.50 percent were trapped. None of these three categories is discarded as being irrelevant to the effectiveness of air bags, but each is studied separately. The data used for study are the intrusion information, collected only for the last year of the NCSS (post-March).

Not trapped:

6a) Of the 82 fatalities not trapped in the post-March data, 78.05 percent were in non-catastrophic crashes (or catastrophic crashes with less than a 20 percent occupant space reduction).

7a) Of these, only 35 had known injuries.

8a) Of these 65.71 percent probably would have been saved by an air bag, 20.00 percent were killed by side or intrusion forces not protected against by an air bag, and 14.29 percent might have been saved (there was some intrusion, but the injuries might have been reduced in severity by an air bag). Of those with a decision on the air bag potential, (that is, excluding those who "might have been saved") 76.67 percent would have been saved.

Unknown if trapped:

6b) Of the 9 fatalities unknown if trapped in the post-March data, 44.40 percent were in non-catastrophic crashes (or catastrophic crashes with less than a 20 percent occupant space reduction).

7b) Of these, only 1 had known injuries.

8b) This person probably would have been saved by an air bag.

Trapped:

6c) Of the 24 fatalities trapped in the post-March, 54.17 percent were in non-catastrophic crashes (or catastrophic crashes with less than a 20 percent occupant space reduction).

7c) Of these, only 7 had known injuries.

8c) Of these, 14.29 percent probably would have been saved by an air bag, 71.43 percent were killed by side or intrusion forces, and 14.29 percent might have been saved by an air bag. (Of the cases with a decision of the probable air bag effectiveness, 16.67 percent would have been saved).

The estimation proceeds backwards, up the chain, accounting for unknown data. Three figures are calculated, for a range of effectiveness and a most likely value. The figures are calculated as follows:

MIN -- A minimum potential effectiveness is calculated by putting all of the "might have been saved" in the "not saved" category.

MID -- a most likely potential effectiveness is calculated by ignoring all of the "might have been saved".

MAX -- A maximum potential effectiveness is calculated by putting all of the "might have been saved" in the "saved" category.

First, exclude the catastrophic crashes with more than 20 percent occupant space loss (45.83% of the trapped occupants and 21.95% of the persons not trapped).

Trapped:

MIN = 14.29% * 54.17 % = 7.74 % savable

MID = 16.70 % * 54.17 % = 9.05 % savable

MAX = 28.57 % * 54.17 % = 15.48 % savable

Unknown if trapped:

MIN = MID = MAX = 44.40 % * 100.00 % = 44.40 % savable

Not Trapped:

MIN = 65.71 % * 78.05 % = 51.29 % savable

MID = 76.67 % * 78.05 % = 59.84 % savable

MAX = 80.00 % * 78.05 % = 62.44 % savable

Second, account for the different savable rates for the different categories of entrapment. The distribution of these categories for front seat occupants subjected to horizontal forces of at least 12 miles per hour longitudinally and who are not ejected is as follows:

64 = 25.50 % trapped

21 = 8.37 % unknown if trapped

166 = 66.14 % not trapped

The three savable rates are averaged according to the distribution of the entrapment categories for the three levels, as follows:

MIN = 25.50 % * 7.74 % + 8.37 % * 44.40 % + 66.14 * 51.29 % = 39.61 % saved

MID = 25.50 % * 9.05 % + 8.37 % * 44.40 % + 66.14 * 59.84 % = 45.60 % saved

MAX = 25.50 % * 15.48 % + 8.37 % * 44.40 % + 66.14 * 62.44 % = 48.96 % saved

Third, to account for the ejection, crash severity, and horizontal forces, multiply by the factors that represent the rate of these subsetting criteria.

MIN = 39.61 % * 92.30 % * 73.27 % * 84.00 % = 22.50 % savable

MID = 45.60 % * 92.30 % * 73.27 % * 84.00 % = 25.91 % savable

MAX = 48.96 % * 92.30 % * 73.27 % * 84.00 % = 27.81 % savable

Thus, the range of potential air bag effectiveness computed from this methodology is 22.5% to 27.8%. Several members of the restraint effectiveness task force had reservations regarding some of the judgments made regarding the ability of the air bag to protect occupants in certain situations. Rear seat occupants, rollover, frontals with longitudinal changes in velocity of less than 12 mph, side portal ejection and excessive intrusion were some of the categories that received particular attention. In response to these concerns "hard copy" review of a number of cases in certain cells was conducted with a view toward making judgments about air bag life saving potential on a case-by-case basis. After this review, it was suggested that the upper estimate of potential air bag effectiveness be adjusted upwards to slightly above 30%. Other members of the task force pointed out that the methodology implied 100% effectiveness in those situations where the air bag was assumed to be effective. Historically, even the most promising safety concepts have fallen far short of 100% effectiveness even when analyzed for those particular kinds of accidents in which they were supposed to work; the point being that various judgments could be made in one direction or the other in each of the cells and the overall effectiveness would shift accordingly. Thus, the analysis must rest on the assumptions and these assumptions translate into a potential effectiveness of 22.5% to 27.8%.

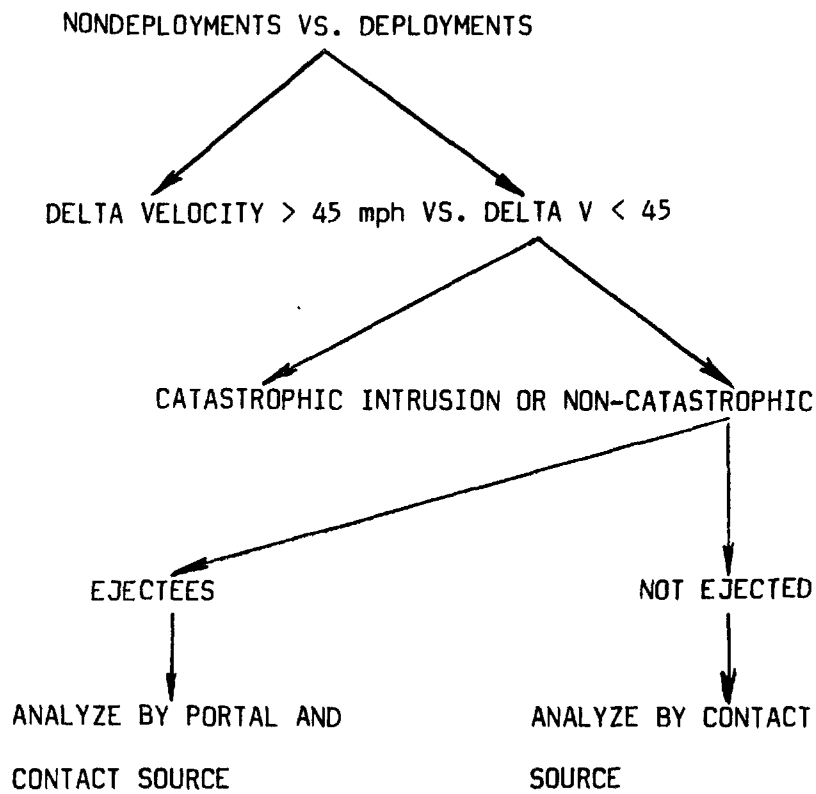
Study #2 - Estimates of Fatality Reduction for Air Bags and Lap/Shoulder Belts - C. Kahane

The technique used in this analysis was to examine a large representative set of unrestrained fatal accident cases (NCSS). The computerized data from each individual case was reviewed and judged as to whether an air bag would have saved the victim. At the end of the review, the number of lives judged potentially "saved" is divided by the total number of cases to obtain an estimate of air bag effectiveness.

The technique has the same obvious limitations as Study #1. A judgment about whether air bags would have been effective had to be made on the basis of the relatively limited information that the data file provides about each case. The judgment cannot be directly tested because it is, of course, impossible to rerun exactly the same crash with air bags.

Therefore, to provide at least an indirect check on the results, the same technique was also applied for lap/shoulder belts. Here, at least, there have been enough statistical analyses of accident data to suggest that effectiveness is in the range of 40-50 percent for belts. Thus, if this technique produced a radically different estimate for belts, its validity for bags would become doubtful. In fact, the technique produced fatality reduction estimates of 51 percent for belts, consistent with the 40-50 percent range, and 25 percent for air bags.

The basic "fault tree" analysis that was used for air bags proceeded as follows:



The analysis for belts was similar except that the non-deployment step was omitted and the cutoff point for delta V was 35 mph rather than 45 mph. The specific details of the rationale for and use of criteria to make the fault tree decisions is contained in the report.[36]

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36 "Estimates of Fatality Reduction for Air Bags and Lap/Shoulder Belts," Charles J. Kahane, Office of Program Evaluation, NHTSA, February 1984.

The result of the application of this technique is that air bags were judged to have been effective in 192 out of 781 unrestrained front-seat fatalities, which is an effectiveness of 25 percent. Lap/shoulder belts were judged likely to be effective for 396 of the 781 cases or 51 percent. Table IV-12 summarizes the effectiveness results by crash mode. Air bag effectiveness is estimated to be 39 percent in frontal crashes and 7 percent in nonfrontal crashes (including nondeployments). Belt effectiveness is 44 percent in frontal crashes and 59 percent in nonfrontals. The results for belt effectiveness, both overall and by crash mode, are reasonably consistent with results of statistical analyses of accident data and provide encouragement that the procedure is relatively accurate. There are several reasons that air bags are estimated to be slightly less effective than seat belts in frontal crashes, despite their superior performance at high Delta V. One is that crashes with side damage and frontal (11-1:00) principal direction of force (PDOF), which are included in the frontal group, tend to have occupant injury mechanisms more characteristic of side impacts than frontals. The other reason is the incidence of ejection and/or secondary rollover following frontal impacts.

TABLE IV-12
AIR BAG AND BELT EFFECTIVENESS BY
CRASH MODE, BASED ON
CASE-BY-CASE ANALYSIS OF NCSS
UNRESTRAINED FRONT-SEAT FATALITIES

	Air Bag Effective?		Lap/Shoulder Belt Effective?	
	Likely	Unlikely	Likely	Unlikely
FRONTAL CRASHES (frontal damage or 11-1:00 force)	167	259	188	238
NONFRONTAL CRASHES WITH LIKELY OR POSSIBLE DEPLOYMENT				
(side, top, back or under carriage damage with secondary frontal impact or 2-3:00, 9-10:00 or nonhorizontal force)	25	294	189	130
NONFRONTAL CRASHES WITH UNLIKELY DEPLOYMENT	0	36	19	17
(side or back damage with 4-8:00 force and no secondary frontal impact)				
TOTAL	192	589	396	385
Percent of NCSS Fatalities (N=781)	25%		51%	

Tables IV-13 and IV-14 run through the entire fault tree analysis for air bags and seat belts, respectively, but with all crash modes lumped together. The numbers in the lower sections of the two tables differ slightly because the air bag analysis excludes nondeployments but includes crashes with Delta V between 36 and 45 mph.

Approximately 40 percent of the fatalities involve speeds beyond the capabilities of current production restraints and/or catastrophic intrusion of vehicle components into the space where the victim was seated. About 15 percent of the victims are ejectees in noncatastrophic crashes. Thus, about 45 percent of the victims were in survivable crashes and remained in the car. Between over half and two thirds of them were killed by contacts with frontal interior surfaces.

Table IV-15 runs through the fault tree analysis separately for the three crash modes (frontals, nonfrontals with likely or possible deployment, nondeployments). Moreover, the categories of crashes are defined in a manner that air bag and seat belt benefits can be shown side by side.

Air bags are likely to be highly effective in frontal crashes that most closely resemble laboratory tests, i.e., integrity is maintained (no catastrophic intrusion, ejection, external objects entering the compartment, or significant secondary impact). As Table IV-15 shows,

TABLE IV-13
"FAULT TREE" ANALYSIS FOR AIR BAGS

	Air Bag Effective? Likely	Unlikely
N of Case (781)		
Nondeployments (36)		36
Likely or possible deployments (745)		
Delta V > 45 (95)		95
Delta V ⩽ 45 or unknown (650)		
Catastrophic intrusion (207)		207
Noncatastrophic (443)		
Ejection (112)		
Thru windshield (8)	8	
Not thru windshield (104)		
Killed by frontal contact (1)	1	
Killed outside car or nonfrontal contact (103)		103
No ejection (331)		
Killed by secondary nonfrontal impact (8)		8
Killed by primary impact (323)		
Fire/immersion		9
External Object		19
Side/top contact		112
Frontal Contact	183	
TOTAL	192	589

TABLE IV-14
"FAULT TREE" ANALYSIS FOR LAP/SHOULDER BELTS

	Belts Effective? Likely	Unlikely
N of cases (781)		
Delta V > 35 (135)		135
Delta V ⩽ 35 or unknown (646)		
Catastrophic intrusion (220)		220
Noncatastrophic (426)		
Ejection (114)	114	
No ejection (312)		
Killed by secondary nonfrontal impact (8)	8	
Killed by primary impact (304)		
Fire/immersion		9
External object		21
Side/top contact	106	
Frontal contact	168	
TOTAL	396	385

about 57 percent of frontal fatalities with Delta V < 45 occurred without loss of compartment integrity. There was catastrophic intrusion at the occupant's seat position in 31 percent of the cases (the majority due to collisions with large trucks or trains), ejection in 7 percent and secondary impact or external objects entering the compartment in 5 percent. These are the reasons that overall air bag effectiveness in frontal crashes on the highway is estimated to be 39 percent despite the near flawless performance of air bags in laboratory tests.

Study #3 - Applicability and Effectiveness of Air Bag Protection for Car Occupants - A. Malliaris

This analysis, like the two preceding analyses, utilizes the NCSS file for a basic source of accident experience. However, unlike the other two it only uses a subset of the file wherein there is a known principal direction of force, known longitudinal delta V, case car injured unrestrained occupants of known seating position, injuries (severity and source) and age.

Air bag applicability was defined as the proportion of occupant casualties that lends itself to air bag mitigation, according to the following three criteria:

TABLE IV-15
"FAULT TREE" ANALYSIS FOR AIR BAGS AND
LAP/SHOULDER BELT, BY CRASH MODE

	Air Bag Effective? Likely	Air Bag Effective? Unlikely	Lap/Shoulder Belt Effective? Likely	Lap/Shoulder Belt Effective? Unlikely
A. FRONTAL CRASHES (frontal damage; other Impacts with 11:00-1:00 Force)				
Delta V > 45 mph		83		83
Delta V ≤ 45 or unknown				
Catastrophic intrusion at occupant's position by:				
Train		3		3
Large Truck		52		52
Other vehicle or fixed object		51		51
Noncatastrophic Crashes with				
Ejection				
Thru windshield	4		4	
Other portals				
Killed in car by frontal contact (36<ΔV<45)	1			1
Killed outside of Car or by non-frontal Contact				
ΔV ≤ 35 or unknown		18	18	
36 < ΔV ≤ 45		1		1
No Ejection				
Killed by secondary non-frontal impact		8	8	
Killed by the primary impact (ΔV ≤ 35 or unknown)				
by exterior object entering vehicle		10		10
by fatal burns		5		5
by nonfrontal contact				
ΔV ≤ 35 or unknown		16	16	
36 < ΔV ≤ 45		12		12
by frontal contact				
ΔV ≤ 35 or unknown	142		142	
36 < ΔV ≤ 45	20			20
TOTAL	167	259	188	238

TABLE IV-15 (CON'T)
"FAULT TREE" ANALYSIS FOR AIR BAGS AND
LAP/SHOULDER BELT, BY CRASH MODE

	Air Bag Effective?		Lap/Shoulder Belt Effective?	
	Likely	Unlikely	Likely	Unlikely
B. NONFRONTAL IMPACTS WITH LIKELY OR POSSIBLE DEPLOYMENT (side, top, back or botton damage; secondary frontal impact of 2-3:00, 9-10:00 as nonhorizontal force)				
Delta V > 45 mph		12		12
Delta V $\leq$ 45 or unknown				
Catastrophic intrusion at occupant's position by:				
Train		10		10
Large Truck		18		18
Other vehcle or fixed object		73		73
Noncatastrophic Crashes with				
Ejection				
Thru windshield	4		4	
Other portals				
Killed in car by frontal contact	0		0	
Killed outside car or by non-frontal				
$\Delta V \leq 35$ or unknown		83	83	
$36 < \Delta V \leq 45$		1		1
No Ejection				
Killed by exterior object entering vehicle		9		9
Killed by fatal burns or drowning		4		4
Killed by nonfrontal contact				
$\Delta V \leq 35$ or unknown		81	81	
$36 < \Delta V \leq 45$		3		3
Killed by frontal contact				
$\Delta V \leq 35$ or unknown	21		21	
$36 < \Delta V \leq 45$	0			0
TOTAL	25	294	189	130

TABLE IV-15, (CON'T)
"FAULT TREE" ANALYSIS FOR AIR BAGS AND
LAP/SHOULDER BELTS, BY CRASH MODE

	Air Bag Effective?		Lap/Shoulder Belt Effective?	
	Likely	Unlikely	Unlikely	Unlikely
C. NONFRONTAL CRASHES WITH UNLIKELY DEPLOYMENT				
(4-8:00 Force; No secondary Frontal Impact)		1		1
Delta V > 45 mph				
Delta V < 45 or unknown				
Catastrophic intrusion at occupant's position by:				
Train		0		0
Large Truck		6		6
Other vehcle or fixed object		7		7
Noncatastrophic Crashes with				
Ejection				
Thru windshield		0	0	
Other portals				
Killed in car by frontal contact		0	0	
Killed outside of or by non-frontal				
$\Delta V \leq 35$ or unknown		5	5	
$36 < \Delta V \leq 45$		0		0
No Ejection				
Killed by exterion object entering vehicle		2		2
Killed by fatal burns		0		0
Killed by nonfrontal contact				
$\Delta V \leq 35$ or unknown		9	9	
$36 < \Delta V \leq 45$		0		0
by frontal contact				
$\Delta V \leq 35$ or unknown		5	5	
$36 < \Delta V \leq 45$		1		1
TOTAL	0	36	19	17

Qualified occupants must:

1) Occupy cars experiencing a longitudinal component of delta V larger than or equal to 10 mph (air bag deployment criterion; runs were also made for 8 and 12 mph);

2) Have at least one injury assigned to contact with frontal interior components; and

3) Occupy cars that experience crash severities lower than a total delta V of 45 mph (protection cutoffs of 40 and 50 mph were also tested).

A novel aspect of this analysis is that it recognizes the existence and frequency of multiple injuries. It further recognizes that the outcome of mitigating one or more injuries may be nil if the most severe injury remains unmitigated. The probability of fatality is projected as a function of the two most severe injuries according to an agency derived algorithm.[37]

In examining the car occupants, each occupant's injury and source of injury data set, both before and after the application of the mitigation criteria, are addressed. Each occupant's overall AIS injury level and each occupant's probability of fatality are tracked. Thus, a distribution of occupants according to AIS as well as the projected fatalities, both before and after mitigation criteria are applied, is derived.

[37] $P=(6.57^{AIS\ 1} * (1.23)^{AIS\ 2}/43{,}673$, from "A Comparison of AIS and ISS Predictions of Fatality on NCSS," S. Partyka, American Association for Automotive Medicine, October 7-9, 1980.

Another novel aspect of this analysis is the use of several different concepts of effectiveness. In the baseline concept, any qualified injury, after mitigation, is allowed a minimum severity of 1, or 2, or 3 depending on crash severity. For longitudinal delta V values between 10 mph (deployment) and 25 mph, the minimum severity of 1 is allowed. The minimum value is raised to 2 or 3 when the said delta V assumes values in the ranges 25 to 35 mph and 35 to 45 mph, respectively. This alternative is judged to give the most likely reflection of the performance of air bags of the 1970's vintage. State-of-the-art air bags of this era met the FMVSS 208 injury criteria at speeds up to 45 to 50 mph in frontal collisions. These criteria were met with wide margins at lower crash velocities, but the margins became very small as the crash speeds approached 45 to 50 mph.

An alternative mitigation concept was to assume full mitigation, that is all qualified injuries are reduced to AIS 1 and no new injuries are induced by virtue of deployment and restraint of the occupant during the crash.

A difficulty encountered with this analysis is the requirement for known delta V and injury contact source since these data are often not available in the NCSS file. For example, information about delta V is not usually available in the case of catastrophic crashes (including almost all collisions with large trucks or trains) or in crashes where the principal direction of force is non-horizontal, for example, in rollovers. Conversely, delta V information is usually available in horizontal, non-catastrophic crashes and predominantly frontal crashes where it is believed that the air bag is most effective. Thus, requiring the availability of delta V information is expected to introduce a bias in favor of air bag effectiveness. In an attempt to minimize this bias, the analysis was stratified by crash mode. In other words, individual determinations of air bag effectiveness were made by crash mode. Results, i.e., fatality reduction, are displayed in Table IV-16.

TABLE IV-16

Crash Mode	Catastrophic Damage	Direction of Force	Area of Damage	Fatality Incidence Percent	Reduction Fatalities Percent
1	No	Horiz	Front	38.0	76.0
2	No	Horiz	Side	21.1	12.4
3	No	Horiz	Rear	1.2	0.0
4	No	No-Horiz	Any	11.6	22.9
5	Yes	Any	Any	28.1	27.9
All	-	-	-	100.0	42.0

The overall effectiveness is calculated as the sum of the products (incidence times reduction of casualties) in each mode, summed over all modes. The most uncertain results in Table IV-16 are those concerning the last two crash modes, namely rollovers and catastrophic damage regardless of the type of impact. Since these determinations are made on relatively few cases for which the needed information is available they are vulnerable to biases and sampling errors. The conservative view is that in these two strata the needed information is available more frequently for situations that involve some form of frontal impact, where the air bag is most effective. Accordingly, it is believed that the casualty reduction in these strata may be over estimated. In recognition of the above potential biases and for simplicity, the author considered two bounds of overall effectiveness. The lower bound results from an adoption of crash modes 1 and 2 as shown in Table IV-16 and total elimination of modes 3,4, and 5 from any consideration. The resulting overall effectiveness is 31.5 percent. The upper bound adopts the results of Table IV-16 as shown yielding an overall effectiveness of 42 percent for fatality reduction. It is believed that modes 1 and 2 would be subject to the same biases and sampling errors, but probably to a lesser degree than modes 3, 4, and 5.

Table IV-17 shows the results of various sensitivity analyses which were performed. Rows 2 and 3 show results for a deployment threshold of 8 and 12 mph respectively, compared to the baseline value of 10 mph. Air bag protection cutoffs at 50 and 40 mph are the variations in entries number 4 and number 5 relative to the baseline cutoff of 45 mph.

TABLE IV-17
SUMMARY RESULTS OF SENSITIVITY OF AIR BAG EFFECTIVENESS ESTIMATES TO VARIOUS INFLUENCING CONDITIONS

	Fatality Reduction %	
Condition	lower Bound	upper bound
1. baseline	31.5	42.0
2. deployment @ 8 mph	33.5	44.7
3. deployment @ 12 mph	30.6	40.8
4. protection cutoff @ 50 mph	34.0	45.4
5. protection cutoff @ 40 mph	27.9	37.2
6. larger reduction of injury severity	32.5	43.3
7. driver only	36.2	48.2
8. front passenger only	23.3	31.1

The variation displayed in number 6 involves a larger reduction in injury severity. It assumes that the severity of all injuries qualified for mitigation are reduced to a severity of AIS=1 throughout the domain of applicability, from deployment at 10 mph to cutoff at 45 mph. The baseline assumes that the injury severity increases from AIS=1 to 2 to 3; i.e., the injury severity reduction decreases as the cutoff severity is approached. The last two entries resolve the projected effectiveness by seating position for driver and front seat passenger. The baseline refers to all occupants.

Ford argued (74-14-N35-065) that this study was restricted to that group of crashes in which air bags would be expected to be most effective. The agency has already acknowledged that the most uncertain results are in the rollover and catastrophic damage crash modes due to the absence of all needed data. On the other hand, there is no basis and it is unreasonable to assume that no protection at all is offered in these crash modes. An examination of the NCSS detailed data of crashes with catastrophic damage reveals the following: These crashes are not as unsurvivable as they are generally characterized. Based on 313 occupants recorded in NCSS for car occupants in catastrophic crashes, the survival rate is 64 percent, even without the benefit of any form of restraint.

Renault expressed the view (74-14-N35-050) that air bag effectiveness could not exceed 20 percent because the protection is not omnidirectional. They claimed that protection was poor in the case of successive impacts and is non-existent in the case of ejection. Renault did not supply any data in support of their claim. The agency's analysis of unrestrained fatalities showed enough persons killed by simply striking the object directly in front of them to justify estimates higher than 20 percent.

Similar considerations hold for crash modes with non-horizontal impact. In such modes the most severe impact may be non-horizontal, but secondary impacts exist--either before or after the most severe impact--of sufficient force to deploy the air bag and provide some protection by cushioning the occupant and/or by reducing the rattle space during the rollover.

The Pacific Legal Foundation and Volkswagen (74-14-N35-046) criticized the agency's new studies as being subjective and based on the assumption that air bags work more or less as predicted. Current biomechanics knowledge is sufficiently adequate to lend confidence to such an assumption, based on laboratory data and the fact that air bags have at least been deploying when needed based on field experience and statements made by manufacturers. Section 4 of this chapter summarizes the results of the extensive testing of air bags that the agency has conducted over the past 10 years.

Study #4 - Air Bag Injury Effectiveness from Field Data.

The National Center for Statistics and Analysis (NCSA) maintains an automated data system on air bag vehicles that have been involved in accidents investigated by NHTSA. For each accident, this data system contains information regarding the accident severity and level of injury of occupants. Although this file was developed primarily for case retrieval and tabular summary purposes, it does have value for certain quantitative analyses. The file was last up-dated on December 22, 1983 and at that time contained data on 547 accidents and 778 occupants of air bag equipped vehicles.

The file was screened for front seat occupants of air bag equipped vehicles involved in frontal accidents with known delta V and injury level. A comparable search was made of the NCSS file with the further restrictions that the occupants were unrestrained and in a standard full size or luxury car, since the ACRS cars are all large cars. Table IV-18 displays the

AIS≥2 and AIS≥3 injury rates for both the ACRS and NCSS car occupants. The effectiveness of air bags, calculated for each 10 mph increment of delta V is also displayed in Table IV-18.

TABLE IV-18
AIR BAG FIELD DATA COMPARISON WITH NCSS - FRONTAL CRASHES

Percentage Distribution of Occupant Injuries and Effectiveness by Delta V

V	TOTAL OCCUPANTS		AIS ≥2 (%)		AIS ≥ 3 (%)		ACRS EFFECTIVENESS	
	NCSS	ACRS	NCSS[38]	ACRS[39]	NCSS	ACRS	2+	3+
1-10	3914	73	4.4	1.4	1.0	0	68.2%	100%
11-20	3150	92	15.0	12.0	4.7	3.3	20	29.8
21-30	485	39	38.7	38.5	21.6	10.3	0.5	52.3
31-40	79	8	66.1	50.0	37.3	25.0	22.2	33
41+	46	2	91.8	100.0	73.8	100.0	-8.9	-35.5
WEIGHTED AVERAGE			12.08%	9.19%	4.63%	2.86%	23.9%	38.2%

The effectiveness was calculated for ranges of delta V in an attempt to normalize the differences in severity distribution between the NCSS and ACRS files. The agency believes that there has been significant underreporting of ACRS crashes, particularly at the lower severity levels. If the less severe ACRS crashes have indeed been underreported this would lead to a reduction in apparent air bag effectiveness. In any event, the data in the ACRS file is very sparse, particularly at the higher delta V's and higher AIS levels, and the results thus have limited statistical significance. However, several noteworthy trends are evident from Table IV-18. First, the air bag appears to have a noticeably higher

38 NCSS
Standard full size and luxury cars in NCSS file, unrestrained front seat occupants in frontal crashes.

39 ACRS FIELD DATA
Full size GM and Ford vehicles equipped with air bags, front seat occupants in frontal crashes.

effectiveness at the higher injury levels (AIS $\geq$ 3 as compared to AIS $\geq$ 2). This trend is consistent with the crash test data and intuitive reasoning. A case by case review of the air bag crash injury data shows that the AIS$\geq$2 injuries include a large number of upper and lower extremity injuries. The arms and legs of the air bag restrained occupant are not necessarily contained by the bag and may be free to contact the interior surfaces of the vehicle.

The second trend evident from Table IV-18 is that the air bag appears to be most effective in the delta V range of 21-30 mph and tails off in the speed ranges above and below. Once again this is consistent with the crash test results and intuitive reasoning.

Third, contrary to a widely held belief that air bags only deploy at delta V above 10 mph, Table IV-18 shows that 34 percent of the deployments in frontal crashes occurred below 10 mph and that the bags were apparently effective at mitigating injuries at those speeds.

The effectiveness results by delta V were weighted according to the distribution of injuries by delta V within the NCSS file. The weighted sum of injuries and effectiveness over the entire speed range was calculated to be 23.9% for AIS $\geq$ 2 and 38.2% $\geq$ 3. It must be remembered that these values are for frontal accidents only and would be lower if side, rear and rollover crashes could have been included in the calculations. However, they are interesting particularly because they do show reasonably high effectiveness for the more severe injuries and as such disagree with the fatality effectiveness from the field data which is now calculated to be zero.

Ford contends that this study contains serious and discrediting methodological flaws. The basis for this conclusion appears to be a belief that the calculated effectiveness values for the 1-10 mph delta V range are too high. Ford says: "Even if a few air bags do deploy in accidents below 10 mph delta V, it doesn't seem plausible that those few deployments could mitigate over two-thirds of the moderate or greater injuries."

Analysis of the computerized file of the air bag fleet experience indicates that 29.3 percent of all air bag deployment cases occurred at 10 mph or below. Thus, Ford's contention that deployments do not occur below sensor threshold velocity is erroneous. Threshold velocity is defined as the perpendicular fixed rigid barrier car crash speed below which air bag deployment will not occur. Certainly it is easily perceived that a crash engaging less than full frontal cross section of a car might not cause a longitudinal car delta V reaching threshold, but could impart local vehicle crush rates at the bumper impulse detector which prematurely anticipates a delta V sufficient to initiate air bag deployment. The agency does concede that there is large uncertainty in the 0-10 mph effectiveness figure since it is based on one injured occupant; however, as Ford points out the AIS ≥ 2 and AIS ≥ 3 effectiveness estimates are 13.8 percent and 50.8 percent even when the 1-10 mph data are excluded. The agency agrees with Ford that it would be helpful to further match the air bag and NCSS samples using damage pattern, object struck, occupant age, sex and seating position. However, as Ford points out, there are too few air bag cases available to allow this more refined estimate.

4. Other Studies of Air Bag Effectiveness

General Motors Safety Research and Development Laboratory conducted an in-depth case-by-case field accident fatality study of restraint system effectiveness in 1973.[40] A jury of four engineers, whose backgrounds included experience in the design, development and testing of both active and automatic restraint systems, analyzed accident cases involving 706 fatally-injured occupants. After determining the series of events and complications which led to an occupant's death, each restraint system considered was rated for its likelihood of fatality prevention. The restraint systems chosen for evaluation and the resultant fatality reduction potential were as follows:

lap belt alone - 17%
lap and shoulder belt - 31%
air bag - 18%
air bags and lap belt 29%

Methodologically this study appears to be sound and is quite similar to several of the recent studies performed within the agency. However, all the results appear to be on the conservative side, particularly the belt restraint numbers, which we now believe to be higher.

[40] Restraint System Effectiveness -- A Study of Fatal Accidents, Richard Wilson and Carol Savage, Proceedings: Automotive Safety Engineering Seminar, June 20-21, 1973.

One possible explanation for the different results is that the collection of 706 fatals may not be a nationally representative sample. Comparing, for example, the fatals by collision configuration in the GM sample with the 1982 FARS results shows some rather substantial differences, particularly for frontal collisions where air bags are expected to be most effective.

Collision Configuration	Incidence, Percent 1982 FARS	GM File
Frontal	55.2	44.1
Side	26.9	27.2
Rear	5.0	1.0
Rollover	12.9	20.5
Other	-	7.2
Total	100.0	100.0

Pacific Legal Foundation argued (74-14-N35-078) that DOT used precisely the same type analysis that GM had offered and NHTSA had rejected in the 1977 rulemaking on automatic restraints. The agency agrees that we are now adopting a methodology on air bags that we previously had reservations about. However, the agency believes that the new studies offer significant refinements over prior work. The new studies use the NCSS file as a base and as such should be more representative of the national accident picture. Most of the decision making process was done by computer using specific objective criteria. This is not to say that the process does not involve a degree of judgment, which it does. Results were reviewed by the Task Force and other agency personnel representing a wide range of technical expertise and should reflect a degree of impartiality, which may or may not have been present in the GM study.

Ford Motor Company published a study on restraint system effectiveness in 1971.[41] For each of 15 occupant restraint systems studied, mathematical modeling of the occupant restraint - vehicle system established potential head and chest decelerations of the occupants in a number of narrowly categorized crash situations. Human tolerance formulations were used to then convert these decelerations into effectiveness values for each crash situation studied. These effectiveness values, which reflect the ability of a restraint to save lives in each given crash situation, were then applied to accident data showing the relative frequency of fatalities occurring in each such situation. Summing the results for all situations leads to an overall estimate of lives saved by each restraint.

The overall fatality effectiveness estimates derived from this methodology for passenger car occupants were as follows:

lap belt alone - 40.2%
lap and shoulder belt - 58.2%
front seat air bag - 27.2%
front seat air bag w/lap belt - 45.3%

The results of the Ford study are of course largely a function of the mathematical models used, human tolerance levels chosen and the breakout of accident data that was available (1969 data) at the time of the analysis. Although much of this data is now rather obsolete, it is interesting that the estimates of restraint effectiveness are not all that different from the agency's current estimates.

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[41] Restraint System Effectiveness, Ernest S. Grush, Shermen E. Henson and Orville R. Ritterling, Report No. S-71-40, Ford Motor Company, Automotive Safety Affairs Office, September 21, 1971.

Donald F. Huelke and others in a 1979 study[42] estimated the number of deaths and injuries that could be prevented by various restraint systems. Three experienced crash investigators reviewed data concerning fatalities of front seat car occupants that had occurred at high speeds in rural areas. The researchers investigated these deaths between January 1, 1973 and December 31, 1977. Fatalities that occurred in vans, pickup trucks, larger trucks and the rear seats of cars were excluded from the review. Of the 101 people killed (under conditions within the range of the study) only four were wearing belts.

One significant conclusion of the Huelke 1979 study was that approximately 42-51 percent of the people killed had no chance of survival, regardless of the type of restraint used. The General Motors 706 case study came to a similar conclusion. The specific results of the Huelke study with regard to potential effectiveness of various restraint systems for reducing fatalities were as follows:

lap belt - 9.2-15.9%
lap shoulder belt - 30.6-32.4
air bags alone - 23.2-27.4
air bag and lap belt - 32.6-35.3

This study suffers from the same deficiency as the General Motors study in that the representativeness of the sample of accidents is unknown. As the author points out, the accidents are predominantly high speed and rural and thus would tend to understate effectiveness.

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[42] Donald F. Huelke and others, "Effectiveness of Current and Future Restraint Systems in Fatal and Serious Injury Automobile Crashes," SAE 790323, 1979.

6. Summary and Conclusions -- Air Bag Effectiveness

The preceding sections have discussed a number of new analyses and summarized some prior analyses of air bag effectiveness. The agency based its latest estimates (as detailed in Table IV-1) principally upon the new studies that have been conducted. The agency has greater confidence in these new studies principally because they are based on the NCSS file, which is a relatively large, representative set of unrestrained fatal accident cases. However, even the results of the new analyses have some uncertainty. For the most part they rely heavily on judgments about whether an air bag would save a victim. This technique has obvious limitations. Death in highway accidents is very unpredictable; many people have walked away from seemingly unsurvivable wrecks, while others are found dead at the scene of a low severity accident with no obvious aggravating factors to account for the fatality.

There is little disagreement over the conclusion that air bags will likely function very well in frontal or near frontal collisions up to speeds approaching 45 mph in which passenger compartment integrity is maintained and that bags will offer little or no protection in rear end collisions. However, uncertainty underlines the attempts to estimate air bag effectiveness in side or angle impacts, in rollover crashes and in catastrophic frontal crashes. The agency is undecided on the latter and the wide range of estimated effectiveness is a reflection of that uncertainty.

The lower end of the range (20-25%) is generally consistent with the assumption that air bags will have fairly low effectiveness in side, rollover and catastrophic frontal crashes. As progressively more optimistic assumptions are made regarding their performance in these types of crashes the overall effectiveness estimate approaches 40%.

The earlier studies done outside the agency loosely fit the general conclusions described above; i.e. conservative estimates of effectiveness in crashes other than non-catastrophic frontal have led to estimates toward the lower end of the range. Given the great diversity of analytical techniques employed and the large time spans among the various studies, their consistency is quite remarkable.

The field data on air bag effectiveness for fatalities (zero effectiveness, with upper confidence bound 46 percent) were not used by the agency in calculating its final determination of air bag fatality effectiveness except to the extent that they discouraged the agency from contemplating values of air bag effectiveness substantially above 40 percent. These data were inconsistent with injury data for the same cars, were too sparse, and had confidence bounds that were too wide.

V. RESTRAINT USAGE

This section on restraint usage is divided into two parts. The first presents and discusses data on seat belt usage. The second part presents the derivation of the usage estimates used in the calculation of benefits for the several types of restraint systems.

Observed daytime manual belt use by drivers in 19 major cities throughout the country has been 11-14 percent over the 1978-1983 period. Automatic belt usage in the relatively few vehicles with automatic systems has been close to 80 percent. However, many of these systems were purchased voluntarily and usage thereof is likely higher than if they were a required installation. In addition, the great majority of these automatic systems have ignition interlocks, which prevent the cars from being started without the belts in place; future systems are not expected to have this feature -- and the Department is prohibited by law from requiring them -- and usage will probably be substantially less.

Given the uncertainty about public acceptance and usage of automatic belts, a range of automatic belt usage is estimated -- 20%-70%. This estimate is based on surveys on manual belt usage rates and an analysis which compares survey data on why people do not use their manual belts with the characteristics of automatic belts which might obviate these stated reasons.

A range of manual belt usage that could be realized under mandatory seat belt usage laws is also estimated. Based on the experience in the Canadian provinces and 17 other countries that have enacted mandatory usage laws and for which data are available, a range of 40-70 percent manual belt usage is estimated.

Air bags are not used per se; however, there are factors which might render the air bag unavailable for protection in certain instances. It has been estimated that about 2% of all vehicle exposure may be without air bag protection, resulting in an air bag "readiness factor" of 98%. Three factors were considered as contributing to reducing the readiness factor: failure to repair or replace the air bag after a prior deployment, deliberate disablement or removal, and basic reliability of the system.

A. Seat Belt Usage Data

1. Manual Belts

a. Observational Surveys

The agency has collected safety belt usage data in 19 cities nationwide since 1978. Observed daytime driver usage of manual safety belts in these cities was 14.0 percent in 1983 (See Table V-1). Front seat passenger belt usage is lower than driver usage. In 1983, front center passenger seat belt usage was 5.0%; front right passenger seat belt usage was 8.4%.

For this analysis, the agency did not adjust the current rate of 14.0% seat belt usage for drivers, 5% for front center seat occupants and 8.4% for front right seat occupants for possible future changes. Higher usage of manual belts in the future would reduce the estimated benefits for the several alternatives. Lower manual belt usage than shown would have the opposite effect.

TABLE V-1
OBSERVED DRIVER USAGE OF SEAT BELTS[1]

1978	13.0%
1979	10.9%
1980	Not Collected
1981	11.4%
1982	11.3%
1983	14.0%

b. Personal Interview and Telephone Surveys

Several nationwide surveys conducted for NHTSA have included questions on respondents' seat belt usage. Table V-2 shows the results of 8 surveys conducted over the 1978-1984 period. In part A, the results of 6 of the surveys are presented for comparison by aligning usage response categories as follows: 1) "always or almost always" to include "almost all the time" and "always;" 2) "more than half the time" to include "most of the time;" 3) "less than half the time" to include "only sometimes" and "sometimes;" and 4) "never or almost never" to include "rarely" and "never".

1 Source: 1978-1982 --
"Restraint System Usage in the Traffic Population," Opinion Research Corporation, May 1983, DOT HS-806-424, p.2.

Source: 1983 --
"Progress Report on Restraint System Usage in the Traffic Population," Goodell-Grivas, Inc., January 1984.

TABLE V-2
RESULTS OF SURVEYS ON MANUAL
SEAT BELT USAGE
(Percent)

A.

	1978[2]	1978[3]	1979[4]	1980[5]	1982[6]	1984[7]
Always or Almost Always	16	24	24	22	19	19
More than Half the Time	9	8	8	6	14	21
Less than Half the Time	18	15	18	14	28	30
Never or Almost Never	56	52	50	59	39	30

B.

	1981[8]	1982[6]	1983[9]
Frequent	22	29	33
Sometimes	38	30	34
Infrequent	40	41	33

[2] Home interview survey, 2,016 respondents; "Public Attitudes Toward Passive Restraint Systems," DOT-HS-803-570 Peter D. Hart Research Associates, Inc., August, 1978.

[3] Telephone survey, 1,500 respondents; "1978 Survey of Public Perceptions on Highway Safety," DOT-HS-803-179 Teknekron Research, Inc., September, 1978.

[4] Telephone Survey, 1,500 respondents;" 1979 Survey of Public Perceptions on Highway Safety," DOT-HS-805-165 Teknekron Research, Inc., July, 1979.

[5] Telephone survey, 1,500 respondents; "1980 Survey of Public Perceptions on Highway Safety," DOT-HS-805-702 Automated Services, Inc., September, 1980.

[6] Telephone survey, 1,020 respondents; "A Study of Demographic, Situational and Motivational Factors Affecting Restraint Usage in Automobiles," DOT-HS-806-402, "Lawrence Johnson and Associates, Inc., February, 1983.

[7] Telephone Survey, 1,000 respondents; "Trends in Public Knowledge and Attitudes Toward Occupant Restraint Systems," McGinley Marketing Research Co, Inc., monthly report, January 1984.

[8] Telephone survey, 1,200 respondents; "National Safety Belt Study", F. Newport and L. Tarrance, September, 1981.

[9] Telephone survey, 1,000 respondents; "Impact of Travel Patterns and Driving Behavior on Crash Involvement," V. Lance Tarrance and Associates, July 1983, DOT-HS-806-458.

Part B shows the results of two additional surveys, which derived three seat belt usage categories -- frequent, sometimes, and infrequent. Part B also includes this classification as reported in the Lawrence Johnson and Associates survey.

As shown, the results of these surveys are fairly similar. From 16 to 24 percent of the respondents say they use seat belts always or almost always. Notice, however, that this percentage is somewhat higher than the findings of observational surveys (Table V-1).[10] There is a large variance among surveys in the proportion of those saying they use seat belts never or almost never; this group comprises 30-59 percent of the respondents (30 percent--January 1984).

c. Surveys on Reasons for Using/Not Using Belts

Many surveys have been conducted to ascertain the reasons that people do or do not wear seat belts. Table V-3 reports the results of two telephone surveys sponsored by NHTSA in 1979 and 1980, conducted by Teknekron and Automated Services, respectively. There have been a few more recent national surveys on the subject, two of whose results are presented in section XI. The manner in which the question was asked, the categories into which responses are summarized, and the percentage distributions thereof vary somewhat from survey to survey. It is felt that the two

[10] This tendancy for respondents to over report their seat belt use was documented by Waller and Barry in their 1969 report; "Seatbelts: A Comparison of Observed and Reported Use;" P. Waller and P. Barry, The University of North Carolina Highway Safety Research Center, May 1969, DOT-HS-007-113.

surveys sponsored by the agency that are presented herein form a reasonable basis for estimating a range of future usage rates for automatic belts as presented later in this section.

TABLE V-3
REASONS FOR NOT WANTING TO USE MANUAL BELTS
(Percent)

Reason	Teknekron[11] 1979	Automated Services[12] 1980
Don't want to be bothered, lazy, forgetful	13.9	21.7
Uncomfortable	13.2	15.5
Inconvenient to use	15.1	17.2
Don't want to be restrained	7.7	8.8
Afraid of being trapped in car during accident	10.7	11.0
Doubt value of safety measure	4.5	5.8
Other	17.9	6.1
No reason	17.1	13.8

The surveys indicate that one of the primary reasons that people do not buckle up is that they do not want to be bothered and are lazy and/or forgetful. These problems could be negated by automatic belt systems. Other major considerations that hold down belt usage are lack of comfort and inconvenience of use. These factors may or may not be influenced by automatic belts, depending on the specific belt designs and the true underlying reasons manifest in this particular response. Other reasons given for non usage -- "Don't want to be restrained," "afraid of being

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11 "1979 Survey of Public Perceptions on Highway Safety," DOT-HS-805-165 Teknekron Research, Inc., July 1979, p.34.

12 "1980 Survey of Public Perceptions on Highway Safety," DOT-HS-805-702 Automated Services, Inc., September 1980, p.45.

trapped in car during accident," and "doubt value of safety system" are not likely to be overcome by automatic belt systems but instead may be amenable to solution through educational programs.

In 1977, General Motors funded a research project conducted by Market Opinion Research (MOR)[13] to determine what factors affect seat belt usage and to devise strategies to increase seat belt usage. The MOR Study found that the most significant factors affecting belt usage, in their order of most frequent occurrence, are:

1) Attitude - Overall feelings about necessity of using belts, including (misplaced) fear of being trapped by belts during an accident.

2) Interaction - Driver or passenger asks them to wear belts. The respondents also stated that when the source of encouragement was more remote (media campaign), it was less compelling.

3) Comfort and Convenience - MOR concluded that although inconvenience is a significant complaint (about one-third of the individuals so complained), it does not generally affect the decision either to begin using belts or continue their use. Comfort and convenience are more secondary than primary factors. However, freedom of movement is a characteristic that can lead to increased use.

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13 "An Analysis of the Factors Affecting Seat Belt Use, "Market Opinion Research, 1977.

4) Belt Design and Car Size - The smaller cars have higher usage. The more complex the belt system is, the less it is used; the more freedom of movement it allows, the more often it is used; the more severe the warning system (starter interlock, continuous buzzer, 4-8 second buzzer, light), the higher the rate of disconnect; however, these coercive devices result in higher usage rates.

5) Events - People wear belts more often in adverse weather; people try belts more often at the time of a new car purchase and during driver training than at other times. Those who develop the habit of attaching belts, as part of a check-off system to start the car, habitually wear them.

6) Demographic Characteristics - A composite sketch of the typical user reveals a person who is married, with a high education level, and in a high income range.

MOR found belt usage similar to that found in the studies conducted for NHTSA -- 17% confirmed belt users, 40% moderate belt users, 43% non-users. MOR believes that at the high end of the range, all moderate belt users could become confirmed users -- making total usage 57%.

Although MOR did not find comfort and convenience of major importance, an SAE paper[14] which was based on the MOR study, states that "the comfort and convenience of the belts, or other safety systems, is the key in determining the use of that system."

Another outcome of the MOR study is that for non-users of belts, the most important factor relating to seat belt use is a "new car." This suggests that people might try the seat belts in a new car.

2. Detachable Automatic Belts

As discussed in the October 1981 Analysis,[15] the Department does not have data which can be used to precisely predict detachable automatic belt usage. The limited data available were gathered in three ways -- (1) observation of on-road usage, (2) usage from accident reports, and (3) telephone surveys.

a. Observed Usage

Detachable automatic belts were installed in approximately 390,000 1975-1982 model year VW Rabbits. In 1983, when automatic belts were marketed by VW as an option rather than standard equipment, fewer than 4,000 Rabbits were sold with the automatic system. A total of 10,000

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14 "A Comparative Analysis of Factors Impacting on Seat Belt Use," Timothy J. Kuechenmeister (GM), Andrew J. Morrison (MOR) and Mitchell E. Cohen (MOR), June 11-15, 1979, SAE 790687.

15 "Final Regulatory Impact Analysis, Amendment to FMVSS No. 208, Occupant Crash Protection, Rescission of Automatic Occupant Protection Requirements," NHTSA, October 1981.

1978/1979 GM Chevettes were sold with detachable automatic belts. The 1980 Chevette was equipped with a non-detachable belt and will be discussed in section 3. Goodell-Grivas, Inc. observes and records seat belt usage data for NHTSA in 19 cities. The most recent data, collected over the May-October 1983 period, show the following results:

TABLE V-4

BELT USAGE DATA-1983

	Automatic Belt		Manual Belt	
	Usage	Observations	Usage	Observations
VW Rabbit	74.9%	398	30.6%	1,092
Chevette	82.4%	17	15.0%	1,315

The preceding table indicates that VW Rabbit drivers are using their automatic belts about 75 percent of the time and Chevette drivers about 82 percent. However, the number of Chevette observations is too small to be considered reliable and also may include some observations of 1980 MY vehicles with the non-detachable belt system. Table V-5 combines data from all observations from November 1977 to October 1983. Data for 1982 and earlier years were collected by Opinion Research Corporation. The aggregated data suggest that VW Rabbit usage may have fallen off approximately 5% in recent times from the six year average of 80%. Chevette usage exhibits the opposite trend with recent usage being 15% higher; however, it must again be pointed out that the recent data are very limited. While even the combined Chevette data contain too few observations to draw precise usage estimates, the 95% confidence bounds being 54 to 83% usage, usage rates within this confidence interval are from four to six times the manual belt usage rate of 14 percent, indicating that the automatic Chevette system substantially increased usage.

TABLE V-5

BELT USAGE DATA-1977-1983

	Automatic Belt		Manual Belt	
	Usage	Observations	Usage	Observations
VW Rabbit	80%	1,343	32%	3,380
Chevette	70%	43	14%	4,691

In order to ascertain any change in automatic restraint usage as vehicles age, observational data on restraint usage in VW Rabbits were collected by model year from November 1980 to October 1982 (Table V-6).

TABLE V-6
USE OF RESTRAINTS IN VW RABBITS[16]

	Automatic		Manual		
MY	Observation	% Usage	Observation	% Usage	Difference
75	6	50.0	75	28.0	22.0
76	27	70.4	101	25.7	44.7
77	41	87.8	109	22.9	64.9
78	77	87.0	158	24.7	62.3
79	83	89.2	190	27.9	61.3
80	97	84.5	192	30.2	54.3
81	63	90.5	97	24.7	65.8
82	4	100.0	16	31.3	68.7

Table V-6 indicates that the automatic belt usage rate remains relatively constant and at a high level for perhaps the first 5 years of vehicle use. (The midpoint of the observation period was November 1981.) The data suggest that usage tapers off after roughly the 5 year mark, which may

16 NHTSA tabulation based on data collected November 1980-October 1982 by Opinion Research Corporation; reference: "Restraint System Usage in the Traffic Population," ORC, May 1983, DOT-HS-806-424.

partly reflect the attitudes of second or third owners, but the number of observations is too small for the early model years to reach a firm conclusion in this regard. There is no known reason, however, why usage would drop dramatically in the sixth year or so.

The automatic restraint system usage rates discussed above cannot be considered rates likely to be achieved for detachable automatic belts in the national fleet of vehicles for the following reasons: 1) both the VW system and the MY 1978-79 automatic belt-equipped Chevettes had ignition interlocks, which have been shown to greatly increase usage. The Department cannot require ignition interlocks and it is unlikely that vehicle manufacturers would voluntarily include them; 2) VW owners appear to be atypical regarding seat belt usage judging by their manual belt usage rate of 32%, which is more than twice as high as the observed fleet average usage. However, this does not obviate the fact that features of the automatic system itself that brought about substantial increases in usage over manual belt rates, might increase usage in other vehicles as well, although automatic belt usage likely would not be as high as in Volkswagens; 3) both cars were subcompacts, which have higher usage than larger cars; 4) some Rabbit and Chevette owners opted for (i.e., voluntarily purchased) the automatic belt, although as discussed below, the restraint system appeared to play only a minor role in the purchase decision (page V-19).

Another possible source of data which might help predict the usage of detachable automatic belts is a study conducted in 1978-1979 by General Motors. This study examined the usage rates of several different types of restraint systems in rental cars at a Florida airport. In this survey, GM fitted ninety Chevette rental vehicles with five different restraint systems and an onboard electronic monitor to record belt use by the driver. The five restraint systems included three two point automatic systems, one of which had an interlock, and two manual systems. The results of this study are shown in the following table:

TABLE V-7
CHEVETTE BELT RESTRAINT SYSTEM USE STUDY
FINAL DATA

Description	Warning System	Automatic Shoulder Belt Use Rate	Manual Belt Usage Rate	Ignition Starts
1. Auto with interlock	Continuous Light -- Shoulder Belt	74%	15% (Manual Lap Belt)	13,600
2. Auto w/o interlock	Continuous Buzzer -- Shoulder Belt	57%	12% (Manual Lap Belt)	14,200
3. Auto w/o interlock	Continuous Light -- Shoulder Belt	23%	13% (Manual Lap Belt)	13,200
4. Manual Three Point	Continuous Buzzer --	--	28% (Lap/Shoulder Belt	13,160
5. Manual Three Point	Production 4-8 Second Light and Buzzer	--	13% (Lap/Shoulder Belt)	13,450
			TOTAL:	67,610

System No. 3 consisted of a 2-point, detachable automatic belt and continuous light without an ignition interlock. This system had a usage rate of 23 percent. System No. 1 was the same belt design except that it came equipped with an interlock. This system showed a 74 percent usage rate. Thus, it may be inferred that the interlock added 51 percentage points to the usage rate. Since the 74 percent usage rate is similar to that observed in Rabbits, it could be construed that it is the interlock, and not the automatic feature, which predominantly accounts for the high belt usage in those cars. Although telephone survey results for the 1980 Chevettes, which do not have an ignition interlock, show usage rates of 70 percent, the 1980 Chevette system was not detachable.

Because this survey measured only rental vehicles, results may not be indicative of the usage for privately owned vehicles. For example, long term defeat measures, such as physically removing the system's automatic capability, would not be reflected in the survey. Also, some drivers in the survey may have accepted the automatic systems temporarily, but might remove them from their personal vehicles or disable the warning and interlock features. For these reasons, the GM survey seems to be at best an indicator of the effect of automatic belts and interlocks.

Professor William Nordhaus in a comment to the docket asserts that the Chevette rental car survey contains three basic flaws -- 1) the lack of public documentation on survey methodology and execution, 2) his understanding that participants in the survey were informed that they were involved in a study of seat belt usage, bringing into play the so-called Hawthorne effect which may change participant behavior, and 3) his concern over whether the rental agency took suitable steps to ensure that all belts were attached before a new customer used a car. The agency has requested clarification of these points from GM. GM stated that agreement was reached with the rental company that the automatic belts would be attached for each new customer, but documentation related to the Hawthorne effect or the overall survey methodology and execution has not been provided to the Department.

b. Usage in VW Rabbits Involved in Accidents

What the agency believes are the best and most recent data on seat belt usage of accident involved VW Rabbits are reported in Table V-8. These data, collected for NHTSA by the Highway Safety Research Center of the University of North Carolina, have not previously been published.

TABLE V-8
VW RABBIT RESTRAINT USAGE IN ACCIDENTS

	Automatic		Manual		Difference
State	Usage (%)	No. of Observations	Usage (%)	Number of Observations	in Usage (%)
New York 1975-82	52	3,162	26	8,939	26
North Carolina 1975-83	48	2,205	17	4,745	31
Maryland 1975-82	63	1,833	31	4,313	32
Colorado 1975-79	50	457	27	1,386	23
Average/Total	53	7,657	25	19,383	28

There is considerable difference between the observed usage of VW automatic belts of 80%, as shown in Table V-5, and the usage found in VW's involved in accidents reported above (53%) (also, in manual belt usage, 32% vs. 25%). This may be due to a number of reasons:

1) People who detach or otherwise deactivate their automatic belts may be less safety conscious and more likely to be involved in crashes; thus, they may be over-represented in the sample.

2) Since the accident data used are state data, which are typically recorded after the fact by police, they may not accurately reflect actual usage. There is no evidence to suggest, however, that an inherent bias was entered that would affect the difference between the automatic and manual usage. In fact, an analysis made on cases listing usage as "unknown" shows no bias between the two systems.

3) The observed usage could be too high. While there is no compelling reason to question the accuracy of the observed usage (since it was recorded by personnel specifically trained for the task), the observational data were recorded in 19 cities but do not cover rural area usage, which might be somewhat lower. It appears highly unlikely, however, that omission of rural area usage from the observational data accounts for the large differences in the observational and accident usage data.

c. Telephone Surveys

Two telephone interview studies were conducted by Opinion Research Corporation[17] about automatic belt owner usage and attitudes in GM Chevettes and VW Rabbits. One of the studies covered MY's 1978 and 1979 and the second covered MY 1980 vehicles. The VW Rabbit system is a 2-point system

[17] "Automatic Safety Belt Systems Owner Usage and Attitudes in GM Chevettes and VW Rabbits", Opinion Research Corporation, May 1980 and February 1981, DOT-HS-805-399 and DOT-HS-805-797.

with a knee bolster and a starter interlock, anc did not change in MY's 1978-1980. In MY's 1978 and 1979, the GM Chevette system was a two-point automatic shoulder belt with a knee bolster, a starter interlock and a manual lap belt. However, in MY 1980, the Chevette design was changed to a 3-point automatic lap shoulder belt. The MY 1980 Chevette design was coercive in that it was basically non-separable. However, it did not include a starter interlock. All three of these systems included an emergency release button. In the case of the VW Rabbit and 1978-79 Chevettes with the 2-point system, the release button fully disconnected the belt. However, with the starter interlock, the belt must be reconnected to start the car. In the case of the 1980 Chevette, the release button only disconnected the lap belt portion of the 3-point belt, leaving an elongated shoulder belt still connected, which would offer little safety value. Since the car did not have a starter interlock, the lap belt could remain disconnected.

Usage of these belt systems compared to manual belt systems in the same models, according to the telephone surveys, is shown in the following table. While automatic Rabbit and Chevette usage from the telephone surveys is in the range of observed usage, the manual system usage in both telephone surveys is higher than currently observed usage.

TABLE V-9

	MY's 1978-79 Percent who say they wear safety belt always or almost aways	MY 1980 Percent who say they wore safety belt the last time	Observed Data from ORC and Goodell-Grivas Studies
Automatic Rabbit	89%	89%	81-90%
Manual Rabbit	46%	48%	26-36%
Automatic Chevette	72%	70%	60-82%
Manual Chevette	34%	31%	11-15%

Factors which might explain why Rabbit owners use their belts more frequently than Chevette owners as well as a number of other findings of the surveys, are outlined below:

1) Rabbit owners typically have higher education levels and earn more money. These demographic characteristics have been positively correlated with usage.[18] This is also shown by the higher usage of manual belts by Rabbit owners.

2) More Chevette owners than Rabbit owners found the automatic belts inconvenient and/or uncomfortable.

[18] Opinion Research Corporation, May 1980, Ibid., pp. 50-53. A similar conclusion was reached in the Market Opinion Research Survey -- see page V-8.

3) In the MY 1978-79 models, 10% of the 2-point belt Chevette owners and 11% of the Rabbit owners had defeated the interlock system. In the 1980 models, 22% of the 3-point belt Chevette owners and only 5% of the Rabbit owners had removed the automatic belt or "fixed" it so that it could not be used.

4) When asked what type of restraint system the owner would like if purchasing another new car, the owners answered:

	MY's 1978-79		MY 1980	
	Automatic Chevette Owners	Automatic Rabbit Owners	Automatic Chevette Owners	Automatic Rabbit Owners
Prefer automatic	41%	80%	44%	74%
Prefer Manual	49%	12%	4[illegible]%	20%
Other/no opinion	10%	8%	7%	6%

5) The restraint system seems to play a very minor role in the purchase of a car. Only 5% of MY 1980 Chevette owners and 12% of MY 1980 Rabbit owners specifically requested the automatic belt at the time of purhase. Of the MY's 1978-79 owners, 55% of the Chevette and 37% of the Rabbit owners did *not know they were getting* the automatic belt at the time of purchase. These numbers declined somewhat in MY 1980 when 37% of Chevette owners and 25% of Rabbit owners were not aware that their cars were equipped with automatic restraints. Asked why they decided to buy a car with automatic belt systems, the MY 1980 owners replied:

	Automatic Chevette	Automatic Rabbit
Only car available with all the other options I wanted.	38%	39%
Only model available for immediate delivery.	19	17
Liked the automatic belt.	12	23
Gave discount because of belt system.	3	-

Belt usage by those who knew at the time of purchase that their car had an automatic belt was higher than for those who did not know. For the Rabbit, usage was 90% for those who knew and 85% for those who did not know. For the Chevette, the figures were 74% and 62%, respectively. While automatic belt purchasers who were not aware that their cars were so equipped are similar to purchasers of mandated automatic restraints, the use-inducing systems on the above cars are not expected to be widely included in future models, particularly the interlock system. Thus, comparisons between these usage rates and what can be expected for all cars need to be made carefully.

6) Another question asked was whether the MY 1980 owners wore seat belts in their other cars or their previously owned car the last time they drove. Only 25% of the automatic Chevette owners stated that they used their manual belts the last time they drove another car, while 33% of the automatic Rabbit owners claimed they used their manual belts the last time they drove another car. Thus, either the automatic nature of the belt, the

use-inducing features, and/or simply the "newness" of the vehicle greatly increased belt usage, and our data do not permit us to separate the contributions of the three factors.

7) Sixty-seven percent of MY 1980 Rabbit owners said that if there were no interlock they would use the belt, 25% would probably not use it, and 7% would never use it. This can be compared to the owners' first impressions and impressions after they had owned the car for a while:

	First Impression		Later Impression	
	Automatic Chevette	Automatic Rabbit	Automatic Chevette	Automatic Rabbit
Favorable	39%	61%	49%	77%
Unfavorable	54	32	44	18
No opinion	7	7	7	5

Of the Rabbit owners, 61% were favorably impressed when they first tried the system. This is close to the 67% that said they would use the restraint even if it did not have an interlock. The Chevette owners had a lower percentage with a favorable first impression.

Telephone survey data indicate that there is some decrement in usage of automatic belts over time. Owners of MY 1978-79 Chevettes, who participated in a 1979 survey, were called back in 1981.[19] Their reported usage was lower than they had reported in 1979.

[19] "Automatic Safety Belt Systems: Changes in Owner Usage over Time in GM Chevettes and VW Rabbits," Opinion Research Corporation, August 1981, DOT-HS-806-058.

	Reported Usage		
	1979	1981	Percentage Point Change
MY 1978 Rabbits	89.1%	83.0%	-6.1
MY 1978-79 Chevettes	73.9%	62.8%	-11.1

Reported Rabbit belt usage declined 6.1 percentage points over the two years, an average of 3.0 percentage points per year. The reported decrement in Chevette belt usage was larger, 11.1 percentage points over the two years or an average of 5.5 percentage points a year. Note that this reported decline in automatic belt usage over the 2-year period does not agree with on-road observational data shown in Table V-6, which indicates that automatic belt usage in VW Rabbits did not change as the vehicles aged over the first five years of use.

Surveys in 1979 and 1980 by Teknekron Research, Inc., and Automated Services, Inc., respectively, asked licensed drivers what they thought of the idea of automatic belts in the next cars they purchased. The responses were as follows:

TABLE V-10

PUBLIC OPINION OF AUTOMATIC BELTS

RESPONSE	1979 %[20]	1980[21]
A Great Idea	38.0	45.3
Tolerate	25.0	29.1
Disconnect	32.3	21.9
Other	1.2	3.8
Don't Know	3.5	-

These surveys indicate a general willingness to try automatic belts, but they also indicate a hard-core non-user group (32.3% and 21.9% said they would disconnect the system in 1979 and 1980, respectively).

3. Non-Detachable Automatic Belt

The agency has usage data on one non-detachable automatic belt system, the Toyota motorized system:

[20] "1979 Survey of Public Perceptions on Highway Safety," Teknekron Reksearch, Inc., July 1979, DOT HS-805-165, p.44.

[21] "1980 Survey of Public Perceptions on Highway Safety," Automated Services, Inc., September 1980, DOT HS-805-702, p. 51.

Toyota Motorized System

On-Road		Telephone and Mail	
Observations	Percent Usage	Survey Responses	Percent Usage
203	96	755	92

Two hundred and three on-road observations were recorded with 96 percent usage.[22] Telephone and mail surveys found 92 percent usage for 755 respondents.[23] The agency does not believe that these Toyota usage data can be used to estimate usage of non-detachable belts for the entire fleet because of the voluntary aspects of purchasing the automatic belt cars and because this motorized system would probably not be used by many manufacturers due to its expense.

While the MY 1980 Chevette automatic restraint system, which disconnected at the lap belt portion of the 3-point belt leaving an elongated shoulder belt, might be considered a non-detachable belt, the agency does not have any observed usage data on this system. A telephone survey found 70 percent usage for 1,002 respondents.[24]

22 "Safety Belt Usage Among Drivers," Opinion Research Corp., May 1980, DOT HS-805-398; "Restraint System Usage in the Traffic Population," Opinion Research Corp., May 1983, DOT HS-806-424; "Progress Report on Restraint System Usage in the Traffic Population," Goodell-Grivas, Inc., November 1983.

23 "Automatic Safety Belt Usage in 1981 Toyotas," JWK International Corp., February 1982, DOT-HS-806-146.

24 "Automatic Safety Belt System Owner Usage and Attitudes in GM Chevettes and VW Rabbits (1980 Models)" Opinion Research Corp. February 1981, DOT-HS-805-797.

It is possible that the usage rates of automatic belts with interlocks may be similar to those of non-detachable automatic belts. Although there are significant differences in both the physical design and the nature of the usage inducement in these systems, they are similar in requiring considerable effort on the owner's part in order to defeat their automatic protection features. However, as previously discussed, the available surveys that examine usage of interlock systems (GM survey and VW Rabbit usage data) are not representative because they are implicitly biased since they represent mostly persons who are more than typically safety conscious, or persons who do not own the sampled vehicles. Therefore, usage data on existing automatic belt systems with an interlock should not be considered indicative of future usage rates for non-detachable belts.

The GM rental car study does indicate that more stringent use-inducing systems will result in higher usage rates. For example, the most stringent system (System 1), which included a starter interlock, had a usage rate that was 30 percent (17 percentage points) higher than the second most inducive system (System 2), which had only a continuous buzzer. The buzzer system was, in turn, nearly 150 percent (34 percentage points) higher than the least inducive automatic belt system (System 3), which had only a continuous light. The interlock system (System 1) was a full 51 percentage points higher than the least inducive automatic system (System 3), as mentioned earlier. As discussed above, some issues have been raised on the methodology of this study.

B. Restraint Usage Level Estimation

In this section, restraint usage levels for the calculation of benefits are estimated. The available data do not permit a precise estimate of future automatic seat belt usage rates; therefore, an estimate of a lower and an upper usage boundary to establish a range of expected usage for automatic seat belts is developed. The actual future usage level is expected to fall at some point within the estimated range and not at either extreme. An air bag readiness factor is also estimated.

1. Automatic Seat Belts

A range of possible levels of usage of automatic seat belts will be calculated based on all the data available to the agency on observed on-road usage of manual belts, self-reported manual seat belt usage, and attitudes on seat belt usage. In addition, approaches are employed to estimate usage based on automatic and manual seat belt usage data from telephone surveys, on-the-road observations, and accident reports.

The first approach for estimating a range of possible automatic seat belt usage is to consider observed on-road usage. The 1983, 19-city, observed driver manual belt usage rate of 14.0% (Table V-1) could be accepted as the minimum level of usage of automatic belts to be expected. As discussed below, however, other information supports a somewhat higher lower bound for automatic belt usage.

A second approach is to look at the results of surveys on self-reported manual seat belt usage to gauge occupants' actual practices regarding belt usage. Table V-2 presents the results of 8 surveys on manual seat belt use. Based on the table, manual seat belt users can be segregated into those who say they use belts always or almost always, those who say they never or almost never use belts, and those that fall somewhere in between. "Always or almost always" has a range of 16-24 percent and averages 21 percent. This is fairly consistent with the 17 percent confirmed belt users found in the 1977 Market Opinion Research study discussed above. However, these figures are higher than actual usage rates recorded in roadside observations in 19 cities over the period, which ranged from 11-14 percent (Table V-1). One interpretation would be that while respondents apparently overstate their actual belt use, a fact documented by Waller and Barry as mentioned above, in their own minds they consider themselves to be belt users. Such an interpretation would suggest a lower boundary on automatic belt use of approximately 20 percent, with some certainty that at least this percentage of occupants would use automatic belts.

The percentage of occupants who never buckle up might serve to help approximate the percentage of hard core non-users, those who likely would not use detachable automatic belts. Table V-2 reports a percentage of respondents in the six surveys who say they never or almost never buckle up ranging from 30-59 percent, with an average of 48 percent. In three of the six surveys, the 1978 Hart (56%), the 1982 Lawrence Johnson (39%), and the 1984 McGinley survey (30%), this response means "never" or no use of belts. Two additional surveys reported by Newport and Tarrance (1981) and Tarrance and Associates (1983) showed 40 percent and 33 percent "infrequent" users, respectively. The 1982 Lawrence Johnson survey response was also classified into frequent, sometime, and infrequent users, with 41 percent being classified as infrequent users. The foregoing suggests that about 30-40 percent of vehicle occupants could be classified as non-users of manual belts. This is reasonably consistent with the 43 percent non-users found in the 1977 Market Opinion Research study. Some unknown proportion of these manual belt non-users could become users of automatic belts, since they would have the convenience of not having to buckle up. As shown in Table V-10, 27 percent of the licensed drivers surveyed (average of the 1979 and 1980 surveys) said they would disconnect automatic belts. This suggests that perhaps 5-15 percent (30%-40% less 27%) of those who never wear manual belts might wear automatic belts.

A third approach in attempting to gauge future automatic belt usage is to look at the reasons people give for not using manual belts. Table V-3 provides results of two surveys sponsored by NHTSA on the subject. Interviewers asked both seat belt users and non users for reasons for not wearing belts. The number of respondents who reported no reasons for disliking or not using belts, an average of 15.5 percent for the two surveys, is according to one of the surveyers, Teknekron Research, Inc., probably the true indicator of how many people in the sample wear their safety belts, although it cannot be proven.

An indicator of hard core non-users who would be most unlikely to use a belt system, including an automatic, detachable system, is the percentage stating as the reasons they do not want to use manual belts (1) they don't want to be restrained, (2) they are afraid of being trapped in a car during an accident, or (3) they doubt the value of belts as a safety measure. Following is the tabulation of these responses:

	1979	1980	Average
"Don't want to be restrained"	7.7%	8.8%	8.3%
"Afraid of being trapped in car during accident"	10.7%	11.0%	10.9%
"Doubt value as safety measure"	4.5%	5.8%	5.2%
	22.9%	25.6%	24.2%

Twenty four percent of the respondents gave reasons for not using manual belt systems that would also pertain to automatic belt systems. This indicates that an upper boundary of automatic belt usage would be approximately 76 percent. As far as overall belt usage expectations are concerned, the pertinent question is what proportion of the remaining approximately 60 percent who are neither present belt users nor established hard core non-users might be induced or compelled by features of automatic belt systems into using them. This suggests that this portion of the population could be positively influenced toward increased belt usage by effective public information and education programs and improved belt designs.

Reasons for not wearing belts that could be negated by the automatic belt systems are " don't want to be bothered, lazy, forgetful" (17.8%) (Table V-3). If the problem of being bothered, lazy and forgetful were the only reason for this 17.8 percent of the people not buckling up. we could derive an approximate lower bound for automatic belt usage of 33 percent (15.5 percent with no reason (users) plus the 17.8 percent who said they did not want to be bothered or were lazy or forgetful). However, we do not know how many of the 17.8 percent might also have other reasons for not buckling up which would preclude them from using automatic systems as well. Therefore, the most that can be said is that a lower usage rate bound would fall within the 15-33 percent range.

While the analysis points to a lower usage boundary of 15-33 percent, actual usage would probably be above this limit. It is likely that some of those who found manual belts uncomfortable (14.4%) or inconvenient to use (16.2%) will find that these problems do not exist with automatic belts. A 1976 survey of owners of 1975 Volkswagens, including 2,196 with automatic systems and 561 with manual systems, asked respondents to relate their experience with specific comfort and convenience problems associated with automatic and manual belt systems. Table V-11 shows the percent of persons by type of belt system who indicated they have experienced the various problems. The right hand column indicates the extent to which particular problems were more prevalent in Volkswagens with manual belts than with automatic belts. The automatic system was superior in all areas of comfort and convenience shown relating to the belt system itself. The obvious inconvenience associated with the automatic belt system is that of getting in and out of the car. The experience and opinions of owners of both types of belt systems indicate that some, perhaps a substantial number, of those who do not use manual belts because they are inconvenient and uncomfortable will use automatic belts because they find that these problems no longer exist or their severity is significantly reduced. Other data indicating

TABLE V-11
PERCENT WITH PROBLEM[25]

ISSUE	AUTOMATIC	MANUAL	DIFFERENCE ADVANTAGE-AUTOMATIC OVER MANUAL
Jewelry Lost, or Damaged	10	14	4%
Belt Falls off Shoulder	10	19	9
Belt Hard on Clothing	16	36	20
Belt Rubs on Face or Neck	19	42	23
Belt Exerts Pressure on Chest	19	39	20
Belt Chafing or Rubbing Chest	23	38	15
Belt Hinders Reach for Glove Compartment or Controls	25	43	18
Padded Knee Panel (Auto)	16	--	-16
Belt Interferes With Entering Car (Auto)	37	--	-37
Belt Interferes With Exiting Car Auto	38	--	-38
Fastening or Buckling Belt (Manual)	--	38	38
Belt Retractor Locks When Buckling (Manual)	--	42	42
Belt Interferes With Entering Back Seat (Manual)	--	50	50
Belt Attachments Inaccessible (Manual)	--	44	44

that automatic belts are more comfortable and convenient than manual belts are presented in Chapter XI.

These findings on the attitudes of Rabbit owners are not supported, however, by the results of the survey of Chevette (and Rabbit) owners reported above (p. V-19). Forty nine percent of the owners of MY's 1978-79

25 "Passive vs. Active Safety Belt Systems in Volkswagen Rabbits: A Comparison of Owner Use Habits and Attitudes;" Opinion Reasearch Corporation, August 1976, DOT-HS-801-958.

Chevettes with automatic belts and 49 percent of the owners of similar MY 1980 Chevettes said they preferred manual belts, compared to 41 percent and 44 percent, respectively, who preferred their automatic belts.

In conclusion, the attitudinal surveys discussed appear to support a lower boundary of automatic seat belt usage of 15-33 percent and an upper boundary in the area of 75 percent. The lower limit range is just above the observed driver manual belt usage rate of 14 percent and is consistent with the value of 20 percent drawn from self-reported usage data discussed in the previous section; the upper limit is 5-15 percentage points higher.

Another approach to estimating automatic seat belt usage entails investigation of usage rates for the relatively few automatic systems in place. Table V-12 presents data on automatic and manual belt use in VW Rabbits and Chevrolet Chevettes. The VW Rabbit accident data are the most recent and best available. Data on usage of the motorized automatic belt system in Toyota Cressidas are not included since, as stated previously, the agency believes that this luxury system is not likely to be typical of future systems.

In analyzing and interpreting the Rabbit and Chevette automatic restraint usage data in Table V-12, it should be understood that for reasons enumerated above (page V-11), the usage rates reported are higher, possibly substantially, than could likely be expected in a future fleet of automatic belt equipped vehicles. The high usage rate is principally attributable to the starter interlock on the VW system and on MY 1978-79 Chevettes, and to the greater propensity, especially for the Rabbit owners, to use seat belts.

It is readily noticeable that VW restraint usage rates for accident data are markedly lower than rates ascertained from surveys (discussed above, pages V-13 and V-14). Usage estimates based on accident restraint usage data are therefore shown separately. Estimates based on combinations of accident and survey restraint usage rates are also shown.

One method of using these data for estimating future use of automatic belts, which compensates for the high Rabbit and Chevette owner usage rates, is not to use the rates per se but to assume that the relationships between usage rates for automatic and manual belts for Rabbits and Chevettes will apply in the future to vehicles that currently do not have automatic belts. Column (c) of Table V-12 shows the percentage point increment of automatic belt usage over manual belt usage. One possibility is to take the increment that automatic belt usage is over manual belt and add it to the current fleet usage rate to estimate the future fleet automatic belt usage rate.

TABLE V-12
AUTOMATIC AND MANUAL BELT USAGE

On-Road Observations[26]	(a) Automatic Usage (Percent)	Number	(b) Manual Usage (Percent)	Number	(c) Differences in usage (a)-(b)	(d) Multiplier (a) / (b)
1977-83 VW Rabbit	80	1,343	32	3,380	48	2.5
1980-83 Chevette	70	43	14	4,691	56	5.0
Weighted Average observation data	80	1,386	22	8,071	58	3.6
Accident Data VW Rabbit[27]						
1975-82 New York	52	3,162	26	8,939	26	2.0
1975-83 North Carolina	48	2,205	17	4,745	31	2.8
1975-82 Maryland	63	1,833	31	4,313	32	2.0
1975-79 Colorado	50	457	27	1,386	23	1.9
Weighted Average Accident Data	53	7,657	25	19,383	28	2.1
Telephone Surveys[28]						
MY 1978-80 Rabbit	89	2,023	47	425	42	1.9
MY 1978-79 Chevette	72	1,002	34	216	38	2.1
MY 1980 Chevette	70	1,002	31	208	39	2.3
Weighted Average Telephone Surveys	80	4,027	40	849	40	2.0
Range of Values	50-89	-	14-47	-	29-56	1.9-5.0
Weighted Averages						
Rabbit Accidents	53	7,657	25	19,383	28	2.1
Rabbit, Observation & Surveys	85	3,366	34	3,805	51	2.5
All Rabbit	63	11,023	25	23,188	38	2.5
Chevette	71	2,047	16	5,115	55	4.4
Rabbit and Chevette Excl. Acc.	80	5,413	23	8,920	57	3.5
Overall Average	64	13,070	23	28,303	41	2.8

26 Opinion Research Corporation, "Safety Belt Usage Among Drivers," May 1980, DOT-HS-805-398, and "Restraint System Usage in the Traffic Population," May 1983, DOT-HS-806-424, collected November 1980 to October 1982; Goodell-Grivas, Inc., 1983 data.

27 Collected for NHTSA by Highway Safety Research Center, University of North Carolina, not previously published.

28 Opinion Research Corporation, "Automatic Safety Belt System Owner Usage and Attitudes in GM. Chevettes and VW Rabbits," May 1980 and February 1981, DOT-HS-805-399, DOT-HS-805-797.

For example, the average automatic belt usage increment for on-road observations, 58 percentage points, could be added to the observed 1983 driver manual belt usage rate of 14 percent to derive an estimated automatic belt usage rate of 72 percent. This has been termed the incremental approach.

Another possibility is to take the ratio of automatic belt use to manual belt use and assume that this relationship would hold for the future fleet of vehicles. This has been termed the multiplier approach to estimating future automatic belt usage. Column (d) of Table V-12 shows the ratios of automatic to manual belt usage rates. The multiplier (ratio) for on-road observations is 3.6. The multiplicative technique entails multiplying this factor by the current 19-city driver usage rate (14 percent) to derive estimated future use (3.6 x 14%≈50%). Table V-13 presents various estimates of future automatic belt usage based on the incremental and multiplier approaches applied to a manual belt usage rate of 14 percent, the observed, 19-city 1983 value for drivers of the on-road fleet.

As shown in Table V-13, the incremental approach for estimating future automatic belt usage produces a range of 42-71 percent with a value of 55 percent for all data; the multiplier approach produces a range of 29-62 percent usage with a value of 39 percent for all data. Note that the averages excluding accident data are higher, 71 percent usage

TABLE V-13
ESTIMATED FUTURE AUTOMATIC BELT USAGE RATES FROM APPLYING INCREMENTAL AND MULTIPLIER FACTORS[29]
(PERCENT)

Data Source	Incremental Approach	Multiplier Approach
Rabbit Accidents	42	29
Rabbit Observation and Surveys	65	35
All Rabbit	52	35
Chevette Observations and Surveys	69	62
Rabbit and Chevette Excl. Acc.	71	49
All Rabbit and Chevette	55	39
Range	42-71	29-62

applying the incremental approach and 49 percent applying the multiplier approach. This is not surprising given the markedly lower restraint system usage rates, especially automatic belt usage, in VW Rabbits involved in accidents.[30] Note that the above rates apply only to drivers; full front usage would be about 5 percentage points lower.

[29] Based on data in Table V-12; increments and multipliers applied to 1983 driver manual belt usage rate of 14 percent, based on observations in 19 cities.

[30] An estimate of automatic belt usage incremental and multiplier values can be developed for vehicles involved in fatal accidents using FARS data and employing a methodology presented in the preliminary regulatory impact analysis. (PRIA, footnote p. IV-16) Assuming manual belt usage for VW Rabbits of 30%, fatality effectiveness ranges of 35-50% for automatic belts and 40-50% for manual belts, and given that for VW Rabbits the FARS data indicate that the fatality rate for automatic belts is 19.3% less than the fatality rate for manual belts as used (PRIA, Table IV-5, page IV-15), incremental automatic belt usage over manual belts would be 33-53 percentage points. Thus, total usage of Rabbit automatic belts in fatal accidents would be 63-83%. Using a manual belt usage rate of 25% as found in accidents would result in an increment of automatic belt use over manual belt of 34-53 percentage points, nearly identical to the previous calculation. The calculated incremental usage is largely insensitive to the manual belt usage rate. In this latter example, usage of Rabbit automatic belts in fatal accidents would be 59-78%.

Table V-14 summarizes the estimates of automatic seat belt usage rates developed in the preceding analysis based on (1) on-road observations of driver manual belt use in all cars, (2) surveys in which respondents state their manual seat belt usage rates, (3) attitudinal surveys on why the driving public does not wear manual belts and on problems experienced with manual and automatic systems, and (4) on observational and telephone surveys and accident statistics on automatic and manual belt use. For the first three data categories, estimated bounds of automatic seat belt usage are presented, with the lower bound relating to confirmed or dedicated users and the upper bound reflecting that there will be a group of hard-core non-users of coercive automatic restraints. The lower and upper usage rate bounds that are estimated are not themselves likely to be the actual rates realized. Although probabilities have not been developed, actual usage is expected to fall within the range established by these lower and upper bounds. For the fourth category of data, a number of possible usage rates (not bounds), derived by employing the multiplier and incremental approaches, are presented.

From the data and information available, the agency has derived an estimated range of automatic seat belt usage of 20-70%. The estimate of 20 percent for the lower restraint usage boundary is based on the observed 1983 driver manual belt usage rate (14%), telephone and home-interview surveys on manual belt use (20%), and on reasons people give in surveys for not buckling up (15-33%). The estimate of 70 percent for the upper boundary is based on the estimates derived from surveys on manual belt use (60-70%) and surveys on why people do not buckle up (75%).

TABLE V-14
ESTIMATED USAGE RATES FOR AUTOMATIC BELTS
(PERCENT)

Data Source	Lower Bound	Multiplier Method[31]	Incremental Method[31]	Upper Bound
1983 Driver Manual Belt Use, on-road Observations in 19 Cities	14			
Telephone and Home-Interview Surveys on Manual Belt Use	20			60-70
Stated Reasons on Why People Don't Buckle up	15-33			75
Telephone Surveys		28	54	
On-Road Observations		50	72	
Accident Data		29	42	
Average-Telephone and Observation Data (Excl., Acc.)		49	71	
Average-All Data		39	55	
Low and High Point Estimates		28-50	42-72	

Overall Estimate: Lower Bound 20%
Upper Bound 70%

The estimates that are based on the multipier and incremental approaches are consistent with the 20-70% range. The two approaches are distinct methods for estimating usage, and each set of values should not be interpreted as deliniating a lower and an upper boundary.

[31] See Table V-12. The higher and lower figures are not to be considered ranges; both are point estimates of the usage rate.

Of the two boundaries, the lower is perhaps the most controversial. Based on the information before it, the agency believes that usage of automatic belts would be higher than for current manual belts and that a lower usage bound of 20 percent, as supported by the foregoing analysis, is reasonable. However, General Motors believes that both non-detachable and detachable automatic belt usage rates will fall to manual belt usage rates; increased usage will last only until the belt is disconnected the first time. In that case, usage would be below the estimated range. In its response to the SNPRM, GM estimated that automatic belts might increase usage by 5 percentage points - the comment did not indicate for how long. Honda feels that long-run usage of automatic belts may not be better than current manual usage, the key determinants being comfort and convenience. Ford believes that while the use of automatic belts will be higher than for manual belts for a period, reflecting increased usage by occasional manual belt users, over the long run usage of automatic and manual belts will be equivalent. Other manufacturers believe there will be little, albeit some, increase in usage. Chrysler feels that automatic belt usage will be less than 10 percent higher than manual belt usage.

On the other hand, the American Seat Belt Council believes usage of automatic belts will be 50 percent, roughly between the current observed rate for drivers of 14 percent for manual belts and 80 percent for in-use automatic belts. Professor William Nordhaus applies a usage increment for automatic belts of 33 percentage points in his calculations, based on the VW accident experience in the Fatal Accident Reporting System and NHTSA assumptions on restraint effectiveness that were published in the Preliminary Regulatory Impact Analysis. Adding this increment to the current driver manual belt usage rate of 14 percent results in an automatic belt usage rate of 47 percent for drivers. John Graham found that expert opinion varies on how much automatic belts would increase usage. His survey of 7 experts found that detachable belts would increase usage by 10 percentage points with an 80 percent confidence interval of 5 to 40 percentage points.

The critical difference between automatic belts and current manual belts--inertia--could increase usage substantially. Once an automatic belt is connected, it continues to function automatically until disconnected. The agency believes that inertia will increase automatic over manual belt usage but cannot estimate the amount. General Motors states, however, that the inertia effect of automatic belts can only be assumed until the belts are first detached. However, disconnecting belts does not necessarily mean that they will stay disconnected. Current occasional users may reconnect them, and the inertia effect would again be operational. Also, other occupants may reconnect them and leave them connected when they get out.

Usage rates could also be affected by use-inducing or reminder mechanisms such as a continuous buzzer, a 4-8 second buzzer, or a light. The American Seat Belt Council believes that a continuous buzzer could double usage and that buzzers, chimes, and lights could all increase usage; Volvo thinks that usage can be improved through a visual warning plus an audible signal consisting of a "ticking" sound that is no more annoying than the sound in turn signal systems; Volkswagen feels that a continuous buzzer might be as effective as an interlock. Ford, on the other hand, feels that while a continuous buzzer would induce some borderline non-users to use belts, driver irritation and counteraction to defeat the system could be expected. (A 4-8 second buzzer is required with current manual belts and is also required for automatic belts.) However, neither a continuous buzzer, nor an interlock system may be required by the agency.

An issue arises -- whether to establish different bounds for detachable and non-detachable belts. The difference between the two systems refers to the webbing release mechanism. The detachable belt has a push button "buckle release" which, when pressed, physically disconnects the belt. The non-detachable belt has a "spool release" mounted on the retractor to allow for emergency egress. When actuated, additional webbing is released from the retractor spool, but the belt cannot be completely separated. Thus far, the 1980 Chevette and Toyota Cressidas since MY 1981 are the only production vehicles that have been equipped with non-detachable automatic belts.

Numerous auto manufacturers, IIHS, two restraint system suppliers (Breed Corporation and American Seat Belt Council), a state agency, a consumer group and an individual provided comments on non-detachable belt usage and acceptance. A representative sampling of comments follows:

GM -- The public will not accept the coercive non-detachable belt as shown with the 1980 Chevette. Fear of entrapment and general annoyance would lead many hard core non-users to defeat non-detachable belts. While there would be an initial increase in usage, long term usage of either detachable or non-detachable belts would fall to manual belt usage rates.

Ford -- There is bound to be some adverse reaction to non-detachable belts due to fear of entrapment. Although initially higher, long range usage of non-detachable belts would eventually drop down to detachable belt rates, which would be equivalent to rates for manual belts.

Volkswagen -- Hard core non-users would find non-detachable belts more objectionable than detachable belts.

Honda -- Non-detachable belts would not be accepted by the public because of entry/exit problems, entrapment, and poor appearance. Hard core non-users will react adversely. In the short run, non-detachable belts would increase usage; in the long run usage is dependent upon comfort.

Nissan -- There would be no difference in the long run usage rates of detachable and non-detachable belts. Non-detachable belts would engender adverse public reaction.

Saab Scania -- 15-30 percent of the driving public may not have any belts after non-detachable belts are made inoperable.

Breed -- There will be significant levels of disconnect with non-detachable belts. European experience indicates 20 percent will not use belts.

American Seat Belt Council -- 10-20 percent are hard core non-users who will cut out non-detachable belts. This would result in enough irate people to provoke Congress to repeal the requirement.

Massachusetts Department of Public Health -- To maximize the usage of automatic belts, they should not be readily detachable.

Motor Voters, a consumer group -- the required installation of automatic belts, especially those designed to make disconnection difficult, would engender public reaction not merely to defeat the belts, but to defeat the entire rule.

Insurance Institute for Highway Safety -- The IIHS survey, which the agency believes does not yield valid results (see Chapter XI), indicates only 12 percent would damage a non-detachable belt.

John Graham -- A survey of 7 experts in the field found that non-detachable belts would cause substantial public irritation and ultimate rejection by Congress. A survey of 4 behavioral experts estimated that 55 percent of motorists would dismantle non-detachable belts. A fifth behavioral expert believed that Congress would outlaw non-detachable belts.

In summary, the docket comments indicate a diversity of opinion on differences in usage of detachable and non-detachable belts. Some commenters stated that detachable and non-detachable belts would provide the same level of usage. Others discussed the two belt systems separately, indicating that a detachable belt may increase the usage of occasional users, while the non-detachable belt might affect all but the hard core non-users. However, nearly all commenters indicated that non-detachable belts would engender adverse public reaction by at least the hard core non-users (10-20 percent of drivers) with possible ultimate rejection by Congress.

Another distinction made between detachable and non-detachable belts is in long term availability. If 10-20% of drivers cut out non-detachable belts, they will be unavailable to future owners or users of these cars. When they are sold and resold, the proportion of cars with cut-out belts would increase.[32]

The agency believes that some increment of usage should be imputed to non-detachable belts, since some effort would be required to deactivate the system. However, because the information available does not permit such precision, separate usage bounds for detachable and non-detachable belts are not estimated. Usage rates for future non-detachable automatic belt systems would probably be above usage rates for future detachable systems, with both rates falling within the estimated 20-70% usage range.

The effect of a starter interlock, which prevents a vehicle from being started if the belt is not attached, warrants further discussion because of its possible large impact on usage. Practically all of the information gathered on actual usage of automatic belts and incorporated into the foregoing analyses pertained to usage in VW Rabbits, and to a lesser extent, GM Chevettes. As discussed above, both of these cars had detachable belt systems with an interlock, except for the approximately

[32] Twenty-one states currently have periodic motor vehicle inspections which could counter this problem. Eight of these states already have safety belts on their inspection check list.

10,000 1980 MY Chevettes which had a non-detachable lap-shoulder belt system with no interlock. It would be difficult to argue that an interlock system, which prevents the car from being started if the belt is detached, does not increase usage. Volkswagen has stated to the docket that the interlock is the real use inducing factor and has advised against using the high usage rates of automatic systems with interlock in VW Rabbits to predict usage rates for fleets of other vehicles. And, as presented above, the Chevette rental car study showed a 51 percentage point higher usage rate for automatic belts with interlock (Table V-7). While restraint usage in rental cars may not be indicative of usage rates in private cars, and belts may not have been reattached after each rental, it nevertheless seems likely that much of the difference in usage is attributable to the interlock.

The only evidence that an interlock system is not the primary use inducing feature is the limited telephone survey data on usage in MY 1978-79 Chevettes with interlock (72%) and MY 1980 Chevettes with an automatic belt system without interlock (70%). (Table V-9) However, the MY 1980 system disconnected only at the lap belt portion of the 3-point belt leaving an elongated shoulder belt, which was in effect a non-detachable belt; it seems reasonable to presume that this characteristic increased usage. The agency believes that the interlock does increase usage and that the usage rates for the future vehicle fleet with detachable automatic belt systems without interlock would be lower than they would be with an interlock.

In view of the preceding and for reasons stated above, estimates of usage of automatic seat belt systems that are based on experience with systems with interlocks are likely higher, possibly substantially, than could be expected in a future fleet of vehicles equipped with automatic belt systems without interlock. Therefore, usage estimates that are presented above, which are based on the Rabbit and Chevette data, are probably higher than should be expected.

The actual usage rate to be realized in the future will of course depend on the many considerations discussed above, such as comfort and convenience and acceptance of the system's appearance, and on education programs to increase usage. National public informational and educational programs could be started before any law mandating automatic belts went into effect and continue thereafter. Such efforts could emphasize the safety benefits of wearing safety belts and highlight the fact that automatic belts are more comfortable and convenient to use than manual belts, a fact verified by numerous studies. Information could also be provided to overcome the concerns of those who report that they doubt the value of belts as safety measures and of those who say they are afraid of being trapped in their vehicles after an accident. The Department believes that such informational and educational programs would play a key role in increasing usage of automatic belts. The future usage rate will also depend on the automatic systems' proven on-road effectiveness in reducing deaths and injuries and the amount of publicity thereon.

2. Seat Belt Usage Under Mandatory Use Laws

This section discusses the potential usage of manual seat belts under state mandatory seat belt usage laws. It also examines various factors that could affect seat belt usage under mandatory usage laws and attempts to estimate a range of probable usage that might be expected under MUL's.

As discussed above, voluntary manual belt use by drivers in 19 major cities throughout the country in 1983, was about 14 percent, while usage by all front seat occupants was 12.5 percent. The extent to which mandatory use laws would increase these usage rates would depend on many factors, the most important being the number and the specific states that pass such laws, the provisions for enforcement and sanctioning for non-compliance in each state, the amount of publicity on enforcement activities, and the extent and quality of education and publicity on the potential benefits of seat belt use. For the purposes of this analysis, the usage rate is estimated at the national level and is based on the assumption that MUL's were universally adopted. (However, to a large degree, the considerations and relationships discussed here would also pertain to seat belt usage under MUL's in individual states). To the degree that MUL's would not be in effect in all states, national usage would, obviously, be less due to lower usage in states without MUL's.

Changes in belt usage rates in countries which have enacted MUL's might serve to gauge how much MUL's would increase usage in the United States. Table V-15 lists the 29 countries with MUL's. As shown, usage laws are in effect in six countries in Asia/Africa/Mid-East, 16 countries in Western

Europe (Iceland and Italy are the only countries of Western Europe that do not require belt usage), five countries in Eastern Europe, seven provinces of Canada, and the Commonwealth of Puerto Rico.

The most common program requirements and enforcement and sanction practices among these countries are summarized below:

Vehicles Covered: Typically passenger cars or cars and vans

Occupants Covered: Typically all front seat occupants

Exemptions: Typical exemptions are based on age, body size, and medical condition.

Enforcement: In two-thirds of the countries, when stopped for another purpose; in one-third either none or advice to buckle up by police.

Fine: In most countries (equivalent of) $10-$20; in a few, none or minimal; in one, up to $250.

Exceptions: Vary widely by country; in most countries, belt usage is not required in vehicles which are moving in reverse.

Table V-16 presents driver seat belt usage rates before and after MUL's went into effect in 17 countries for which such information is available. Usage data for Canada are not included in this table, but are shown and discussed separately below. The manner in which data were collected and the types of roadways and traffic conditions which were surveyed varied from country to country. As shown, usage rates ranged from 5 to 40 percent before MUL's went into effect, to 14 to 95 percent after; usage typically at least doubled and in some cases increased three times or more, depending on the initial usage rate. Based on Table V-16 entries, the average usage, for the 17 countries shown, was 23 percent before mandatory belt usage and 66 percent after -- an increase of 43 percentage points. Admittedly this is a rough calculation given the differences among countries in survey methods and categories of roadway and travel conditions for which seat belt usage data were collected. Nevetheless, this combination of data provides an indication of what usage might be under MUL's given a large number of unknown requirements and operating conditions for any future MUL programs.

TABLE V-15
Countries with Belt Usage Laws

1. Asia/Africa/Mid-East (6)

   Australia
   Israel
   Japan
   Malaysia
   New Zealand
   South Africa

2. Europe-Western (16)

   Austria
   Belgium
   Denmark
   Finland
   France
   Greece
   Ireland
   Luxemberg
   The Netherlands
   Norway
   Portugal
   Spain
   Sweden
   Switzerland
   United Kingdom
   West Germany

3. North America (2)

   Canada (Seven Provinces)
   Puerto Rico

4. Europe-Eastern (5)

   Bulgaria
   Czechoslovakia
   Hungary
   USSR
   Yugoslavia

Source: American Seat Belt Council, International Seat Belt and Child Restraint Laws, April 1981, and other sources.

TABLE V-16
CHANGES IN SEAT BELT USAGE RATES
UNDER MANDATORY USE LAWS[33]

Country	Effective Date of Law	Belt Usage Before	Belt Usage After
Australia	1-72	(1971) 30%	(1972-76) 73-87%
New Zealand	6-72	(1972) 40%	(1975) 89%
France	7-73	20-25%	(1979) 95% highways; 75% country roads; 50% night in cities; 35% day and night in built up areas
Puerto Rico	1-74	(1973) 5%	(1977) 14% (usage has risen to as high as 35% in intervening years)
Sweden	1-75	(1974) 22% streets	(1978) 75% streets
Belgium	6-75	(1974) 17%	(1976) 87% (Subsequent slow decline reported)
Netherlands	6-75	(1974) 11% urban; 24% rural	(1976) 58% urban; 75% rural
Finland	7-75	(1975) 30% highways on week-days; 9% urban traffic	(1975) 68% highways on week-days; 53% urban traffic
Israel[34]	7-75	6% rural	(1977) 70% rural (law applies to inter-urban travel only)

[33] Except as otherwise noted, the source of the information presented in the table was "Effectiveness of Safety belt Usage Laws, "Peat, Marwick, Mitchell & Company, May 1980, DOT-HS-805-490.

[34] "Patterns of Safety Belt Usage Following Introduction of Safety Belt Wearing Law," Hakkart, A.; Ziedel, D.; Technion, Israel Institute of Technology, June 1983.

Country	Effective Data of Law	Belt Usage Before	Belt Usage After
Norway[35]	9-75	(19/3) 13% urban 35% rural	(1980) 77% urban 88% highway
Denmark	1-76	25%	(1980) 70%
Switzerland	1-76 (repealed 10-77) 11/80 reenacted	(1975) 19% city streets 35% highways 42% expressways	(1977) 75% city streets 81% highways 88% expressways
West Germany	1-76	(1975) 55% autobahns 32% country roads 20% city roads 33% weighted average	(1978) 77% autobahns 64% country roads 47% city street 58% weighted average
Austria	7-76	(1975) 10% urban 25% rural	(1978) 20% urban 30% rural (not enforced
South Africa	12-77	(1976) 10%	(1978) 62%
Ireland	2-79	(1978) 20%	(1980) 45%
Great Britain[36]	1-83	40%	95%

Unweighted (by travel) average of rates entered on table:
Usage Before Law
23%
Usage After Law
66%

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[35] "Effectiveness of Safety Belts in Reducing Motor Vehicle Accident Trauma," Draft Report, Transportation System Center, U.S. Department of Transportation, June 1984.

[36] Department of Transport Press Notice 164 (U.K.) 5 April 1984.

The study from which most of the data included in Table V-16 were obtained concluded that the main factors that influence the frequency with which individuals wear their seat belts under MUL's are 1) the level of enforcement applied by police, 2) the natural propensity of individuals to be law abiding, and/or 3) the individuals' personal perspectives regarding their own safety.[37]

A second method for estimating what seat belt usage in the United States under MUL's might be entails reviewing the effects on usage of MUL's in the Canadian provinces that have enacted such laws. Given their geographical proximity to the United States, Canadians have many similar institutions, customs, lifestyles, and attitudes as Americans, and increases in seat belt usage resulting from MUL's in Canada might be a better basis for estimating American usage than looking at the worldwide experience. In addition, the Canadian government has conducted statistically sound belt use surveys in the provinces for several years and consequently reliable data on the effects of the MUL's are available.

Table V-17 presents driver seat belt usage data for six of the seven provinces that have passed MUL's. Usage rates before the effective dates of the laws in the respective provinces, as well as the 1983 rates, are shown. An MUL in a seventh province, Manitoba, went into effect in January 1984, and survey data on the effect on seat belt usage in that province have not been collected to date. Usage rates <u>before</u> MUL's went into effect for the six provinces with laws in effect in 1983 averaged <u>21 percent.</u>

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[37] "Effectiveness of Safety Belt Usage Laws," Peat, Marwick, Mitchell, and Company, May 1980, DOT-HS-805-490.

Usage rates for the same six provinces in 1983 averaged 61 percent, an increase of 40 percentage points under MUL's. Usage rates in 1983 for the four provinces that had no mandatory use laws average 15 percent, somewhat below the rate prevailing in the current MUL provinces before their use laws went into effect.

Under any MUL program, enforcement activities -- and to a great extent public information and educational (PI&E) programs -- are important parts

TABLE V-17
CHANGES IN DRIVER SEAT BELT USAGE IN CANADA
UNDER MANDATORY USE LAWS[38]

Province	Effective Date of Law	Use Before	Use In 1983
Ontario	1-76	23%[39]	60%
Quebec	8-76	18%[39]	61%
Saskatchewan	1-77	32%[39]	54%
British Columbia	10-77	37%[39]	67%
Newfoundland	7-82	9%	76%
New Brunswick	6-83	4%	68%
Manitoba	1-84	12%	12%
Averages weighted by Traffic Counts at Data Collection Sites:			
Provinces with Mandatory Use Laws			61%
Provinces with No Mandatory Use Laws			15%
Unweighted Average Usage Before Laws Passed (Excl. Manitoba)		21%	

38 "Road Safety Leaflet," Transport Canada, December 1983.

39 "The Effectiveness of the Canadian Mandatory Seat Belt Use Laws," Johah, Brian A., and Lawson, John J.; Road Safety Directorate, Transport Canada, December 1983. The rates shown indicate usage during the year prior to the effective date of the mandatory use laws. Usage generally increased during the 2-year period prior to the laws' effective dates.

of the effort to increase seat belt use. Any attempt to estimate usage under prospective MUL's in a given country based on the experience in another country(ies) must consider respective activities in these two areas, especially the enforcement area.

Studies on the effect of PI&E programs under MUL's were conducted by the Canadian Federal Government as well as by provincial governments. One study reported that PI&E programs increased the amount of public opinion favorable to seat belt usage and increased the public knowledge regarding the benefits of seat belt usage but had very little effect in increasing seat belt usage.[40]

However, experience in other foreign countries indicates that public information and media programs can be effective in improving belt usage rates. Notably, Great Britain ran several seat belt usage media campaigns in the 1970's and early 1980's. The first such program raised usage in the affected area from 14 percent to 29 percent over a 3 week period. However, when the advertising was withdrawn usage began to slip and was back to 22 percent after 3 months. Later campaigns were successful in raising usage to the 29-33 percent level. Above this level additional advertising appeared to make little or no impression. Extensive publicity was also used preceding the implementation of Great Britain's seat belt use law in January 1983. One thrust of publicity began at the end of September 1982, with national newspaper advertisements incorporating a clip-and-return coupon to obtain two informational leaflets. Posters were also printed and

[40] Peat, Marwick, Mitchell and Company, Op. Cit., findings from interviews with officials from the Provinces of Ontario and Saskatchewan.

distributed to local safety organizations along with the two informational leaflets. The second round of publicity began in early January using national newspaper advertisements and a national poster campaign. Upon implementation of the law, seat belt usage increased to approximately 95 percent, from a level of 40 percent prior to enactment of the law in August 1982, and has remained at that level.

In Canada, the seat belt law is generally enforced in conjunction with enforcement of other traffic laws and varies somewhat from province to province. A study to measure the effect of increased enforcement activities on belt usage was conducted in Ottawa from September 1979 through April 1980.[41] The number of citations issued increased 975 percent during the week of increased enforcement and dropped substantially over the next six months. During the period of increased enforcement, mass media publicity on the enforcement program, and educational programs explaining the benefits of seat belt use were conducted. Seat belt use went from a pre-demonstration rate of 58 percent to 80 percent during the period of increased enforcement and educational activity, then to 77 percent one month later, and down to 70 percent six months later.

Based on these studies, it appears that seat belt usage that would be achieved under MUL's in the United States would depend on the extent of enforcement, the severity of sanctions, and the amount and quality of mass media publicity and educational programs. The Department is currently undertaking numerous public informational and educational programs and

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41 "Effects of a Selective Traffic Enforcement Program on Seat Belt Usage," Jonah, B.; Dawson, N.; Smith, G.; Transport Canada; in Journal of Applied Psychology, 1982, Vol. 67, No. 1.

other promotional activities to increase voluntary seat belt usage. For example, increases are being sought through a number of comprehensive community-based programs currently being implemented across the country. These programs include the basic components of the Department's national campaign, such as face to face education through a variety of networks, the use of mass media programs, and incentive programs. Most of these activities to increase voluntary seat belt usage could be continued under MUL's as well. An incentive oriented program in Chapel Hill, North Carolina, produced an increase from a usage rate of 24 percent prior to the program to a peak of 41 percent; the usage rate was 35 percent 5 1/2 months after the project ended. In addition, usage could be affected by civil litigation penalties in which insurance payments associated with auto accident injuries would be reduced if seat belts were not being worn when the injury occurred.

Given the large number of unknowns associated with any future MUL programs that might be adopted by the states that could affect seat belt usage, especially the degree of enforcement and harshness of penalties for non-compliance, it is difficult to estimate a specific belt usage rate that would likely occur under MUL's; therefore, a range of usage is estimated. The most reasonable basis for estimating usage would appear to be the Canadian experience with MUL's, supported by the experience in 17 countries as presented above, and assume the same increase in usage would apply to the U.S. As discussed above, driver seat belt usage in the six Canadian provinces with MUL's (in effect in 1983) increased 40 percentage points over the pre-MUL rates. Assuming that other front seat occupants experience a similar increase in usage, i.e., a 40 percentage point increase over the 1983 rate of 12.5 percent for all front seat occupants, results in an estimate of usage under MUL's of 52.5 percent. This rate compares with an estimate of 55.5 percent derived by applying the 17-country, 43 percentage point increase under MUL's, which is felt to be less reliable.[42]

The foregoing suggests a best estimate of seat belt usage under MUL's of approximately 55 percent. It is noted, however, that the average seat belt usage rate of 66 percent in the 17 countries with MUL's falls above the 55 percent level. It is also noted that belt usage in the Canadian provinces with MUL's was 44 percent in 1980 and 47 percent in 1981, before increasing substantially to 56 percent in 1982 and 61 percent in 1983.[43] The foregoing instances of seat belt usage rates somewhat above and below the 55 percent level suggest that it would be appropriate to estimate a range of usage rather than adopt the point estimate of 55 percent. Acknowledging a high degree of uncertainty, the Department believes that an estimated range of seat belt usage under MUL's of 40-70 percent is reasonable.

[42] The multiplier method of estimating seat belt usage, which was discussed earlier in this chapter, would produce a usage estimate of 36 percent for front seat occupants (both the Canadian and 17-country experience produce multipliers of 2.9). However, it is felt that the incremental approach for estimating usage is more appropriate, since the estimate derived by employing that method produces an estimate more in agreement with the rates experienced under MUL's in other countries. The fact that voluntary usage in the U.S. is lower than was usage in other countries before their MUL laws became effective does not mean that usage under MUL's in the U.S. would be lower than in other countries. The Department believes that the degree of enforcement of MUL's is the key determinant of usage (and to a lesser extent public information and education) rather than the inclination of individuals to voluntarily use seat belts.

[43] Transport Canada, Op. Cit.

3. Air Bags

Air bags are not "used" per se; instead an air bag "readiness factor" is substituted for usage in the calculation of benefits. There are four subsets of the readiness factor: First, those cases in which an air bag has been deployed in an accident and has not been repaired prior to another accident; second, inadvertent deployments of air bags that are not repaired; third, the actual reliability of the air bag; fourth, those individuals who disable or dismantle the air bag for whatever reason (fear of deployment, philosophical reasons, etc.).

An estimate of the potential number of air bag cars in the total fleet being driven with the air bag unrepaired or otherwise inoperative can be estimated as follows:

a. Unrepaired Accident Deployments

If all cars had air bags, 0.8% of them would be in deployment accidents each year (see the Insurance Section (Section VII) for the derivation of this figure), and 36% of these cars would be repaired, or 0.29% of the fleet. In the long run, when all cars in the fleet have air bags, 1.2% of total vehicle exposure would occur with unrepaired air bags, assuming none of the air bags was repaired, calculated as follows:

Age	Exposure[44]		Cumulative Probability of Surviving Deployment		Total
1	.1811	X	.0029	=	.0005
2	.1511		.0058		.0009
3	.1326		.0087		.0012
4	.1183		.0116		.0014
5	.1058		.0145		.0015
6	.0924		.0174		.0016
7	.0782		.0203		.0016
8	.0620		.0232		.0014
9	.0460		.0261		.0012
10	.0325		.0290		.0009
Total	1.0000				.0122

The Department has no data with which to estimate the proportion of deployed bags that would be repaired. Assuming 38% of the air bags are not repaired (See the Insurance Section for assumptions leading to the estimate), 0.46% (.38 x .0122) of the car fleet would be without operable air bags.

b. Unrepaired Inadvertent Deployment

The Department knows of 16 inadvertent deployments over the lifetime of the 12,187 air bag cars. There may have been more inadvertent deployments that were not reported. Five of these deployments were on the road and may not happen with new cars because of safeguards built into the sensing systems utilized in the newer air bag designs. The remaining 11 deployments occurred mainly in vehicle servicing situations which may or may not occur as frequently with the new systems depending on their design, particularly

[44] Percent of vehicle miles travelled by age multiplied by scrappage rates.

the sensor locations. Assuming that a similar percent of inadvertent deployments would occur with future systems results in an estimated 0.0009 inadvertent deployments over the average car's lifetime. The agency has no data to accurately determine what percent of inadvertently deployed air bags would go unrepaired, although it is likely that inadvertent deployments in a service facility would be repaired by that establishment. If 30% of the air bags were not repaired, then an additional .03%(.0009x.30) of all car exposure would be without air bags due to owners not repairing the bags.

General Motors and Volkswagen stated that air bag systems should be designed to 99.999% and 99.9985% reliability, respectively, against inadvertent deployment. Using these design goals and assuming a 30% non-repair rate, car exposure without air bags resulting from inadvertent deployment would be 0.0003% or 300 cars in a 100 million car fleet.

c. Air Bag Reliability

The electronic and mechanical reliability of the air bag system is expected to be designed to high standards. Systems should be designed to deploy properly in crashes at least 99.99% of the time (General Motors and Volkswagen) leaving a 0.01% failure rate at most.

d. Owner Dismantling

Some commenters indicated that they would dismantle and/or remove an air bag from their vehicles. Without data to determine what percent of air bags would be dismantled, the Department assumes that perhaps 1-2% of all cars on the road would be so affected over the long run.

In summary, combining all four factors results in approximately 2% of all car exposure being without air bags in the long run -- resulting in an air bag readiness factor of 98%.

4. Belt Usage With Air Bags

Docket commenters brought forth three theories regarding belt use with air bags:

a) Belt use would decline because people would believe that the air bag gives complete protection. The Department believes that education may be able to overcome this knowledge gap, if it exists.

b) Belt use would remain the same -- those who wear belts now would continue to do so.

c) Belt use would increase -- because lap belt usage in the past was near 20% and the shoulder belt makes today's belts uncomfortable to some people, more people would wear a lap belt.

The Department does not know whether manufacturers would supply a lap/shoulder belt with the air bag (as Mercedes is doing) or a lap belt. It is possible that lap belt usage would be higher than lap/shoulder belt usage. On the other hand, people who are not in the habit of using belts might not change their habits simply because an air bag and lap belt replaced the lap/shoulder belt. In the absence of such data, the benefits calculations in the FRIA are based on the assumption that current belt usage will continue with air bags.

VI. SAFETY BENEFITS

In this chapter the estimated effectiveness of a restraint system when used (see Chapter IV), and the projected usage of that restraint system (see Chapter V) are combined numerically to estimate the number of lives saved and injuries reduced. The major results of this analysis are shown in Table VI-1.

TABLE VI-1

SAFETY BENEFITS
INCREMENTAL REDUCTION IN

	Fatalities			AIS 2-5 Injuries			
	Low	Mid-Point	High	Low	Mid-Point	High	AIS 1 Injuries
Air Bags Only	3,780	6,190	8,630	73,660	110,360	147,560	255,770
Air Bags With Lap Belts (12.5% Usage)	4,410	6,670	8,960	83,480	117,780	152,550	255,770
Air Bag With Lap/ Shoulder Belts (12.5% Usage)	4,570	6,830	9,110	85,930	120,250	155,030	255,770
Automatic Belts							
(20% Usage to	520	750	980	8,740	12,180	15,650	22,760
70% Usage)	5,030	6,270	7,510	86,860	105,590	124,570	172,120
Mandatory Belt Use Laws (in all States)							
(40% Usage to	2,830	3,220	3,590	47,740	53,440	59,220	82,510
70% Usage)	5,920	6,720	7,510	100,430	112,410	124,570	172,120

These estimates are annual benefits assuming full implementation. The low, mid-point, and high estimates are based on the effectiveness ranges. The mid-points are shown only for illustrative purposes. The calculated benefits are over and above those accruing from current levels of restraint usage (12.5%). Belt usage with air bags in the second and third cases on Table VI-1 is assumed to be at current levels of restraint usage (12.5%). Total belt usage with automatic belts is assumed to range between 20 and 70 percent. The automatic belt safety benefits shown in Table VI-1 are based on the center seat position being exempt from the standard and the assumption that center seat occupants will wear the manual lap belt as often as drivers and front right seat passengers (20-70%). Incremental safety benefits for mandatory use laws (MULs) are shown if MULs are effective in all States and usage is assumed to range between 40 and 70 percent.

A detailed analysis of potential impact on safety benefits of applying or exempting the front center seat position from the automatic restraint requirements is presented below under section F. For illustrative purposes, the impact of different alternatives affecting this seating position have been calculated using the mid-points of the effectiveness ranges.

A. Passenger Car Occupant Fatalities

Based on Fatal Accident Reporting System (FARS) data, the total number of passenger car occupant fatalities for 1982 was 23,098. Of this total, an estimated 21,224 (92 percent) were front seat occupants. This 92 percent figure, comparing front seat to all occupant fatalities with known seating position, has held constant since 1975 when FARS was initiated.

Table VI-2 shows the front seat passenger car occupant fatalities for 1975 to 1982 based on FARS data. The "unknown" seating position fatalities have been distributed between front and rear seats according to the respective percentages of "known" fatalities.

Table VI-3 presents the number and percentage of front seat passenger car fatalities with known seating positions. The "other front" fatalities would include such cases as when a child is standing on the floor or someone is lying down across the front seat.

TABLE VI-2
FRONT SEAT PASSENGER CAR OCCUPANT FATALITIES[1]

1975	23,900
1976	24,000
1977	24,700
1978	26,000
1979	25,700
1980	25,200
1981	24,700
1982	21,200
1983	20,400 (Preliminary Estimate)

[1] These are rounded to the nearest hundred fatalities; fatalities with unknown seating position are distributed between front and rear seats according to the distribution of known fatalities.

TAB.E VI-3
FRONT SEAT PASSENGER CAR FATALITIES
WITH KNOWN SEATING POSITION

	DRIVER	FRONT MIDDLE	FRONT RIGHT	OTHER FRONT	TOTAL
1975	16,270	644	5,601	21	22,536
%	72.2	2.9	24.8	0.1	100
1976	16,375	602	5,714	24	22,715
%	72.1	2.7	25.1	0.1	100
1977	16,967	577	5,992	14	23,550
%	72.0	2.5	25.4	0.1	100
1978	18,224	627	6,180	16	25,047
%	72.7	2.5	24.7	0.1	100
1979	18,267	513	5,968	6	24,754
%	73.8	2.1	24.1	-	100
1980	17,966	526	6,012	9	24,513
%	73.3	2.2	24.5	-	100
1981	17,722	460	5,844	6	24,032
%	73.8	1.9	24.3	-	100
1982	15,225	373	5,202	16	20,816
%	73.1	1.8	25.0	0.1	100

Table VI-4 presents a projection of front seat fatalities by seating position for the year 1990. Typically, in an analysis where full implementation would not occur for 10 or more years, one would project fatalities from the effective date of a rule 10 years into the future (say 1998, assuming an implementation date of 1988). However, the agency has only projected fatalities to the year 1990 and assumes that the magnitude of fatalities would not change significantly between 1990 and 1998. Furthermore, the relative safety benefits of the alternatives would not be affected by an increase in the fatality projection. Total passenger car fatalities for 1990 are forecast to be 26,700;[2] 92 percent of these (24,560) are estimated to be front seat occupant fatalities. The distribution by seating position takes into consideration the trend of declining front middle seating position fatalities and the possibility that, as downsizing continues, there will be a diminishing number of 6-seat passenger cars. Thus, the percentage of front middle seating position fatalities is estimated to decline to 1.5 percent of all front seat fatalities. It should be noted, however, that recent market trends indicate a renewed interest in large cars. Driver fatalities appear to have reached a new plateau of over 73 percent starting in 1979; thus, the average for 1979-1982 (73.5 percent) is assumed to also be the 1990 value. This leaves a residual of 25.0 percent for front right fatalities.

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2 "Traffic Safety Trends and Forecast," NHTSA, September 1983.

TABLE VI-4
PROJECTED FRONT SEAT PASSENGER CAR OCCUPANT FATALITIES
BY SEATING POSITION
(1990)

	DRIVER	FRONT MIDDLE	FRONT RIGHT	OTHER FRONT	TOTAL
1990	18,050	370	6,140	-	24,560
%	73.5	1.5	25.0	-	100.0

B. Passenger Car Occupant Injuries

The annual distribution of front seat passenger car occupant injuries (excluding fatalities) was estimated on the basis of 1982 data from the National Accident Sampling System (NASS). Since AIS 1 injuries constitute 86 percent of all front seat injuries, this analysis will examine AIS 1 injuries and AIS 2-5 injuries separately. These 1982 distributions, as well as the projections for 1990, are shown in Table VI-5.

TABLE VI-5
DISTRIBUTION OF FRONT SEAT PASSENGER CAR OCCUPANT INJURIES BY AIS LEVEL
FOR 1982 AND PROJECTED FOR 1990
(EXCLUDING FATALITIES)

ACTUAL -- 1982

AIS INJURY LEVEL	DRIVER	FRONT MIDDLE	FRONT RIGHT	OTHER FRONT	TOTAL
0	5,978,394	209,734	1,882,971	4,934	8,076,033
1	1,388,519	29,914	515,786	2,526	1,936,745
2	187,660	6,467	47,417	1,604	243,148
3	45,627	289	16,100	0	62,016
4	5,592	0	2,411	0	8,003
5	3,233	0	728	0	3,961
% OF AIS 1 INJURIES	71.7	1.5	26.6	0.2	100
AIS 2-5 INJURIES	242,112	6,756	66,656	1,604	317,128
(%)	76.3	2.1	21.0	0.6	100

PROJECTIONS FOR 1990

	DRIVER	FRONT MIDDLE	FRONT RIGHT	OTHER FRONT	TOTAL
AIS 1 INJURIES	2,110,000	40,000	800,000	-	2,950,000
(%)	71.5	1.5	27.0	-	100
AIS 2-5 INJURIES	290,000	5,000	75,000	-	370,000
(%)	78.5	1.5	20.0	-	100

There were almost 2 million AIS 1 injuries and over 315,000 AIS 2-5 injuries in 1982. Table VI-5 shows their distribution by seating position. Based on the agency's belief that the number of occupants and injuries in the front center seating position will decline, the agency assumes that in 1990 the same percentage of injuries as fatalities will occur in the front center position (1.5%).

For 1990, the percentage of injuries by seating position is determined by comparing 1982 data with the 1981 data and rounding to the nearest 0.5 percent. (In 1981 for AIS 1 injuries -- 69.7 percent were drivers, 3.0 percent front middle, 27.1 percent front right and 0.2 percent others; for AIS 2-5 injuries -- 78.8 percent were drivers, 2.1 percent front middle, 18.9 percent front right and 0.2 percent others.)

Total AIS 2-5 injuries for 1990 are determined by comparing projected 1990 fatalities to 1982 fatalities and applying this factor to 1982 injuries (i.e.,

$$\frac{24{,}560}{21{,}200} = 1.16 \times 317{,}128 = 370{,}000 \text{ AIS 2-5 injuries}).$$

Total AIS 1 injuries for 1990 are determined in the same manner except that the total is increased by a correction factor to take unreported accidents into consideration.

There is some debate as to the magnitude of the correction factor which should be used with NASS data. The Insurance Institute for Highway Safety (IIHS) commented that the number of motor vehicle injuries are underreported by NASS. IIHS submitted a study comparing Northeastern Ohio Hospital Emergency Department entries versus police reports of accidents. The findings of this report note that to overcome biases introduced by the underreporting of injuries to the police, the non-fatal injury numbers should be multiplied by 1.4.[3]

[3] Docket No. 74-14-N32-1668, "Northeast Ohio Trauma Study," Barancik, etal., American Journal of Public Health, July 1983, Vol. 73, No. 7.

NHTSA recognized the underreporting problem in NASS and sponsored a study by Westat Inc. to estimate the magnitude of the problem.[4] The Westat study is not a definitive treatise on the subject; it has problems relating to respondents not wishing to tell about unreported accidents over the telephone, etc. However, it is more nationally representative than a study done in one state, especially since reporting practices vary considerably from state to state.

The results of the Westat study are:

- -- 0.27 unreported injury accidents per NASS injury accident;
- -- 0.14 unreported accidents requiring hospital treatment for each NASS accident requiring hospital treatment; and
- -- no unreported accidents requiring a hospital stay.

The findings of the Westat study and the Ohio study are significanty different; the Westat study proposes a multiplier for hospital treated injuries of 1.14, whereas the Ohio study indicates a value of 1.4. The agency believes it is more appropriate to apply the results of the Westat study to the NASS accident data because the Westat study was specifically designed to address the issue of underreporting on a national basis.

4 "National Accident Sampling System, Nonreported Accident Survey," Westat Inc., Contract DOT-HS-9-02128, November 1981.

One limitation of using the Westat study for this analysis is that injury severity by AIS level for unreported accidents is unknown. Since there were no unreported accidents requiring a hospital stay, none of the injuries would be AIS 4 or 5. Since AIS 1 injuries are 86 percent of all injuries and since we are dealing with unreported accidents, almost all of these injuries would probably be AIS 1 injuries. For this analysis the agency assumes that all of these injuries are AIS 1 injuries.

The adjustments to the AIS 1 injuries for unreported accidents are included in the 1990 projections and are calculated as follows:

1.16 x 1,936,745 1982 AIS 1 injuries =	2,247,000	1990 reported injuries
1.16x0.27x2,253,873 1982 AIS 1-5 injuries =	706,000	1990 unreported injuries
	2,950,000	AIS 1 injuries

C. Range of Impacts on Fatalities and Injuries

The following formula is used to determine the number of fatalities that would occur in 1990 if no one uses restraints. A similar formula is used for AIS 1 and AIS 2-5 injuries:

$$F_{NR} = \frac{F_c}{1-(U_c)(E_F)}$$

Where: F_{NR} = Fatalities in 1990 if no one uses restraints

F_c = Fatalities in 1990 with current restraint usage

U_c = Current Restraint Usage

E_F = Fatality effectiveness

When applying this formula for different effectiveness estimates (low, mid-points, and high estimates of effectiveness), F_C and U_C remain constant while effectiveness changes. Thus, F_{NR} varies depending on the effectiveness estimate used in the formula. For illustrative purposes, the effectiveness estimates for the three-point manual belts for the driver and right front, and lap belts for the front middle seating position use the mid-points of the ranges.

	Driver	Front Middle	Front Right
1990 Fatalities (F_c)	18,050	370	6,140
1990 AIS 1 Injuries	2,110,000	40,000	800,000
1990 AIS 2-5 Injuries	290,000	5,000	75,000
Manual Belt Usage (U_c)	.140	.050	.084
Fatality Effectiveness(E_F)	.45	.35	.45
AIS 1 Injury Effectiveness	.10	.10	.10
AIS 2-5 Injuries Effectiveness	.50	.30	.50

This gives the following results:

Fatalities assuming no one used restraints (F_{NR})	19,260	377	6,380
AIS 1 injuries assuming no one used restraints	2,140,000	40,200	807,000
AIS 2-5 injuries assuming no one used restraints	311,830	5,080	78,290

The values in Tables VI-6 through VI-9 are the incremental reductions of fatalities or injuries when compared to current belt usage levels. These are derived from the following formula shown for fatalities. A similar formula is used for AIS 1 and AIS 2-5 injuries.

Incremental Fatalities Reduction = Total Fatality Reduction - Fatality Reduction at Current Usage Levels

$$F_I = (F_{NR})(U_P)(E_F) - (F_{NR} - F_c)$$

Where: F_I = Incremental fatality reduction

F_{NR} = Fatalities assuming no one used restraints

U_P = Projected usage level

E_F = Fatality Effectiveness

F_c = Fatalities in 1990 with current restraint usage

As mentioned previously, F_{NR} varies with the effectiveness estimates (low, mid-point, and high effectiveness). Thus, when calculating benefits for automatic restraints, it is implicit (in the formula) that the low effectiveness estimate for manual belts is used to calculate a "low" estimate of current manual belt fatality reduction, which is subtracted from the "low" fatality reductions for air bags derived from the low effectiveness estimate for air bags. In calculating safety benefits throughout this analysis, low effectiveness for manual belts is compared to low effectiveness estimates for air bags, mid-point effectiveness to mid-point estimates and high effectiveness is compared to high estimates.

Separate estimates are provided for mandatory belt use laws, automatic belts, and airbag systems. These values represent annual fatality or injury reductions at full implementation (that is, when all cars are equipped with a particular restraint device or when mandatory belt use laws are effective in all States).

Table VI-6 presents incremental safety benefits for all front seating positions[5] for three different effectiveness estimates -- low end of the range, the mid-point for illustrative purposes, and the high end of the range. Tables VI-7, VI-8, and VI-9 present incremental safety benefits by seating position assuming the mid-points of the effectiveness ranges, for illustrative purposes. Some of these values in Tables VI-7, VI-8, and VI-9 are used in the following center seat position discussion.

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[5] That is, full front seat air bags; for automatic belts it is assumed that the center seat is exempt from the standard and manual lap belt usage in the center seat equals belt usage of the driver and front right seat passenger.

TABLE VI-6

SAFETY BENEFITS
INCREMENTAL REDUCTION IN

	Fatalities			AIS 2-5 Injuries			
	Low	Mid-Point	High	Low	Mid-Point	High	AIS 1 Injuries
Air Bags Only	3,780	6,190	8,630	73,660	110,360	147,560	255,770
Air Bags With Lap Belts (12.5% Usage)	4,410	6,670	8,960	83,480	117,780	152,550	255,770
Air Bag With Lap/ Shoulder Belts (12.5% Usage)	4,570	6,830	9,110	85,930	120,250	155,030	255,770
Automatic Belts							
20% Usage	520	750	980	8,740	12,180	15,650	22,760
30%	1,420	1,850	2,280	24,370	30,860	37,440	52,640
40%	2,320	2,950	3,590	37,990	49,540	59,220	82,510
50%	3,230	4,060	4,900	55,610	68,230	81,000	112,380
60%	4,130	5,160	6,200	71,240	86,900	102,790	142,250
70%	5,030	6,270	7,510	86,860	105,590	124,570	172,120
Mandatory Belt Use Laws (in all States)							
40% Usage	2,830	3,220	3,590	47,740	53,440	59,220	82,510
50%	3,860	4,380	4,900	65,300	73,100	81,000	112,380
60%	4,890	5,540	6,200	82,860	92,760	102,790	142,250
70%	5,920	6,720	7,510	100,430	112,410	124,570	172,120

Table VI-7

ANNUAL FATALITY REDUCTION
MANDATORY BELT USE LAWS IN ALL STATES
(ASSUMING MID-POINTS OF EFFECTIVENESS RANGES --
MANUAL BELT EFFECTIVENESS IS 45 PERCENT FOR DRIVER
AND FRONT RIGHT PASSENGER AND 35 PERCENT FOR FRONT MIDDLE LAP BELT)

Incremental Savings Over Current Usage Levels of Manual Belts[6]

Usage	Driver	Front Middle	Front Right	Total
40%	2,260	50	910	3,220
50%	3,120	60	1,200	4,380
60%	3,990	70	1,480	5,540
70%	4,860	90	1,770	6,720

TABLE VI-7 Cont'd
AUTOMATIC BELTS, (ASSUMING MID-POINTS OF EFFECTIVENESS RANGES --
EFFECTIVENESS IS 42.5 PERCENT FOR DRIVER AND
FRONT RIGHT PASSENGER AND 35 PERCENT FOR FRONT MIDDLE LAP BELT)

Incremental Savings Over Current Usage Levels of Manual Belts

Usage	Driver	Front Middle	Front Right	Total
20%	430	20	300	750
30%	1,250	30	570	1,850
40%	2,060	50	840	2,950
50%	2,880	60	1,120	4,060
60%	3,700	70	1,390	5,160
70%	4,520	90	1,660	6,270

6 Assumes usage levels of manual belts in 1990 are the same as current usage rates - 14.0 percent driver, 5.0 percent front middle and 8.4 percent front right. Fatalities reduced by current usage levels in 1990 are 1,210 drivers, 7 front middle, and 240 front right.

TABLE VI-7 Cont'd

AIR BAGS (ASSUMING MID-POINTS OF EFFECTIVENESS RANGES --
30 PERCENT EFFECTIVE WITHOUT LAP BELT,
45 PERCENT EFFECTIVE WITH LAP BELT AT
CURRENT USAGE LEVELS, AND AIR BAGS WITH LAP/SHOULDER BELTS ARE 50 PERCENT
EFFECTIVE WITH CURRENT USAGE LEVELS; READINESS FACTOR IS 98 PERCENT)

Incremental Savings Over Current Usage Levels of Manual Belts

Restraint System	Driver	Front Middle	Front Right	Total
Air Bag With No Belt Usage	4,450	100	1,640	6,190
Air Bag With Lap Belt (12.5% Usage)	4,850	110	1,710	6,670
Air Bag With Lap/ Shoulder Belt (12.5% Usage)	4,980	110	1,740	6,830

TABLE VI-8

ANNUAL NUMBER OF AIS 1 INJURIES REDUCED AT FULL IMPLEMENTATION ASSUMING
A MANUAL OR AUTOMATIC RESTRAINT SYSTEM WITH 10 PERCENT EFFECTIVENESS

Incremental Savings Over Current Usage Levels of Manual Belts[7]

Usage	Driver	Front Middle	Front Right	Total
20%	12,800	600	9,360	22,760
30%	34,200	1,010	17,430	52,640
40%	55,600	1,410	25,500	82,510
50%	77,000	1,810	33,570	112,380
60%	98,400	2,210	41,640	142,250
70%	119,800	2,610	49,710	172,120

7 Assumes usage levels of manual belts in 1990 are the same as current usage rates - 14 percent drivers, 5 percent front middle and 8.4 percent front right, AIS 1 injuries reduced by current usage levels in 1990 are 30,000 drivers, 200 front middle and 6,780 front right.

TABLE VI-8 Cont'd

ANNUAL NUMBER OF AIS 1 INJURIES REDUCED ASSUMING 10 PERCENT EFFECTIVENESS FOR AIR BAG, AIR BAG WITH LAP BELT, OR AIR BAG WITH LAP SHOULDER BELT; READINESS FACTOR IS 98 PERCENT

Incremental Savings over Current Usage Level of Manual Belts

Restraint System	Driver	Front Middle	Front Right	Total
Air Bag With No Belt Usage	179,720	3,740	72,310	255,770
Air Bag With Lap Belt (12.5% Usage)	179,720	3,740	72,310	255,770
Air Bag With Lap/ Shoulder Belt (12.5% Usage)	179,720	3,740	72,310	255,770

TABLE VI-9

ANNUAL NUMBER OF AIS 2-5 INJURIES REDUCED WITH MANDATORY BELT USE LAWS IN ALL STATES, ASSUMING MID-POINTS OF EFFECTIVENESS RANGES -- MANUAL BELT EFFECTIVENESS IS 50 PERCENT FOR DRIVER AND FRONT RIGHT PASSENGER AND 30 PERCENT FOR FRONT MIDDLE LAP BELT

Incremental Savings Over Current Usage Levels of Manual Belts[8]

Usage	Driver	Front Middle	Front Right	Total
40%	40,540	530	12,370	53,440
50%	56,130	690	16,280	73,100
60%	71,720	840	20,200	92,760
70%	87,310	990	24,110	112,410

8 Assumes usage levels of manual belts in 1990 are the same as current usage - 14 percent driver, 5 percent front middle and 8.4 percent front right. AIS 2-5 injuries reduced by current usage levels in 1990 are 21,828 drivers, 76 front middle and 3,288 front right.

TABLE VI-9 Cont'd
ANNUAL NUMBER OF AIS 2-5 INJURIES REDUCED ASSUMING
MID-POINTS OF EFFECTIVENESS RANGES --
AUTOMATIC BELT EFFECTIVENESS IS 52.5 PERCENT FOR DRIVER AND FRONT RIGHT
PASSENGER AND 35 PERCENT FOR FRONT MIDDLE LAP BELT

Incremental Savings Over Current Usage Levels of Manual Belts

Usage	Driver	Front Middle	Front Right	Total
20%	7,800	230	4,150	12,180
30%	22,610	380	7,870	30,860
40%	37,420	530	11,590	49,540
50%	52,230	690	15,310	68,230
60%	67,040	840	19,020	86,900
70%	81,860	990	22,740	105,590

TABLE VI-9 Cont'd
ANNUAL NUMBER OF AIS 2-5 INJURIES REDUCED ASSUMING MID-POINTS OF
EFFECTIVENESS RANGES -- AIR BAGS ARE 35 PERCENT
EFFECTIVE, AIR BAGS WITH LAP BELTS ARE 55 PERCENT EFFECTIVE WITH CURRENT
USAGE LEVELS AND AIR BAGS WITH LAP/SHOULDER BELTS ARE 60 PERCENT EFFECTIVE
WITH CURRENT USAGE LEVELS; RESTRAINT READINESS FACTOR IS 98 PERCENT

Incremental Savings Over Current Usage Rates of Manual Belts

Restraint System	Driver	Front Middle	Front Right	Total
Air Bag With No Belt Usage	85,130	1,670	23,560	110,360
Air Bag With Lap Belt (12.5% Usage)	91,550	1,700	24,530	117,780
Air Bag With Lap/ Shoulder Belt (12.5% Usage)	93,690	1,700	24,860	120,250

The Insurance Institute for Highway Safety (IIHS) (74-14-N35-022) argues that this formula does not take into account that belt users are less frequently involved in serious accidents. IIHS contends that even with 70-80 percent automatic or manual belt use, non-users will be so overinvolved that actual reductions may fail to match use rate increases. According to this theory, risk-prone drivers will never wear belts and those drivers are overinvolved in accidents. Thus, IIHS would argue that while the Department's effectiveness estimates have taken into account the seriousness of the accident, they have not been corrected to reflect this overinvolvement; in the IIHS view, this results in overstating safety benefits. However, no data are available to either validate this theory or to attempt to quantify its possible effects. That is, it is not possible to estimate the number of risk-prone drivers who do not use their belts and the percentage of accidents in which such drivers are involved.

On the other hand, in his comments to the SNPRM (Docket No. 74-14-N35-079) Professor Nordhaus states that the Department's manual and automatic belt effectiveness estimates are too low; he argues that those drivers that are more likely to buckle-up, perhaps 45 percent of all drivers, are not risk-prone drivers and will thus be involved in less serious accidents. Therefore, the analysis understates safety benefits in Professor Nordhaus'opinion. As noted above, the Department has not made changes in its analysis to account for this possibility in the absence of specific data.

Professor Nordhaus also argues that the 19.3 percent reduction in fatality rates for VW automatic restraint Rabbits should be used to determine fatality reductions for automatic belts and that any combination of usage rates and effectiveness should result in a 19.3 percent reduction in fatalities. He contends that it is illogical to take effectiveness estimates from one data set and combine it with usage estimates from another. This argument ignores the reasons why the Department did not use VW Rabbit automatic belt usage data (see Chapter V) and the fact that the Department is analyzing fatality reductions for all cars, not just VW Rabbits with an interlock. He also demonstrates a lack of understanding of

NHTSA's analysis of the Rabbit accident data. As Professor Nordhaus stated, the automatic belt Rabbit fatality rate is 19.3 percent lower than that for manual belt Rabbits. This rate results from some increase in usage as well as the effectiveness of the belts. Knowing the fatality rate, and usage in accidents we can solve for effectiveness and arrive at a 54 percent figure (see p. IV-25). However, the usage figure to derive this effectiveness number is much lower than that actually observed and since observed usage is deemed a more reliable figure than that estimated for accidents the agency solved again for effectiveness using the observed usage and arrived at a 39 percent value. Nordhaus argues that this methodology is invalid. The agency disagrees because Nordhaus fails to recognize the uncertainty inherent in the accident usage data. The agency's calculations take into account this uncertainty and the effect it has on belt effectiveness.

D. Breakeven Point Analysis of Safety Benefits

This section examines the safety benefit breakeven points among systems. That is, at what automatic or manual belt usage level would the belt system provide the same safety benefits as air bags. Because of the ranges in air bag, automatic belt, and manual belt effectiveness, the breakeven point analysis is complicated.

Table VI-10 shows the breakeven points under a number of effectiveness assumptions. The breakeven points range from 44 percent to over 100 percent; these are the extremes of the effectiveness ranges. Thus, mandatory belt use laws or automatic belts would have to increase belt usage to at least 44 percent to achieve the same benefits as an air bag and lap belt, at the present rate of belt usage (12.5%). Figure VI-1 shows the relationship between automatic belts and air bags with lap belts. If the lap belt with the air bag system was not used by any occupants, the breakeven points would range from 39 percent to 100 percent.

TABLE VI-10
BREAKEVEN POINT ANALYSIS SAFETY BENEFITS

Fatalities Effectiveness		Breakeven Point[9]
Air Bag[10]	Automatic Belt	
Low (20%)	Low (35%)	63%
Mid-Point (30%)[11]	Mid-Point (42.5%)	74%
High (40%)	High (50%)	81%
Low (20%)	High (50%)	44%
High (40%)	Low (35%)	Over 100%
Air Bag	Manual Belt	
Low (20%)	Low (40%)	55%
Mid-Point (30%)	Mid-Point (45%)	70%
High (40%)	High (50%)	81%
Low (20%)	High (50%)	44%
High (40%)	Low (40%)	Over 100%

9 The breakeven point is the point at which usage of safety belt systems provide equal life saving benefits to air bag systems.

10 Air bags with lap belts at 12.5% usage of lap belts.

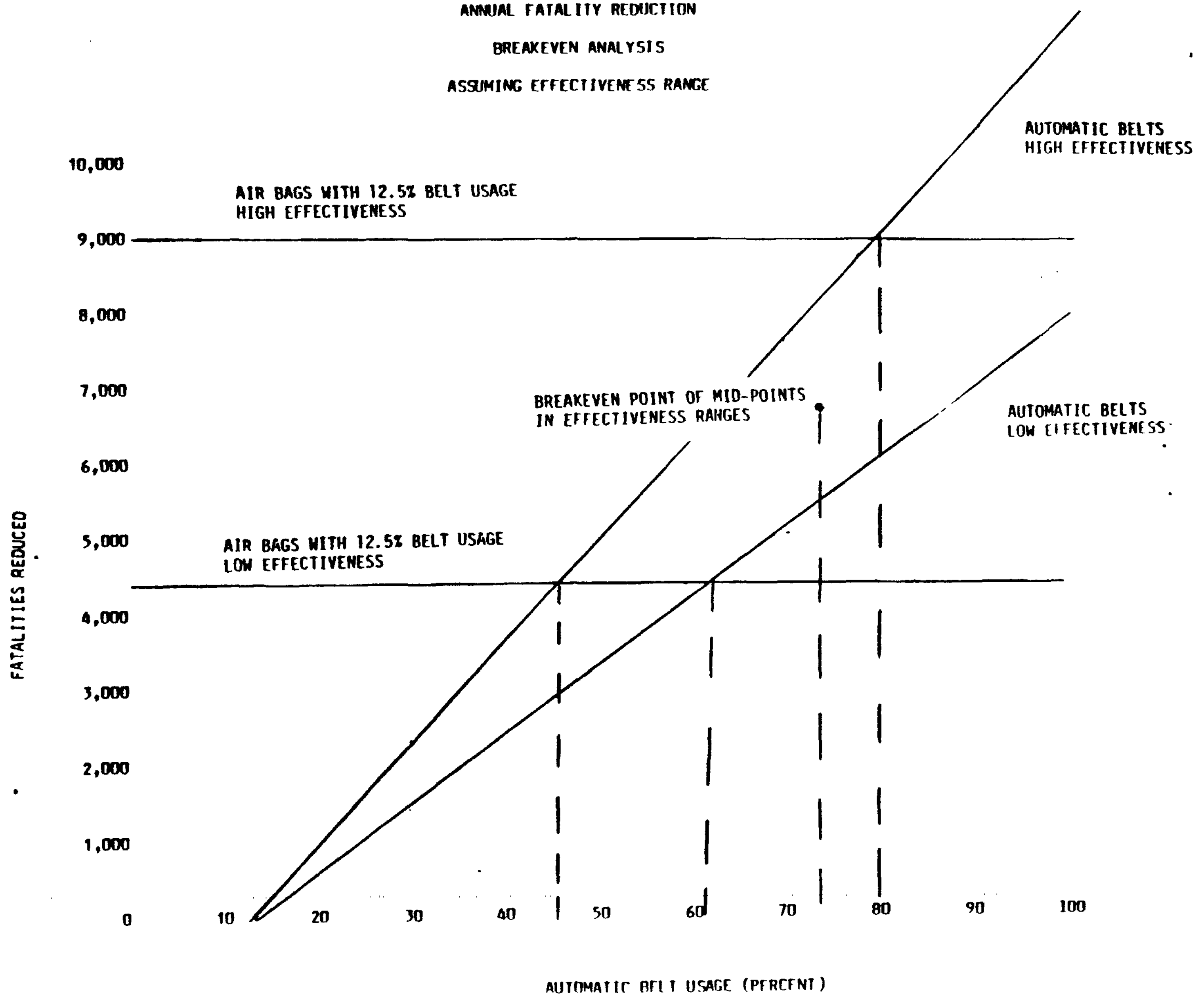
11 Mid-points are shown for illustrative purposes.

Figure VI-1

ANNUAL FATALITY REDUCTION

BREAKEVEN ANALYSIS

ASSUMING EFFECTIVENESS RANGE



For AIS 2-5 injuries, the breakeven points between air bags with lap belts at current usage rates and manual or automatic belt usage are nearly the same, ranging from 49 percent to over 100 percent.

It must be noted that, in the above discussion, the "breakeven" points are simply the points at which estimated safety benefits are equal. They do not take into account the cost factor, thus they do not represent a measure of cost-effectiveness.

E. Time Phase Analysis of Fatality Benefits

One of the advantages of a mandatory belt use law is that it impacts all cars in the fleet rather than only new cars affected by an automatic restraint standard. Thus, it is interesting to examine the benefits of various alternatives over time.

The benefits of an automatic restraint standard over time can be estimated by examining fatalities by vehicle age. Table VI-11 shows the 1982 distribution of passenger car occupant fatalities by model year (FARS data). The model year 1982 and 1983 cars are combined to show the effect of the first full year implementation of an automatic restraint standard.

The percent of fatalities for any particular year is highly dependent upon sales in that model year (notice lower percentages than expected in 1981 and 1975 recession years and higher percentages than expected in the high sales years of 1979 and 1973). Table VI-11 presents 3-year and 5-year moving averages in an attempt to smooth out the data, given the assumption of constant sales per year; however, these smoothing techniques will not work for the initial years or the final years. Finally, a smooth curve is chosen for analytical purposes.

Table VI-11 shows that 10 years after automatic restraints are installed, 74 percent of the fatalities would have been in automatic restraint equipped cars, without taking into account the effectiveness of automatic restraints. This estimate assumes that the recent trend to hold on to cars longer will continue. If this trend does not continue, this 74 percent estimate would increase.

TABLE VI-11
PASSENGER CAR OCCUPANT FATALITIES BY AGE
(BASED ON 1982 FARS)

Model Year	Age	% of Fatals	3-Year Moving Average	5-Year Moving Average	Projected Average Assuming Constant Sales Per Year (%)	Cumulative %
1982+83[12]	<1	5.9	-	-	6.0	6.0
1981	2	8.5	N.C.	-	9.0	15.0
1980	3	9.0	8.9	N.C.	8.9	23.9
1979	4	9.3	8.9	8.4	8.8	32.7
1978	5	8.4	8.2	8.1	8.3	41.0
1977	6	7.0	7.5	7.3	7.4	48.4
1976	7	6.9	6.3	6.9	6.9	55.3
1975	8	5.1	6.3	6.6	6.6	61.9
1974	9	7.0	6.3	6.4	6.4	68.3
1973	10	7.0	6.7	5.9	6.0	74.3
1972	11	6.0	5.8	5.6	5.7	80.0
1971	12	4.4	4.7	4.8	4.8	84.8
1970	13	3.8	3.6	3.8	3.7	88.5
1969	14	2.7	2.9	2.9	2.8	91.3
1968	15	2.3	2.3	2.1	2.2	93.5
Pre 1968	>15	6.7			6.5	100.0
		100.0%			100.0%	

N.C. = Not calculated in order to not include the <1 year average for 1982+83.

[12] 1982 models had 5.7 percent of fatalities and the 1983 models had only 0.2 percent of fatalities.

Table VI-12 presents a year-by-year (time phase) analysis of the fatality benefits of an automatic restraint standard, air bags, or automatic belts, and a mandatory belt use law. Mid-points of the effectiveness ranges are used in this time phase analysis for illustrative purposes.

The time phased benefits of state implemented mandatory belt use laws as an alternative to an automatic restraint requirement depend upon the specific time frame established for state passage and implementation of a belt use law.

When the benefits of the two alternatives are compared, i.e., mandatory use laws versus automatic restraint standards, three timing questions should be considered: 1) the number of states that implement mandatory belt use laws before an automatic restraint requirement would become effective; 2) the percent of all occupants covered by a mandatory restraint use law, by year; and 3) the level of compliance that would result.

Table VI-12 presents three hypothetical scenarios with different implementation schedules. All these scenarios assume a starting point equivalent to the effective date of an automatic occupant protection standard. Scenario 1 assumes all states will pass a mandatory belt use law very quickly and have it implemented by the effective date of the standard. Scenario 2 assumes 67 percent of the population will be covered under mandatory use laws before the effective date of the standard and automatic restraints would not be required. No reduction in fatalities is assumed for 33 percent of the population. Scenario 3 assumes 20 percent of the population will be covered by mandatory use laws by the effective date of an automatic restraint standard and the remaining 80 percent of the population will be in states where automatic restraints (automatic belts are assumed for this analysis) are required.

A comparison of the data for the hypothetical mandatory belt use law scenarios in Table VI-12 shows that if all states quickly pass a mandatory belt use law and usage increased to 70 percent or more, short term benefits (over the next 10 years) would be about 2.5 times higher than benefits with air bags or automatic belts with 70 percent usage. It also shows that the only condition under which automatic belts would provide equal or more benefits than mandatory use laws would be if usage of automatic belts was near the high end of the usage range and manual belt usage under mandatory use laws was at the low end of the range.

TABLE VI-12

TIME PHASE ANALYSIS OF FATALITY BENEFITS

Year	Air Bag With Automatic Belt: 12.5% Usage of Lap Belt	20-70% Usage	Mandatory Belt Use Law: 40-70% Usage[13] Scenario 1	Scenario 2	Scenario 3
1	400	50-380	3,220-6,720	2,160-4,500	680-1,650
2	1,000	110-940	3,220-6,720	2,160-4,500	730-2,100
3	1,590	180-1,500	3,220-6,720	2,160-4,500	790-2,540
4	2,180	250-2,050	3,220-6,720	2,160-4,500	840-2,980
5	2,730	310-2,570	3,220-6,720	2,160-4,500	890-3,400
6	3,230	360-3,030	3,220-6,720	2,160-4,500	930-3,770
7	3,690	410-3,470	3,220-6,720	2,160-4,500	970-4,120
8	4,130	460-3,880	3,220-6,720	2,160-4,500	1,010-4,450
9	4,560	510-4,280	3,220-6,720	2,160-4,500	1,250-4,770
10	4,960	560-4,660	3,220-6,720	2,160-4,500	1,090-5,070
TOTAL (1-10)	28,470	3,200-26,760	32,220-67,200	21,600-45,000	8,980-34,850
11	5,340	600-5,010	3,220-6,720	2,160-4,500	1,120-5,350
12	5,660	640-5,320	3,220-6,720	2,160-4,500	1,160-5,600
13	5,900	660-5,550	3,220-6,720	2,160-4,500	1,170-5,780
14	6,090	680-5,720	3,220-6,720	2,160-4,500	1,190-5,920
15	6,240	700-5,860	3,220-6,720	2,160-4,500	1,200-6,030
TOTAL (1-15)	57,700	6,480-54,220	48,300-100,800	32,400-67,500	14,820-63,530

[13] Definition of Hypothetical Scenarios:

Scenario 1 -- All states pass mandatory use law for all front seat passenger car occupants by the effective date of an automatic restraint standard.

Scenario 2 -- 67% of all front seat occupants are covered by a mandatory use law. The remaining 33% are assumed to have no reduction in fatalities.

Scenario 3 -- 20% of all front seat occupants are covered by a mandatory use law. New cars in the remaining 80% of the states are equipped with automatic belts with 20-70% belt usage.

Some commenters stated that they favored a combination of alternatives--automatic restraints and mandatory belt use laws. This consideration could maximize the short run and long run benefits, unless usage of automatic and manual belts was very low--in which case airbags would still provide more benefits. Not only can this combination provide benefits to the current fleet of cars but the mandatory belt use law might also increase the benefits of the automatic restraint equipped cars by increasing usage of automatic belts or manual belts with the air bag.

Table VI-13 presents examples of fatality benefits assuming airbags or automatic belts are required and mandatory seat belt use laws are implemented. The time phasing of these scenarios is taken from the child restraint experience and is shown in Table VI-13. Increasing belt usage with airbags by mandatory seat belt usage laws can greatly increase total benefits (from 28,476 lives saved to possibly 49,480 over the first 10 years). Also, this combination of alternatives can have a large advantage over mandatory belt use laws alone, in the long run.

The advantage of combining mandatory belt use laws and an automatic restraint (in this case automatic belt) requirement compared to an automatic belt requirement alone are a large increase in benefits over the

10-year phase in period (3,200-26,760 lives saved for automatic belts alone compared to 16,760-41,020 when automatic belts are combined with MULs). However, the benefits of the combined mandatory belt use law and automatic belt requirement, compared to a mandatory belt use law alone, depend on how well the mandatory belt use laws work. If mandatory belt use laws result

TABLE VI-13

TIME PHASE ANALYSIS OF FATALITY BENEFITS

Year	Assumed Percent of States With MUL	Air Bag With 12.5% Usage of Lap Belt and Mandatory Belt Use Law 40-70% Usage	Automatic Belt and Mandatory Belt Use Law 40-70% Usage[14]
1	2	460-580	110-560
2	2	1,060-1,120	170-1,050
3	6	1,750-1,930	360-1,810
4	8	2,380-2,600	490-2,410
5	30	3,430-4,190	1,150-3,760
6	94	5,270-7,490	2,930-6,290
7	94	5,590-7,660	2,910-6,290
8	94	5,890-7,820	2,900-6,290
9	94	6,190-7,970	2,880-6,280
10	94	6,470-8,120	2,870-6,280
TOTALS		38,480-49,480	16,760-41,020

[14] Benefits peak in year 6 since the percent of states covered by a mandatory belt use law does not increase after this point and after year 6 there are more automatic belt cars on the road than manual belts. Using the midpoints of the effectiveness range, automatic belts are 2.5 percentage points less effective than manual belts.

in the same usage as automatic restraints and can be passed in every state then, since manual belts may be more effective than automatic belts, there would be additional benefits by not requiring automatic belts. However, if a combination of the two alternatives, automatic belts and mandatory belt use laws, result in automatic belts having higher usage rates than manual belts, then there would be an advantage to the combination of the two alternatives.

F. Center Seating Position

1. Considerations Related to Center Seating Position

This section analyzes the effect that deleting the requirement of automatic occupant protection for front center seating positions would have on fatalities and injuries. Mid-points of the effectiveness ranges are used in this center seating position analysis for illustrative purposes.

The Department proposed alternatives eliminating the automatic restraint requirements for the middle front seating position for two reasons:

a) The Department is concerned that the alternative requirements of FMVSS 208 may inadvertently result in the demise of six-seat passenger cars. Although most of the alternatives call for a performance standard and do not specify the method of compliance, manufacturers, because of cost considerations, may opt to provide automatic seat belts in lieu of air bags. There is no known practical method that can provide automatic seat belt protection for front center seat occupants. Vehicle manufacturers that supply automatic belts to meet the requirement would probably use a console or other means to eliminate the middle seating position. The net result is that six-seat cars as we know them today may no longer be produced. Of course, full front air bags could provide automatic protection for all three front seating positions and allow retention of six-seat passenger cars.

Roger Maugh of Ford stated[15] "The requirement for automatic protection for the front center seating position essentially eliminates the three-passenger front seat type of passenger cars. There is no known practical three-passenger front seat automatic seat belt concept. Then such a requirement also makes it unlikely that six-passenger car types should be continued even with air bags because of the unsolved problem of the hazards air bags pose to out-of-position passengers. We were doing our testing with that air bag designed to basically accept the energy and decelerate two 90 percent mannikins...and, of course, what that means is that you end up putting an air bag in there that has a tremendous amount of energy. It is that tremendous amount of energy that...gives you the problem of the out-of-position occupant." However, as indicated in Chapter III, the agency does not believe that the out-of-position occupant is a large problem.

Even if automatic protection is not required in the center seat position, the center seat position may be eliminated if a manufacturer chooses to use non-detachable automatic belts because of the difficulty presented by the

[15] Testimony of Roger Maugh, Ford, at the Kansas City Hearing, December 2, 1983, pg. 283 and 296.

belts in getting in and out of the center seat. If manufacturers are allowed to use detachable automatic belts, then the center seat position can be utilized by detaching an outboard seating position belt.

b) The second reason is related to the small and declining number of fatalities and injuries associated with this seating position. As shown in Table VI-3, there were 644 fatalities in 1975 in the front middle seating position, 373 in 1982, and an estimated 340 in 1983; these comprise less than 2 percent of all front seat passenger car fatalities. With the continued down-sizing in cars, there would be, in the absence of the standard, fewer and fewer (although not zero)[16] six-seat cars on the highway, resulting in fewer front middle seating position fatalities. As shown in Table VI-4, front middle seat fatalities are expected to account for only 1.5 percent of all front seat fatalities in the future (roughly 370 fatalities in 1990). Also, data from the Nationwide Personal Transportation Study[17] indicate that from 1969 to 1977, the percent of vehicles with six or more occupants on trips of all purposes has declined from 2.7 percent to 1.9 percent. Thus, automatic restraints for the front center seating position would not yield as many benefits as originally thought when the standard was issued in 1977.

One of the commenters indicated that the center seat position should not be exempt from the standard since young children were frequently injured in this seating position. In the October 1981 FRIA, the agency examined this

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16 In 1982, one-third of the cars sold were six-seat cars.

17 "Nationwide Personal Transportation Study -- Automobile Occupancy," Report No. 1, April 1972, U.S. DOT, Federal Highway Administration, p. 12, and data from the 1977 Nationwide Personal Transportation Study.

issue. The 1980 FARS data indicate fatalities in the age group 0-5, young children, represented 23.4 percent for front center positions, but only 3.3 percent for front right positions. The 1981 and 1982 FARS data indicate roughly the same percentages, with 0-5 year old children representing 23.3% and 24.7% of all front center seat occupant fatalities. Preliminary 1983 FARS data show 18.8% of all front center seat occupant fatalities were 0-5 year old children. However, the total front center seat fatalities also dropped in 1983. The decrease in child fatalities in this seating position is believed to be the result of three factors relating to child restraint usage: 1) child restraint usage increased in 1982 and 1983 due to child restraint laws, 2) the effectiveness of child restraints, and 3) more children are being put into the rear seats (58% in 1983 FARS data versus 52% in 1982), perhaps as a result of child restraint laws. The Department would expect the proportion of center seat child fatalities to decrease as child restraint usage increases.

There are also convenience and "peer pressure" arguments associated with eliminating the front center seating position from the standard. If the center seating position is not required to be provided with automatic restraints, the manufacturers may be able to design detachable automatic belts for a bench seat; thus allowing the center seat to be utilized without air bags. (The center seat would still be required to be equipped with the current manual lap belt.) However, the automatic belt might have to be disconnected in order to allow a passenger to get into the middle seating position. The question then arises as to what percent of the automatic belts would be reconnected. If some people don't reconnect them, then usage declines and some of the benefits of requiring automatic protection -- or at least for the right front passenger -- could be lost.

On the other hand, the MOR study[18] stated that interaction between driver and passengers was a significant factor affecting belt usage. Since normally one would enter the front center position from the passenger side, the driver's automatic belt would not need to be disconnected and the driver may encourage the reconnection of the right front belt and/or the use of the center seat lap belt. Thus, center seat lap belt usage could conceivably increase compared to expected usage in cars with only manual belts.

In addition to Ford's comments noted earlier, AMC, the American Automobile Association and Consumers Union, indicated that they favored exempting the center front seating position from the automatic occupant protection requirement. Chrysler recommended the center front seat be exempted to improve the test procedure as applied to airbag systems.

2. Benefit Calculations

As shown in Tables VI-4 and VI-5, it is estimated that 1.5 percent of front seat fatalities and injuries would occur in the front center seating position (370 fatalities and 5,000 AIS 2-5 injuries). These estimates assume a ceteris paribus situation: That FMVSS 208 is not in effect and

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18 "An Analysis of the Factors Affecting Seat Belt Use," Market Opinion Research, 1977.

that no other measures would affect occupant injuries or the number of six-seat cars being sold. Mid-points of the effectiveness ranges are used in these benefit calculations for illustrative purposes.

Given current lap belt usage in the center seat position (5 percent) and lap belt effectiveness in reducing fatalities (35 percent), the number of fatalities that would occur if no one wore restraints is 377 [370/1-(.05)(.35)]. Thus, seven lives are being saved by current levels of manual belt usage.

Because there is currently no known practicable means to automatically restrain center seat occupants by belts, if the center front seat position was covered by the standard, then these occupants would likely have to be protected by air bags. _If_ all six seat cars were equipped with air bags, front center seat occupant fatalities would decline by 114 (377 deaths x roughly 0.31 effectiveness for air bags at the mid-point of the effectiveness range with 5.0 percent lap belt usage x .98 readiness factor for air bags). Subtracting from this the number of fatalities that would be avoided by manual belts (seven) leaves a net savings of 107 lives. Similar calculations for AIS 2-5 injuries result in manual belts saving 76 AIS 2-5 injuries, air bags saving 1,779 AIS 2-5 injuries, for a net savings of air bags over manual belts of 1,703 AIS 2-5 injuries. However, manufacturers may not equip large numbers of cars with air bags or may still eliminate the center seating position. Thus, these savings are unlikely to be realized, unless air bags are mandatory.

Requiring automatic protection for the front center seat will result in shifts in seating position, if the center seat is eliminated. Some persons who would otherwise sit in the front center position would switch to the front outboard or rear seats. Data from the 1982 FARS show that in those accidents where the front center seat occupant was killed, 20 percent of the time there was no one sitting in the right front seat. If, under a mandate for automatic occupant protection, manufacturers comply by providing automatic seat belts, and assuming that there is a console or other means of keeping people from sitting in the center front seat, it is assumed that 20 percent of current front center seat occupants would sit in the front right seat and 80 percent would move to the rear seat. Similarly for injuries, 1982 NASS data show that 17 percent of the time when the center seat was occupied in all accidents, there was no one in the right front seat.

The following analysis is done strictly from a statistical viewpoint. That is, given that there will be a serious (towaway) or fatal accident, statistically, how much better or worse off is an occupant by sitting in a seat other than the front center seat? No attempt is made to account for the number of accidents that may not occur because the "distraction" factor of having a front center seat occupant is eliminated. (Some accidents may occur because the front center seat occupant distracts the driver from paying attention to the road.) Conversely, it is assumed that no additional accidents occur because the driver may turn around to converse with someone who is now a rear seat passenger or to check on a child in the rear seat. By analyzing the probability of injury or death of shifts in seating position, the agency is making two additional assumptions: (1) there is available seating space elsewhere in the car, and (2) the probability of teing injured or killed does not change from the current distribution. Should there not be available seating space, either of three outcomes are possible: (1) an additional car will be used; or (2) the sixth passenger will not take the trip, resulting in the analysis overstating potential death and injury, but there will also be a decrease in vehicle utility; or (3) the sixth occupant may sit in a non-designated seating position (e.g., on a front center console, two people in one designated seating position such as two children in one seat, in the rear of a stationwagon, or on someone's lap) with unknown but most likely negative safety results.

The Fatal Accident Reporting System (FARS) is the main source of data on fatalities. FARS includes only those accidents in which there was a fatality. Fatality rates for each seating position are developed from FARS data by dividing fatalities in a given seating position by the number of occupants in that seating position for all fatal accidents (see Table VI-14). Similarly, 1982 AIS 2-5 injury rates are taken from NASS injuries and observations.

TABLE VI-14
FATALITY AND INJURY RATES[19]
FOR OTHER THAN DRIVER POSITIONS

	1982 FARS	1982 NASS AIS 2-5 Injuries
FRONT CENTER	.2400	.0279
FRONT RIGHT	.3774	.0274
ALL REAR SEATS	.2218	.0212

[19] The ratio of fatalities or injuries to all occupants in a given seating position. Driver fatality rates are not included since FARS data would tend to bias the fatality rates of drivers upwards compared to other seating positions, since drivers are frequently the only occupant in a fatal accident. A comparison with NCSS data gives us confidence that the relative fatality rates for other seating positions are not affected by the FARS reporting criteria.

Thus, data show that the front right seat has a much higher fatality rate than the front center seat, but the injury rates are virtually identical. The rear seats are statistically the best seating positions.

Table VI-15 shows the calculations for determining how fatalities and injuries would change if the center seating position could not be used.

TABLE VI-15
THE HYPOTHETICAL EFFECT ON FATALITIES AND INJURIES OF SHIFTING SEATING POSITIONS

	1982 FARS Data Used For 1990 Fatalities	1982 NASS Data Used For 1990 AIS 2-5 Injuries
Front Center Occupants	1,571	182,079
20% Move to Front Right Seat for Fatalities, 17% For Injuries	314	30,953
Casualty Rate of Front Right Seat[20]	x .3774	x .0274
New Front Right Casualties	119	848
80% Move to Back Seats For Fatalities, 83% For Injuries	1,257	151,126
Casualty Rate of Rear Seats	x .2218	x .0212
New Rear Seat Casualties	279	3,204
Total New Casualties	397	4,052
Minus Old Casualties Assuming No Restraint Use	-377	-5,080
Change In Casualties	+20	-1,028

[20] These rates could be adjusted to indicate the casualty rate with automatic belts rather than with manual belts. The fatality rate changes slightly to .3777, but this does not change the new front right casualties from 119. The injury rate would not change from .0274, the change is in the rounding.

There could be 20 more fatalities per year without the center seating position. The moving of 20 percent of the center seat occupants to the front right seat, which has a higher fatality rate, increases fatalities, while the moving of the remaining 80 percent to the rear seat reduces fatalities.

For AIS 2-5 injuries, the results are very different. AIS 2-5 injuries could be reduced by 1,028 per year, basically by forcing people into the back seat. Both the fatality and injury calculations assume no increase in automatic belt usage over the 12.5% current manual belt usage.

Another assumption that can be made for hypothetical purposes is that belt usage for the right front passenger will increase with the installation of automatic belts to 20-70 percent total usage. Table VI-16 shows the calculations under this assumption. At the same time, it is assumed that manual belt usage of the rear seat occupants would not increase with the installation of automatic belts.

Table VI-16 shows that 6 to 31 lives could be saved, and an additional 47 to 248 AIS 2-5 injuries could be reduced, because some people who would have been sitting in the front center seat might now be buckled up in the front right seat.

Table VI-17 shows the net impact on fatalities and injuries of continuing the requirement for automatic protection in the front center seat and the use of a console in the front center seating position given the assumptions in this analysis. There is very l ttle impact on fatalities (+14 to -11). There could be a reduction in AIS 2-5 injuries of 1,074 to 1,276 per year if no one could sit in the front center seat.

TABLE VI-16
THE HYPOTHETICAL EFFECT ON FATALITIES AND INJURIES
ASSUMING RIGHT FRONT PASSENGERS INCREASE
BELT USAGE WITH AUTOMATIC BELTS

	Current Manual Belt Usage (8.4%)		Automatic Belt Usage (20%)		Automatic Belt Usage (70%)	
	Fatalities	AIS 2-5 Injuries	Fatalities	AIS 2-5 Injuries	Fatalities	AIS 2-5 Injuries
New right front seat fatalities/ injuries from previous center seat occupants	119	848	119	848	119	848
Increase in belt usage	0	0	11.6%	11.6%	61.6%	61.6%
Effectiveness	N/A	N/A	42.5%	47.5%	42.5%	47.5%
Benefits due to belt usage	N/A	N/A	6	47	31	248

TABLE VI-17
NET IMPACT ON FATALITIES AND AIS 2-5 INJURIES
OF ELIMINATING THE FRONT CENTER SEATING POSITION

	FATALITIES	AIS 2-5 INJURIES
Impact of moving from front center seat	+20	-1,028
Impact of front right seat using restraints (20-70% Total Belt Usage)	-6 to -31	-47 to -248
NET	+14 to -11	-1,074 to -1,276

Another possible scenario can be analyzed. Assume that the front center seat is exempt from the standard and this seating position remains in the car with entrance available by detaching an automatic belt. Then assume these front center seat occupants, being influenced by outboard occupants, use their belts 20-70% of the time. The benefits in this case would be 19-85 lives saved and 230-990 AIS 2-5 injuries reduced.

Conclusions--Center Seating Position

Requiring automatic protection for the front center seating position leaves the manufacturers of six-seat passenger cars at least two options--air bags or elimination of the center seating position. If all cars used air bags, an estimated 107 of the projected 370 fatalities could be saved, and 1,703 of the projected 5,000 AIS 2-5 injuries could be reduced. If the manufacturers used a console to eliminate the front center seating position, there would probably be very little impact on fatalities. However, there could be a reduction in AIS 2-5 injuries of 1,074 to 1,276. Thus, a reduction of 21-34 percent of the AIS 2-5 injuries is possible (1,074 to 1,703/5,000). The big disadvantage of requiring automatic protection in the front center seat is the potential demise of the six-seat passenger car.

If the front center seat is exempt from the standard, 19-85 fatalities and 230-980 injuries would be reduced if usage increased 20-70 percent. These reductions are larger than those which could be obtained by eliminating the center seat position, but smaller than those anticipated from air bags. The injury benefits are smaller than either supplying air bags or eliminating the center seating position. Nonetheless, the analysis shows that not requiring automatic protection for the front center seat, while requiring it for the outboard positions, can lead to reductions in injuries and fatalities, compared to the current situation of having manual belts in all seating positions.

G. "Risk Compensation" Hypothesis

There were several commenters to the docket regarding risk compensation. Notably, a study by John G. U. Adams (74-14-N32-1675), a study by Adrian K. Lund and Paul Zador (74-14-N32-1671), Professor E. Scott Geller (74-14-N32-1008), John Graham (74-14-N35-063) and Professor Lloyd Orr (74-14-N35-076).

The "risk compensation" theory is described by Lund and Zador[21] as:

> "If drivers are forced to receive more protection than they would choose voluntarily, they respond with riskier driving that compensates, more or less, for the forced increase in protection."

A 1982 paper by John Adams, a British professor, suggests that mandatory use laws (MULs) are ineffective.[22] The report argues that: (1) The decrease in road fatalities since 1973 was greater in four countries that did not have (MULs) than in 13 countries that did; and (2) the evidence

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21 Adrian K. Lund and Paul Zador, "Mandatory Belt Use and Driver Risk Taking," IIHS, 1983.

22 John G. U. Adams, The Efficacy of Seat Belt Legislation, SAE Paper Series, 820819, June 1982.

supports the hypothesis that "protecting car occupants from the consequences of bad driving encourages bad driving"--more commonly referred to as the "Risk Compensation Hypothesis."[23]

There are several factors that cast serious doubts on the validity of Adam's analytical approach. For example:

(1) Adams uses "total traffic" fatalities rather than "car occupant" fatalities in his analysis. This approach could easily yield distorted results since, as his report notes: "Occupant fatalities comprise 37 percent of all highway fatalities in Japan, 42 percent in Britain, 56 percent in France and 72 percent in the United States."[24]

(2) Adams also notes: "Road death statistics can fluctuate substantially from year to year in a way that frequently mystifies the experts. In a particular country, in a particular year, other influences might obscure or greatly exaggerate the effect of a seat belt law."

Lund and Zador reviewed past studies about the theory and find the result of these studies to be inconclusive. As an MUL became effective in the province of Newfoundland of Canada in July 1982, the authors conducted a research project as to driver behavior before and after the law became effective. As a control, Lund and Zador undertook similar experiments in Nova Scotia, which was unaffected by an MUL. The result of their study showed no riskier driver behavior after implementation of the law--i.e., no

23 First advanced by S. Peltzman, "The Effect of Automobile Safety Regulation," Journal of Political Economy, 1975.

24 Adams, ibid., p. 2.

evidence of risk compensation. This is the only study that the agency is aware of that presents a before-and-after comparison of MUL-related behavior observations under controlled conditions.

Professor Orr disagrees with the Lund and Zador Report indicating that the changes in behavior may be more subtle and that the small changes in behavior dismissed by Lund and Zador may, in fact, be significant. Professor Orr offers a myriad of reasonable behaviors which could partially offset the benefits of MUL's or automatic restraint requirements. For example, parents may be more willing to allow teenagers to drive to late night recreational activities, if they know they will be buckled-up or have an air bag. John Graham, however, concludes, based on three separate studies, that there is no substantial empirical evidence for the risk-compensation theory nor is there any evidence that even if it were valid it would apply to a crashworthiness measure such as is the subject of this rulemaking.

In summary, the Department finds no <u>data</u> to convince it that the risk compensation theory applies in the case of mandatory use laws, or automatic restraints. Nor has it found any data to help quantify this effect. The Department has already reduced its manual belt effectiveness estimates based on data that indicates unrestrained occupants are involved in more serious accidents than today's restrained occupants. After this correction, the foreign experience, which should include any risk compensation effects, appears to agree with our estimates of effectiveness for manual belts (see Chapter IV). Since the automatic belt effectiveness estimates are derived from the manual belt effectiveness estimates, safety benefits from automatic belts may also include any risk compensation effects. However, the air bag effectiveness estimates would not include any risk compensation effects, if they exist.

H. Benefits of a Gradual Introduction of Automatic Occupant Protection

Tables VI-18, VI-19, and VI-20 show the reductions in fatalities, AIS 2-5 and AIS 1 injuries, respectively, over the lifetime of the cars sold during a gradual introduction of automatic occupant protection. Reductions are shown for two possible scenarios: under the first scenario, automatic belts would be used for 10, 25 and 40 percent of the fleet for the first, second and third years; under the second, air bags would be provided for 6.67, 16.67 and 26.67 percent of the fleet for three consecutive years, respectively. The benefits should be added to those that accrue under full implementation of the standard. (see Table VI-1).

I. Benefits of Mandatory Use Laws

Table VI-21 shows the safety benefits that would occur if states containing a total of 67 percent of the Nation's population enacted mandatory use laws, without the implementation of the automatic restraint requirements of FMVSS 208. Of course, benefits would be higher if additional states passed mandatory use laws.

TABLE VI-18
INCREMENTAL REDUCTION IN FATALITES
OVER THE LIFETIME OF THE MODEL YEAR FLEET
CENTER SEAT EXEMPT
BASED ON LOW-HIGH EFFECTIVENESS ESTIMATES

	MY 1987 10% Automatic Belts, 6.67% Air Bags	MY 1988 25% Automatic Belts; 16.67% Air Bags	MY 1989 40% Automatic Belts; 26.67% Air Bags
Air Bags Only	250-570	620-1,420	990-2,260
Air Bags with Lap Belt (12.5% Usage)	290-590	720-1,470	1,160-2,350
Air Bags with Lap/ Shoulder Belts (12.5% Usage)	300-600	750-1,500	1,200-2,390
Automatic Belts (20% Usage to	50-100	130-250	210-390
70% Usage)	500-750	1,260-1,880	2,010-3,000

TABLE VI-19
INCREMENTAL REDUCTION IN AIS 2-5 INJURIES
OVER THE LIFETIME OF THE MODEL YEAR FLEET
CENTER SEAT EXEMPT
BASED ON LOW-HIGH EFFECTIVENESS ESTIMATES

	MY 1987 10% Automatic Belts, 6.67% Air Bags	MY 1988 25% Automatic Belts; 16.67% Air Bags	MY 1989 40% Automatic Belts; 26.67% Air Bags
Air Bags Only	4,830-9,700	12,080-24,240	19,330-38,780
Air Bags with Lap Belt (12.5% Usage)	5,490-10,030	13,710-25,070	21,940-40,100
Air Bags with Lap/ Shoulder Belts (12.5% Usage)	5,650-10,200	14,120-25,480	22,590-40,770
Automatic Belts (20% Usage to	870-1,570	2,190-3,910	3,500-6,260
70% Usage)	8,690-12,460	21,720-31,140	34,740-49,830

TABLE VI-20
INCREMENTAL REDUCTION IN AIS 1 INJURIES
OVER THE LIFETIME OF THE MODEL YEAR FLEET
CENTER SEAT EXEMPT

	MY 1987 10% Automatic Belts, 6.67% Air Bags	MY 1988 25% Automatic Belts; 16.67% Air Bags	MY 1989 40% Automatic Belts; 26.67% Air Bags
Air Bags Only	16,810	42,010	67,220
Air Bags with Lap Belt (12.5% Usage)	16,810	42,010	67,220
Air Bags with Lap/ Shoulder Belts (12.5% Usage)	16,810	42,010	67,220
Automatic Belts (20% Usage to	2,280	5,690	9,100
70% Usage)	17,210	43,030	68,850

TABLE VI-21
ANNUAL SAFETY BENEFITS OF
MANDATORY USE LAWS
AFFECTING 67% OF THE POPULATION

INCREMENTAL FATALITY REDUCTION

	EFFECTIVENESS		
USAGE	LOW (40%)	MID-POINT (45%)	HIGH (50%)
40%	1,900	2,160	2,410
70%	3,970	4,500	5,030

INCREMENTAL AIS 2-5 INJURY REDUCTION

	LOW (45%)	MID-POINT (50%)	HIGH (55%)
40%	31,990	35,800	39,680
70%	67,290	75,310	83,460

AIS 1 INJURY REDUCTION

		10%	
40%	---	55,280	---
70%	---	115,320	---

VII. INSURANCE PREMIUM REDUCTIONS

The potential reduction in fatalities and injuries that are likely to result from mandated automatic restraints could produce a corresponding decrease in legal, medical and rehabilitation expenses. The reduction in these and other expenses associated with fatalities and injuries which are traditionally covered, at least in part, by insurance policies, would decrease insurance company payouts. On the other hand, it is possible that the additional cost of automatic restraints may increase insurance company payouts for certain property damage claims. Since insurance premiums are generally based on loss experience, it is assumed that shifts in this experience will eventually be reflected in the premiums paid by consumers.

Generally, three types of insurance provide coverage for injuries suffered in automobile accidents; automobile insurance, health insurance, and life insurance. Possible changes in insurance premiums for each type of insurance are examined in detail in this chapter. A summary of these changes is shown in the table below for the range of possible effectiveness rates. Note that savings occur in automobile, health, and life insurance due to fatality and injury reduction while costs associated with air bag deployments may cause a small increase in automobile insurance policies that cover property damage (collision and comprehensive insurance). The numbers in this summary table are derived from Tables VII-3, VII-17, VII-19, and VII-23 respectively for automobile insurance savings, automobile insurance losses, health insurance, and life insurance.

SUMMARY OF RANGE OF POTENTIAL NET EFFECTS ON INSURANCE PREMIUMS FROM AUTOMATIC RESTRAINT REQUIREMENTS

	Per Vehicle Annual Savings ($)	Per Vehicle Lifetime Savings ($)	Total Annual 1990 Fleet Equivalent Savings ($M)
Air Bags			
Automobile Insurance			
Savings-Safety	9-17	62-115	1108-2046
Loss-Deployment	(3)	(18)	(312)
Health Insurance	4- 8	29- 54	521- 962
Life Insurance	0- 1	3- 7	62- 136
Total	10-23	76-158	1379-2832
Automatic Belts (For 20 Percent Assumed Usage)			
Automobile Insurance	1- 2	5- 14	89- 243
Health Insurance	0- 1	2- 7	42- 114
Life Insurance	0	0- 1	7- 14
Total	1- 3	7- 22	138- 371
Automatic Belts (For 70 Percent Assumed Usage)			
Automobile Insurance	10-14	65- 94	1146-1676
Health Insurance	5- 7	31- 44	539- 788
Life Insurance	1	4- 6	71- 106
Total	16-22	100-144	1756-2570

Note that any changes in insurance premiums are likely to lag behind actual changes in loss experience. Moreover, the full value of the changes indicated in the above table would probably not occur until roughly 10 to

15 years after any of the proposed rules would be implemented-when the entire vehicle fleet has already been replaced with vehicles containing automatic restraints. Both safety benefits and premium reductions in intervening years would be considerably smaller because safety benefits would only accrue to the newer vehicles in the fleet. The "Total Annual Savings" column in the above table reflects a hypothetical situation in which the entire 1990 passenger car fleet was equipped with automatic restraints and had been so long enough to affect insurance experience. It is provided here in order to remain consistent with safety benefit calculations, which were based on 1990 fatality and injury forecasts.

A. Automobile Insurance

Automobile insurance plans include a variety of different coverages. Basically these include personal injury liability and medical coverage, which pays for bodily injury caused by accidents; physical damage liability, which covers damage to property of others caused by the policyholder; collision insurance, which covers damage to the policyholder's vehicle from accidents; and comprehensive coverage, which covers damage to the policyholder's vehicle from non-motor vehicle accident causes such as fire, flood, and theft.

Premiums paid for the first two of these coverages, personal injury liability and medical, would be reduced by the safety benefits that result from automatic restraints. Premiums paid for the remaining three coverages, physical damage liability, collision and comprehensive, may be increased to cover higher replacement and book value costs associated with air bags (the relatively low cost of automatic belts would have an insignificant effect on insurance premiums).

In the following sections, estimates will be made of the effect on premiums for each of these coverages. The effect of safety benefits on personal injury coverage will be examined first, followed by the added premium costs that may result for the various physical damage coverages.

1. Personal Injury Premium Reduction from Safety Benefits

The potential safety benefits associated with automatic restraints have prompted some insurance companies to offer premium reductions for cars equipped with these devices. These reductions are currently based on expected savings in both claims and expenses associated with first party[1] injury coverage. Based on a recent survey of insurance companies, NHTSA estimates that about 40 to 70 percent of all automobile insurance policies nationwide offer discounts of up to 30 percent on vehicles that have some form of automatic restraint.

This analysis is based on the assumption that the reduction in fatalities and injuries associated with automatic restraints will result in cost savings that will be passed on to consumers via premium reductions. While it is not certain what level of fatality and injury reduction would occur, insurance industry testimony indicates that savings from injury reduction

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[1] Under first party coverage, the policy holder collects compensation for losses from the insurer. Third party coverage refers to compensation paid by the policy holder's insurer to other persons involved in the crash.

will in fact be passed on to consumers. In past Public Hearings,[2] some insurance industry representatives indicated that they could not provide any assurances regarding the transfer of cost savings to consumers. Specifically, State Farm said a decision can only be made after a careful assessment of the impact of automatic restraints when an adequate number of cars are on the highway. However, in recent public hearing on FMVSS 208 State Farm stated that "substantial cost reductions . . . will be reflected in the rates which will be charged State Farm policyholders." In subsequent comments to the SNPRM, State Farm reaffirmed that insurance savings will be passed on to the consumer and labeled such savings as "substantial" while suggesting that the DOT estimates are conservative.

Other companies, have also stated that savings would be reflected in lower premiums. In recent public hearings,[3] Nationwide Insurance Co. cited existing discounts for automatic restraints, bonus coverage for seat belt users, and recent rate decreases in 19 jurisdictions as evidence that decreases in fatality and injury experience will, in fact, be passed on to consumers through premium reductions. Nationwide reiterated this view in comments to the SNPRM. Other commenters also testified that premiums would reflect changes in injury experience. These include the American Insurance Association,[4] the United States Automobile Association,[5] Allstate Insurance

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2 Public Hearing Concerning the Automatic Restraint Requirements of FMVSS 208, "Occupant Crash Protection, Volumes I and II," August 5-6, 1981, U. S. DOT, Diversified Reporting Services.

3 Public Hearing on Issue of Automatic Restraint Systems, Overland Park, Kansas, 12/1/83.

4 Public Hearing on Issue of Automatic Restraint Systems Overland Park, Kansas, 12/1/83.

5 Public Hearing on Federal Motor Vehicle Safety Standard 208, Occupant Crash Protection 11/28/83, Los Angeles, California.

Company,[6] The Automobile Club of Southern California,[7], the National Association of Independent Insurers,[8] and James P. Corcoran, Superintendent of Insurance of the State of New York.[9] Recently (6/84), New York State passed a law that would require insurance companies to offer discounts to drivers who have automatic restraints in their cars. Finally, the Automobile Club of Michigan, an affiliate of AAA, stated that they have committed to the Michigan Legislature to reduce premiums by 20 percent on the day a mandatory seat belt law becomes effective in Michigan.[10]

Insurance industry claims of premium reductions notwithstanding, the Department is still uncertain regarding the amount of premium reductions to be passed on to policyholders. The Department sought additional estimates of insurance savings through questions in the SNPRM, but insurance companies failed to provide further specifics regarding possible policy holder savings. The insurers claim they already offer 20 to 40 percent premium discounts for automatic restraint-equipped vehicles. However, these only apply to first-person injury payments, a relatively small part of total premiums. USAA was the only insurer to translate this "30 percent discount" into dollars, and at the Los Angeles public hearing stated it amounted to about $3 per year.

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6 Public Hearing on Federal Motor Vehicle Safety Standard 208, Occupant Crash Protection, 11/28/83, Los Angeles, California.
7 Public Hearing on Federal Motor Vehicle Safety Standard 208, Occupant Crash Protection 11/29/83, Los Angeles, California.
8 Public Hearing on Federal Motor Vehicle Safety Standard 208, Occupant Crash Protection, Washington, D.C. 12/7/83.
9 Public Hearing on Federal Motor Vehicle Safety Standard 208, Occupant Crash Protection, Washington, D.C. 12/5/83.
10 Docket 74-14-N33-129

The above discounts often apply only to air bags, not automatic belts. Nationwide, Aetna, Allstate, and GEICO related their current discounts to air bags only. Only Kemper stated it offered premium reductions for both automatic belts and air bags.

Insurers, in general, continued to refuse to estimate reductions for personal liability premiums. As in the past, only Nationwide offered a quantified estimate, $31 per year, for air bags, for all personal injury premiums. Several other companies stated the Nationwide estimate appeared reasonable while others claimed, because of industry competitiveness and because rates are based on experience, that "substantial" reductions would occur. However, Allstate stated that it was hard to predict reductions due to passive belts because manufacturers might produce "poorly performing automatic belts" which might not save any lives or prevent any injuries.

Overall, although it appears that some level of insurance premium reduction will result from automatic restraints, the exact level of that reduction is uncertain, and is highly dependent on the success of the restraint system in reducing deaths and injuries.

Current premium reductions are associated with first party injury coverage only. The following analysis of insurance cost savings is based on the assumption that as the fleet is replaced with more vehicles equipped with automatic restraints, insurance companies could begin to experience cost savings that would allow them to extend premium reductions to third party premiums as well as first party premiums. For competitive reasons, insurance companies may eventually discontinue the practice of offering vehicle specific discounts and offer, instead, general reductions in first and third party injury premiums.[11]

Estimates of insurance premium reduction have varied considerably. For example, data provided by Nationwide Mutual Insurance Companies to the FMVSS 208 docket[12] indicated that the installation of air bags in all automobiles would reduce private passenger first and third party liability premiums by 24.6% or $31 annually per insured car. However, the Insurance Commissioner of NY State, James Corcoran, estimates that, based on NY State data, annual premium savings of $66 per insured vehicle could be realized if automatic restraints were required. NHTSA has not adopted these estimates for several reasons: 1) the Nationwide estimate reflects expectations of air bag safety benefits that are inconsistent with current agency estimates. It was derived in 1976 and does not reflect what the agency believes to be the best estimate of air bag effectiveness. 2) The Corcoran estimate reflects data from one state only and is not nationally representative. Premiums in New York State tend to be higher than those in the overall country.

[11] This assumption is based on general discussions with representatives of the insurance industry. For further discussion, see comments of William Nordhaus, Docket No. 74-14-NPRM-N20-110 (pp. 11-12) and Docket No. 74-14-NPRM-N22-032 (pp. 12-13).

[12] Docket No. 74-14-N20-100, and 74-14-N35-038.

In Chapter IV a range of effectiveness rates is estimated for the various forms of automatic restraints. In the following pages, the mid-points of these ranges will be used to illustrate the methodology on which final estimates are based. Results for the entire range of estimates are listed in Table VII-3.

The safety benefits derived from an automatic restraint device are a function of both its effectiveness in reducing injuries and its usage rate. Based on data developed in Chapter IV (air bag effectiveness weighted by current belt usage) air bags are estimated to be 31.9 percent effective in preventing fatalities, 36.9 percent effective in preventing AIS 2-5 injuries and 10 percent effective in preventing AIS 1 injuries. NHTSA currently does not have data which indicate the part of insurance payouts that result from death as opposed to injuries. Fatalities make up less than 1.5 percent of all injuries and the incidence of AIS 2-5 injuries outnumber deaths by a ratio of almost 14 to 1. However, liability payments for deaths would typically be much higher than for most injuries (an exception to this might occur with AIS 4 or 5 injuries, which can involve expensive long term medical problems).

Allstate insurance estimated that 1 percent of their injury losses under personal injury protection, uninsured motorist, and bodily injury liability coverages are associated with instant or immediate fatalities.[13] FARS, NASS, and NCSS data, which are used to estimate safety benefits in this analysis, define a fatality as any death that occurs within 30 days of the accident. Considering the Allstate estimate of one percent of losses for

[13] Docket No. 74-14-032-6106.

instant or immediate fatalities, it will be assumed for this analysis that 10 percent of all losses are associated with deaths that occur within 30 days of the accident.[14] The remaining 90 percent of losses will be divided between AIS 2-5 and AIS 1 injury categories. This division will be based on the assumption that the aggregate economic cost of lost productivity and medical expenses reflects the appropriate ratio of insurance payouts. A recent NHTSA report, The Economic Cost to Society of Motor Vehicle Accidents[15] indicates that for these costs (exclusive of fatalities) roughly 16 percent is incurred from AIS 1 injuries and 84 percent is incurred for AIS 2-5 injuries. Overall weights would thus be 10 percent for fatalities, 75.6 percent for AIS 2-5 injuries, and 14.4 percent for AIS 1 injuries. Weighting the above mentioned effectiveness estimates by these factors, an average effectiveness (in reducing costs from injuries and fatalities) of 32.5 percent is derived for full frontal air bags.[16]

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[14] Allstate was not able to precisely define "instant or immediate," but the semantic description seems to imply death on impact. Such cases would require minimal medical attention and would therefore be less expensive than other fatalities which would typically require treatment in intensive care units. The use of a 10 percent estimate reflects both additional fatalities that occur within 30 days and the higher treatment costs that occur for those fatalities. While there are no data to confirm the accuracy of this estimate, it should be noted that the analysis is not overly sensitive to this variable. Prior to receipt of the Allstate estimate, an analysis was performed based on societal costs as measured in the 1/83 NHTSA report The Economic Cost to Society of Motor Vehicle Accidents. That analysis weighted fatalities to injuries in a 73-27 ratio rather than the 10-90 ratio used here. The overall results were roughly 8 percent lower than the savings estimated in this analysis. The 73-27 split was also used in the 10/83 PRIA. The large difference between this ratio and the Allstate estimate probably indicates that insurance payouts do not fully cover the value of lost productivity associated with fatalities.

[15] The Economic Cost to Society of Motor Vehicle Accidents, January 1983, DOT-HS-806-342.

[16]

Fatalities:	.319	effectiveness	x	.10	=	.032
AIS 2-5 Injuries:	.369	effectiveness	x	.756	=	.279
AIS 1 Injuries:	.10	effectiveness	x	.144	=	.014
		TOTAL				.325

Similarly, lap and shoulder belts, when used, are estimated to be roughly 43.7 percent effective in reducing fatalities and injuries.[17] The higher overall effectiveness of seat belts is due to their ability to reduce injuries for side, rear and rollover impacts as well as frontal impacts. However, currently seat belts are worn by only 14 percent of the driving population (12.5 percent of front seat passengers)[18] whereas air bags would protect virtually all front seat occupants.

A.M. Best Company (a publisher of insurance industry statistics) lists the 1982 value of private passenger liability premiums at $20.9 billion. Data from the insurance industry[19] indicates that 66 percent of this total or $13.8 billion is for personal injury coverage. The remainder is for damage to property. Best data show that roughly 73.5 percent of these premiums, or $10.1 billion will be paid out to accident victims as incurred losses from motor vehicle accidents. These losses could be reduced if automatic restraints were to result in fewer fatalities and injuries. Best data also indicate that loss adjustment expenses such as claim adjustment, legal fees, assessment costs, etc. represent 12.1 percent of premiums earned. Some of these costs represent expenditures that are relatively fixed. For example, some companies have their own claim adjusters and legal staff that would be paid a salary regardless of small variations in the accident rate.

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[17]

Fatalities:	.45 effectiveness	x	.10	=	.045
AIS 2-5 Injuries:	.50 effectiveness	x	.756	=	.378
AIS 1 Injuries:	.10 effectiveness	x	.144	=	.014
	TOTAL				.437

[18] Current usage rates for front driver, center and right seating position are .14, .050, and .084. The percent of projected 1990 front seat fatalities for the driver, center and right seating positions are 73.5, 1.5, and 25.0% (.14 x .735) + (.050 x .015) + (.084 x .250) = 12.5% average usage rate for front seat.

[19] See Docket 74-14-N32-6106 and 74-14-N32-6126

Other companies, however, hire claim adjusters as needed and even the larger companies may pay commissions to their own claim adjusters or hire additional legal staff if needed.

Although the short run effect of decreased injuries on these expenses is unclear, over the long run, lower injury rates should result in a proportional decrease in loss adjustment expenses. It will therefore be estimated that a total of 86 percent of premiums (73.5 percent incurred losses plus 12.1 percent loss adjustment) will be affected by reductions in injuries and fatalities. It should be noted that this reflects overall industry experience: for different companies the percentage may be higher or lower.

The above premiums cover roughly 111,560,000 vehicles[20] for an average personal injury liability premium of $124 per vehicle. Of this amount, 86 percent or $107 might vary with improvements in safety.

As mentioned above, safety benefits are a function of both effectiveness and usage rates. For this analysis, the product of these variables will be referred to as the safety factor. The safety factor of the current vehicle fleet as compared to the current fleet if it were air bag equipped is as follows:

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[20] Data from Automobile Insurance Plans and Services Office (AIPSO) indicates that in 1982 there were 111,564,554 vehicles (including light trucks and MPV's) covered by private passenger automobile liability policies.

1983 Fleet
.437 effectiveness x .125 usage = .055 (safety factor for front seats) x .486 (percent of all motor vehicle fatalities in front seat of automobiles)[21] = .027 (1983 fleet safety factor)

1983 Fleet (Air bag equipped)
.325 effectiveness x .98 usage = .319 x .486 = .155 (air bag equipped fleet safety factor)

Full frontal air bags would therefore increase the safety of the current fleet by 12.8 percentage points. This could reduce the average annual premium by $14.[22] These savings, which would accrue after the entire fleet has been equipped with air bags, would be applicable to the entire insured passenger car fleet. It is not certain when the existing fleet will be replaced. This could occur as early as 1998, but it is more likely to be early in the first decade of the new century before all vehicles are replaced. Since it is difficult to project vehicle sales that far into the future, for illustrative purposes, we will estimate total savings for 1998. In 1998, the insured passenger car fleet is estimated to be roughly 126 million vehicles.[23] Total annual savings would therefore be $1.8 billion.[24]

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[21] For this analysis it will be assumed that insurance losses are proportional to fatalities. Passenger car occupants are 52.8% of all fatalities. Front seat fatalities are 92% of all occupant fatalities. .92 x .528 = .486

[22] Assuming that incurred losses are directly proportional to the incidence of death and injury, the total variable loss per vehicle in 1982 if the safety effectiveness factor had been 0 (i.e. no seat belt usage) would be $110 (107/1-.027=$110). .128 x $110 = $14.08. Note that this represents an average savings. Savings for more accident prone groups, such as 18-24 year old male drivers, would probably be considerably higher while savings for drivers in low risk groups would be lower.

[23] Based on current forecasts, NHTSA estimates a passenger car fleet of 135 million in 1998. Data from AIPSO indicates that roughly 90% of all passenger cars are covered by liability insurance. Data from Nationwide Mutual Insurance Co. indicates that passenger cars pay 10 percent of commercial liability premiums. Based on AM Best data, commercial premiums total $4.7 Billion in 1982. Assuming the same average premium cost for commercial as for private policies the total number of cars with commercial insurance is 3,790,000 ((.10 x $4.7B)/$124). This represents roughly 3.4 percent of the total number of vehicles with private passenger liability coverage. Therefore, it is estimated that 93% of all vehicles have liability coverage. .93 x 135M= 126M.

Had the entire fleet been equipped with air bags in 1990 (the base year for fatality and injury benefit calculations), total annual savings would have been $1.6 billion.

Over the life of each vehicle, the discounted value of insurance savings (assuming a 10 percent discount rate and a 10 year vehicle life) would be $95.[25] Spread over the entire vehicle fleet (including uninsured vehicles), the discounted value is $89.[26]

Other alternatives being considered involve the use of detachable or nondetachable belts. There is considerable uncertainly regarding the actual usage rates that would eventually result from these systems. Estimates derived in Chapter V range from 20 to 70 percent. Table VII-1 shows the derivation of premium decreases for various usage levels of automatic belts. Table VII-2 summarizes the potential insurance premium benefits resulting from various usage rates that might occur for automatic belt systems, as well as those associated with the effectiveness rate expected for air bags. Safety belt usage laws are also under consideration in this analysis. Such laws would involve use of the current safety belt system which may be slightly more effective than automatic systems. Benefits from such laws would therefore be somewhat higher than those shown in Table VII-1.

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24 Note that light trucks, MPV's and other vehicles may also eventually receive some reduction in their liability premium. Although these vehicles would not contain automatic restraints, they may still benefit from the reduced injury experienced by passenger car occupants through lower liability settlements when the driver of the non-passenger cars is at fault.

25 The conversion factor for a 10% discount rate over 10 years is 6.758
6.758 x 14.08 = $95.

26 126m (insured vehicles) x $95/135m (all vehicles) = $88.81.

TABLE VII-1
ANNUAL PREMIUM SAVING FROM AUTOMATIC BELTS

Usage Rate	Safety Factor[27]	Percentage Point Increase[28]	Decreases in Premium[29]
20	.040	.013	$1.43
30	.061	.034	3.74
40	.081	.054	5.94
50	.101	.074	8.14
60	.121	.094	10.34
70	.141	.114	12.54

TABLE VII-2
SUMMARY OF POTENTIAL AUTOMOBILE PERSONAL INJURY INSURANCE PREMIUM SAVINGS[30]
AIR BAGS AND AUTOMATIC BELTS, MID-POINT EFFECTIVENESS
(1982 $)

	Per Insured Vehicle		Per Vehicle (Includes Uninsured)			
Automatic Belts: Usage Rate	Annual Savings	Life-Time[31]	Annual Savings	Life-Time[32]	Total Annual Savings 1998 Fleet (M)[33]	Total Annual Savings 1990 Fleet Equivalent (M)[34]
20	1	10	1	9	180	160
30	4	25	3	24	471	419
40	6	40	6	37	748	665
50	8	55	8	51	1026	912
60	10	70	7010	65	1303	1,158
70	13	85	12	79	1580	1,404
Air Bag:						
Effectiveness						
33	14	95	13	89	1774	1,577

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27 Usage Rate x Effectiveness (.416) x % Front Seat Passenger Car Fatalities (.486).

28 Safety Factor minus 1983 Fleet Safety Factor (.027).

29 Percentage Point Increase x estimated current premium rate with no belt usage ($110).

30 The values shown for manual or automatic belts must be considered as upper limits since they do not account for the apparent lower usage of safety belts by those involved in accidents as compared to the general population.

31 Present discounted value over 10 year lifetime at 10% discount rate.

32 Present discounted value over 10 year lifetime at 10% discount rate..

33 Per insured vehicle annual savings x 126 m insured vehicles (based on 135 m passenger car fleet in 1998).

34 Per insured vehicle savings x 112 m insured vehicles (based on 120 m passenger car fleet in 1990).

The above estimates, as well as all previous methodology in this chapter, have been derived from the mid-points of the estimated ranges of effectiveness discussed in Chapter IV. Given the uncertainty which is partially responsible for the establishment of these ranges, consideration should also be given to the upper and lower bounds of premium savings that could result when the low and high effectiveness values were considered. Table VII-3 compares the low, mid-point, and high effectiveness estimates for air bags, for automatic belts at 20 percent usage, and for automatic belts at 70 percent usage. Note that as a simplifying measure the

TABLE VII-3
SUMMARY OF POTENTIAL AUTOMOBILE PERSONAL INJURY INSURANCE PREMIUM SAVINGS FOR LOW, MID-POINT, AND HIGH EFFECTIVENESS RATES
(1982$)

	Insured Vehicles		All Vehicles			
	Annual Savings	Lifetime Savings	Annual Savings	Lifetime Savings	Total Annual Savings 1998 Fleet (Millions)	Total Annual Savings 1990 Fleet Equivalent (Millions)
Air Bags:						
Low Eff.	10	67	9	62	1,247	1,108
Mid Eff.	14	95	13	89	1,774	1,577
High Eff.	18	123	17	115	2,302	2,046
Automatic Belts - 20% Usage:						
Low Eff.	1	5	1	5	100	89
Mid Eff.	1	10	1	9	180	160
High Eff.	2	15	2	14	273	243
Automatic Belts - 70% Usage:						
Low Eff.	10	69	10	65	1,289	1,146
Mid Eff.	13	85	12	79	1,580	1,404
High Eff.	15	101	14	94	1,885	1,676

mid-point of lap and shoulder belt usage was used to define the 1983 base safety factor for both the high and low effectiveness estimates. Use of low or high estimates of base safety factors in various combinations with automatic restraint safety factors would have a minimal effect on the material results of this analysis.

2. Auto Physical Damage Premium Increases from Air Bag Replacement Costs

Although personal injury liability premiums might decrease because of automatic restraints, air bag deployment would make repair bills for vehicles involved in accidents somewhat higher. In addition, the cost of air bags would raise the average book value of passenger cars. This may, in turn result in higher auto physical damage premiums.

Three basic types of physical damage insurance could be affected by the addition of air bags to the vehicle fleet: Collision insurance, which covers repair of all damage to the driver's car caused by an accident, property damage liability insurance, which covers repairs for third party losses, and comprehensive insurance which covers damage or loss of the insured car due to fire, theft, and vandalism. Since both collision and liability insurance cover similar types of losses (i.e. damage from motor vehicle accidents), they will be examined together.

Note that, in the course of public testimony and comment on this rule, several commenters have stated that collision and comprehensive insurance premiums would automatically increase as higher vehicle prices (reflecting the addition of the air bag) pushed vehicles into higher cost categories. This would occur because collision and comprehensive premiums are often based on "symbol" categories which classify vehicles in a specific price range. As the price of the vehicle increases to reflect added air bag costs, some vehicles would move out of one "symbol" category and into the next, resulting in a higher premium for that vehicle. NHTSA does not have the data needed to make a precise estimate of the number of vehicles that would be affected. However, based on an examination of current symbol categories, roughly 10-15 percent of all vehicles appear likely to experience such a shift. It should be noted, however, that this shift is essentially a temporary phenomenon. In discussion with the Insurance Service Office (ISO), the organization that determines symbol rates for much of the industry, NHTSA has confirmed that this effect would occur, but that ultimately, competition in the insurance industry would result in modified ISO symbols that would reflect actual loss experience. Thus, long-run changes in comprehensive and collision insurance rates would reflect only increased insurance losses due to replacement costs for air bags and higher book values associated with totalled vehicles. Since this analysis examines the long-term effects of automatic restraints, no estimate is provided for the short-term increases that will result in the initial years of an automatic restraint rule.

In comments to the SNPRM, two insurers, GEICO and Kemper, agreed that air bags would result in higher physical damage premiums, although quantitative estimates were not supplied.

a. Motor Vehicle Accident Losses - Collision and Property Damage Liability Insurance

Both collision and property damage liability insurance policies will have to absorb additional costs for replacing deployed air bags, for the value air bags add to vehicles that are totalled, and for the added cost that will result when some damaged vehicles are considered "totalled" instead of repairable because of the added cost of replacing the air bag.

Replacement of deployed air bags: This cost is a function of both the number of air bag deployments and the cost of actually replacing a deployed air bag. The number of expected deployments is estimated as follows:

NASS data indicate that 2,300,000 passenger cars were involved in towaway accidents in 1981 when there were roughly 105.8 million passenger cars in use. Therefore 2.2 percent (2.3m/105.8m) of all passenger cars were involved in a towaway accident.

Generally speaking, air bags are intended for deployment when the longitudinal delta V (change in velocity) is 12 mph or greater. By combining data from NCSS and NASS, it can be estimated that 24.7 percent of all passenger car towaways experienced a frontal impact of this nature and magnitude. This included accidents in which the primary impact force was within 60 degrees of the centerline of the impacted vehicle. Table VII-4 illustrates the derivation of this number.

TABLE VII-4

PERCENT OF TOWAWAY ACCIDENTS LIKELY TO DEPLOY AIR BAGS

Direction of Force	NCSS Cumulative Percent >=12 MPH	x	NASS Percent of Towaway	=	Cumulative Percent >= 12 MPH
10 O'Clock	6.7		7.3		.49
11	31.6		10.1		3.19
12	41.9		41.5		17.39
1	32.2		9.5		3.06
2	7.2		7.9		.57
					24.70

Although air bags are generally intended to deploy at impacts equivalent to a delta V of about 12 mph, experience with the current air bag fleet indicates that a number of deployments occur at delta V's somewhat below 12 mph. There are several reasons why this might occur, including safety margins built into the sensors to insure air bag deployment, other characteristics of the sensor mechanism which limit its ability to precisely measure passenger compartment delta V, and errors in reporting accident characteristics. It is likely that this last factor - reporting error - is responsible for a significant part of reported below 12 mph deployments. The actual delta V is difficult to estimate after the fact of an accident. The agency has developed techniques for inferring delta V from structural deformation of the vehicles and other crash site evidence, but the ability to do so within one or two miles per hour is certainly not assured.

Both safety margins and limitations in sensor mechanisms are factors that will continue to affect real air bag deployment rates in any future vehicle fleets. To the extent that errors in accident reporting understate actual impact speeds, the previous estimates of deployment accidents could be understated so these errors would also effect any estimate of total deployment. It is therefore appropriate to reflect these factors in estimating future deployment rates.

An analysis of NHTSA's computerized file of the air bag fleet experience indicates that 34% of all air bag deployments occurred when reported longitudinal delta V's were below 12 mph.

Based on current experience, the total number of air bag deployments that would be expected after the entire vehicle fleet was equipped with air bags (roughly 1998) is computed as follows:

135 million (total passenger car fleet in 1998) x .022 (percent of p.c. fleet involved in towaway accidents) x .247 (percent of p.c. towaways with frontal impact > = 12 mph delta V)/ .66 (adjustment for below threshold deployments) = 1,111,500 deployments.

It should be emphasized that the adjustment for below threshold deployments reflects the experience of air bag systems designed in the mid to late 1970's and installed only on larger, more expensive vehicles. It therefore may not be representative of the type of performance that will occur on future vehicle fleets. Specifically:

o The vehicles in future fleets will probably be much smaller than the vehicles in the current sample fleet. Even today's fleet is on average, much smaller than the typical air bag fleet car. This will require a change in air bag system designs to reflect the need for faster bag inflation (due to shorter distance between the driver and the struck object) and to reflect the likelihood of the higher delta V's typically experienced by smaller, lighter vehicles.

o The driving experience of owners of current air bag equipped vehicles is probably not typical of the overall driving population. Since air bags were only installed on the larger, more expensive vehicles the accident experience of these vehicles should reflect the more cautious driving habits of the older more affluent population that typically purchases this type of vehicle. Moreover, at least some owners of air bag equipped vehicles chose to purchase the air bag and the voluntary purchase of a vehicle with an air bag in itself implies an overall concern for safety on the owner's part, which should be reflected in more conservative driving habits.

The actual "below threshold" deployment of future air bag fleets is uncertain. Generally, however, the more conservative driving habits of the current fleet would imply that the overall number of low-speed deployments should be less for the fleet as a whole than for the current air bag fleet. Moreover, future sensor designs should, through experience and technological advancement, be better able to accurately sense the more serious accidents that require air bag deployment. The above estimate based on current "below threshold" deployment experience might therefore be considered an outside bound of actual deployment incidence in the late 1990's.

A lower bound for deployment incidence can be computed by estimating that in the future, sensors will still typically be set to go off at a level somewhat below the 12 mph threshold in order to provide a safety margin for deployment, but that quality control and improved design will eliminate most unnecessary deployments. Assuming 10 mph as a reasonable safety margin, the lower bound would be estimated as follows:

135 m (vehicles) x .022 (towaway rate) x .342 (% of p.c. towaways with frontal impact > = 10 mph delta[35] V) = 1,015,740.

These estimates are based on vehicles towed away from the scene of the accident. Potentially, a number of non-towaway vehicles may also be involved in collisions that are of severe enough delta V that they should also result in air bag deployment. An examination of the 1982 NASS file indicates that there were 17,180 vehicles involved in non-towaway collisions with a delta V of 10 mph or greater. It is difficult to directly relate these vehicles to the total number of non-towaway accidents because NASS only examines a small percentage of all non-towaways.[36] Instead, we will estimate that the number of non-towaway deployments in the late 1990's will increase in direct proportion to the size of the vehicle fleet. The total estimate should therefore be 21650 ((135m/107m)x17180). Adding this to the previous low estimate (based on 10 mph delta V) gives a total of 1,037,390 deployments.

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[35] Derived as in Table VII-4 using 10 mph instead of 12 mph NCSS data.

[36] NASS only examines non-towaways that are reported to the police and involve an injury or the towaway of another vehicle. Most other types of accidents would be very minor and would probably not involve air bag deployments.

Similarly there were 7914 vehicles involved in non-towaway collisions with a delta V of 12 mph or greater. In the late 1990's this could grow to 9972 (135m/107m)x7914). Applying this figure to the methodology based on 12 mph delta V's gives a total of 15,109 (9972/.66). Adding these to the previous high estimate (based on 12 mph delta V) gives a total of 1,126,609 deployments.

Expected deployments for a total fleet equipped with air bags in the late 1990's could therefore be between 1,037,390 and 1,126,609 each year. Based on this analysis, it will be estimated that 1,100,000 passenger cars will be involved in an accident that will result in an air bag being deployed.

This represents roughly .8 of one percent of the passenger car fleet. By comparison, comments provided by GM, Ford, and Chrysler to the public docket estimated deployment rates equivalent to 1 percent, .7 of one percent, and .8 of one percent respectively. Similar comments by insurance companies indicated probable deployment rates of .9 of one percent for Allstate and 1.8 percent for the Automobile Club of Michigan.[37]

Of the air bags that will be deployed, a certain number will be replaced but others will not because the vehicle will have been totalled or because the owner chooses not to replace the air bag. To estimate the number of vehicles that are totalled, we must examine the relationship between book value, crash losses, and vehicle exposure.

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[37] Docket 74-14 Notice 32.

Table VII-5 shows the development of the average book value of vehicles for the last 10 model years based on average depreciation rates and average retail sales prices. In Table VII-6, average loss data by deductible category is shown by model year. Also shown in Table VII-6 is the estimated value at which a vehicle would be "totalled" instead of repaired. This estimate represents 60 percent of the average book value derived in Table VII-5. Sixty percent was chosen based on discussions with the insurance industry and it represents a general "rule of thumb" frequently used in the industry to account for scrap value, overhead costs, etc.

The data in Table VII-6 are not precise estimates of average repair cost because they do not include costs that exceed the vehicle's book value. In addition, accidents below the deductible amount are not included. These effects are offsetting in nature but their net effect is unknown. From these data, it will be estimated that, based on today's experience, vehicles over 6 years old that are involved in an accident severe enough to deploy an air bag will be scrapped instead of repaired.

This estimate is based on the fact that the average cost to repair a 7 year old car plus the deductible amount exceeds the value at which the vehicle is likely to be totalled in 3 of the 4 deductible categories.

The effect of excluding costs that exceed book value of some totalled vehicles implies higher overall costs, but under those circumstances, the assumption of year old vehicles being totalled would still hold. The effect of excluding accidents below the deductible amount implies lower actual costs, but very few such accidents are expected to occur below $50 or $100.

In the $50 category, the value falls about $60 short of the scrappage threshold, but the effect of excluding costs that exceed book value on totalled vehicles has probably understated the actual costs of the category without much offsetting effect from the exclusion of low damage accidents.

TABLE VII-5
AVERAGE BOOK VALUE BASED ON DEPRECIATION RATES AND RELATIONSHIP OF POST 1976 BOOK VALUES TO 1976 BASE

Year	Age	Percent of Original Price Remaining[38] x	Avg. Retail Sales Price[39] =	Avg. Book Values	Ratio N/1976	Inverse Ratio
1982	1	.798	9910	7908	6.154	.162
1981	2	.657	8850	5814	4.525	.221
1980	3	.546	7340	4007	3.118	.321
1979	4	.446	6950	3100	2.412	.415
1978	5	.362	6470	2342	1.823	.549
1977	6	.294	6120	1799	1.4	.714
1976	7	.235	5470	1285	1.0	1.0
1975	8	.182	4750	865	-	-
1974	9	.133	4390	584	-	-
1973	10	.085	3930	334	-	-

TABLE VII-6
AVERAGE LOSS DATA BY MODEL YEAR AND DEDUCTIBLE CATEGORY[40]

Year	Age	$50	$100	$200	$250	Avg.	Scrappage Threshold[41]
1974	9	419	516	714	760	618	350
1975	8	726	721	821	919	782	519
1976	7	663	764	854	953	817	771
1977	6	703	848	987	1101	927	1079
1978	5	802	944	1086	1216	1026	1405
1979	4	793	988	1167	1322	1089	1860
1980	3	828	1029	1222	1300	1129	2404
1981	2	873	1086	1315	1444	1209	3488
1982	1	1000	1261	1557	1681	1417	4744

38 Sales Weighted Average Derived from Depreciation Rates in "Cost of Owning and Operating Automobiles and Vans," 1982, Federal Highway Administration.
39 Source: NADA ref: Automotive News, 1983 Market Data Book Issue.
40 SOURCE: Insurance Services.
41 Computed as 60 percent of column 5 in Table 5.

Estimates of air bag deployed vehicles that will be scrapped are dependent on exposure data. It will be assumed that the portion of vehicles over 6 years old that are involved in an accident that deploys the air bag is equal to the relative exposure of such vehicles (number of vehicles x miles driven). These figures were first developed in the 6/79 Final Assessment of the Bumper Standard, and are listed in column 3 of Table VII-8.

From Table VII-8, the relative exposure of a vehicle 7 years old is .0782; therefore 86,020 (.0782 x 1.1m) vehicles 7 years old will be involved in an accident that will both deploy the air bag and total the vehicle. The relative likelihood of a similar occurence in later years that will be derived below will be applied to this number in Table VII-9.

The number of vehicles 6 years old or younger that would be totalled will be estimated by considering the relative book values, potential replacement costs, and travel exposure of the various model years.

These functions are derived in Table VII-5, VII-7, and VII-8. In Table VII-9, these functions are combined and related to the base estimate for 7 year old vehicles to produce estimates of air bag deployed but scrapped vehicles for passenger cars 1-6 years old. Note that the estimate is a direct function of potential repair cost and relative exposure, but an inverse function of book value.

The estimates in Table VII-9 are based on loss experience in today's vehicle fleet. However, for vehicles with deployed air bags, the added replacement cost of these devices may increase the portion of vehicles that are scrapped instead of repaired. To account for these vehicles, an estimate of the relative average repair costs for vehicles with deployed air bags will be made based on the data in Table VII-6. Table VII-10 shows the data in Table VII-6 altered to reflect the addition of air bag replacement costs. In addition the scrappage threshold has been revised upward to reflect the added book value caused by the air bag. Based on this table, it appears that the potential added $800 cost of repairing a vehicle with a deployed air bag will result in a 3 year shift of the threshold for model year vehicles that would be expected to be 100 percent scrapped in a collision that is serious enough to deploy the air bag.

TABLE VII-7
ESTIMATES OF RELATIVE POTENTIAL
REPLACEMENT COSTS BY MODEL YEAR

Year	Age	Avg. Retail Price	x	CPI Multiplier[42]	=	1982 Value of Avg. Retail Sales Price	Ratio N/1976
1982	1	9910		1.0		9910	1.052
1981	2	8850		1.066		9434	1.002
1980	3	7340		1.182		8676	.921
1979	4	6950		1.354		9410	.999
1978	5	6470		1.508		9756	1.036
1977	6	6120		1.617		9896	1.051
1976	7	5470		1.722		9419	1.000

[42] CPI all items index. The CPI New Car index was considered for use but rejected because poor sales and competitive pressure has kept new car prices from rising as fast as aftermarket materials and repair costs. There is also a CPI auto parts and equipment index but it did not exist prior to 1978. The PPI motor vehicle parts index was also rejected because it is felt that its extremely small sample (prior to 1982) is not a reliable indicator of price changes in the diverse market for vehicle replacement parts.

TABLE VII-8

RATIO OF EXPOSURE BY MODEL YEAR

Year	Age	Relative Exposure[43]	Ratio N/1976
1982	1	.1811	2.316
1981	2	.1511	1.932
1980	3	.1326	1.696
1979	4	.1183	1.513
1978	5	.1058	1.353
1977	6	.0924	1.182
1676	7	.0782	1.000
1975	8	.0620	-
1974	9	.0460	-
1973	10	.0325	-

TABLE VII-9
ESTIMATED VEHICLES IN ACCIDENTS THAT DEPLOY
AIR BAGS AND ARE SUBSEQUENTLY SCRAPPED RATHER
THAN REPAIRED -- BASED ON CURRENT COST/BOOK VALUE RELATIONSHIPS

Year	Age	Exposure Ratio	x	Potential Cost Ratio	x	Inverse of Book Value Ratio	=	Ratio of Scrapped Vehicles to 1976 Base	Total Vehicles w/ Deployed Air Air Bags Scrapped[44]
1982	1	2.316		1.052		.162		.395	33977
1981	2	1.932		1.002		.221		.428	36816
1980	3	1.696		.921		.321		.501	43096
1979	4	1.513		.999		.415		.627	53934
1978	5	1.353		1.036		.549		.770	66235
1977	6	1.182		1.051		.714		.887	76300
1976	7	1.000		1.000		1.000		1.000	86020
1975									68000
1974									51000
1973									36000
								TOTAL	551,378

[43] The percent of total lifetime VMT, as a function of surviving vehicles x average miles driven by vehicle age. These figures were initially derived in "Final Assessment of the Bumper Standard," U.S. Department of Transportation, NHTSA, June 6, 1979 DOT-HS-804-718.

[44] For 1977-1982, Ratio of Scrapped Vehicles to 1976 Base x 86020 (1976 base). For 1973-1976, Relative Exposure from Table VII-8 x 1.1m.

In Table VII-11, the estimates from Table VII-9 are re-calculated based on this new threshold year (a 4 year old vehicle instead of 7 year old vehicle). By comparing this estimate of vehicles scrapped to the one from Table VII-7, it can be estimated that 304,429 additional vehicles would be scrapped rather than replaced.

Although higher repair costs may induce insurance companies to total these vehicles, owners may in some instances, prefer to keep their vehicles and not replace the air bag. Such a decision would be attractive to owners whose vehicle sustained only superficial damage and remains in good running order since it would allow them to avoid the expense and uncertainty of purchasing a new car. It would also be attractive to insurance companies because their settlement loss would not reflect the added cost of air bag replacement. On the other hand, persons who have just been saved from death or injury by the air bag may become convinced of its value and prefer to purchase a new vehicle rather than drive their repaired vehicle without an air bag. Data do not exist to indicate which part of these vehicles will actually be repaired rather than scrapped. For purposes of this analysis it will be assumed that half of these vehicles will be repaired without the air bag. Therefore 152,215 vehicles will be potentially scrapped due to the added cost to air bag repairs.

From air bag deployments then, there are four basic groups of vehicles:

244,193	vehicles repaired with air bag replaced
551,378	vehicles scrapped due to accident severity
152,215	vehicles scrapped due to added replacement costs
152,214	vehicles repaired without the air bag

1,100,000	vehicles with deployed air bags

TABLE VII-10
RELATIVE AVERAGE COST ESTIMATE
FOR VEHICLES WITH DEPLOYED AIR BAGS

Year	Age	Avg. Loss	Avg. Deductible	Air Bag Repl. Cost	Revised Avg. Cost	Revised Scrappage Threshold
1974	9	618	154	800	1572	376
1975	8	782	154	800	1736	556
1976	7	817	154	800	1771	816
1977	6	927	154	800	1881	1135
1978	5	1026	154	800	1980	1474
1979	4	1089	154	800	2043	1946
1980	3	1129	154	800	2083	2508
1981	2	1209	154	800	2163	3614
1982	1	1417	154	800	2371	4897

TABLE VII-11
ESTIMATED VEHICLES IN ACCIDENTS THAT DEPLOYED
AIR BAGS AND ARE SUBSEQUENTLY SCRAPPED RATHER THAN REPAIRED --
BASED ON POST AIR BAG COST/BOOK VALUE RELATIONSHIPS

Year	Age	Exposure Ratio	x	Potential Cost Ratio	x	Inverse of Book Value Ratio	=	Ratio of Scrapped Vehicles to 1979 Base	Total Vehicles w/Deployed Air Bags Scrapped[45]
1982	1	1.531		1.053		.390		.629	81852
1981	2	1.277		1.033		.533		.683	88879
1980	3	1.121		.922		.773		.737	95906
1979	4	1.00		1.00		1.00		1.00	130130
1978	5								116380
1977	6								101640
1976	7								86020
1975	8								68000
1974	9								51000
1973	10								36000
								Total	855807

A different loss will be incurred for vehicles in each of these categories. For repaired vehicles, this cost will be the full replacement cost of the air bag system. In chapter VIII the initial cost of full front air bags was estimated to be $320. The total replacement cost of these bags is estimated to be roughly 2.5 times this amount or $800.

[45] For 1980-1982, Ratio of Scrapped Vehicles to 1979 Base x 130130 (1979 base) for 1973-1979, Relative Exposure from Table VII-8 x 1.1m.

The cost of replacing these bags will be borne partly by collision insurance and partly by physical damage liability insurance. Estimates from major insurance companies[46] indicate that the percent of property damage loss borne by collision is roughly 60 percent, with the remaining 40% borne by liability coverage.

Data from the Automobile Insurance Plan Service Office (AIPSO) indicates that 63% of all passenger cars are covered by collision insurance. As noted in footnote 22, roughly 3 percent of all passenger cars are covered under commercial liability policies. It will be estimated here that all of these vehicles are also covered by physical damage policies. Thus, 66 percent of all passenger cars are estimated to have collision insurance. Also, from footnote 22, 93 percent of all cars have liability coverage. The total annual cost to insurance companies to cover the replacement of deployed air bags is therefore estimated as follows:

Loss Ratio=60% (Collision loss)/40% (property damage liability loss)=1.5

Total Replacement Cost=244,193 replaced air bags x $800 = $195,354,400

Insured property damage liability loss=x

$$x/.93 + 1.5x/.66 = \$195,354,400$$

x=$58,349,582 (total loss incurred for property damage liability)

1.5x=$87,524,373 (total loss incurred for collision insurance)

By implication, these costs would cover 72,937 vehicles under property damage liability and 109,405 vehicles under collision insurance (x/$800).

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[46] Docket Numbers 74-14-32-6106 and 6126.

The total annual cost to insurance companies to cover the replacement of deployed air bags is thus $145,873,955 for 182,342 vehicles.[47]

Individual vehicles that are scrapped due to the added replacement costs of air bags would have a net added insurance loss of between $1 and $800, depending on the repair cost for the rest of the vehicle and the vehicle's book value.

Data are not available to determine the exact average increase that will occur from this effect. For purposes of this analysis, it will be assumed that the chances of any given net increase are equal (i.e., repair costs are equally distributed in that range). The average net increase would therefore be half of the maximum loss or $400. The total annual cost to insurance companies to cover air bag costs in these scrapped vehicles is therefore $45,464,458.[48]

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[47] Generally it might be assumed that some persons would choose not to replace a deployed air bag after an accident; however, for the insured population this replacement would be free and it will therefore be assumed that all insured vehicles will have the bags replaced.

[48] Applying the same formula used above for repaired vehicles:
152,215 scrapped vehicles x $400 = $60,886,000

x/.93 + 1.5x/.66 =	$60,886,000			
x =	$18,185,783	(P.D.L.)	for	45,464 vehicles
1.5x=	27,278,675	(collision)	for	68,197 vehicles
	----------			-------
Total	$45,464,458			113,661

The remaining 551,378 vehicles will be scrapped because they were in an accident of enough severity to "total" the car regardless of the presence of the air bag. The added loss in these vehicles should therefore be a function of the remaining book value of the air bag.

The effect that an air bag will have on passenger car book values is uncertain. It could be argued that the air bag will remain unused until an accident and will thus retain nearly its full value, increasing used car book values by hundreds of dollars. Conversely, it is possible that consumers will not perceive the added value of these devices in used cars. Since there is no evidence to predict the actual valuation of air bags in used cars, this analysis will assume that they will depreciate at the same rate as the rest of the vehicle.

In Table VII-12, the average depreciation rate of a vehicle in a total loss accident is computed based on the number of vehicles estimated to be

TABLE VII-12
AVERAGE DEPRECIATION OF SCRAPPED VEHICLES

Year	Age	Deployed and Scrapped Vehicles	Weight by Model Year	×	Cumulative Average Depreciation[49]	=	Avg. Depreciation
1982	1	33977	.062		20.2		1.25
1981	2	36816	.067		34.3		2.30
1980	3	43096	.078		45.4		3.54
1979	4	53934	.098		55.4		5.43
1978	5	66235	.121		63.8		7.72
1977	6	76300	.138		70.6		9.74
1976	7	86020	.156		76.5		11.93
1975	8	68000	.123		81.8		10.06
1974	9	51000	.092		86.7		7.98
1973	10	36000	.065		91.5		5.95
TOTAL			1.000				65.90

[49] 1 - Percent of original price remaining (from Table VIII-5).

scrapped with deployed air bags in Table VI-9. In essence, this estimate is a function of exposure ratios, potential cost to repair, and the average book values of vehicles by model year.

The average value of an air bag in a "totalled" vehicle is therefore estimated to be $110 ((1-.659) x $320). The total value of all air bags in vehicles with deployed air bags scrapped due to accident severity is therefore $45,289,412[50].

Added cost from scrapped vehicles without air bag deployment: Each year, a certain number of vehicles will be totalled in accidents that do not result in air bag deployment. The higher book value of these vehicles resulting from air bags will increase insurance losses associated with their replacement. This cost is a function of the number of vehicles that will be considered total losses after an accident and the average depreciated value of an air bag in these vehicles.

The number of vehicles typically lost each year in accidents will be estimated based on insurance company experience. Estimates of totalled vehicles obtained from major insurance companies varied considerably. AAA of Michigan estimated that 1.5 percent of their insured vehicles were

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[50] Applying the same formula used previously for repaired vehicles:
551,378 scrapped vehicles x $110 = 60,651,580
x/.93 + 1.5x/.66 = $60,651,580
x = $18,115,765 (P.D.L.) for 164,689 vehicles
x = $27,173,647 (coll.) for 247,033 vehicles

Total	$45,289,412	411,722

"total losses" each year.[51] Allstate Insurance Company's experience was considerably different. They estimated that roughly .4 of one percent of their insured vehicles are scrapped annually.[52] State Farm's experience fell between these two extremes. Salvage rates from State Farm imply annual "totals" covered by insurance of .7 of one percent.[53] Estimates include all salvaged vehicles, regardless of salvage method (scrapped, auctioned, etc.). This analysis will be based on the State Farm estimate, both because of its moderate nature and because of State Farm's position as the largest underwriter of automobile insurance.

The total number of insured vehicles that should be expected to be "totalled" in the late 1990's would therefore be 945,000 (135m x .007).

From this number, we must deduct the 411,722 scrapped vehicles with deployed air bags (which have already been accounted for). Thus 533,278 additional insured vehicles will be scrapped that did not have their air bags deployed. Note that no deduction was made for vehicles scrapped because of the added cost of air bags because these represent additional scrappages over and above those predicted by current experience.

As previously mentioned, the average value of an air bag in a totalled vehicle is estimated to be $110. The total insurance loss of all air bags in vehicles normally scrapped each year that do not have deployed air bags

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51 Testimony of Clifford Brown, V.P. and Secretary, the Automobile Club of Michigan at Public Hearings on FMVSS 208, 12/7/83, Washington D.C.

52 Docket No. 74-14-32-6106.

53 In 1982 State Farm salvaged 136,100 cars and light trucks and held 14.7 percent of the market. This implies a national total of 925,850 salvaged vehicles at a time when there was 137.9 in such vehicles in use or .007 of the vehicle population.

is therefore $58,660,580 (533,278 x $110). Sixty percent of this loss or $35,196,348 would accrue to collision insurance and 40 percent or $23,464,232 would accrue to property damage liability insurance. These costs would cover damages to 319,967 vehicles (collision insurance) and 213,311 vehicles (P.D.L.), respectively.

The total expected loss from air bags that will be borne by collision and property damage liability insurance policies is summarized in Table VII-13.

TABLE VII-13

SUMMARY OF COLLISION AND PROPERTY DAMAGE
LIABILITY LOSSES - AIR BAG DEPLOYMENTS IN 1998

	COLLISION		PROPERTY DAMAGE		TOTAL	
	$	VEH.	$	VEH.	$	VEH.
Repaired	87,524,373	109,405	58,349,582	72,937	145,873,955	182,342
Scrapped-A/B	27,278,675	68,197	18,185,783	45,464	45,464,458	113,661
Scrapped-Severity	27,173,647	247,033	18,115,765	164,689	45,289,412	411,722
Scrapped-No Deployment	35,196,340	319,967	23,464,232	213,311	58,660,580	533,278
Total	177,173,043	744,602	118,115,362	496,401	295,288,405	1,241,003

b. Comprehensive Insurance

Comprehensive insurance policies will have to absorb additional costs for the value air bags add to vehicles that are stolen. Data from the Federal Bureau of Investigation indicates that roughly .7 percent of all passenger cars were stolen in 1982. Data were not available to indicate the number of vehicles that were recovered, however, the value of recovered vehicles was roughly 54 percent of the value of those vehicles that were stolen. Data from the insurance industry however indicates that roughly two-thirds of all thefts are recovered.[54] From these data, it is estimated that, on a nationwide basis, roughly two-thirds of all stolen vehicles are recovered, leaving .2 percent of all passenger cars as total thefts. Applying this percentage to total passenger cars in 1998, the estimated number of passengers car total thefts will be 270,000 (135m x .002).

Data from AIPSO indicates that 73 percent of all passenger cars are covered by comprehensive policies. As noted in footnote 23, an additional 3 percent may be covered by commercial policies. Total comprehensive coverage is therefore estimated to be 76 percent. The total number of insured vehicles that would become total thefts would therefore be 205,200 (270,000 x .76).[55]

The cost to insurance companies for these stolen vehicles would be increased by the average depreciated value of air bags in the vehicles. To determine this value we must consider the relative likelihood of vehicles of different ages being stolen. Table VII-14 shows the estimated numbers of vehicles of a specific model year still surviving in 1982. In Table VII-15, these estimates are combined with data from the National Automobile Theft Board and the FBI to estimate the chance of theft by vehicle age. These data show that just over one percent of available vehicles are stolen for each model year. The large deviation from this trend in 1982 is

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[54] Individual estimates of total thefts vary considerably. Both State Farm and Allstate provided data indicating that about .2 percent of their insured vehicles were total thefts. AAA of Michigan however found 1.8 percent of their covered vehicles to be total thefts. A recovery rate of two-thirds produces a national estimate that is consistent with the State Farm and Allstate estimates.

[55] Note that this estimate may be somewhat conservative since those vehicles that are more likely to be stolen are probably more likely to be covered by comprehensive insurance.

unexplained, but may be the result of reporting or registration lags. Although logic might argue that newer cars are more likely to be stolen, actual experience appears to show no such bias.[56]

TABLE VII-14
ESTIMATE OF SURVIVING VEHICLES BY
MODEL YEAR IN 1982

Year	Domestic Sales	Imports Sales	Total[57]	Survival Pro.[58]	#Vehicles in 1982
1974	7448920	1,403,035	8,851,956	.519	4,594,165
2975	7050120	1,577,000	8,627,120	.661	5,702,526
1976	8606573	1,493,000	10,099,573	.784	7,918,065
1977	9104454	2,071,160	11,175,554	.873	9,756,259
1978	9307998	2,000,500	11,308,498	.929	10,505,595
1979	8315622	2,327,932	10,643,554	.962	10,239,099
1980	6578275	2,396,934	8,975,209	.982	8,813,655
1981	6206296	2,326,376	8,532,672	.993	8,472,943
1982	5756660	2,220,911	7,977,571	.998	7,961,616

TABLE VII-15
RATIO OF THEFTS TO SURVIVING FLEET
BY MODEL YEAR

Year	Age	% of Total Thefts	# Thefts by Model Year	# Surviving Vehicles	Thefts/ Surviving Vehicles
1974	9	6.52	51126	4594165	.011
1975	8	7.5	58810	5702526	.010
1976	7	10.86	58157	7918065	.011
1977	6	12.72	99742	9756259	.010
1978	5	14.0	109779	10505595	.010
1979	4	15.44	121463	10239099	.012
1980	3	12.68	99428	8813655	.011
1981	2	12.21	95743	8472943	.011
1982	1	7.59	59516	7961616	.007

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56 Note, however, that due to higher exposure, more new cars, in absolute terms, are generally likely to be stolen. It may be that the higher availability of newer cars is roughly proportional to the higher theft demand for these vehicles, leaving the ratio of stolen cars/available cars basically unchanged from model year to model year.

57 Source: Automotive News, 1983 Market Data Book Issues.

58 Source: Final Assessment of the Bumper Standard, NHTSA, 6/1/79, DOT-HS-804-718.

From Table VII-15 it is apparent that, although a vehicle's age does not significantly influence the rate of theft, vehicle population does. To determine the average depreciated value of air bags in stolen vehicles therefore, it is appropriate to weight annual depreciation rates by model year population size.

In Table VII-16, cumulative average depreciation rates are combined with survival probability ratios to estimate the average depreciation in a stolen vehicle. With a $320 initial purchase price for air bags, the average remaining value of these devices in a stolen vehicle is $135 ((1-.578)x$320). The total loss associated with air bags in these stolen vehicles is therefore $27,702,000 (205,200 x $135).

In addition to theft losses, higher book values would also increase losses associated with damage caused by fire, flood, etc. Allstate Insurance Company provided data which indicate that .2 percent (in addition to the .2 percent stolen) of vehicles covered by comprehensive policies are lost to fire and flood. Assuming the value of the air bags in these vehicles is also a function of survival probability, an additional $27,702,000 in losses would be incurred. The total loss paid for by comprehensive insurance would therefore be $55,404,000.

An additional loss may be incurred on comprehensive policies due to inadvertent deployments. These deployments may occur when sensors are inadvertently set off while the vehicle is being repaired or as a result of incorrect installation. In Chapter V, it is estimated that .00001 of all passenger cars might experience an inadvertent deployment each year (see

Chapter V for a complete discussion of inadvertent deployment). Total inadvertent deployments would therefore be 1,350 in the late 1990's (.00001x135,000,000). The maximum cost to repair these air bags would be just over one million dollars (1,350x$800=$1,080,000). Since many and probably most of these deployments will occur because of negligence by garage personnel,[59] it is likely that restoration of the air bag will, in most cases, be paid for by the establishment that is responsible. This would not impact automobile insurance companies, and would have only an insignificant effect on liability insurers for the repair establishment. The small number of inadvertent deployments which are not the responsibility of a repair establishment would likewise have an insignificant effect on comprehensive premiums.

TABLE VII-16
AVERAGE DEPRECIATION OF
STOLEN VEHICLES

Age	Probability of Survival[60]	Relative Weight By Age	Cumulative Average Depreciation[61]	Average Depreciation
1	.998	.123	20.2	2.49
2	.993	.123	34.3	4.22
3	.982	.121	45.4	5.49
4	.962	.119	55.4	6.59
5	.929	.116	68.3	7.40
6	.873	.108	70.6	7.63
7	.784	.097	76.5	7.42
8	.661	.082	81.8	6.71
9	.519	.064	86.7	5.55
10	.384	.047	91.5	4.30
		1. 00		57. 8

[59] Roughly 70 percent of inadvertent deployments that have occurred with currently equipped vehicles were service related.

[60] From Table VII-14.

[61] From Table VII-12.

With roughly 102,600,000 vehicles carrying comprehensive coverage (135m x .76), 89,100,000 vehicles carrying collision insurance (135m x .66) and 125,550,000 (135 m x .93) vehicles carrying property damage liability insurance, the additional incurred losses from air bags may cause annual comprehensive premium increases of roughly $.54 per insured vehicles (55,404,000/102,600,000), collision premium increases of $1.99 per insured vehicle ($177,173,043/89,100,000) and property damage liability premium increases of $.94 per insured vehicle (118,115,362/125,550,000). On a per vehicle basis (including uninsured vehicles) these losses average $.41 for comprehensive insurance, $1.31 for collision insurance, and $.88 for property damage liability insurance. These costs are summarized in Table VII-17.

TABLE VII-17
SUMMARY OF POTENTIAL AUTOMOBILE PHYSICAL DAMAGE PREMIUM COSTS RESULTING FROM AIR BAGS
(DOLLARS)

	Per Insured Vehicle Annual Cost	Per Vehicle Lifetime Cost	Per Vehicle Annual Cost	Per Vehicle Lifetime Cost	Total Annual Cost 1998 Fleet (m)	Total Annual Cost 1990 Fleet Equivalent[62] (m)
Collision	1.99	13.45	1.31	8.85	177.2m	157.5m
Property Damage Liability	.94	6.35	.88	5.95	118.1m	105.0m
Compre-hensive	.54	3.65	.41	2.77	55.4m	42.2m
TOTAL[63]			2.60	17.57	350.7m	311.7m

62 The 1990 fleet equivalent estimate is computed by scaling down the 1998 total annual cost by the ratio of the 1990 fleet size to the 1998 fleet size (120/135).

63 No total is provided for per insured vehicle figures because each type of insurance covers a different number of vehicles. The addition of these numbers would therefore not be meaningful.

B. Health and Other Insurance

In 1979, health insurance premiums in the U.S. totaled $66 billion, and benefit payments were $57 billion. About 85 percent of the population was covered by one or more forms of health insurance. About 68 percent of all car owners had some form of major medical insurance.[64]

Direct statistics on the amount paid by the health insurance industry to automobile crash victims are not available. However, a recent survey by the All-Industry Research Advisory Committee (AIRAC) provides some indication of the magnitude of health and other insurance benefits paid to people who have been in motor vehicle crashes.[65] AIRAC found that for the 1,107 persons whose claims had been closed with payment from some source, automobile insurance provides 67.5% of the payments, Group Health about 22.3%, government 5.6%, and workers' compensation 3.5% of the total payments. Using these percentages, a rough estimate can be made that insurance payments to these beneficiaries from all other sources (exclusive of auto insurance) amount to about one half (47 percent) of the auto insurance payments.[66] Assuming that this ratio can be applied to automobile insurance savings as well (see Table VI-1), the potential reduction in

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64 Health Insurance Institute, 1980-81, Source Book of Health Insurance Data, p. 6.

65 All-Industry Research Advisory Committees (AIRAC), Automobile Injuries and Their Compensation in the U.S., Volume 1, p. 126.

66 $(22.3 + 5.6 + 3.5)/67.5 = 46.5$

health, government, and workers compensation under the various automatic restraint alternatives would be between $85 million and $834 million annually.[67]

Based on current projections, in 1998, the U.S. population should be roughly 265 million persons. Assuming that 85 percent of them are covered by some form of health insurance (as is the case today), these reductions represent an annual savings of between $0.40 and $3.70 per insured individual.[68]

Table VII-18 lists the range of total and annual savings, as well as the discounted value of these savings, for air bags and the range of possible belt usage rates. As with automobile insurance, these numbers were computed based on mid-points of the range of effectiveness rates for illustrative purposes. In Table VII-19, estimates are provided for the range of effectiveness values in order to provide bounds for possible health insurance savings.

[67] From Table VII-2, the lowest savings estimate is $ 180 M x .47 = $ 85 M
the highest savings estimate is $1774 M x .47 = $834 M

[68] 265 M x .85 = 225 M insured persons
85 M/225 M = .38
834 M/225 M = 3.71

TABLE VII-18
HEALTH INSURANCE
SAVINGS[69]

Automatic Belts: Usage Rates	Automobile Ins. Total Annual Savings	Health Ins. Total Annual Savings[70]	Health Ins. Per Vehicle Annual Savings[71]	Health Ins. Per Vehicle Lifetime Savings[72]
20	180	85	.63	4.26
30	471	221	1.64	11.06
40	748	352	2.61	17.62
50	1026	482	3.57	24.13
60	1303	612	4.53	30.63
70	1580	743	5.50	37.20
Air Bags: Effectiveness				
33	1774	834	6.18	41.75

69 Note that the estimates in Table VII-18 assume a lost adjustment expense ratio for health insurance that is similar to that for automobile insurance. NHTSA has found evidence that overall administrative costs are higher for automobile insurance than for health insurance. Assuming that loss adjustment costs are less for health insurance, the above estimates would overstate the savings resulting from health insurance. However, since the loss adjustment cost savings represents only 14 percent of total savings, any potential error that might result form this assumption would not significantly affect the overall estimate of insurance savings.

70 Total Annual Automobile Insurance Savings x. 47.

71 Total Annual Health Insurance Savings/135 M Vehicles.

72 Discounted over a 10 Year Lifetime at 10% discount Rate.

TABLE VII-19
SUMMARY OF POTENTIAL HEALTH INSURANCE PREMIUM SAVINGS
FOR LOW, MID-POINT, AND HIGH EFFECTIVENESS RATES
(1982$)

	Per Vehicle Annual Savings	Per Vehicle Lifetime Savings	Total Annual Savings 1998 Fleet (Millions)	Total Annual Savings 1990 Fleet Equivalent (Millions)
Air Bags:				
Low Eff.	4	29	586	521
Mid Eff.	6	42	834	741
High Eff.	8	54	1,082	962
Automatic Belts - 20% Usage:				
Low Eff.	0	2	47	42
Mid Eff.	0	4	85	76
High Eff.	1	7	128	114
Automatic Belts - 70% Usage:				
Low Eff.	5	31	606	539
Mid Eff.	6	37	743	660
High Eff.	7	44	886	788

The AIRAC survey found that for the cases in which more serious injuries occurred -- those with costs exceeding $25,000 -- automobile insurance paid only about 23 percent of the total benefits while group health and government sources paid about 77 percent. The number of cases in the survey with payments of this magnitude was so small, however, that these figures are only suggestive of the experience with major crash injuries.

C. Life Insurance

The reduction in fatalities associated with automatic restraints would reduce life insurance payouts by eliminating some payments for term insurance policies and delaying payments connected with whole life policies. Term insurance provides coverage for a limited period of time, usually no more than several years. Policies of this type expire at the end of the contract period and when they are renewed, their premium cost reflects the added age and corresponding increase in chance of death of the policyholder. Term insurance premiums thus frequently become prohibitively expensive for older individuals. Because term insurance benefits are not paid unless the policyholder dies during the contract period, the full face value of these policies would be saved by the insurance company if an automatic restraint device prevented the premature death of a policyholder. Roughly 65 percent of the value of all life insurance policies comes from term policies.

Whole life policies, which involve the payment of fixed premiums over a person's lifetime, account for most of the remaining 35 percent of life insurance policies. Generally, the face value of these policies will be paid to the insured's beneficiary on the death of the policyholder regardless of when that death occurs. Fatalities prevented by automatic restraints will therefore not prevent the payment of the face value of these policies by the insurance company. It will, however, delay these payments and allow insurance companies to make money by investment and by continuing to collect premiums until the policyholder's death at a later date.

The following analysis is based on data from the 1983 Life Insurance Fact Book published by the American Council of Life Insurance:
In 1982, life insurance policies in force had a face value of $4,476,659 million. The population of the U.S. in 1982 was 232.1 m. Therefore, the average life insurance coverage per person was $19,288 (4,476,659m/232.1m). Of this, 65 percent or $12,537 represents the average term insurance coverage per person, and 35 percent or $6,751 represents the average for other types of life insurance (including whole life endowment and retirement income).

The savings that would accrue to life insurance companies from term insurance would therefore be computed as the product of the average term value per person and the number of annual fatalities prevented. Table VII-20 summarizes these savings for the range of usage rates for automatic belts and for air bags. Mid-points of the range of possible effectiveness estimates are used for illustrative purposes.[73]

[73] Note that because of the relatively small values derived, no adjustment has been made for deaths that occur from other causes during the term of the policy. Such an adjustment would have a minute effect on an already small value.

TABLE VII-20
TERM LIFE INSURANCE SAVINGS

Automatic Belts: Usage Rate	Lives Saved 1990	Total Savings[74]	Per Vehicle Annual Savings[75]	Per Vehicle Lifetime Savings
20	750	$ 9,402,750	.08	.53
30	1,850	23,193,450	.19	1.31
40	2,950	36,984,150	.31	2.08
50	4,060	50,900,220	.42	2.87
60	5,160	64,690,920	.54	3.64
70	6,270	78,606,990	.66	4.43
Air Bags: Effectiveness				
33	6,670	83,621,790	.69	4.71

In addition to the above savings for term insurance, insurance companies will benefit to some extent through the delay of payments connected with whole life policies. For these policies, the net cost to insurance companies of a premature death is the lost premiums and interest revenue that would have been derived had the policyholder lived a normal life span. Over a very long period of time, it is conceivable that the additional revenue from these sources would be passed on to consumers through lower premiums. The average age of a motor vehicle fatality is roughly 30 years, and most whole life policies mature at 65-69 years of age. This implies 35-40 years of lost premiums and interest. However, many policyholders choose to terminate their policies for cash value prior to maturity. In 1982, 10 percent of all ordinary life insurance policies were voluntarily terminated by the policyholder. If this same rate continues, over half of

[74] Lives saved x $12,537.
[75] Total savings/120 m vehicles. Fatality estimates are based on 1990 projection. The total passenger car fleet size is estimated to be 120 million in 1990.

the policies in force in any given year will be voluntarily terminated within 10 years. It thus appears unlikely that an average motor vehicle fatality will cut premium and revenue collection by more than 10-15 years.

A rough estimate of added revenue from whole life policies will be made by computing the value of the additional investment earnings and premiums gained by the extension of the policyholder's life.

Life insurance premiums totalled 49,464 million in 1982 or 1.1 percent of the face value of associated policies (49,464/4,476,659). Annual premium collections on whole life policies would therefore average $74 (.011x6,751). In 1982, of the total income received by life insurance companies, 71.5 percent was from premiums and 28.5 percent was from investment earnings and other income. The $74 additional premium revenue collected each year would therefore eventually represent $104 in additional income to the insurance company (74/.715). The current tax rate for life insurance companies is 2.3 percent of revenue, leaving a net annual revenue gain of $102 per fatality prevented. As discussed above, this income may continue for an average of roughly 15 years. Therefore, once a steady state is reached, the annual income gains per fatality prevented will be $1,530 ($102x15). Table VII-21 summarizes the savings for the range of usage rates for automatic belts and for air bags. Once again, mid-point effectiveness values are used for illustrative purposes.

TABLE VII-21

WHOLE LIFE INSURANCE SAVINGS

Automatic Belts: Usage Rate	Lives Saved 1990	Total Savings[76]	Per Vehicle Annual Savings	Per Vehicle Lifetime Savings
20	750	1,147,500	.01	.06
30	1,850	2,830,500	.02	.16
40	2,950	4,513,500	.04	.25
50	4,060	6,211,800	.05	.35
60	5,160	7,894,800	.07	.44
70	6,270	9,593,100	.08	.54
Air Bags: Effectiveness				
33	6,670	10,205,100	.09	.57

Table VII-22 summarizes total savings for both term and whole life insurance policies.

TABLE VII-22

POTENTIAL LIFE INSURANCE SAVINGS

	-Term Insurance Savings-		--Whole Life Savings--		---------Total-------	
Automatic Belts: Usage Rate	Per Vehicle Annual	Per Vehicle Lifetime	Per Vehicle Annual	Per Vehicle Lifetime	Per Vehicle Annual	Per Vehicle Lifetime
20	.08	.53	.01	.06	.09	.59
30	.19	1.31	.02	.16	.21	1.47
40	.31	2.08	.04	.25	.35	2.33
50	.42	2.87	.05	.35	.47	3.22
60	.54	3.64	.07	.44	.61	4.08
70	.66	4.43	.08	.54	.74	4.97
Air Bags: Effectiveness						
33	.69	4.71	.09	.57	.78	5.28

[76] Lives saved x $1,530.

As discussed above, mid-point effectiveness estimates were used to derive the numbers in the preceeding tables. The full range of potential life insurance savings is shown in Table VII-23 below.

TABLE VII-23
SUMMARY OF POTENTIAL LIFE INSURANCE SAVINGS
FOR LOW, MID-POINT, AND HIGH EFFECTIVENESS RATES
(1982$)

	Per Vehicle		Total Annual Savings 1990 Fleet Equivalent (Millions)
	Annual Savings	Lifetime Savings	
Air Bags:			
Low Eff.	0	3	62
Mid Eff.	1	5	93
High Eff.	1	7	136
Automatic Belts - 20% Usage:			
Low Eff.	0	0	7
Mid Eff.	0	1	10
High Eff.	0	1	14
Automatic Belts - 70% Usage:			
Low Eff.	1	4	71
Mid Eff.	1	4	88
High Eff.	1	6	106

Table VII-24 summarizes the potential overall effects on insurance premiums that may result from automatic restraint requirements.[77]

[77] There are obvious differences between these numbers and the estimates used in the 10/83 Preliminary Regulatory Impact Analysis. Reasons for these differences include: use of different effectiveness and usage estimates; the recognition of possible change in loss adjustment costs, rather than just incurred losses; the reduction of the overall liability premium applicable to changes in safety; the recognition of additional types of physical damage losses; the use of more refined or current data; the inclusion of commercial as well as private passenger premiums in loss considerations.

TABLE VII-24

SUMMARY OF POTENTIAL EFFECTS ON INSURANCE PREMIUMS FROM AUTOMATIC RESTRAINT REQUIREMENTS

	Per Vehicle Annual Savings ($)	Per Vehicle Lifetime Savings ($)	Total Annual Savings (M) 1990 Fleet Equivalent
Air Bags[78]			
Automobile Insurance			
Savings-Safety	9-17	62-115	1108-2046
Loss-Deployment	(3)	(18)	(312)
Health Insurance	4-8	29-54	521-962
Life Insurance	0-1	3-7	62-136
Total	10-23	76-158	1379-2832
Automatic Belts[79] (For 20 Percent Assumed Usage)			
Automobile Insurance	1-2	5-14	89-243
Health Insurance	0-1	2-7	42-114
Life Insurance	0	0-1	7-14
Total	1-3	7-22	138-371
Automatic Belts (For 70 Percent Assumed Usage)			
Automobile Insurance	10-14	65-94	1146-1676
Health Insurance	5-7	31-44	539-788
Life Insurance	1	4-6	71-106
Total	16-22	100-144	1756-2570

[78] Full frontal air bags.
[79] The values shown for manual automatic belts must be considered as upper limits since they do not account for the apparent lower usage of safety belts by those involved in accidents as compared to the general population.

VIII. COST AND LEADTIME ANALYSIS

Consumer prices and other life cycle costs were estimated for a variety of front seat occupant restraint systems, including the present manual belt system, different types of automatic belt systems, and air bags. NHTSA estimates are summarized in Table VIII-1 in $1982. The costs of manual belts are based on teardown studies and comments to the docket and are believed to be typical of high production belt costs. The automatic belt costs were developed from agency teardown studies and comments to the docket. The air bag costs are based on teardown data on two systems and docket comments.

Non-motorized automatic belts are estimated to cost consumers about $40 per car more than manual belts. At full implementation, air bags are estimated to cost consumers about $320 more than manual belts for full front seat protection. Lifetime additional fuel costs for these restraint systems are estimated to add $11 for non-motorized automatic belts, and $44 for full front air bags.

The full implementation air bag cost estimate is based on 1,000,000 units per year production level, which is believed to be representative of full production system costs. At 300,000 units per year air bag costs are estimated to be $340 more than manual belts and at the one hundred thousand unit annual volume level, it is estimated full front air bags would cost consumers approximately $600 more than manual belts. At production levels of 10,000 units per year, full front air bags are expected to be about $1,500 more than manual belts . All of the air bag cost estimates are believed appropriate for compact and larger cars. Cars smaller than compact size may require some additional features such as staged inflation, which would tend to increase the consumer cost. The agency does not have current estimates of the cost increases for staged inflation. The agency has estimated the cost of an all-mechanical air bag to be approximately $250 for three front occupants with the system in full production. At present the all mechanical air bag is not in production.

TABLE VIII-1

PER VEHICLE COST IMPACTS

NHTSA ESTIMATES

	Incremental Cost	Lifetime Energy Costs	Total Cost Increase	Required Leadtime
Manual Belt System	Base			
Automatic Belt System (2 pt or 3 pt non-power high volume)	$40	$11	$51	24-36 Mo.
Air Bag - Driver Only (High volume)	$220	$12	$232	36 Mo.
Air Bag - Full Front (High volume)	$320	$44	$364	36-48 Mo.

A. System Descriptions

1. Air Bag System

a. Overview

The principal components of early air bag designs included:

- crash sensors
- a bottled gas inflator, release valve, and distribution manifold for each air bag
- an air bag, decorative cover; and
- a system readiness monitor.

Various crash sensor designs were tested by potential air bag suppliers, automobile manufacturers, and by NHTSA contractors. The designs tested included predictive sensors (accoustical, optical, radar, radar impact switch, and proximity) and crash actuated sensors (mechanically extended probes and electro-mechanical inertial systems). The electro-mechanical inertial system emerged predominant by the early 1970's because of its reliability and relative low cost. Various mounting locations were tested such as the bumper, radiator support brackets, firewall and transmission tunnel. Because different vehicle models exhibit different crash energy management characteristics, no one combination of sensor number and location emerged as a dominant design.

Bottled gas inflators had a number of drawbacks, primarily their uncertain shelf-life and the heavy weight of the pressure vessel. Pyrotechnic infl.tors utilizing solid propellant to generate gas at a controlled rate for air bag inflation were developed to overcome these drawbacks. A pyrotechnic driver air bag inflator was successfully developed by 1973 and, today, all air bag systems utilize pyrotechnic inflators for both driver and passenger positions. (See Chapter III for a discussion of sodium azide, the active gas generator in most inflators.)

Diagnostic modules and system readiness indicators warn users of malfunctions, and aid servicing technicians in fault diagnosis. Electronic capacitors provide a power source for bag deployment in the event that battery power is lost early in the crash.

By 1973, air bag systems were considered reliable enough to be offered on certain General Motors cars. The GM system represented a compromise between old and new air bag technology. The crash sensing system combined a bumper impulse detector (an early idea) with a passenger compartment sensor. The passenger compartment sensor consisted of a diagnostic unit and a backup sensor for the bumper detector. In addition, the electronics module was designed to distinguish between high speed and low speed crashes.

The driver air bag module consisted of a steering wheel hub mounted pyrotechnic inflator, bag, and decorative cover. Knee restraint padding was provided below the instrument cluster to prevent driver "submarining." The passenger module consisted of two air bags actuated by a two-stage hybrid inflator. For low speed deployment, bottled argon gas was released assisted by one pyrotechnic gas generator. For high speed deployment, the argon gas was r leased at a faster rate, assisted by a second pyrotechnic gas generator.

A readiness indicator light to warn of system malfunction was activated with engine ignition and remained lit while the diagnostic system performed a readiness check, after which the light went off automatically if the system was operable.

About 11,000 GM air bag equipped full-size cars were sold before the program terminated in 1976.

Since the end of production of the GM systems other manufacturers continued to develop air bag systems. However, none entered into production until the Mercedes system was offered as a supplement to the driver's three point manual belt beginning with the 1984 model year.

b. Mercedes Air Bag System

At present, there are no manufacturers that offer air bags for all front seating positions. However, Daimler Benz AG offers an optional front passenger restraint system in their Mercedes automobiles, which combines air bag technology with existing three point belts. The underlying design philosophy of the Mercedes system views the air bag as a supplement to the current three-point belt system.[1]

1 See Docket submission 74-14-N32-5886.

The Mercedes Benz Supplemental Restraint System (SRS) consists of a driver air bag and knee bolster combined with the existing driver three-point belt system and an automatic Emergency Tensioning Retractor (ETR) for the right front passenger three-point belt system. The system is activated in frontal crashes of 12 mph barrier equivalent velocity (BEV) or higher by an electronic sensor. Both the driver air bag and the Emergency Tensioning Retractor are fired pyrotechnically.

The electronic sensor module performs three basic functions: crash sensing, system readiness, and system safing, that is, keeping the air bag systems from operating inadvertently. The driver air bag module consists of a sodium azide propelled gas generator, bag, and cover. To prevent driver "submarining" and to limit femur loads, a corrugated steel tubular knee bolster is installed.

In Model Year 1984 a minimum of 10 percent of 190 series cars (the new "baby" Mercedes which weighs approximately 2650 pounds with a wheelbase of 104.9 inches) and 10 percent of the large S class cars are expected to be equipped with the SRS. Total vehicles so equipped will be about 5000. In Model Year 1985 a minimum of 10 percent of Model 380 SL (a luxury convertible sports touring car) will be offered with SRS; adding approximately 1000 vehicles to the annual total. Finally, in Model Year 1986 the SRS may be available on 10 percent of the entire Mercedes product line if justified by ordering rates.

c. Other Developments

Recent innovations in air bag system design have achieved a reduction in cost and complexity and the design of systems capable of being retrofitted to existing cars. Much of the development effort has been expended for driver only systems since passenger systems present a much more complex problem in terms of bag deployment times and occupant kinematics.

The concept of a modularized driver only air bag for retrofit to existing vehicles is not new. Over the last 10 years at least three such systems have been proposed. These systems are: The Control Laser Crash Cushion, the Romeo Kojyo System currently being developed and manufactured under agency contract, and the Breed System which is the subject of an agency-sponsored technology evaluation contract as noted in Chapter III.

In the early 1970's, Control Laser Corporation of Pompano Beach, Florida, developed a system that could be mounted on the steering wheel hub of passenger cars. The system consisted of a self-contained sensor, inflator, bag, and cover, which could be screwed into the steering wheel hub of any car with a concave steering wheel. No electrical connections were necessary since the sensor was a mechanical, gravity type actuated by impact. Bag actuation was accomplished by a bottled nitrogen gas inflator contained within the module. The Control Laser system was tested successfully in actual crash tests using human volunteers.

After Secretary Coleman's decision to proceed with an air bag demonstration program in 1976, Control Laser's air bag development and marketing program ended, since the company was not a party to the agreement and aftermarket demand appeared insufficient to proceed further.

Romeo Kojyo Co. of Tempe, Arizona, is developing a kit for a retrofit air bag consisting of the following components:

o Steering Wheel - a four-spoke air bag steering wheel, designed for retrofit use, is produced for R-K by Takata Kojyo Co., Ltd., of Tokyo, Japan, and is similar to designs used by GM, Ford, Volvo, BMW, and Daimler Benz.

o Air Bag and Module - designed specifically to interface with the steering wheel and also produced by Takata Kojyo. The air bag material and the air bag itself planned for the NHTSA program are production materials and designs from Volvo and BMW programs not now commercially available.

o Gas Generator - designed and presently being used on Daimler Benz production vehicles, the GG-4 gas generator is produced and supplied by Bayern-Chemie GmbH of Ottobrunn, West Germany.

o Crash Sensor - designed for use on BMW production vehicles, the crash sensor is supplied by Technar, Inc., of Arcadia, California. Technar also supplies the diagnostic system and the complete wiring harness and connectors.

The Breed system is currently being developed by the Breed Corporation of Lincoln Park, New Jersey. The Breed inflator retrofit air bag system has no electronics. It consists of a complete air bag system, including sensors, contained entirely within a module installed in the steering wheel hub. For retrofit purposes, this concept allows the installation of the driver system in any existing vehicle by exchanging the stock steering wheel for a steering wheel/air bag module assembly. The s nsor-primer-initiator gas generator assembly fits entirely inside the folded air bag cover module and this package is mounted entirely within the steering wheel hub.

When the system senses an acceleration crash pulse in the occupant compartment steering column sufficient to require air bag deployment, a ball sensing mass in the crash sensor moves a mechanical latching system to release a firing pin which in turn initiates a pyrotechnic primer. The sensor primer then initiates the ignitor, which in turn initiates combustion of the primary gas generator material in the identical manner as in the electrically intiated systems.

The various technologies involved in activating an air bag inflator by mechanical means are established and have been used for many years in military ordnance applications. The mechanical latching and release mechanism for the firing pin is a direct adaptation of the technology used in military munitions. The technique to ensure safety when installing the retrofit air bags is also adapted from munition technology. When the integrated air bag unit is detached from the steering column, a safing pin is withdrawn and the unit cannot be activated regardless of how hard it is shocked. Upon installing the air bag module on the steering column, a pin on the column shaft enters the sensor/inflator body and arms the unit. The inflator is a minor modification of the standard driver inflators already in production. The bag is the same as those used in current systems.

A further discussion of the possible implications of the Breed system can be found in Chapter III.

2. Automatic Belts

Safety belts, whether manual or automatic, protect occupants from collisions with interior components of the vehicle during a crash. The important difference between automatic belts and manual belts is that the automatic belt system does not involve driver or passenger action for fastening. Four designs have been advanced: "two point" and "three point", non-motorized and motorized. In addition, there are detachable and non-detachable variations of these designs.

Automatic detachable belts are designed with an easily accessible release mechanism so that, in an emergency, the belts can be disconnected to allow exit from the vehicle. To again obtain the protection from an automatic belt, the belt must be manually reattached. An example of this type of belt is the VW automatic seat belt, which has an emergency release mechanism on the B-pillar. The VW design is coupled with a starter interlock to prevent engine ignition with the belt detached.

Non-detachable automatic belts do not have an emergency release mechanism but rather have a "continuous" belt. To provide emergency egress, the belt system allows the reel out of additional webbing so that the belt can be easily pushed away from the body. An example of this type system is the Toyota Cressida motorized automatic safety belt system. Some designs have been developed which include pretensioning devices that would retract a certain length of webbing during the first few milliseconds of a crash to compensate for any slack which might be created by the retractor and the occupant's clothing. For example, the Mercedes system incorporates such a device in the passenger three-point belt as part of their SRS (see page VIII-5).[2]

The difference between the two-point and three-point configurations is the way they control lower body forward motion in a crash. The two-point configurations employ a knee bolster attached to the dash. The current VW system employs two-point system components. The three-point designs employ a lap belt rather than a knee bolster to control lower body motion. Automatic three-point belts are similar in configuration to the present three-point manual lap and shoulder belts. They are different, however, in that they may have to be attached at a different part of the door or pillar to allow entry and exit when they are in the non-detached position.

Motorized belts utilize a small motor to move the upper portion of the shoulder belt along a guide rail assembly in the door. This system greatly improves the ease with which the occupant can enter/exit the vehicle. The design used in the Toyota Cressida includes a manual lap belt and a knee bolster in addition to the automatic shoulder belt. The manual belt is needed for proper use of child safety seats.

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[2] SAE Technical Paper Series, Number 790321 - Advanced Restraint System Concepts, W. Reidelbach and H. Scholz, 1979.

B. Automatic Restraint Cost Analysis

1. Air Bag Systems

a. Docket Comments

Table VIII-2 summarizes the Docket comments submitted by manufacturers, suppliers, and other interested parties pertaining to the incremental consumer costs resulting from the addition of air bag systems to passenger cars. Note that prices are shown in $1983, as submitted by the manufacturers. Since the agency's teardown studies reflect 1982 economics in subsequent tables the figures are converted to $1982. This allows a greater degree of accuracy in measuring differences in cost/price estimates.

TABLE VIII-2
MANUFACTURER/SUPPLIER ESTIMATES
AIR BAG SYSTEMS
VEHICLE PRICE INCREASES
(OVER MANUAL BELT CARS)
($1983)

	Air Bags	
	Driver-Side	Full-Front
GM	510[3]	838
Ford		807
Chrysler	500[4]	800
Mercedes	880[5]	
Renault		1,000*
Jaguar	900	1,800*
AOPA		185[6]
Breed	45	141
Romeo Kojyo	150[7]	

* Manufacturers' rough estimate, no back-up data supplied.

[3] At 3 Million Units.
[4] At 1 Million Units.
[5] Includes Pre-Tensioned Passenger Belt Plus Driver Lap/Shoulder Belt.
[6] At 1 Million Units.
[7] Retrofit; Does Not Include Installation.

General Motors, in its December 19, 1983 docket submission estimated unit costs for driver only and full front seat air bag systems at annual production volumes of 250,000 and 3,000,000 units respectively. These estimates are presented in Tables VIII-3, and VIII-4.

Ford provided cost estimates for all of its automatic restraint designs to NHTSA on a proprietary basis. Consequently, they are not published in this analysis with the exception of the total price shown in Table VIII-2.

The Mercedes-Benz SRS discussed previously retails for $880 per car as an option. This price is for the entire system. Agency estimates for the air bag portions are discussed below.

Breed Corporation submitted an estimate of $141 per car incremental price at a volume of one million units annually for their all-mechanical air bag designs. In addition to its docket comments, Breed supplied a cost/volume estimate to NHTSA's Office of Contracts and Procurement in conjunction with the company's unsolicited proposal to equip police fleets with all mechanical driver air bag systems. Based on the docket comments and the unsolicited proposal, NHTSA compiled estimated consumer costs for the Breed system - driver and passenger - at four different annual volumes. These estimates are shown in Table VIII-5. However, it should be noted that these estimates do not appear to cover vehicle modifications and fixed overhead items incurred by vehicle manufacturers when installed as original equipment. When such expenses are taken into account, NHTSA believes that the estimates shown in Table VIII-6 best represent consumer costs for mechanical air bag systems versus those for current electronic systems.

TABLE VIII-3
AIR BAG SYSTEM UNIT COSTS
GM - $1983
(Line 10 Shows $1982)

	Driver Only	CNTR + R-F Passenger	Driver Plus CNTR + R-F Passenger
1. Incremental Variable Costs			
Driver Module	128		128
Passenger Module		296	296
Sensor(s)	35		35
Diagnostic Module	112		112
Other Electrical	26	2	28
Vehicle Changes	65		65
Other	20		20
2. Decremental Variable Costs Elimination of Current Belt System Components [8]	2		2
3. Total Incremental Variable	388	298	686
4. Incremental Variable Margin	147	82	229
5. Incremental Fixed/ Mixed Costs Allocated Per Unit	147	82	229
6. Incremental Before Tax Profit/Unit (4.-5.) [9]	0	0	0
7. Net to Manufacturer	535	380	915
8. Add: Dealer Discount (18%) [10]	117	84	201
9. Incremental Retail Price Increase	652	464	1,116
10. $1982 (.958 x 9)	625	445	1,070
Volume	250 K	250 K	250 K

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[8] At lower volumes adding air bags results in a slight increase in belt component costs according to GM

[9] No profit is assumed by GM

[10] Reflects higher dealer discount applied to full size/luxury type cars

TABLE VIII-4
AIR BAG SYSTEM UNIT COSTS, 3 MILLION UNITS PER YEAR
GM - $1983
(Line 10 Shows $1982)

	Driver Only	CNTR + R-F Passenger	Driver Plus CNTR + R-F Passenger
1. Incremental Variable Costs			
Driver Module	118		118
Passenger Module		218	218
Sensor(s)	22		22
Diagnostic Module	72		72
Other Electrical	26	2	28
Vehicle Changes	61		61
Other	14		14
2. Decremental Variable Costs Elimination of Current Belt System Components	(2)	(3)	(5)
3. Total Incremental Variable	311	217	528
4. Incremental Variable Margin	107	52	159
5. Incremental Fixed/ Mixed Costs Allocated Per Unit	107	52	159
6. Incremental Before Tax Profit/Unit (4.-5.) [11]	0	0	0
7. Net to Manufacturer	418	269	687
8. Add: Dealer Discount (18%) [12]	92	59	151
9. Incremental Retail Price Increase	510	328	838
10. $1982 (.958 x 9.)	489	314	803
Volume	3 MIL	3 MIL	3 MIL

[11] No profit is assumed by GM
[12] Reflects higher dealer discount applied to full size/luxury type cars

TABLE VIII-5
BREED SYSTEM UNIT COSTS
(Breed Co. Estimates)
($1982)

At Volumes Of

Driver Only	100K	300K	1000K	2500K
Sensor	6.00	5.50	5.00	4.75
Inflator	25.00	20.00	15.00	14.00
Bag/Cover	10.00	9.00	8.00	7.00
Tot MFR	41.00	34.50	28.00	25.75
Mfr Profit (15%)	6.15	5.18	4.20	3.86
Dealer Cost	47.15	39.68	32.20	29.61
Dealer Profit (30%)	14.15	11.90	9.66	8.88
Installation	5.00	5.00	5.00	5.00
Consumer Cost	66.30	56.58	46.86	43.49
Driver and Passenger				
Sensor (3)	18.00	16.50	15.00	14.25
Inflator (3)	75.00	60.00	45.00	42.00
Bag/Cover (3)	30.00	27.00	24.00	21.00
Tot MFR	123.00	103.50	84.00	77.25
Mfr Profit (15%)	18.45	15.53	12.60	11.59
Dealer Cost	141.45	119.03	96.60	88.84
Dealer Profit (30%)	42.45	35.71	28.98	26.65
Installation	15.00	15.00	15.00	15.00
Consumer Cost	198.90	169.74	140.58	130.49

TABLE VIII-6
NHTSA ESTIMATES
MECHANICAL VS. ELECTRONIC AIR BAG SYSTEM COSTS

(AT 1 MILLION UNITS ANNUALLY)

		Driver Plus	
	Driver[13]	1-Passenger[14]	2-Passenger[15]
Mechanical System			
Sensor(s)	$ 6	$ 17	$ 17
Driver Module	41	42	41
Passenger Module		58	89
Vehicle Modifications	16	20	20
Fixed/Other/Profit	21	44	55
Dealer Markup	11	25	30
Consumer Cost	$95	$206	$252
Electronic System (Mercedes)			
Sensor(s)	$ 85	$85	
Driver Module	40	40	
Passenger Module		55	
Vehicle Modifications	20	25	
Fixed/Other/Profit	49	68	
Dealer Markup	26	37	
Consumer Cost	$220	$310	
Electronic System (Ford)			
Sensor(s)	$ 63		$ 63
Driver Module	39		39
Passenger Module			85
Vehicle Modifications	20		25
Fixed/Other/Profit	40		70
Dealer Markup	22		38
Consumer Cost	$184		$320

[13] For driver only air bags, mechanical systems will cost approximately 60% less than electronic systems.

[14] For driver/1-passenger air bags, mechanical systems will cost approximately 35% less than electronic systems.

[15] For driver/2-passenger air bags, mechanical systems will cost approximately 20% less than electronic systems.

Romeo Kojyo, under their current contract with NHTSA, has quoted driver air bag retrofit kits at $500 apiece in batches of 100 to 1,000. This quotation includes the bag module, electronics, and knee bolster but not the installation costs. At an annual volume of 1 million, Romeo Kojyo estimates a unit price of $150 exclusive of installation.

In April 1981, Ralph Rockow of Talley Industries testified that, in quantity, air bags could be produced at an incremental consumer price of $185. This estimate assumed 2 million units a year. In his November 29, 1983 statement before the Public Hearing held by NHTSA in Los Angeles, Mr. Rockow, now President of Dynamic Science, stated that the price increase of $185 was still achievable as a result of the simplified designs currently evolving if high volumes are realized.

The Automotive Occupant Protection Association (AOPA) incorporated the Rockow estimate in its docket comments which is presented below for a full front passenger system at 2 million units annual volume:

$ 65	Module (air bag, inflator, sheet metal)
30	Sensors, Diagnostic System, Wiring
10	Slip-ring Assembly, Decorative Cover, Misc.
$105	Total Cost for Parts
37	Installation & Special Tooling (36%)
$142	Total Cost per Vehicle
21	Profit to Manufacturer (15%)
$163	Cost to Dealer
49	Dealer Profit for Optional Accessory (30%)
$212	TOTAL PRICE TO CONSUMER FOR AIR BAG (Including all markups)
$212	TOTAL PRICE TO CONSUMER
27	Incremental Cost Reduction for Changing from Today's Three-Point Belts to Manual Lap Belt
$185	PRICE INCREASE PER CAR TO CONSUMER

Although a number of manufacturers submitted cost estimates in response to the Notice, only Ford commented specifically on NHTSA's analysis of restraint system costs. These comme ts are treated below in detail.

1. "Ford's review of the NHTSA cost estimate for Ford designed air bags leads us to believe that the Costs presented in Table V-4 for the "modified Ford driver only" and "modified Ford driver and 2 passengers" air bag systems are not properly adjusted to 1982 economic levels. It appears that the costs in Table V-4 were derived by adjusting upward the values in NHTSA's cost study by a factor of 1.06, an adjustment (based on the 1981-1982 difference in the CPI All Items Index) used elsewhere in the discussion of costs to adjust 1981 costs to 1982 economic levels."

The agency did not apply a single overall factor as Ford surmised. Rather, NHTSA contracted with Corporate Tech Planning, Inc., and Pioneer Engineering and Manufacturing Company to update their 1979 estimate of automatic restraint component variable costs (DOT-HS-9-02110) to 1982 economics (P.O. DTNH-22-82-P-02075), and evaluated vehicle modifications and overhead costs internally.

A summary of the variable cost estimates to the major subsystems is presented in Table VIII-7. Only the primary components were considered. Costs such as vehicle modifications to accommodate the air bag system and the cost of shipping the system from the vendor to the automobile assembly plant were not included.

The piece costs of the Ford air bag system as a whole decreased by about 11% during the period. Most items showed an inflationary increase of about 10%; the cost reduction is driven by the decrease in a single high-cost item, the microprocessor.

TABLE VIII-7

FORD AIR BAG SYSTEMS

PER UNIT VARIABLE COSTS (1979 VS 1982)

	ANNUAL PRODUCTION VOLUMES								
	300,000			1,000,000			2,500,000		
COMPONENT	1979	1982	Δ	1979	1982	Δ	1979	1982	Δ
DRIVER'S MODULE	$39.29	$43.82	+$ 4.53 (+11.5%)	$35.36	$39.44	+$ 4.08 (+11.5%)	$33.40	$37.25	+$ 3.85 (+11.5%)
PASSENGER MODULE	88.83	94.00	+ 5.17 (+5.8%)	79.95	84.59	+ 4.64 (+5.8%)	75.71	80.50	+ 4.74 (+6.3%)
DIAGNOSTIC MODULE	65.36	28.15	- 37.21 (-56.9%)	60.50	26.06	- 34.44 (-56.9%)	58.53	25.21	- 33.32 (-56.9%)
CRASH SENSORS (5)	37.67	40.68	+ 3.01 (+8.0%)	33.90	36.61	+ 2.71 (+8.0%)	32.02	34.58	+ 2.56 (+8.0%)
TOTALS	$231.15	206.65	-24.50 (-10.6%)	209.71	186.70	-23.01 (-11.0%)	199.66	177.54	-22.12 (-11.1%)

Driver's Module - The Driver's Module increase in cost of 11.5% was due to an increase in the overhead rate (about one-third of the total) and to increases of direct labor of purchased items. For instance, the air bag itself increased about 11% (about 3.5% of the Driver's Module overall increase) and a 12.9% increase in the cost of the gas generator contributed about 5% to the overall increase.

Passengers' Module - The Passengers' Module increased in cost by about 6%. Essentially, the same factors were at work here as on the Driver's Module, although the Passengers' Module is larger and more expensive due to larger components. Very nearly the same labor is required for both Modules. Consequently, the cost increases are about the same, though the percentage increase is small for the more costly Passengers' Module.

Diagnostic Module - The cost of the Diagnostic Module dropped 56.9% due primarily to a reduction in the cost of the microprocessor. In 1979, a $35.00 mil-spec device was included. In 1982, an automotive grade device at $4.40 was included. The reduction reflects both semiconductor industry-wide price reductions due to improved technology, and the availability of commercial grade devices designed to automotive operating requirements.

The $4.40 1982 microprocessor price includes $1.00 for burn-in test of each unit. Such extensive testing is appropriate for devices employed in critical automotive safety applications.

Advances in printed circuit board technology have led to price reductions, also. Printed circuit board price decreases contributed about 7% of the total cost reduction.

Increases in labor rates and in the prices of purchased material contributed increases of 5.4% and 8% against the overall cost decrease.

Crash Sensors - The cost of the Crash Sensors increased by about 10% primarily due to increases in automotive industry wage rates.

Other Costs - Since the Corporate Tech/Pioneer study update was limited to primary system component variable costs only, NHTSA developed its variable cost estimates for "vehicle changes" internally. In addition, NHTSA used standardized internally developed mark-up rates to arrive at "Dealer Cost" and "Consumer Cost." These mark-up rates were derived from historical analysis of corporate cost behavior as extracted from the annual report (Form 10-K) submitted yearly by the companies to the Securities and Exchange Commission. Table VIII-8 compares Ford's understanding of NHTSA's methodology with NHTSA's actual cost estimate at an annual volume of 300,000 units.

TABLE VIII-8

CORPORATE TECH/PIONEER/NHTSA
FORD MODIFIED AIR BAG SYSTEM COSTS
(300,000 Units, $1982)

	FORD[16] 1982$	NHTSA 1982$
Modified Ford Driver Only		
Diagnostic Module[17]	$35	$28
Crash Sensors	38	41
Driver Module	39	44
Vehicle Changes	23	20
Subtotal Variable Costs	$126	$133
Manufacturer's Markup (33%)	42	44
Cost to Dealer	$168	$177
Dealer's Markup (13.6%)	23	24
Consumer Cost	$191	$201
Modified Ford Driver + 2 Passengers		
Diagnostic Module	$ 35	$ 28
Crash Sensors	50	41
Driver Module	52	44
Passenger Module	118	94
Vehicle Changes	37	25
Subtotal Variable Costs	$292	$232
Manufacturer's Markup (33%)	96	77
Cost to Dealer	$388	$309
Dealer's Markup (13.6%)	53	41
Consumer Cost	$441	$350[18]

[16] As understood by Ford on pp. 15-16 of Appendix 1, Docket Comment 74-14N32-5634, dated December 19, 1983.
[17] Substitution of Automotive grade microprocessor for Mil-Spec grade.
[18] Rounded down from $351.02.

2. "In adjusting the Talley Industries air bag cost estimate, NHTSA added to the updated Talley quote the cost difference between two lap belts and two three-point belts, apparently based on the consumer cost of average belts shown in Table V-2. The reason for this adjustment should be stated, because it is not obvious. If the intent was to add the cost difference between two outboard lap belts and two outboard three-point belts, the methodology used to estimate such a difference is faulty because outboard lap belts are much more costly than center front lap belts. Costs of lap belts vary widely depending on the seating position for which they are designed, and estimating the cost of driver or right front passenger lap belt based on center front passenger lap belt costs would be inaccurate. The front center lap belt is similar to the rear center lap belt, but front belts must be longer to fit occupants with the seat in full-forward, full-up position and to reach the center floor pan, which is typically lower than the rear floor pan. Rear outboard belts are more expensive than center belts because they include retractors. Front outboard lap belts are still more expensive because they are longer and have more elaborate boots to accommodate adjustment of the front seat and to facilitate one-hand buckling. In addition, the driver's belt system has a belt warning system switch and related wiring."

Ford is correct in that the reason for this adjustment was to add the cost difference between two outboard lap belts and two outboard three-point belts. Furthermore, Ford is correct in asserting that center front lap belts are not strictly comparable to front outboard belts if for no other reason than the absence of a retractor in the former.

To ascertain what, if any, estimating errors result from this difference, NHTSA conducted a simplified analysis of cost changes realized by deleting appropriate components from a 1980 Citation three-point belt system based on agency teardown data (DOT-HS-806-295, April 1982, Final Report). The result of this analysis is shown in Table VIII-9.

TABLE VIII-9
ESTIMATE OF FRONT OUTBOARD LAP BELT COSTS 1982$

Component	Variable Cost	Consumer Cost
Total 3-point Belt System (2)	$25.99	$39.99
Delete Emergency Locking Retractor (2)	(18.09)	(27.40)
Delete Shoulder Belt Webbing (2)	(3.93)	(5.95)
Add Automatic Locking Retractor (23) (Same as rear outboard retractor)	13.51	20.46
Total Absolute Costs Front Outboard Lap Belts	$17.48	$27.10

NOTE: Component costs taken from DOT-HS-806-295, April 1982.

The resultant cost for front outboard lap belt appears to be about $27 or $12 less than the three-point systems. If a cost of $6-$8 is accepted as reasonable for a center front lap belt, then the resulting total system cost for three front lap belts should be somewhere in the neighborhood of $33-$35. NHTSA's estimate in the PRIA was $34 for three front seat lap belts with outboard ALR's.

Granting the validity of Ford's criticism and the somewhat simplified analysis above, it does not appear that the method used by NHTSA in the PRIA significantly mis-stated the total cost of front lap belts to the point of distorting the total costs of an air bag system as derived from the Tally estimates.

On page 19 in Appendix I of its December 19, 1983 Docket submission, Ford provided additional comments on the subject of front outboard lap belt system costs.

"One major difference between Ford's and the agency's estimates of cost savings for vehicle modification is in the seat belt system savings. The NHTSA estimate includes a $16 savings estimated to result from substitution of a lap belt system for the double-retractor (ELR-ALR) 1981 Lincoln/ Mark VI lap/shoulder belt system. This belt system has now been replaced by a lower cost single-retractor continuous-loop system on the 1984 Lincoln and Mark VII. The continuous-loop system was used on all Ford cars except the Lincoln and Mark VI in 1981, and is now used on most domestic and imported car lines. Ford's estimate, which used the 1981 Ford/Mercury continuous loop belt system as the base, showed only a $4 variable cost savings for changing from continuous loop lap/shoulder belts to front seat lap belts, complete with retractors, twist boots (to permit seat adjustment and one-hand buckling), and a driver's seat warning system switch."

Ford is correct in stating that a single retractor/continuous loop system is less expensive than the double retractor ELR-ALR system. Hence, the savings resulting from deletion of the continuous loop systems and substitution of ALR lap belts will be less.

Ford cites a variable cost savings of $4 which, using agency formula mark-ups, translates into a consumer savings of about $6. This is $6 less than the $12 consumer savings shown in the simplified Citation analysis described above. Differences of this magnitude may be accounted for by the differences between belt system designs that exist between different car sizes and models.

3. The comments contained in the Preliminary Regulatory Impact Analysis (p. V-15) regarding Ford's 1979 estimates of air bag costs are misleading and NHTSA's resulting modifications of the Ford cost estimates are inaccurate.

NHTSA's analysis states (p. V-15) that "Ford's 1981 estimate, indexed to 1982 economics, is $875 at 200,000 units, roughly 2 1/2 times NHTSA's estimate for that production volume." Ford's July 1979 estimate of "...approximately $825 a unit (at 1982 economic conditions)..." (Mr. J. C. Eckhold's letter of July 5, 1979 to Ms. Joan Claybrook) was already stated at 1982 economics and should not have been adjusted. (The economics level of our estimate was also specified in our March 16, 1981 comments to Docket 74-14; Notice 20 [74-14-NPRM-N20-104, Attachment, page 7]).

Ford is correct. The $825 unit cost for air bag systems was stated in 1982 economics and no further adjustment was necessary.

4. "NHTSA's remarks state "that some of (Ford's) component quotes from vendors were at production levels much lower than 200,000 units. Specifically, the diagnostic module cost was based on 6,000 to 13,000 units, and the passenger module costs were based on 13,000 units." We believe that these statements are untrue because, after submitting the reference cost estimates to NHTSA in July of 1979, Ford decided to limit optional availability of the air bag system to the Lincoln and Mark VI car lines, and during 1980 obtained vendor quotes for the same components at a production level of 11,000 units per year. These later quotes indicated much higher costs than those contained in our original July 1979 cost estimates. For example, the quoted cost (at 11,000 units per year and 1982 economics) for the diagnostic module was about $100 (versus $50 in our earlier, higher volume estimate) and the passenger air bag module quote was about $500 (versus $179). Remarks in the NHTSA cost estimate such as "Price to Ford based on 10,000 units, 1981 economics" (regarding the diagnostic module) refer to these lower volume quotes which were developed about the time of the NHTSA study, not to the earlier quotes on which our July 1979 estimates were based.

NHTSA's remarks also claim ". . . that Ford may not have considered some vehicle modification cost saving items. . ." and that ". . . the vehicle modification estimate included in the Ford estimate did not take into account cost savings which would result from the removal of some components, such as the glove box. . . ." We believe the Ford cost estimate included all of the appropriate cost savings items. The cost of the glove box, in particular, was removed from neither our estimates nor the agency's original estimate because the glove box and glove box door were simply relocated (and made smaller), in our design, not removed, resulting in a minor cost saving and retention of this essential customer feature. Ford did not delete the cost and weight of items such as the steering wheel ornament and the instrument panel nameplate because we believe these items will be redesigned or relocated, rather than deleted."

Proprietary data submitted by Ford in its December 19, 1983 Docket comments indicate that diagnostic module and passenger air bag module unit costs [

] Ford is correct in stating that NHTSA's remarks refer to the lower volume quotes as opposed to the July 1979 estimates.

With regard to vehicle modifications, NHTSA was incorrect in its assertion that the Ford estimates did not include savings that would result from removal of the glove box. Glove box removal is not a modification contemplated by any of the manufacturers.

5. "The agency also criticized Ford's use of a 46 percent mark-up on variable cost. Ford's cost estimating methodology does not apply an average mark-up to variable cost because this method of cost estimating is inaccurate, particularly at low volumes. We amortize fixed program expenditures such as tooling and engineering over the number of units we plan to produce. Applying an industry average markup of 33 percent may be reasonable for some volumes, but it cannot be applied at all volumes. We would point out that Ford's estimate of fixed cost allocation plus manufacturer's profit was equivalent to 46 percent of variable cost at a volume of 200,000 units, but it was only 29 percent of variable cost at 800,000 units. Coincidentally, Ford's allocation of fixed cost plus profit at NHTSA's assumed volume of 300,000 units would be practically equivalent to NHTSA's markup of 33 percent.

Ford's use of a 22 percent dealer profit margin (equivalent to an 18 percent dealer discount) reflects the markup traditionally applicable to the large cars on which we planned to use our air bag system. It was not intended to represent the dealer profit margin on the average car. NHTSA's estimate of dealer profit margin may be more accurate if air bags are mandated on all cars, but Ford's margin estimate is more accurate if air bags are used primarily on full-size and luxury cars."

Ford is correct in asserting that the use of average markup rates is not appropriate for all volumes, particularly low volumes. However, it is incumbent on the agency to examine the cost and price impact of air bag technology at both high and low volumes. Therefore, agency cost estimates reflect air bag availability all across the product spectrum. Hence the use of standard markup rates.

6. "Another component for which NHTSA's cost estimate varies from Ford's is the diagnostic module. (p. V-17) Ford's estimate was based on its design which includes special high-reliability specifications (similar to military specifications) for the diagnostic module's microprocessor. NHTSA's estimate used an automotive grade microprocessor in place of Ford's high-reliability microprocessor. Although the automotive grade microprocessor may perform satisfactorily, Ford's air bag designs still specify premium microprocessors because we are reluctant to specify a less-reliable component for this critical link in the system."

NHTSA does not take issue with the judgment of Ford's designers that reliable microprocessors are necessary. Although mil-spec grade electronics may be used initially, the agency believes automotive grade electronics are likely as designs mature. Therefore, NHTSA believes that long term cost estimates based on use of automotive grade electronics are appropriate.

b. <u>NHTSA Analysis</u>

The agency independently assessed the cost and weight impacts of adding air bags to passenger cars through teardown analysis of actual air bag systems. A complete Ford 1979 level driver and passenger air bag system and a 1981 Mercedes-Benz driver and passenger air bag system were disassembled into their component parts. Using automotive engineering cost estimating techniques, the variable or "piece" cost of each component was estimated exclusive of any fixed overhead expenses incurred in the production of air bag systems. Both teardowns were updated to 1982 economics. (See final report DOT-HS-9-02110 and Passive Restraint Cost Study Update dated December 1982, P.O. DTNH22-82-P-02075.)

Tables VIII-10 and VIII-11 present the estimates for the Ford and Mercedes air bag systems at the 1 million units per year level. These include NHTSA's best estimate of the variable cost of required vehicle modifications. The cost estimates also include certain component modifications suggested by the contractors for high volume production.

The major cost/price estimating assumptions used to arrive at a consumer retail price equivalent (RPE) are:

1. Unit Variable costs are marked up by a factor of 1.33 to arrive at "wholesale" or "dealer" cost. This mark-up factor is based on historical analysis of GM, Ford, Chrysler, and AMC annual income statements and represents the volume weighted average historical ratio of variable costs to wholesale price or dealer cost.

2. The "dealer discount" is assumed to be 12 percent, which corresponds to a manufacturer mark-up of 13.75 percent from wholesale price.

The design modifications made to the Ford system have been discussed above. The design modifications to the Mercedes system are shown in Table VIII-12. The agency's estimate of vehicle modifications cost are shown in Table VIII-13.

TABLE VIII-10
AIR BAG SYSTEM UNIT CCSTS
FORD
NHTSA ESTIMATES
$1982 CORP. TECH/PIONEER

	Driver Only	CNTR + R-F Passenger	Driver Plus CNTR + R-F Passenger
1. Incremental Variable Costs			
Driver Module	39		39
Passenger Module		85	85
Sensor(s)	37		37
Diagnostic Module	26		26
Other Electrical Vehicle Changes	20	5	25
2. Decremental Variable Costs Elimination of Current Belt System Components [19]			
3. Total Incremental Variable (1.-2.)	122	90	212
4. Incremental Variable Margin (.33 x 3.) [20]	40	30	70
5. Net to Manufacturer (3. + 4.)	162	120	282
6. Add: Dealer Discount (12%)	22	16	38
7. Incremental Retail Price Increase	184	136	320
Volume	1 MIL	1 MIL	1 MIL

[19] Included in Vehicle Changes
[20] Includes Fixed Costs Plus Other Costs Plus Profit

TABLE VIII-11
AIR BAG SYSTEM UNIT COSTS
MERCEDES
NHTSA ESTIMATES
MODIFIED BY CORP. TECH/PIONEER
$1982

	Driver Only	R-F Passenger	Driver Plus R-F Passenger
1. Incremental Variable Costs			
Driver Module	40		40
Passenger Module		55	55
Sensor(s)	61		61
Diagnostic Module [21]			
Other Electrical	24		24
Vehicle Changes	20	5	25
2. Decremental Variable Costs Elimination of Current Belt System Components [22]			
3. Total Incremental Variable (1.-2.)	145	60	205
4. Incremental Variable Margin (.33 x 3.)[23]	49	19	68
5. Net to Manufacturer (3. + 4.)	194	79	273
6. Add: Dealer Discount (12%)	26	11	37
7. Incremental Retail Price Increase	220	90	310
Volume	1 MIL	1 MIL	1 MIL

21 Included in Sensor Cost
22 Included in Vehicle Changes
23 Includes Fixed Costs + Other Costs + Profit.

TABLE VIII-12

MERCEDES-BENZ REDESIGN ASSUMPTIONS FOR VOLUME PRODUCTION COST SAV:NGS

SENSOR-DIAGNOSTIC MODULE

- Use of a single rather than two printed circuit boards, and layout for automatic component insertion.
- Substitution of two integrated circuits for 65 separate discrete components.
- Elimination of stand-offs for component mounting.
- Redesign of RFI filtering and shielding to eliminate difficult assembly process.
- Substitution of mechanical crimping (solderless) connections at both ends of the wiring harness.
- By using a slightly larger single printed circuit, the assembly process of stacking two smaller boards and resulting hand soldered interconnection are eliminated resulting in savings of two ribbon cables, two hand soldered riveted terminal strips, a micarta insulation layer with threaded steel posts and nylon separators.
- Use of automated assembly techniques and test.

PASSENGER MODULE (AIR BAGS)

- Elimination of neoprene coating of air bag. Domestic designs have found coating not needed.
- Elimination of seam doublers (reinforcement strips). Destructive tests by Uniroyal indicated that seam doublers are not needed.

DRIVER'S MODULE

- Elimination of neoprene coating.
- Elimination of seam doublers.

TABLE VIII-13
VEHICLE MODIFICATION AND INSTALLATION COST ESTIMATES

NHTSA ESTIMATE
(Current Design System)

	Driver & 2 Pass.
Steering Column	$8.31
Climate Control Reroutings	-
Passenger Module Mounting Structure	5.45
Wiring	16.69
Driver Knee Padding	1.54
Installation and Labor	4.56
Freight and Packaging	4.65
Warranty	10.35
Instrument Panel and Small Glove Box Reductions	[5.08]
Remove Shoulder Belts	[21.13]
Total Variable Cost	$25

In evaluating the estimates for the incremental consumer costs resulting from the addition of air bags to passenger cars, NHTSA considered three fundamental issues:

1. The differences in design assumptions between industry estimates and agency teardown analyses,

2. The price to the customer for air bag systems currently available in the marketplace, and

3. The annual volumes most likely realized.

With regard to different design assumptions, one major difference is in the cost of the diagnostic module and associated electronics. As stated elsewhere in this analysis, Ford believes that military specification grade electronics are necessary in view of product liability considerations whereas NHTSA has assumed that automotive grade electronics will suffice. For the purpose of comparison, NHTSA is providing an estimate which assumes that a military specification grade diagnostic module will be employed for a Ford type system. Table VIII-14 provides NHTSA's estimate using a military specification grade diagnostic module with a variable cost of $65, based on teardown analysis and Ford's proprietary submission. NHTSA believes that automotive grade electronics will be employed resulting in a customer cost of about $60 less than that for military specification grade electronics.

TABLE VIII-14
AIR BAG SYSTEM COSTS
NHTSA ESTIMATE OF
FORD
ORIGINAL DESIGN
$1982

DRIVER PLUS	Driver Only	CNTR + R-F Passenger	Driver Plus CNTR + R-F Passenger
1. Incremental Variable Costs			
Driver Module	44		44
Passenger Module		94	94
Sensor(s)	41		41
Diagnostic Module	65		65
Other Electrical Vehicle Changes	20	5	25
2. Decremental Variable Costs Elimination of Current Belt System Components	a/	a/	a/
3. Total Incremental Variable (1.-2.)	170	99	269
4. Incremental Variable Margin (.33 x 3.)	57 b/	33 b/	90 b/
5. Net to Manufacturer (3. + 4.)	227	132	359
6. Add: Dealer Discount	31	18	49
7. Incremental Retail Price Increase.	258	150	408
Volume	300K	300K	300K

a/ Included in Vehicle Changes
b/ Includes Fixed Costs + Other Costs + Profit

To summarize the agency's position on differing design assumptions, NHTSA asserts that the component costs contained in its teardown analysis of the Ford and Mercedes systems represent the best available estimates at annual volumes of 300,000 or more over the long run. Furthermore, NHTSA has seen no evidence that the vehicle modifications required for air bag installation are as extensive as those provided for by GM and Ford.

The second issue is basically a question of what air bag systems are currently available to the American motoring public. Only Mercedes-Benz currently markets an air bag system as an option on certain of its car lines. As described elsewhere, the Mercedes SRS consists of a driver air bag to be used <u>with</u> the driver's 3-point belt and pyrotechnic Emergency Tensioning Retractor for the front passenger's 3-point belt. The SRS currently retails for $880 per car. The significance of this price is that it is achieved at an annual volume of only about 5,000 cars per year in the U.S. given Mercedes' assumption of a 10 percent installation rate on certain 1984 model cars.

Since Mercedes provided no detailed data on the cost of the SRS versus its price at projected volumes, the exact split between the price of the air bag and the pyrotechnic tensioner cannot be determined. From the August 15, 1982 <u>Black Book New Car Invoice Guide</u>, published by Hearst Business Media Corporation, NHTSA determined that all Mercedes cars are sold by the factory to the dealer at a 20 percent discount from the suggested retail price which corresponds to a 25 percent markup from dealer cost. Generally, option markup rates are significantly higher than standard markup rates. However, in estimating the wholesale price of the SRS, NHTSA used the 20 percent dealer discount derived from the Black Book. This results in a dealer cost per SRS of $704 ($880 x .80).

NHTSA estimates the price split between driver air bag and passenger ETR to be as shown below:

	Wholesale Price	Markup Factor	Retail Price a/
Driver Air Bag	$650	1.25	$813
Passenger ETR	54	1.25	67
	----	----	----
	$704	1.25	$880

a/ At an annual volume of 5,000 cars.

The ETR estimate may be on the low side and represents NHTSA's "best guess" in the absence of concrete cost/price data. Additionally, the markup factor may be too low given that the SRS is an option. These uncertainties likely result in the wholesale price being overstated for the driver air bag.

Of major significance is the order of magnitude in this estimate when compared to GM's driver only air bag estimate.

	---Driver Only Air Bag System---	
	Incremental Consumer Price	Annual Volume
Mercedes (NHTSA Estimate)	$813	6,000
GM (Comment #1666)	$650	250,000

Granting that there are differences in basic design between Mercedes and GM vehicles, Mercedes appears to be charging its customers a price 25 percent higher than that of GM for a driver only system that is optional equipment and sold at an annual volume which is 42 times lower than that quoted by GM.

Analysis of the docket responses indicates that the estimates for electronic air bag systems included in the NHTSA Preliminary Regulatory Impact Analysis are still adequate. Also indicated is that if mechanical air bag systems prove feasible, the cost will be approximately 40 to 80 percent of the electronic systems.

The industry estimates are approximately $500 higher than NHTSA's. This is because in our view the industry estimates are not representative of recent outside quotations, full air bag fleet volumes, and long term upgrading of designs and manufacturing innovations. A comparison between NHTSA and industry estimates is shown in Table VIII-15 with summary explanations of differences.

The third and final issue considered by NHTSA in its evaluation of air bag cost estimates is that of annual sales volume. The agency believes that a volume of 1 million units annually for estimating purposes best represents the number of units that would be produced for wide spread application of a particular air bag system design. As shown in the PRIA (October 1983), incremental consumer costs at the highest volume assumption the agency considered, 2.5 million per year, results in a cost reduction of about $20 per unit as compared to the 1 million level, and the 1 million unit per

Table VIII-15

INDUSTRY ESTIMATES (OVER)/UNDER NHTSA

		NHTSA -Base-	Industry Differences: Ford		Industry Differences: GM		Industry Differences: AOPA
Annual Volume		1.0 mil.	[redacted]		3.0 mil.		2.0 mil.
I. Electronics							
Sensors	$37			$15		$ 3	
Dia. Module	26	63		[46]	[31]	26	$29
II. Driver and Pass. Modules		124			[212]		27
III. Modifications, etc.		25			[73]		3
Variable		$ 212			$ [316]		$ 59
IV. Non-Variable		70			[89]		21
V. Dealer Mark Up		38			[113]		[8]
Cost to Car Buyer		$ 320	$ [487]		$ [518]		$ 72

<u>Summary Difference Explanations</u>

I. <u>Sensors</u> -
Differences in sensor estimates are due to the number of sensors used in each design (NHTSA and Ford 3 single and 1 dual versus GM only 2).

<u>Diagnostics</u> -
Industry estimates are 2.5 to 2.6 times NHTSA's. Compared to the Ford estimate, the microprocessor represents the significant portion of the cost difference. This, we believe, is because the Ford design still specifies a premium (similar to military specifications) grade micro-processor; whereas, NHTSA's estimates assume use of commercial.

GM did not provide any explanations of their design or estimates.

II. <u>Modules</u> -
Industry estimates are 2.0 to 2.7 times the NHTSA estimates. Since the NHTSA estimates are even higher than the AOPA, NHTSA speculates manufacturers' estimates have not been updated to reflect recent outside quotations, full air bag fleet volumes, and cost savings innovations.

III. <u>Modifications</u> -
GM and Ford estimates are higher than NHTSA. The differences result primarily because industry included significant amounts for steering wheel and column modifications (Ford [redacted] GM $138 versus NHTSA $8.3).

IV. <u>Non-Variable and Dealer Mark Up</u> -
The total rate used by GM is comparable to NHTSA. Ford, however, used low volume manufacture and large car dealer mark up rates. This inflated their mark up estimates for a full fleet implementation, approximately [redacted]

NOTE: Blocked off material contains confidential information, bracketed numbers are higher than NHTSA estimate.

year level is about $20 lower in cost than the 300,000 unit per year level.

For annual volumes lower than 300,000 units, there is little consistent data with which to formulate a cost/price estimate. Based on teardown analyses and the "best guess" as to the cost of the Mercedes driver system, the agency estimates that, at an annual volume of 100,000 units per car manufacturer, a full front seat air bag system will retail for about $600. For annual volumes of less than 10,000 units per car maker, this figure rises to about $1500. These estimates are based on extrapolation of the cost relationships between the Mercedes driver and passenger module in NHTSA's teardown analysis as well as the cost of the Romeo Kojyo system, which is $500 per kit in batches of 1000. With regard to the Romeo Kojyo system, the assumption is that a retrofit passenger module would be about twice the cost of a driver module or about $1,000. This assumption is based on the following:

o The passenger system will be comprised of two driver inflators similar in design to the Mercedes passenger system analyzed in NHTSA's teardown study.

o The passenger bag will be approximately double the size of the driver bag.

At very low volumes there are no scale economies realized since each unit is virtually hand fabricated. Hence cost will be proportional to labor and material content only.

To summarize the agency's position on air bag costs and weights:

o The full front seat air bag sys em will cost the consumer $320 per car at an annual volume of 1 million units.

o At annual volumes of 100,000 units or less, full front air bags may cost anywhere from $600-$1500 per car. At volumes of 10,000 units per year or less, the latter figure is most representative.

o The development of a successful all mechanical air bag system may reduce the unit price of a full front system to about $200 for a driver plus 1-passenger system and $250 for a driver plus 2-passenger system based on an annual volume of 1 million units in each case.

o Current design electronically activated air bags will add 21 pounds to the weight of a typical vehicle according to NHTSA's teardown analyses. Incremental weight estimates for adding air bag systems to passenger cars are summarized in Table VIII-16. Only GM, Ford, and Jaguar submitted such estimates to the docket. NHTSA finds no basis for changing its incremental weight estimates based on the docket comments since supporting documentation is insufficient.

TABLE VIII-16
AIR BAGS
INCREMENTAL WEIGHT ESTIMATES
NHTSA AND INDUSTRY ESTIMATES

NHTSA (PRIA)	21 LBS
GM	56 LBS
Ford	40 LBS
Jaguar	35 LBS

2. Automatic Belt Systems

Table VIII-17 summarizes the docket comments submitted by automakers concerning automatic belt incremental consumer costs per car.

Of the major automakers, only GM provided a detailed cost estimate in its Docket submission. The GM estimate was for a high volume 4-door sedan with two front seats and three-point detachable automatic belts with single door mounted retractors. No provision was necessary for knee bolsters. Table VIII-18 provides the GM estimate.

Thomas E. Lohr, an engineer claiming extensive experience in the design of active and automatic seat belts with GM, Allied Chemical Corp., Irvin Industries, and Allen Industries, submitted detailed cost estimates for "Y" and "V" type three-point automatic belts.[24] It is Mr. Lohr's position that NHTSA's mark-up factor of 1.33 from variable cost to dealer cost is far too high since the basic resources (e.g. tooling) for automatic belts are already in place, requiring little investment. A mark up of 1.11 is far more appropriate. Mr. Lohr estimates that the incremental cost of "Y" type belts will be $45 and "V" type belts will be $42 (Docket Comment # 74-14-N30-030). NHTSA does not believe tooling and other basic resources are in place for automatic belts. Note that Mr. Lohr's comments apply only to three point automatic belts.

[24] "Y" belt - lap and shoulder belt join into a single belt which joins center console. "V" belt - lap and shoulder belts join at the center console.

TABLE VIII-17

AUTOMATIC BELTS
PER VEHICLE PRICE INCREASES
(OVER MANUAL BELT CARS)
INDUSTRY ESTIMATES

	$1983
GM	45
Ford	165
Chrysler	115
Renault	200
Jaguar	150[25]
Honda	150-170
Nissan (Power)	370[26]
(Mechanical)	230
Peugeot (Power)	380-400[27]
Lohr	45

25 As of 1/12/84 1 British Pound = $1.402 or $1 = .7135 Pound
26 At an estimated volume of 10,000 units/mo.
27 At an annual volume of 19,000-20,000 units.

TABLE VIII-18

AUTOMATIC BELT SYSTEM COSTS
GM ESTIMATES

3-PT DETACHABLE - SINGLE RETRACTOR
DECEMBER 19, 1983[28]

	Driver	R-F Passenger	Driver Plus R-F Passenger	
1. Incremental Retail Price Increase $1983	22	23	45	(43)*
2. Less: Dealer Discount	4	4	8	(8)*
3. Net to Manufacturer (1.-2.)	18	19	37	(35)*
4. Incremental Variable Costs				
Belt Equipment	25	26	51	
Vehicle Changes	6	5	11	
5. Decremental Variable Costs Elimination of Current Belt System Components	(20)	(20)	(40)	
6. Total Incremental Variable (4.-5.)	11	11	22	(21)*
7. Incremental Variable Margin (3.-6.)	7	8	15	(14)*
8. Incremental Fixed/ Mixed Costs Allocated Per Unit	7	8	15	(14)*
9. Incremental Before Tax Profit/Unit (7.-8.)[29]	0	0	0	0

* $1982

[28] The columns **Driver** and **R-F Passenger** are estimated.
[29] No profit is assumed by GM.

The agency has conducted teardown analyses of existing and conceptual belt systems for the VW Rabbit, 1980 Chevrolet Chevette, and the 1982 Toyota Cressida to determine the costs and weights of automatic belts over or under current three-point manual systems. The contractors were Corporate Tech Planning/Pioneer Engineering (augmentation of Contract No. DTNH22-82-C-07179). The results of NHTSA's teardown cost analyses are shown in Table VIII-19 along with the estimates provided by high volume manufacturers in their docket comments.

TABLE VIII-19

BELT SUMMARY ESTIMATES

Industry Estimates		Annual Volume	Automatic	Manual	Automatic Over Manual
Domestic					
1. Ford		mil.*	$240	$75	$165
2. GM	3 pt.	5.0 mil.	$105	$60	$ 45
3. Chrysler	3 pt.	1.0 mil.	180	65	115
AMC (No estimates provided. Stated $70 for manual belts is realistic).					
Sales Weighted Average			~~$143~~	~~$64~~	~~$ 79~~
4. LOHR	3 pt.	8.0 mil.	90	46	45
NHTSA Estimates					
5. VW detachable	2 pt.	300K	$132	$99	$28-33
6. VW non-detachable	2 pt.	300K	126	99	27
7. VW non-detachable	3 pt.	300K	113	99	14
8. Chevette detachable	3 pt.	300K	91	60 GM Av.	31
9. Chevette detachable	3 pt.	300K	91	64[30]	27
Toyota Cressida Power (NHTSA Est)					
10. With manual lap belts	2 pt.	300K	211	64	147
11. Without lap belts	2 pt.	300K	178	64	114
Other Imports and Low Volume					
Nissan Power	2 pt.	120K	$ 370	$ 80-100	$290-270
Nissan	2 pt.	120K	230	80-100	150-130
Honda	2 pt. & 3 pt.	N.G.	200-270	50	150-220

* Proprietary.

[30] GM and industry averages used for baseline because NHTSA did not develop manual belt teardown estimates for the Chevette and there is no Cressida manual belt design.

TABLE VIII-20

SYSTEM WEIGHT IN POUNDS

NHTSA ESTIMATES

	Driver	Passenger	Total	Automatic (Over)/Under Manual
VW Designs				
3-Point Manual	14 lbs.	6 lbs.	20 lbs	(Base line) lb.
2-Point Automatic	16	11	27	(7)
2-Point Automatic (non-detachable)	16	10	26	(6)
3-Point Automatic (non-detachable)	12	7	19	1
Chevette Design				
3-Point Automatic	7	6	13	0
Toyota Cressida			25 lbs.	(10)

Table VIII-20 summarizes the agency's teardown weight analysis for VW based automatic belt systems, the Chevette 3-point automatic system, and the Toyota Cressida motorized automatic belt system. System weights are expressed both as absolute weights and incremental to current manual belt systems. For the VW systems, the driver side absolute weights are greater than the passenger side weights due to the inclusion of steering column components not used in VW cars sold elsewhere than the U.S. The weight of manual belt systems also includes these components, thus the incremental weights for automatic restraints are comparable. Also note that the 3-point automatic belts are lighter than the 2-point automatic belts because the latter includes the weight of the knee bolster.

In the PRIA, the agency estimated the cost of current front seat belt systems to be $50 per car. The teardown analyses and Docket comments indicate that this figure is too low (see Table VIII-19). On a sales weighted basis, NHTSA now estimates that front seat belt systems currently cost the customer $64 per car.

The agency's conclusions as to the cost and weight impacts of automatic belts versus manual belts are summarized below:

o Non-motorized detachable automatic belts without interlocks that meet the minimum requirements of the standard are estimated to have an incremental consumer cost of about $28 per car over manual belts. These estimates (typical for high production volumes) were developed from teardown studies.

o Automatic belts, including amounts for industry planned safety and convenience enhancement features that exceed the minimum requirements of the standard, are estimated to have an initial consumer cost of about $40 per car more than manual belts. This is $12 more than NHTSA's estimate of $28 for non-motorized minimum requirement designs. The additional $12 provides for manual lap belts which may be retained with 2-point automatic designs and a 5 percent fleetwide installation rate for Cressida type motorized and VW type interlock systems. Table VIII-21 provides NHTSA's definitive estimate for automatic system cost impacts.

TABLE VIII-21

PER UNIT
COST OF AUTOMATIC BELTS OVER MANUAL
INCLUDING STANDARD EXCEEDING FEATURES
NHTSA ESTIMATES

	Ford	GM	Chrysler	Across Fleet	Average Car
Automatic Belt Design	2-pt.	3-pt.	3-pt.	NA	NA
Annual Volume	mil*	5.0 mil	1.0 mil	NA	NA
Incremental Cost					
Av. for Meeting Minimum Requirements	$28	$28	$28	$NA	$28.0
Item Exceeding Standard					
Manual Lap Belts with 2-pt. Designs[31]					6.7
5% with Power Belts (380,000 vol)[32]				4.3	4.3
10% with VW Type Interlock[33]				2.5	.25
Cost Per Car (For Features Exceeding the Standard)					11.25
Total Cost per Car for Standard					$39.25

* Proprietary.

o *The industry sales weighted average incremental cost for non-motorized* belts is $79 or $51 higher than NHTSA's. This is principally because the industry estimates included amounts for two additional door mounted retractors, electrically activated pendulum blockers, driver and passenger knee bolsters in some 3-point automatic designs, manual lap belts with

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31 Based on proprietary data.

32 Power belts $114 over manual less $28 covering 5 percent of 7.6 million annual fleet.

33 $5 per car for VW type interlock cover 5 percent of 7.6 million annual fleet.

retractors and manufacturing and dealer markup rates higher than normal. With normal markup rates the industry estimates sales weighted average would be reduced to $62 or $34 higher than NHTSA's estimate.

o The incremental weight penalty associated with the addition of automatic belts for front outboard passengers is estimated to be five pounds for mechanical systems.

4. Alternative Capital Investment Requirements

The automatic restraint capital investment requirements for the auto industry are shown in Table VIII-22 for those commenters which provided such data. Capital expenditures are defined as outlays for property, plant, machinery, equipment, and special tools to be used in the production of automatic restraint systems.

TABLE VIII-22
INDUSTRY INVESTMENT[34]
(Current Economics)
INDUSTRY ESTIMATES

Manufacturer	Annual Volume	Automatic Belts	Air Bags Driver	Air Bags Full Front
Domestic				
GM	250K		$49M	$67M
	3,000K		428M	573M
	High	$125M		
Ford		(Deleted-Proprietary)		
Chrysler	High	$37M	$12M	$89M
Foreign				
Honda	High	$5M		
Renault	Low	$1.5M		

Because most manufacturers provided no docket comments on the subject of capital investment, the data in Table VIII-21 are thus incomplete. In addition, a major manufacturer - Ford - specifically requested confidential treatment of all cost and investment data. Nevertheless, on the basis of what is available, NHTSA estimates the impact of automatic restraints on auto industry capital spending as shown below for all automatic belt and for all air bag equipped fleets. NHTSA does not believe that the implementation of automatic restraint requirements will alter the magnitude of planned capital spending over the next several years. However, the expenditures estimated below will preclude the auto makers from investing in other projects. Hence, these expenditures represent a true cost in terms of lost opportunities.

[34] Defined as expenditures directly involving acquisition of property, plant, machinery, equipment, and tools.

Domestic and Foreign For All New Cars	NHTSA ESTIMATES OF 3 Years Total Capital Investment[35]	Annual Investment[36]
Air Bags	$1.3 Billion	$.43 Billion
Automatic Belts	.5 Billion	.17 Billion

There are other product related expenses associated with the introduction of automatic restraints, chief among which are Engineering, Research, and Development Expenses (E, R & D). Table VIII-23 summarizes the estimates of E, R, & D spending for those manufacturers that provided such data.

In terms of unit retail price impact, depreciation and amortization of capital expenditures; E, R, & D, and other overhead expenses are reflected in the formula mark-up from unit variable cost described earlier. Unit variable costs are first accumulated then marked up by a pre-determined overhead rate to cover each unit's pro rata share of overhead expenses.

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35 Developed from Docket Comments and Proprietary Data.

36 GM, Ford, and Chrysler alone are expected to spend a total of $10 billion in capital investments in 1984. Automatic restraints will account for less than 5 percent of this.

TABLE VIII-23
OTHER PRODUCT RELATED EXPENSES[37]
INDUSTRY ESTIMATES

Manufacturer	Annual Volume	Automatic Belts	Air Bags Driver	Air Bags Full Front
Domestic				
GM	250K		$12M	$20M
	3,000K		35M	65M
	High	$40M		
Ford		(Deleted-Proprietary)		
Chrysler	High	$65M	$26M	$70M
Foreign				
Jaguar				$1.4M[38]

[37] Primarily Engineering, Research, and Development (E, R, & D).
[38] Development Cost = 1 Million Pounds Sterling which equals $1.4 Million at the January 12 exchange rate $1 = .7135 Pounds.

C. Leadtime Considerations

Several manufacturers submitted comments on the leadtime required for the implementation of automatic belts and air bags. The comments for automatic belts ranged from immediately (from Volkswagen for some models only) to more than 4 years (for Ford). For air bags, the range was from 2 years for Mercedes and BMW up to 5 years for some models of Chrysler and Saab.

In order to determine the reasonableness of these comments, the agency considered the principal constraints to implementation of each restraint type. For each type of automatic restraint, the leadtimes for critical components are as follows:

Detachable automatic belts: seat, door, pillar, and floor pan reinforcements - approximately 24 months.

Non-detachable automatic belts: design and testing of non-detachable feature in addition to above items required for detachable automatic belts - one year of additional leadtime is needed - approximately 36 months.

Driver air bag: steering column modification (particularly, if all models at one time) - at least 36 months; longer for small cars.

Passenger air bag: instrument panel and glove box relocations - approximately 24 months. Testing and development - 36 to 48 months; longer for small cars.

Developmental effort has already been expended for detachable belt systems by some companies for some models. Hence, NHTSA believes that introduction of such systems by those companies, for those models already designed to accept automatic belts, only would require placing orders with suppliers and incorporating minor vehicle modifications. A leadtime of 24 months should be sufficient for those companies and models for detachable belts. However, because these are models which will soon be discontinued, manufacturers will either be unable to recoup their investment costs or have to charge significantly higher prices than estimated earlier in this chapter. Models which have not yet been developed for automatic restraints (i.e., which have been designed and/or manufactured since the rescission) would require at least 36 months leadtime. Since very few non-detachable automatic belts have yet been developed or marketed, an additional year would be needed to develop and test spool out features and other components that would maximize consumer acceptability and safety considerations in terms of entry/egress. Thus, at least 36 months leadtime would be required for an across-the-board mandate for automatic belts.

Because some companies are already offering (or preparing to offer) driver air bags in some models, these companies could offer some driver-only air bags with a 24-36 month leadtime. For example, Mercedes could have driver-only air bags available "across the entire model range" by MY 1986. Volvo plans to introduce driver air bags in some MY 1987 models. BMW testified that they could have one model equipped with driver only air bags during the 1985 model year. However, available evidence suggests that a substantial number of vehicle models will require major modifications to the steering wheel and column. To redesign or modify the majority of steering wheels and columns for air bag introduction in 24 months would be disruptive. Since some models have never been designed to accomodate air bags, 36-48 months leadtime appears to be more realistic to equip most cars with driver air bag systems.

Passenger air bags will require extensive instrument panel modifications or redesign; including relocation of the glove box as well as testing to solve problems in occupant kinetics. Given the number of models involved and the available industry staff resources, full implementation would require 36-48 months for passenger air bag systems on large and mid-size cars.

Air bag systems for subcompact cars are expected to require at least an additional year to develop more sophisticated systems for these cars such as 2-stage inflators and more elaborate front end structures. Thus small car air bags are estimated to need 48-60 months leadtime (see Chapter III for more detail).

One constraint on leadtime for air bags could be the availability of the sodium azide propellant for bag inflators. Responses from the sodium azide producers to agency inquiries indicate that, from the date a final rule is issued, 24 months will be required to achieve sufficient production capacity to meet expected demand, assuming fleetwide air bag installation. This will not affect the overall leadtime for air bags.

In order to determine the consequences of incremental implementation on the manufacturers, sales by car line in 1983 were examined to determine if 10 percent implementation could be met by the application of restraint technology to one car line. For American Motors it was determined that the Alliance comprised about 65 percent of the model years sales. For Chrysler, the Omni/Horizon accounted for about 13 percent, and the Reliant/Aries accounted for about 32 percent of the company's sales. Typical model sales for Ford included about 10 percent for the LTD, 21 percent for the Escort, and 11 percent for the Tempo/Topaz. Sales of various GM platforms in 1983 included about 12 percent for the J body, 15 percent for the A body, 16 percent for the B body, and 23 percent for the G body. For the import manufacturers, similar results were found. For example, the Honda Prelude was roughly 12 percent of Honda's sales, and the Accord was about 49 percent. For Nissan the Pulsar represented about 12 percent and the Sentra represented about 40 percent of their 1983 sales. Volvo's sales of their 760 were about 10 percent and their DL sales were about 50 percent of the total. Other manufacturers experienced similar sales patterns. Thus, it is apparent that a requirement that 10 percent of the manufacturers, production be equipped with a particular restraint technology would in general allow just one model to be engineered for this requirement, should that be desired. The agency believes that this approach would impose no undue hardship on the industry.

Energy Costs

In addition to the manufacturers and consumers hardware cost of belt and air bag systems, there is another cost element to consider. The use of an occupant restraint system will slightly increase the weight of the vehicle thereby using more fuel over its lifetime and adding to the lifetime cost of operating the vehicle.

The agency requested more up-to-date information on occupant restraint system weights in the October 1983 analysis. Few of the commenters discussed the weight of the various occupant restraint systems however. Jaguar Cars Inc., GM, and Ford, were the only manufacturers discussing system weight in the docket submissions. Toyota, in the Kansas City hearing, stated that their motorized automatic belt system added 25 pounds to the car. Table VIII-24 shows these comments as well as those other manufacturers responding to the docket but offering no data on system weight.

The agency has also reviewed the latest data from teardown studies. While designs of non-motorized automatic belt systems vary considerably, it appears from tear down studies that a good estimate of the average incremental weight of these systems is 5 pounds. A motorized automatic belt system, such as the Toyota Cressida system, has an incremental weight of about 10 pounds. A typical front seat air bag system incremental weight is estimated at 21 pounds, according to teardown data.

TABLE VIII-24
SUMMARY OF MANUFACTURER DOCKET COMMENTS
ON OCCUPANT RESTRAINT SYSTEM WEIGHT
DOCKET 74-14-N32

		Weight of System (Lbs.)			
Commenter	Comment Number/ Page Number	Manual Belts	Non Motorized Automatic Belts	Motorized Automatic Belts	Air Bags
Jaguar Cars, Inc.	1690/4	6.5	31	-	35
American Motors Corp.	5299/5	N.C.	N.C.	N.C.	N.C.
Saab-Scania	1689/	N.C.	N.C.	N.C.	N.C.
Porsche	1089/	N.C.	N.C.	N.C.	N.C.
GM	1664/8[39]	-	-	-	56
Ford	3115/18	-	25	-	40
Chrysler	5300/	N.C.	N.C.	N.C.	N.C.
VW	1673/	N.C.	N.C.	N.C.	N.C.
Renault	1665/	N.C.	N.C.	N.C.	N.C.
Toyota	Hearing-Kansas City/ 120	-	-	Adds 25 Pounds to Car	-
Mercedes	5886/	N.C.	N.C.	N.C.	N.C.

N.C. = No comment; did not estimate or cover weight of systems in docket response.

Considering all the available information mentioned here, the agency will use the following system weight estimates in calculating the energy costs associated with the various occupant restraint systems:

[39] GM states that there will be no increase in fuel consumption if automatic seat belts are used in place of manual seat belts.

	Weight Increment
Manual belts	Base Case
Non-motorized automatic belts	5 lbs.
Air bags	21 lbs.

The agency has used in previous analyses of rulemaking actions and will use here, a "secondary weight"' factor of one pound for each pound of added weight.[40] Thus, for each additional pound added due to occupant protection systems, one pound of weight is added to the chassis subsystems (i.e., tires, brakes, suspension, etc.) to support the added body weight. The agency also used a rule of thumb that for each pound of weight added to the vehicle, there will be an increase in the lifetime fuel consumption of one gallon.[41]

The calculation of the present discounted value of the lifetime fuel increase is shown in Table VIII-25. The estimated gasoline price for 1987-1996 is based on the price of unleaded gasoline, which by the late eighties is expected to be the bulk of the fuel used in this country. The baseline 1982 fuel price was derived from data provided by Data Resources Incorporated. The percent of total mileage per year is a distribution the agency has used in numerous prior rulemakings, particularly the fuel economy rulemakings. A discount factor of 10 percent is assumed. The results in Table VIII-25 show that for each additional gallon of fuel used over the life of the car, there will be a present discounted value of $1.05 added to the consumer cost. Applying this factor to the estimated

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40 For example, the"FRIA, Amendment to FMVSS 208, Occupant Crash Protection, Rescission of Automatic Occupant Protection Requirements," NHTSA, October 1981.

41 FRIA, Part 581 Bumper Standard, NHTSA, May 1982, p. VII-40 to VII-42.

increased fuel usage, non-motorized automatic restraints represents an additional $11, and the air bag represents an additional $44 over the current system over the life of the car.

TABLE VIII-25
PRESENT DISCOUNTED VALUE OF ONE GALLON INCREASED FUEL CONSUMPTION

Year	Estimated Gasoline[42] Price ($ 1982)	Percent Total Mileage/Year	Factor	Discount[43] Value
1987	$1.27	18.11	1.000	$0.230
1988	1.31	15.11	.909	0.180
1989	1.34	13.26	.826	0.147
1990	1.38	11.83	.751	0.123
1991	1.44	10.58	.683	0.104
1992	1.51	9.24	.621	0.087
1993	1.58	7.82	.546	0.067
1994	1.65	6.20	.513	0.052
1995	1.73	4.60	.467	0.037
1996	1.77	3.25	.424	0.024
				$1.051
				$1.05

[42] U.S. Department of Energy, Energy Projections to the Year 2010, October 1983.
[43] Discount rate assumed to be 10 percent.

IX. COST IMPACTS

This chapter discusses the economic effects of potential increased passenger car costs resulting from a requirement for the installation of automatic restraint systems in new passenger cars. The economic consequences of such a requirement on the automotive industry, its suppliers and the national economy are considered.

Two analytical studies of the cost impact of automatic restraints were submitted to the Docket. An analysis conducted by Barbara C. Richardson and Sherry S. Borener (University of Michigan), sponsored by the Motor Vehicle Manufacturer's Association, concludes that a government requirement for air bags costing between $300 and $600 per car would have severe detrimental effects on the automotive industry and the economy as a whole.[1] In the short run, new vehicle sales are calculated to decrease from a low of 2.7 percent to a high of 9.7 percent annually. Unemployment could be expected to increase from 62,000 to 197,000 persons per year. GNP, wages, disposable income, and personal consumption would decrease and the consumer price index would rise.

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1 Air Bag Restraint Regulation: Potential Domestic Macroeconomic Impacts - Interim Report, Barbara C. Richardson and Sherry S. Borener, University of Michigan, November 1983.

A study by William Nordhaus of Yale University, commissioned by several major insurance companies, found that the net effect on industry sales and employment would be negligible and that the national economy would not be affected adversely.[2]

Using the Richardson and Nordhaus studies as a base NHTSA performed a separate analysis. The results of 13 attitude surveys (see Chapter XI) were used in establishing a rough relationship between automatic restraint costs and the percent of consumers who would purchase them voluntarily. This provides a basis for estimating the potential effects of various price changes on the demand for automobiles and the consequent economic impacts on the automotive industry and the national economy. Assuming an additional cost of $320 per car for an all air bag fleet, (see Chapter VIII) the potential long term loss in annual vehicles sold could range from about 20 to 80 thousand. Long run gains in gross industry revenue could range from $1.7 to $2.4 billion. Both short and long term cost impact estimates are presented in Tables 5, 6 and 7 of this chapter. Increases in annual employment in both the automobile manufacturing and supplier industries would vary from about 30 to 45 thousand. The above estimates assume everything constant except the price increase.

2 Comments of William Nordhaus on Notice of Proposed Rulemaking on Federal Motor Vehicle Safety Standard - Occupant Crash Protection, Docket 74-14, Notice 30, December 1983, Appendix B.

This chapter concentrates primarily on the cost impacts of air bags. The effects on sales, employment and income from a price increase of $40 per vehicle (see Chapter VIII) due to the installation of automatic belts would be minor and could not be quantified with any degree of confidence.

The underlying issue - and the factor that triggers both adverse and beneficial economic effects on both the automotive industry and the national economy - is consumer reaction in the marketplace to government mandated changes in the characteristics and price of the automobile. The discussion which follows explores the nature of consumer demand for automobiles.

A. Demand for Automobiles

Automobile manufacturing plays a major role in the health of the U.S. economy. As a result, the numbers and types of automobiles consumers purchase and the rationale behind their decisions have been the subject of scientific inquiry for at least a half century. The most recent studies are based on sophisticated computer models that dynamically evaluate the interrelationships among many dozens of variables affecting automobile demand. Table IX-1 lists a few of the factors which have been included or considered in these studies. A key issue is that, given these numerous factors which directly or indirectly affect demand, how important is the purchase price, or, more specifically, can the coefficient of this variable in the demand equation be estimated with any degree of accuracy?

Table IX-1
Some Factors Which May Influence Demand for New Automobiles

* Purchase Price
* Life-Cycle Costs
* Interest Rates and Terms of Loan
* Price of Substitutes (e.g. used cars, smaller cars, light trucks, vans, etc.)
* Insurance Costs
* Operating Costs (e.g. fuel)
* Disposable Income
* Anticipation of Future Employment, Income and National Economic Stability
* Family Size
* Population Growth and Age Distribution
* Urbanization
* Effectiveness and Persuasiveness of Advertising
* Registration and Licensing Costs
* Personal Property Taxes
* Relative Safety and Convenience Compared to Other Modes

1. Elasticity of Demand

Quantitative estimates of the effect of price changes on demand are generally expressed in terms of the "price elasticity of demand" which is the percent change in quantity demandec divided by the percent change in price. A basic assumption is that all other factors affecting demand will remain constant. Although automobile price elasticity estimates vary widely, they commonly range from -1 to -1.5 in the short run (1 or 2 years) and -.5 or less over the long run.[3] The reason for the difference over time is that when prices first increase consumers experience "sticker shock" and may be hesitant to buy but after a period of time tend to adjust to the new price.

If, with a 1 percent change in price, demand increases or decreases greater than 1 percent, the demand for the product is said to be price elastic. If the percent change in demand is less than the change in price it is inelastic. Generally, the demand for necessities will be more price inelastic than the demand for luxury goods. There is no consensus on whether automobiles should be considered a luxury or a necessity. Very small percentage increases in price will often be more inelastic than large increases, particularly if the increase does not represent a significant portion of the consumer's budget. For example, assuming a sales volume of 8 million domestically produced passenger cars, an average price of $10,000 and an elasticity coefficient of -1.0, a price increase of $10 would theoretically result in a decline of 8,000 units sold. Practically, however, such a small relative and absolute increase will probably go unnoticed and have little or no effect on demand.

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[3] Sources for a number of elasticity estimates can be found in the Richardson study.

One of the most important uses of the price elasticity concept is in evaluating the effects of price changes on total revenue received by the industry.[4] If the demand for a given product is elastic (an absolute value greater than one) an increase in price will result in a smaller total revenue. Total revenue will increase in cases where elasticity has an absolute value less than one. As discussed later, this point is particularly relevant with regard to some of the short and long term price elasticity estimates used for the automobile industry.

2. Differentiated vs. Homogeneous Products

Precise arithmetic calculations based on classical elasticity theory may be more justifiable with homogeneous products such as wheat or coal than with a highly differentiated product such as a passenger car. In purchasing an automobile consumers generally have a wide range of options, including vehicle size, accessories, and trim. Vans and light trucks can also be considered close substitutes. Many car options are not actually desired, but are nevertheless purchased by consumers who wish to "buy off the lot."

To the extent that consumers do have options and set an upper limit on the amount they are willing to pay for the "package," the impact of a restraint system could be measured by the opportunity cost of not purchasing one of the options, e.g. power windows, power seats, air conditioning, etc. This opportunity cost may be high (equal to or greater than the cost of the

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[4] Total revenue is defined as average price times quantity sold.

restraint) to consumers who buy only what they need or very low for consumers who do not place a high value on the options which they may be forced into by purchasing "off the lot."

3. Other Factors Associated With Automobile Demand

As noted in Table IX-1, price is only one of a large array of factors which influence demand for automobiles. Although very few would dispute the law of a downward sloping demand curve (i.e., as price increases fewer will be purchased and vice versa) this relationship holds in the real world only when everything else has remained constant. However, in the real world this is seldom the case and actual demand often increases or decreases totally independent of the direction of price change. If other factors have a negative impact, demand could decline considerably more than what might have been predicted from a price increase. If changes in these other factors are favorable to sales, a price increase could be completely overshadowed and the effect inconsequential. A few of the more important factors that may offset price effects are discussed below.

a. Income

Changes in consumer income may play a role even more important than price in determining automobile demand. For example, a recent report by the Department of Commerce estimates price elasticity of demand for domestic automobiles at -1.11 and income elasticity at 1.56.[5] Thus a 1 percent increase in income results in an increase in automobile demand of over 1.5 percent. DRI forecasts an increase in real disposable income from $1,095 billion in 1983 to $1258 billion in 1987 - an average annual increase of about 4 percent.[6] Given that the assumptions of both elasticity and income growth are correct, sales (assuming everything else the same) would increase by about 6 percent annually.

b. Interest

For some consumers, monthly payments might be more important than retail price. Under those circumstances, the interest rate and the terms of the loan may play an important role in the purchase decision. For example, as shown in Table IX-2 an increase in the initial price of a vehicle from $9000 to $9500 at 12 percent interest and financed for 3 years will result in a change of monthly payments from $299 to $316.[7] However, a reduction in the interest rate of 4 percent (from 12 percent to 8 percent) results in a payment of $298 for the $9500 vehicle, about the same as that for a $9000 vehicle financed at 12 percent. Similarly, a 12 percent loan for $9500, if taken for 4 years rather than 3, reduces monthly payments by $66 (from $316 to $250), as compared to a $17 (from $316 to $299) smaller payment if the lower priced $9000 automobile is financed at 12 percent for 3 years.

5 Automobile Demand Forecasting Model Bureau of Industrial Economics, U.S. Department of Commerce 1983.

6 U.S. Long Term Review, Fall 1983 Data Resources, Inc.

7 This example assumes that the entire purchase price is financed.

This hypothetical example is used solely to support the contention that many factors in addition to sticker price influence the consumer's purchasing decision. Extending payment periods because of a higher price obviously provides no net economic benefit to the consumer, given the lack of certainty as to the direction of future interest rates.

TABLE IX-2

Monthly Payment By Interest Rate, Payment Schedule And Amount Financed

	$9,000	$9,500	$10,000
3 yrs.			
8%	282.03	297.70	313.37
10%	290.41	306.54	322.68
12%	298.98	315.54	332.15
4 yrs.			
8%	219.72	231.93	244.13
10%	228.27	240.95	253.63
12%	237.01	250.18	263.34
5 yrs.			
8%	182.49	192.63	202.77
10%	191.23	201.85	212.48
12%	200.21	211.33	222.45

SOURCE: Expanded Payment Table for Monthly Mortgage Loans. Financial Publishing Company.

c. Insurance

Insurance premiums represent a significant portion of the total cost of owning an automobile.[8] To the extent that consumers consider life cycle costs, reduced insurance premiums could have a significant positive influence on demand. As described previously, overall reductions in

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8 About 15 percent, as described in Cost of Owning and Operating Automobiles and Vans, Federal Highway Administration, 1982.

insurance premiums for cars with air bags will range from $10 to $23 annually. Over the life of the vehicle the savings would be worth between $76 and $158 dollars.

Nordhaus feels that consumers will be more influenced by life cycle costs than first costs. In a June 13, 1984, submission to Docket 74-14 (Occupant Crash Protection) he estimates that first and third party insurance savings for cars with automatic belts will be approximately $19 annually. The discounted value of these savings over the car life is estimated at $130.

The Nordhaus estimates are based on a situation where automatic belts are used in all cars. If air bags are chosen, some increase in property damage insurance costs could occur.

A complete discussion of the effects of restraint systems on insurance premiums can be found in Chapter VII. Of importance here is the issue of whether consumers only react to vehicle price changes or whether they take into account life-cycle costs in their purchase decisions.

B. Micro-economic Effects of Price Changes

The following sections describe some of the potential economic consequences of a government mandated automatic restraint system on the automotive industry and its suppliers. The emphasis will be on losses (or gains) in passenger car sales, industry revenue, and employment. The discussion relies heavily on the findings of the recently completed studies by Richardson and Nordhaus.

1. Sales

Using an assumed incremental price increase ranging from $300 to $600 per car with price elasticities from -.9 to -1.6 in the short run and -.1 to -.5 in the long run, Richardson reported near term annual sales losses ranging from 167 to 593 thousand vehicles and long term losses from 19 to 185 thousand annually (see Table IX-3). Input data for annual sales (6,088,400) and average annual price in 1982 dollars ($9866) were based on Bureau of Economic Analysis estimates.

Given the assumptions made by Richardson, the above results cannot be faulted. However, Nordhaus expresses strong disagreement with several of the assumptions. He argues first that the automobile manufacturers are more

Table IX-3
Average Annual Loss of Vehicle Sales
(In Thousands of Dollars and Percent)

Vehicle Price Increase	Short Term Elasticity			Long Term Elasticity	
	-.9	-1.28	-1.6	-.1	-.5
$300	167 -2.7%	237 -3.9%	297 -4.8%	19 -.3%	93 -1.5%
$500	278 -4.5%	396 -3.5%	494 -8.1%	31 -.5%	155 -2.5%
$600	334 -5.4%	475 -7.8%	593 -9.7%	37 -.6%	185 -3.0%

Source: Richardson and Borener, op. cit..

likely to comply with restraint requirements by installing automatic seat belts resulting in an initial price increase of $88. He further assumes an average retail price of an automobile at approximately $10,000 and annual sales at 10 million.[9]. Using a short run price elasticity of -1.0 sales will decrease by 90,000 vehicles during the first year _if_ consumers respond only to the initial cost increase and not to life cycle costs. However, Nordhaus contends that consumers are more likely to be concerned with costs over the life of the vehicle and will take into account anticipated reduced injury costs and insurance premium reductions. In this case the net effect on sales will be zero. Under the same assumptions for consumer response and using an elasticity of -0.5 Nordhaus estimates long run (over 1 year) annual sales losses to range from 0 (where consumers consider life cycle costs and benefits) to 45,000 (where consumers consider only initial costs).

Table IX-4 below summarizes the Richardson and Nordhaus estimates of changes in automobile sales resulting from an automatic restraint requirement. Note that these are estimates of changes in vehicles sold. The dollar volume of sales is discussed later in this chapter.

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[9] Nordhaus apparently includes imports in total sales. Richardson included only domestic output.

Table IX-4

Reduction in Annual Automobile Sales

(In Thousands)

	Short Term	Long Term
Richardson	167-593	19-185
Nordhaus	0-90	0-45

There are three reasons for the differences in the estimates. First, the low end of the Nordhaus estimate (no reduction in sales) assumes that consumers see a positive value in automatic restraints and are willing to substitute them for other goods and services. Second, Nordhaus assumes a lower priced alternative; i.e., automatic belts, and third, the price elasticity assumptions differ somewhat. Richardson assumes a range from -.9 to -1.6 in the short run and -.1 to -.5 in the long run. Nordhaus' assumptions are -1.0 in the short run and -.5 for the long run where consumers are concerned only with initial costs.

The concept of price elasticity holds true only under a given set of assumptions, the most important being that all other factors remain constant - including the product being considered for purchase. An automobile with a new automatic restraint system is not the same product as an auto without such a system. Consequently, there is no definitive method for predicting consumer response to a price change unless a determination can be made of consumer reaction to the new product. If consumers perceive the automatic restraint system as an increase in the value of the vehicle equal to its additional cost and if the restraint system provides a utility as high or higher than the next best consumption alternative, then demand will shift upward to a point where quantity demanded and sold at the new price is approximately equal to that at the old price. However, if consumers view automatic restraints as a nuisance or as having a negative value, demand will shift downward.[10] In such a situation there would be a multiple negative impact - a decline in quantity demanded due to the price increase along with a decline due to a downward shift in demand.[11]

At the present time there is considerable uncertainty regarding consumer response to automatic restraints. Although numerous attitude surveys have been conducted their results are often inconclusive and contradictory. Because of the data limitations the results of the brief analysis which follows should be used with caution. However, it should be useful to the extent that it provides a conceptual framework for estimating the effects of a restraint system on automobile sales.

It must first be recognized that consumers are not homogeneous and will react in a variety of ways to a price increase. In some instances consumers, who previously would not purchase a vehicle because of the risk of injury, may now be encouraged to enter the market - assuming the restraints result in a substantial improvement in safety.[12] At the other extreme are those consumers who do not want an automatic restraint at any

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[10] An upward or downward shift in demand describes a situation where more or less of a product is purchased at the same price in contrast to a movement along the demand curve which shows quantities purchased at various prices.

[11] In this case consumers would pay more for a car without an automatic restraint or would pay money to have the device removed.

[12] At present there is no empirical evidence to support an argument that improved restraint systems would increase sales.

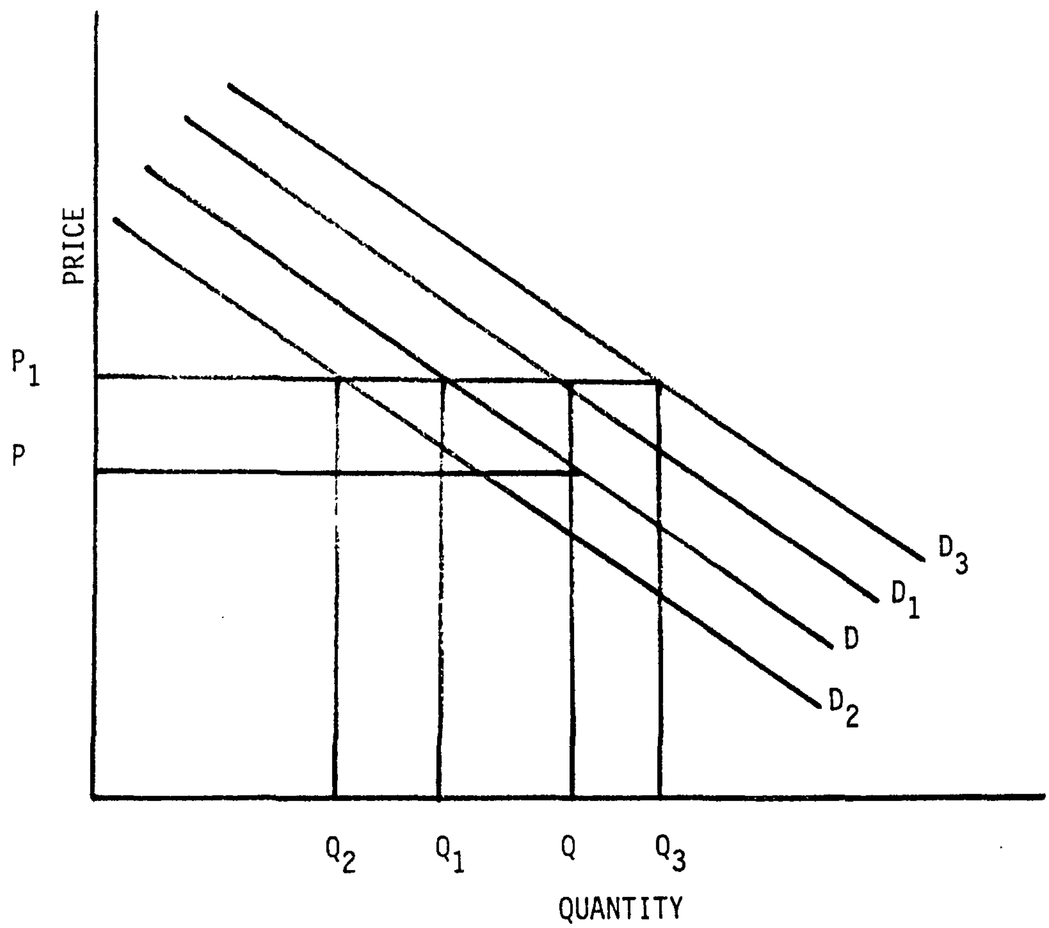
price and would be willing to pay for having it removed or would, if given a choice, pay more for the same car without the system. For purposes of simplifying the analysis it is assumed that, at least in the long run, the above two groups cancel each other in terms of the net effect on sales.

In the middle, and probably representing a large majority, are those who would buy the system at some cost. Some will view the restraint system as a significant increase in the value of the car and would be willing to pay more than the asking price, others would value the system at about equal to the price and the remainder would take the system but not at the price asked. Within this group and at any given price some will experience a "consumers surplus" and others will drop out of the new car market or postpone buying because other needs are of a higher priority (i.e., the incremental utility of a car with an automatic restraint is less than that obtained from another good or service.)

The different ways consumers might respond to a price increase and the effects on sales are described in Figure IX-1. The initial equilibrium point is at the intersection of P and curve D resulting in a quantity demanded of Q. If price is increased to P_1 and to the extent that consumers value the product at an amount at least equal to its price the demand curve will shift upward to D_1 and there will be no change in quantity sold. To the extent that consumers do not place a value on the product equal to its price there will be a northwest movement along demand curve D and quantity sold will decline to Q_1. The curve D_2 describes a situation where consumers place a negative value on the product. The

FIGURE IX-1

HYPOTHETICAL RELATIONSHIPS BETWEEN PRICE AND QUANTITY DEMANDED UNDER ALTERNATIVE ASSUMPTIONS ON CONSUMER REACTION



downward shift in demand suggests that at any given price consumers will buy less of the product. Quantity demanded drops to Q_2.[13] A final possibility is a situation where the product is so much improved that at price P_1 additional consumers enter the market. Demand increases from Q to Q_3. It should be noted that classical price elasticity theory encompasses only one of the above possibilities - and that is the movement along the original demand curve D.

Based on findings from several attitude surveys (see Chapter XI) Figure IX-2 describes a statistical relationship between air bag prices and the percent of consumers who say they would be willing to purchase them as an option. The graph is not meant to relate increased vehicle prices to consumer demand for vehicles. Although, as discussed previously, attitude surveys historically have not been reliable indicators of preferences revealed in the marketplace, it appears from the curve that about 50 percent of all consumers would purchase an air bag if the price were no higher than $250.[14] Before continuing with the analysis several assumptions are required. The first is that those consumers who would willingly purchase an air bag as an option would not hesitate to buy an air bag

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[13] The potential for a downward shift in the demand curve is discussed at length in, "The Costs and Benefits of Automobile Emissions Control and Safety Regulations," James Langenfeld, Washington University, St. Louis, Missouri, October 1983.

[14] The curve in Figure IX-2 is fitted from 37 widely scattered data points contained in 13 surveys. The original equation is $y = 85.35 + .179x + .0001083x^2$ where y represents percent of consumers and x is price. The R^2 value is .62. The probability that the linear and quadratic coefficients are due to chance alone is .0001 and .054 respectively. The scale has been compressed to eliminate 15 percent who would not buy at any price and 11 percent who would buy at any price asked; that is, where the upper portion of the curve becomes vertical and the lower portion crosses the horizontal axis. The curve becomes vertical at a price of $826. The rationale for eliminating the extremes is discussed in the text.

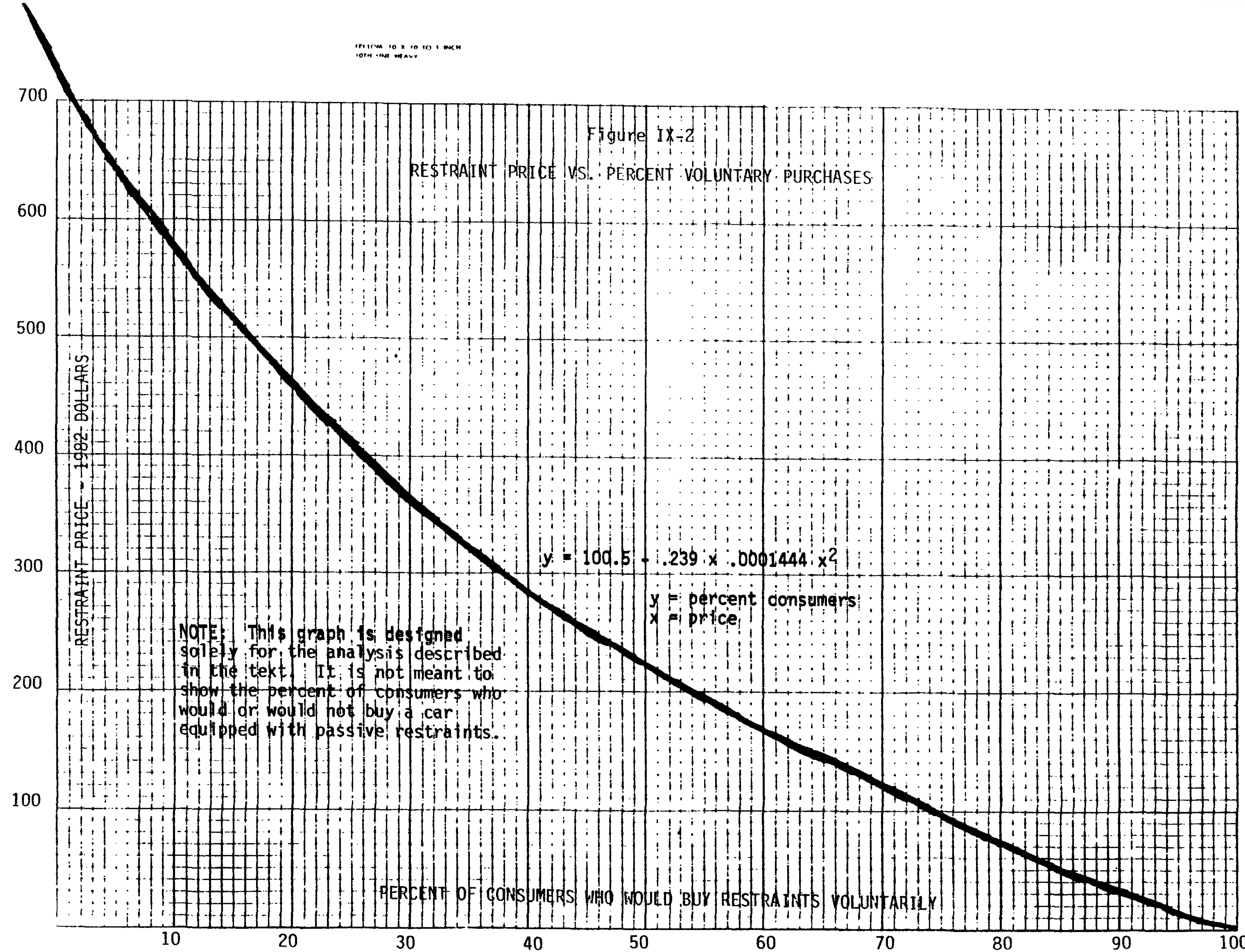
Figure IX-2
RESTRAINT PRICE VS. PERCENT VOLUNTARY PURCHASES
y = 100.5 - .239 x .0001444 x2
y = percent consumers
x = price
NOTE: This graph is designed solely for the analysis described in the text. It is not meant to show the percent of consumers who would or would not buy a car equipped with passive restraints.
RESTRAINT PRICE - 1982 DOLLARS
PERCENT OF CONSUMERS WHO WOULD BUY RESTRAINTS VOLUNTARILY
700
600
500
400
300
200
100
10
20
30
40
50
60
70
80
90
100

equipped passenger car. A second assumption is that the demand curve for new automobiles among those consumers who indicate a willingness to buy at a price of $250 will shift upward to a point where quantity demanded remains the same and that the 50 percent who are not willing to spend this amount will remain on a lower curve. Thus, at a price of $250 about 50 percent are fairly certain to buy a restraint equipped car and the percentage of the remainder who purchase new cars will depend on the elasticity assumptions. Table IX-5 describes several scenarios showing the effects of various assumptions concerning price and percent of voluntary purchases on automobile sales. For example, assuming a price of $250, 50 percent "willing to purchase" from Figure 1X-2 and a short term elasticity of -1.0, annual sales are estimated to decline by 100,000. The calculations are based on an annual sales volume of 8 million and an average price of $10,000.[15]

Table 1X-5 essentially establishes an intermediate position between Richardson who assumes that consumers are totally indifferent to air bags and Nordhaus who contends that consumers will value them at their full price.

[15] Sales and price data based on 1984 projections by Data Resources, Inc., and Bureau of Economic Analysis transactions prices.

TABLE IX-5

Change in Automobile Sales Based on Assumed Variations in Elasticity, Price and Percent Voluntary Purchases

Price	Percent Voluntary	Elasticity Short Term		Long Term	
		-1.0	-1.5	-.1	-.5
$0	100	0	0	0	0
100	75	-20,000	-30,000	-6,000	-10,000
250	50	-100,000	-150,000	-10,000	-50,000
320	35	-170,000	-250,000	-17,000	-80,000
500	20	-320,000	-480,000	-32,000	-160,000
800	0	-640,000	-960,000	-64,000	-320,000

INITIAL AUTOMOBILE PRICE = $10,000
ANNUAL SALES (Domestic) = 8 MILLION
*NHTSA COST ESTIMATE

2. Total Revenue

Total industry revenue, a function of price and quantity sold, is a factor perhaps more important than sales volume in predicting the effects of a price increase on employment and the national economy. To the extent the distribution among the factors of production (labor, capital, etc.) does not change with an increase in revenue, it is possible to experience a net increase in employment, wages, income, etc., even with a decrease in the number of automobiles sold.

Richardson's estimates of revenue changes range from an annual loss of $2.6 billion in the short-run (air bag price at $600 and elasticity at -1.6) to a gain of $3.3 billion in the long-run (air bag price $600 and elasticity -.1). Using the assumptions described in the previous section Nordhaus states, "The effect on sales and profits of automobile companies depends on the pricing assumption, on the consumer perception of safety changes and on the price elasticity. Assuming a long-run price elasticity of -0.5, total revenues are likely to increase from 0.5 to 1.0 percent. Assuming that variable margin per car (i.e., average factory revenue less direct variable costs) is $1,500 per vehicle, the change in annual automobile company profits from imposing the automatic restraint standard are likely to lie in the plus or minus $80 million range."

Table IX-6 shows clearly the sensitivity of total revenue estimates to the wide range of possible assumptions. Based on the assumptions of price, price elasticity and consumer attitudes from Table IX-5, changes in annual sales revenues range from a loss of nearly $4 billion in the short-run to a gain of almost $6 billion in the long-run. Obviously, this range of estimates, as with those of Richardson and Nordhaus, assume that all other relevant factors remain constant.

TABLE IX-6

CHANGE IN TOTAL REVENUE BASED ON SALES ESTIMATES FROM TABLE IX-5
(MILLIONS OF DOLLARS)

Price	Percent Voluntary	Elasticity Short Term		Long Term	
		-1.0	-1.5	-.1	-.5
$0	100	$0	$0	$0	$0
100	75	+598	+497	+739	+699
250	50	+975	+463	+1,898	+1,488
320*	35	+800	-20	+2,385	+1,734
500	20	+640	-1,040	+3,664	+2,320
800	0	-512	-3,968	+5,708	+2,944

INITIAL PRICE = $10,000

BASE SALES = 8 MILLION (Domestic)

*NHTSA COST ESTIMATE

CHANGE IN TOTAL REVENUE = NEW PRICE (e.g., $10,250) TIMES NEW QUANTITY (e.g., 8 MILL - 100 THOUSAND @ E = -1) MINUS BASE SALES TIMES INITIAL PRICE (e.g., $80 BILL) = +$975 MILLION

3. Auto Industry Employment

This section concentrates on employment in the automobile manufacturing industry, including the suppliers of parts, components and equipment which make up the final product.[16] If there is a decline in quantity sold,

[16] Employment effects in the national economy are discussed in the next section.

reduced employment could be expected in automobile assembly and manufacturing plants, as well as in the supplier industries such as tires, glass, lighting equipment, exhaust systems, etc. However, if the drop in demand results from an increase in price due to the installation of an automatic restraint system then an offsetting increase in employment could occur.[17] Perhaps the best predictor of changes in industry employment is total revenue. If demand is elastic -- i.e., a percentage increase in price causes a larger percentage decline in demand -- then total revenue will drop and to the extent that wages and salaries are a function of industry income, employment will decline. By the same reasoning, employment will increase if demand is inelastic.

The econometric model used by Richardson estimates employment effects on the national economy but does not address employment for any specific industry.[18] Regarding offsetting employment in the air bag industries, Richardson, in a later submission to the Docket, states ". . . employment in the air bag production industry is not explicitly addressed in the study. However, the interrelationship of variables within the model allow employment increases in that industry to be addressed implicitly due to increased expenditures on vehicles."[19] She cites several problems associated with industry - specific employment projections. (1) It is not clear what percentages of air bag expenditures would go to labor, capital and profit. (2) It is not known whether there would be additional

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[17] This assumes that the percentage of the product's value attributed to labor remains approximately the same.
[18] The Michigan Quarterly Econometric Model of the U.S. Economy.
[19] December 19, 1983 Submission to Docket 74-14 Notice 3, pg. 7.

expenditures for labor and materials or merely a diversion of resources from other areas. (3) The extent to which the production would come from foreign as opposed to domestic sources is unknown.

Richardson's projected revenue changes vary from an annual short term loss of $2.6 billion to a gain of $3.3 billion in the long-run. To the extent that industry sales revenues and employment are at least roughly related, then the long-run annual employment gain from an assumed $3.3 billion increase in revenue should correspond somewhat to the short-run annual employment loss of nearly 200,000 associated with the $2.6 billion decrease in revenue.[20]

Nordhaus employed the DRI econometric model for his estimates of employment impact.[21] Assuming a price increase of $500 the DRI model yields an annual long term increase in employment in the transportation equipment industry of about 15,000 workers. He assumes that consumers perceive a value of the restraint systems equal to their cost and that the full amount of the added cost is distributed to labor, materials, investment and mark-up in a normal fashion.

The following paragraphs describe NHTSA's estimates of employment effects in the automobile industry.

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[20] The employment loss projection is for the national economy - not the automotive industry specifically.

[21] Data Resources, Inc. "Trendlong 1283"

The initial step in estimating employment effects is to determine the number of workers directly and indirectly engaged in the production of passenger cars. Although employment data on the motor vehicle industry in general are available from the Bureau of the Census, it is not possible to isolate passenger car production from the total. Also, employees involved with the production of passenger car parts and components working in companies where primary output is not automotive are not included. A rough approximation of the total number of employees (or full time equivalents) engaged in the production of automobiles is calculated as follows:

The Census of Manufacturers, Bureau of the Census, lists 1981 employment in the Motor Vehicle and Motor Vehicle Equipment Industry (SIC 371) at 695.6 thousand. The value added by the manufacturers is estimated at $34.8 billion. Therefore, the average value added per employee is approximately $50,000.[22] Assuming that this average holds for all employees either directly or indirectly involved with automobile production and that the total value added in producing 8 million cars at $10,000 per unit is $80 billion, then the number employed would be approximately 1.6 million. Included are employees involved with manufacturing, transporting, financing, selling, etc., the final product.[23] [24]

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[22] Value added per employee in all manufacturing establishments in 1981 was about $44,300.

[23] Not included are those who provide goods and services for a car which is in use, e.g. service stations, repair shops, etc., and employees engaged in the production of new fixed plant and equipment used in the manufacture of automobiles.

[24] The $10,000 price is assumed to be equal to the total value added to that vehicle.

Similar results are obtained using Bureau of Labor Statistics data published by MVMA.[25] These data show that approximately 33,000 manufacturing workers were directly or indirectly employed for each $1 billion of final demand in 1972 dollars. Converting to 1981 dollars results in approximately 33,000 employees for every $1.8 billion in sales or about $55,000 per employee. Using an assumed level of $80 billion in sales yields an estimate of about 1.45 million employees.[26]

For purposes of estimating employment losses or gains in the automobile industry it is assumed that about 1.5 million persons will be directly or indirectly employed in the production of 8 million domestic passenger cars.

The bases for predicting changes in employment are the total revenue assumptions presented in Table IX-6. Total revenue is thought to be a better indicator of employment than vehicle units sold because changes in the vehicle's configuration may result in more or less workers needed per unit of output. Total revenue is a measure of the value of the final product(s) and of the resources used in its production. Therefore, to the extent that the distribution of revenue among various factors of production remain constant, it can be assumed that changes in revenue will result in similar relative changes in resources expended for wages and salaries.

Table IX-7, based on percentage changes in revenue from Table IX-6, shows potential effects on employment under various assumptions for price, price elasticity and the percent of consumers willing to purchase a restraint at

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[25] Motor Vehicle Facts and Figures. Motor Vehicle Manufacturers Association, 1983.

[26] Non-manufacturing employees are not included.

given prices. In the long-run, the employment effects appear positive under all assumptions, reflecting the net increase in revenues from Table IX-6. In the short-run an automatic restraint system costing $500 or more may result in a significant negative impact on employment.

TABLE IX -7
CHANGE IN AUTO INDUSTRY EMPLOYMENT BASED ON ASSUMED
VARIATIONS IN ELASTICITY, PRICE AND PERCENT VOLUNTARY PURCHASES

Price	Percent Voluntary	Elasticity Short Term -1.0	Elasticity Short Term -1.5	Elasticity Long Term -.1	Elasticity Long Term -.5
$0	100	0	0	0	0
100	75	+11,200 (.75)	+9,300 (.62)	+13,900 (.92)	+13,100 (.87)
250	50	+18,200 (1.2)	+8,500 (.56)	+35,600 (2.4)	+27,800 (1.9)
320*	35	+15,000 (1.0)	-400 (-.025)	+45,000 (3.0)	+32,500 (+2.2)
500	20	+12,000 (.80)	-19,500 (-.9)	+68,700 (4.6)	+43,500 (2.9)
800	0	-9,600 (-.64)	-74,400 (-5.0)	+107,000 (7.1)	+55,200 (3.7)

BASE EMPLOYMENT IN PASSENGER CAR PRODUCTION = 1.5 MILLION

NUMBERS IN PARENTHESES ARE PERCENT CHANGES

*NHTSA COST ESTIMATE

C. Macro-economic Effects of Price Changes

It is assumed that the major potential impacts of an automobile price increase on the national economy can be measured by changes in employment, Gross National Product and inflation.

1. National Employment

A significant decline in automobile sales could have a far-reaching impact on the automobile industry, its suppliers and the industries which support highway transportation, e.g., service stations, repair shops, recreational facilities, etc.

Richardson projects nationwide short-term employment losses to range from about 60,000 to 200,000 annually. Long-term changes are not estimated. Nordhaus estimates employment gains in the transportation equipment industry only. These gains range from 3,000 to 15,000 annually depending on the price of the restraint system.

As discussed previously, there are an estimated 1.5 million persons directly or indirectly engaged in the production of passenger cars. Under the assumptions presented in Table IX-7 the employment effects of a mandated restraint system range from an increase of 107 thousand workers to a decrease of 74.4 thousand.

It is generally acknowledged that for every person working in a basic industry such as manufacturing, additional jobs are generated to support both the people employed and the product which is manufactured. With respect to automobile manufacturing such jobs would be found in areas which provide services to the employed persons (e.g., restaurants, recreational facilities, etc.) and in areas which provide goods and services for repairing, maintaining, insuring and financing the vehicle.

Thus, if there is a significant long-term decline in automobile sales and employment there is likely to be unemployment in these secondary support industries. Assuming that 2 persons are employed in support industries for every one employed in automobile manufacturing then, based on Table IX-7, in the short-run at a price of $320 a maximum of 1,200 persons would be without jobs nationally and in the long-run there would be a nationwide increase of nearly 100,000 jobs.[27]

The above estimates oversimplify the real world in several ways, particularly in that they assume no rigidities in either direction. For example, an increase in labor requirements does not necessarily result in the creation of more jobs. It could mean more overtime or a shift from part-time to full-time. It is also possible that a structural realignment could occur meaning only a transfer of workers from one area to another. A loss in new car sales, if temporary, will not necessarily mean an immediate employment loss in those firms supplying goods and services to employed automobile workers. If new car sales decline, there may be a rise in employment in businesses engaged in maintaining and repairing the existing fleet. Also, it should be recognized that Table IX-7 is designed to describe the extremes in terms of employment losses or gains.

[27] Based on the DRI and Wharton models, Chase Manhattan Bank estimates that employment losses in the Transportation Equipment and Allied industries account for one-third to one-half of total job losses. A Cost-Benefit Analysis of the 1979-1985 Fuel Economy Standards, Chase Manhattan Bank 1978.

With a labor force of over 115 million projected for the mid 1980 decade it would be difficult to conclude that a restraint system costing the consumer no more than $500 would result in any measurable impact on national employment or unemployment.

2. Gross National Product

Domestic automobile production historically has accounted for about 3 percent of U.S. Gross National Product. Automobile industry sales are cyclical, and highly dependent on the state-of-the-economy and often a leading indicator of both economic downturns and recoveries.

Assuming a restraint cost of $500, Table IX-6 shows that changes in industry revenue will vary from $+3.7 billion to $-1.0 billion. With total sales of $80 billion, a decrease of $1.0 billion represents a decline of 1.25 percent in industry revenue and about three-hundredths of one percent of 1982 GNP. An increase of $3.7 billion in auto sales revenues increases GNP by about one-tenth of one percent.

Based on the relationships between employment and total revenue the indirect effects of losses or gains in automobile sales should be proportionately equivalent to that of employment. Therefore, it is estimated that an additional 2 dollars of indirect output will be lost or gained for each dollar change in auto industry output. The range of effects on GNP vary from a short run loss of over $3 billion (.10 percent) to a long run gain of $11 billion (.40 percent). The effect on real as opposed to nominal GNP will depend on whether the restraint system is perceived as an improvement in the quality of the automobile. For example, if the restraint is not considered a quality improvement, the estimated increase in GNP will not be as high in real terms. Quality vs. inflationary changes are discussed in the next section.

Richardson projects short-term losses in GNP ranging from .115 to .355 percent - assuming a range of air bag prices from $300 to $600 and elasticity from -.9 to -1.6. Applying these percentages to 1982 GNP yields a decline of national output ranging from $3.5 to $10.6 billion.

Nordhaus, assuming an elasticity of -1 and a price increase of $500, projects a gain in GNP of about one-tenth of 1 percent ". . . over the years following the rule."

Probably the only meaningful inference that can be drawn from these analyses is that because of substantial uncertainty the ranges are wide and if there are any perceptible effects on GNP they will occur primarily in the short-run and in all likelihood will be minor.

3. Consumer Price Index

Under the assumptions described previously, Richardson predicts an increase in the consumer price index of between .22 and .45 percent. However, these estimates of inflationary impact were derived within the Michigan Econometric Model and are not comparable to the Bureau of Labor Statistics' consumer price index.

Using the DRI econometric model, Nordhaus found that a $500 restraint system would leave the consumer price index virtually unchanged.

If the consumer price of the same product increases due to greater costs or greater demand, the increase is considered inflationary. However, if the higher price is due to an improvement in the quality of the product which is equal to or greater than the additional price, there is no effect on inflation. (The Bureau of Labor Statistics generally considers higher consumer costs due to safety equipment and other quality improvements as increased consumption having no effect on the consumer price index.) Therefore, at least in theory, the effect of a restraint system could range from a decline in consumer prices (if the system results in an improvement in the quality of the car which is greater than the additional price[28]) to a hypothetical increase in the price index even greater than the additional cost if the restraint system has a negative effect on the quality of the automobile.

For purposes of establishing a range of possible inflationary effects two assumptions will be used. The first is that the increased quality of the automobile will be exactly equal to the increased price. In this case, the restraint system will have no effect on inflation. At the other end of the range is the assumption that the restraint system adds zero value. The effect on the price index in this situation can be estimated by multiplying the price increase by the weight of new car purchases in the BLS price index. In December 1982, BLS estimated that new cars comprised 3.506 percent of the consumer "market basket." Assuming a price increase of $500

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[28] This is equivalent to a decrease in price.

(5.0 percent) the net effect on the CPI would be (.0351) (.05) or an increase of .18 percent.[29]

D. Synthesis

Table IX-8 summarizes the differences and similarities among the Richardson, Nordhaus, and NHTSA analyses of the economic effects of automatic restraint requirements.

1. Initial Auto Sales and Prices

Richardson uses Bureau of Economic Analysis quarterly domestic sales and transactions prices. Prices are in 1982 dollars. Nordhaus and NHTSA sales volumes are rounded estimates based on DRI projections for 1983 and several years beyond. Nordhaus includes imported vehicles. Except for rounding, per unit price assumptions are essentially the same.

2. Restraint Price

Except for the exclusion of automatic belts in the Richardson study, the assumed increase in automobile prices due to the installation of an automatic restraint system are not significantly different. The NHTSA analysis includes restraint prices at $0 and $800.[30] However, these

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[29] Since BLS does in fact consider safety improvements as an increase in quality this example is purely hypothetical.

[30] The potential for higher prices would be greater at low production volumes.

extremes are not considered realistic and were presented only for illustrative purposes. Table IX-8 assumes a range from $100 to $500 for air bags.

3. Elasticity

The price elasticity estimates, which are indicators of consumer response, have the highest level of uncertainty among all the assumptions. Given this uncertainty, the range of estimates among the three analyses are relatively close.

4. Reduction in Units Sold

Richardson assumes that consumers are indifferent to air bags and view their cost as a simple price increase. Therefore, based on several elasticity assumptions, sales will decline from 167 to 593 thousand in the short run and 19 to 93 thousand in the long run. Nordhaus, assuming a price of $88 for automatic belts, expects annual sales reductions to vary from zero to 90,000, depending on how consumers value the systems. NHTSA estimates annual sales losses to range from a low of six thousand in the long run to a high of 480 thousand in the short run.

5. Total Revenue

Changes in industry revenue are simply the difference between the previous price times quantity sold and the new price times quantity sold. All three analyses anticipate long run increases in total revenue.[31] This implies that the additional price more than compensates for any decrease in number of units sold.

6. Employment

There is considerable variation in the estimates of changes in auto industry and national employment which is accounted for primarily by differences in assumptions on employment generated in the automatic restraint industry. Although Richardson acknowledges the possibility of new employment opportunities, the model used in the analysis is not capable of explicitly identifying employment changes in specific industries. Thus, the short term loss of 62,000 to 197,000 employees directly and indirectly related to automobile production represents an estimate of national rather than industry employment effects. The Nordhaus and NHTSA analyses both assume that the restraint system will result in additional automotive industry expenditures, part of which will be spent on wages and salaries.

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[31] The expected increases in revenue should not be construed as benefits to society. They are a cost in terms of resource expenditures which could have been used elsewhere. The benefits are measured by the lives saved and injuries prevented to determine net societal benefits or costs.

7. Gross National Product and The Consumer Price Index

The projection of effects on GNP and the price index have one thing in common - the relative changes are so small and the number of assumptions needed to perform the calculations are so large that very little confidence can be placed in the estimates. Perhaps the only conclusion that can be drawn is that theoretically there could be some increases or decreases in GNP or an increase in aggregate consumer prices but such changes are not likely to be perceptible in the real world.

TABLE IX-8

ASSUMPTIONS AND ECONOMIC EFFECTS -- SUMMARY

	Short Term			Long Term		
	Richardson	Nordhaus	NHTSA	Richardson	Nordhaus	NHTSA
Initial Annual Auto Sales Volume (Mill)	6.1	10.0	8.0	6.1	10.0	8.0
Initial Auto Price	$9,866	$10,000	$10,000	$9,866	$10,000	$10,000
Restraint Price	$300 to $600	$88 to $500	$100 to $500	$300 to $600	$88 to $500	$100 to $500
Price Elasticity of Demand	-.9 to -1.6	-1	-1 to -1.5	-.1 to -.5	-.5	-.1 to -.5
Reduction in Units Sold (000)	167 to 593	0 to 90[1]	20 to 480	19 to 185	0 to 45[1]	6 to 160
Change in Total Revenue (Mill)	+$130 to -$2,556	---	$+598to-1,040	+$884 to $3,265	$500 to $1,000	$+739to $3,664
Change in Auto Industry Employment (000)	----	+3 to +15[4]	+18 to -20[2]	---	+3 to +15[4]	+13 to +69[2]
Change in National Employment (000)	-62 to -197	0 to +	+54 to -60[3]	---	0 to +	+13 to +207[3]
Change in Gross National Product	-.115% to -.355%	---	+.10%to-.10%[5]	---	+.1%	+.07% to +.18%[5]
Consumer Price Index -- Percent Increase	.215 to .449	0 to .1	0 to .176	---	0 to .1	0 to .176

[1] For automatic belts at $88.
[2] Assuming 1.5 million direct and indirect employment in auto manufacturing.
[3] Assuming a Multiplier of 3.
[4] Transportation Equipment Industry.
[5] Assuming GNP at $3 trillion and a multiplier of 3.

X. SMALL BUSINESS CONSIDERATIONS

An automatic restraint standard could have an effect on those small businesses that would be involved in the production, maintenance or sale of automatic restraints. The direction of this effect might be either positive or negative. Before we can analyze this effect, it is necessary to determine what is actually meant by a small business. After this determination has been made, a brief industry profile of those affected industries will precede an analysis of the effect of a change in restraint requirements on them.

The definition of a small business varies from industry to industry. The definition used to determine whether an industry needs to be considered as a small business under the Regulatory Flexibility Act (Public Law 96-354) is the one that is used to determine whether a business is small enough to qualify for a Small Business Administration (SBA) loan. Under the Regulatory Flexibility Act, rules are required to minimize significant economic impacts on small businesses, small organizations, and small governmental jurisdictions. The Small Business Size Standards applied in this chapter are those revised and effective as of March 12, 1984.

A thorough review of businesses possibly affected by this final rule has led to the conclusion that the seat belt, air bag, dealership and automobile industries need to be analyzed. According to 13 CFR 121.2 a manufacturer of motor vehicle parts and accessories with fewer than 500 employees is considered to be a small business. Because several of the seat belt manufacturers, or their suppliers, and the current air bag companies would fit this definition, they are discussed below.

A motor vehicle dealer (new and used) is considered to be a small business if its annual receipts do not exceed $11.5 million. (13 CFR 121.2). According to the 1983 National Automobile Dealers Association (NADA) Annual, an average dealership had sales of $5.71 million in 1982. This would mean that, according to the new definition, well over half of all dealerships should be classified as small businesses.

A manufacturer of motor vehicles and passenger car bodies is a small business if it has fewer than 1,000 employees. Because there are about a dozen motor vehicle companies that fit this description, motor vehicle manufacturers are briefly considered in this chapter.

A. Seat Belt Manufacturers

1. Industry Profile

The domestic seat belt industry began to grow in the 1960s, when seat belts became standard equipment. Effective January 1, 1968, FMVSS 208 required seat belts for all seating positions in passenger cars. Since most of the companies that became involved in seat belt production were already involved in related manufacturing activities, seat belt production was basically an expansion of existing companies. These domestic producers include seven major manufacturers, four independent primary webbing

TABLE X-1
THE SEAT BELT INDUSTRY

Safety Belt Manufacturers	Total Employment
1. Allied Chemical Corp. Automotive Products Div. Mt. Clemens, Michigan	58,000
2. American Safety Equipment Corp. San Fernando, Calif.	3,700
3. General Safety Corp. St. Clair Shores, Michigan	475
4. Firestone Industrial Products Div. (Hamill Mfg. Co.) Washington, Michigan	1,135
5. Irvin Industries Madison Heights, Michigan	1,875
6. Pontonier Div. of Gateway Ind. Chicago, Illinois	1,000
7. Fisher Body of GM	*
Independent Seat Belt Webbing Suppliers	
1. Murdock Webbing Co. Central Falls, Rhode Island	250**
2. Narricot Industries, Inc. Philadelphia, Pa.	420**
3. Phoenix Trimming Co. Northbrook, Illinois	200**
4. Woven Electronics Co. (formerly Southern Weaving Co.) Greenville, South Carolina	750
Fibers Suppliers	
1. Allied Fibers and Plastics Div. of Allied Corp. Akron, Ohio	58,000 (Allied Corp.)
2. Celanese Fibers Co. Div. Charlotte, North Carolina	41,500 (Celanese Corp.)
3. Threads U.S.A. Div. Gastonia, North Carolina	5,900** (Ti-Caro Corp.)
Metal Supplier	
Header Products, Inc. Romulus, Michigan	110

* Not available
Source: Employment from Dun & Bradstreet, 1983, with the exception of employment at General Safety and Hamill which comes from Standard and Poors, 1983.

**Source: Administrative office of specific company suppliers, three fibers suppliers, and one metal supplier.[1] (See Table X-1.) Due to the large numbers of seat belts required, the companies tend to be automated.

In addition to listing the major seat belt manufacturers, Table X-1 also lists total employment in each company. Some of the safety belt manufacturing companies, such as Allied, are involved in numerous manufacturing activities including the production of fibers, plastics, and electronics. For these companies, seat belt manufacturing is just one of their activities. The seat belt manufacturer with the lowest employment, General Safety Corp., manufactures only seat belts and shoulder harnesses. The five major seat belt manufacturers -- Allied, American Safety, Hamill, General Safety and Irvin -- each make buckles, retractors, inertia reels and pendulums. Of these seat belt manufacturers, only Allied and American Safety Equipment make webbing. All five produce original equipment (95-100 percent) and four produce service equipment (0.1-5 percent). None of these top five manufacturers produces aftermarket equipment.

The independent seat belt webbing suppliers are also listed in Table X-1 with their employment. Murdock Webbing, Narricot Industries, and Phoenix Trimming are small businesses. Webbing production for automotive seat belts accounts for 10-15 percent of Murdock's total production, 75 percent of Narricot's, and 40 percent of Phoenix's.

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1 Source: American Seat Belt Council, Arlington, Va.

Of the seat belt assemblers listed in Table X-1, Allied, American Safety and Hamill each represent about 25 percent of the market. These three, in addition to General Safety and Irvin, account for 93 percent of the market, with Pontonier and Fisher Body comprising the remaining 7 percent.

Most automobile companies have more than one seat belt supplier as a precaution against strikes, natural disasters, and other disruptions. The table below shows the major seat belt suppliers and the automotive manufacturers that they supply. The major seat belt manufacturers also supply seat belts to Honda and Volkswagen in the U.S.

TABLE X-2

Automobile Company Seat Belt Suppliers

Supplier	Auto Companies
Allied Corp	Ford (60% of Allied belts) GM
American Safety Equipment Co.	AMC Chrysler
Hamill	GM (major customer) Ford
General Safety	Cadillac (sole supplier)
Irvin	Chrysler

Source: American Seat Belt Council, Arlington, VA.

There were about 29.8 million seat belts sold as original equipment in automobiles in 1982. This number is derived from the number of automobile sales by designated seating positions as discussed below. We assume that only domestic automobiles have domestically-made belts. The following table shows the number of domestic automobile sales by seating position in 1982.

TABLE X-3

1982 AUTOMOBILE SALES by DESIGNATED

SEATING POSITION [2] (Domestics)

Front Seat	Automobile Sales
2 Positions	3,107,639
3 Positions	2,649,019
Total	5,756,658
Rear Seat	
0 Position	74,605
2 Positions	1,403,066
3 Positions	4,278,987
Total	5,756,658

Thus, 5,756,658 automobiles each had two 3-point belts or a total of 11.513 million 3-point belts (2 x 5,756,658). The positions for lap belts must be added together as follows:

	Positions	Lap Belts
Front Center	2,649,019	2,649,019
Rear Side	5,682,053	11,364,106 (2 x 5,682,053)
Rear Center	4,278,987	4,278,987
	Total	18,292,112

[2] Source: Manufacturers' Specifications, Automotive News.

Thus, in 1982 there were 11.5 million 3-point belts and 18.3 million lap belts.

Although there were 29.8 million seat belts sold as original equipment on cars in 1982, more than this number were actually produced. The industry must inventory enough replacement belts to last for about 10 years. The replacement belts must fit different model cars which require slightly different belts.

2. Potential Effect of an Automatic Restraint Rule Requiring Air Bags on the Seat Belt Industry

As discussed in the introduction, a manufacturer of motor vehicle parts and accessories with fewer than 500 employees is considered to be a small business. Among safety belt manufacturers, only General Safety Corp. falls into this category.

The American Seat Belt Council docket comments of December 19, 1983, state that four seat belt webbing suppliers, Murdock Webbing Co., Narricot Industries, Inc., Phoenix Trimming Co., and Woven Electronics Corp., are not "large and diversified firms with over 1,000 employees." According to the company administrative offices, Murdock Webbing employs 250 people and Narricot Industries employs 420 people. Phoenix, which only manufactures webbing, employs 200 people. Woven, however, employs 750 people. In addition to webbing, the company also manufactures tapes and electronic components.

If 3-point belts were replaced by air bags and lap belts, there would be a reduction in webbing requirements. In the following analysis we assume that lap belts will be used with the air bag even though it is possible that 3-point belts could be used as they are in the Mercedes-Benz. In the <u>Weight and Consumer Price Components of the 1980 General Motors Chevrolet Citation and the 1981 Chrysler Plymouth Reliant</u> teardown analysis, seat belt webbing has been identified and given a weight. From these data, an average weight has been estimated. An average 3-point belt weighs 0.4914 pounds while a lap belt weighs about 0.2225 pounds, i.e., 55 percent of a 3-point belt includes other than lap belt webbing, [1-(0.2225/0.4914)=.55]. Thus, were lap belts substituted for 3-point belts there would be a 55 percent reduction in weight for each 3-point belt.

The data used earlier in this section to calculate numbers of seat belts manufactured in 1982 will be used here to determine the total reduction in webbing requirements. In 1982 there were 11.513 million 3-point belts and 18.292 million lap belts. Taking our weight assumptions as discussed above, the total weight for all 3-pt. belts would be 5.657 million pounds:

(11.513 mill. 3-pt. belts)(0.4914 lbs.) = 5.657 mill. lbs.

Lap belts would total 4.070 million pounds:

(18.292 mill. lap belts)(0.2225 lbs.) = 4.070 mill. lbs.

Thus, 9.727 million pounds was the total weight of webbing in 1982:

5.657 mill. + 4.070 mill. = 9.727 mill. lbs.

Assuming that the 11.513 million 3-point belts became lap belts, they would only weigh 0.2225 pounds each.

(11.513 mill. lap belts)(0.2225 lbs.) = 2.562 mill. lbs.

Thus, the 11.513 million lap belts would weigh only 2.562 million pounds instead of 5.657 million pounds. Total webbing required would be 6.632 million pounds (2.562 + 4.070 = 6.632 mill. lbs.). This is a reduction in webbing requirements of 32 percent.

If 3-point manual belts were replaced by three point automatic belts there may be some change in the total webbing requirements, possibly a slight increase. Due to the diversity of possible designs for three point automatic belts, the agency is not able to quantify the change. Similarly for two point automatic belts there may be some change in total webbing requirement, but the agency is not able to estimate the effect due to the wide diversity of possible designs. In any case, the effect is believed to be small.

B. Air Bag Manufacturers

1. Industry Profile

This is an industry profile which, first, identifies the air bag manufacturers according to what aspect of production they are involved in and, then, discusses possible labor requirements in the air bag industry. The air bag industry--extant for 14 years--will be divided into four subindustries for this analysis. These are (1) manufacturers of sensors, (2) manufacturers of gas generators, (3) manufacturers of the air bag fabric, and (4) assemblers. The air bag industry is currently small and undeveloped, since few air bags are being manufactured. Thus, labor requirements and prices are high. It is believed that as production increases, the industry will become more automated and less labor intensive. It was shown in Chapter VIII, that as more units are produced, prices will drop.

Sensors

The air bag sensors are made primarily by Breed Corp, Lincoln Park, NJ, and Technar, Arcadia, California. Breed employs roughly 100 people and the majority of their revenue is associated with defense contracts. While Breed has been involved in development work with Mercedes-Benz, it is currently supplying sensors to Ford on a limited basis. Breed has developed a mechanical system where the air bag fuse is set off by a mechanical ball contained in the steering column. Breed has been involved in sensors and fusing work for the government and the military.

Technar is supplying a sensor system and diagnostic module to Romeo Kojyo for 500 highway patrol cars in six states. Technar employs about 100 people. This includes an engineering staff of seven and a clerical/technical support staff of nine. The other personnel are engaged in corporate management and manufacturing production. In addition to designing and producing crash sensoring systems for automobiles, Technar makes sensors for aircraft and missiles. Its products include predominantly acceleration, pressure and temperature sensors.

Gas Generators (Inflators)

There are currently three producers of air bag gas generators. Thiokol, in Brigham City, UT, makes generators for Ford. Talley Industries, Mesa, AZ, also makes inflators for use in their completed modules. Rocket Research of Redmond, WA, has been involved in the past, and could become involved in the future.

In the early '70s Bayern-Chemie, Gmbh, a German company, began to research and develop future systems for occupant protection cooperatively with Daimler-Benz AG. They were able to draw on their experience from rocket technology to develop a solid gas generator. Bayern-Chemie, which produces 15-20,000 gas generators per year, also supplies gas generators to Romeo Kojyo.

Air Bag Fabric

Air bag material basically consists of commercially available fabric manufactured under rigorous specifications and coated with neoprene. Currently, Uniroyal (a large company with nearly 50,000 employees) is the only domestic company that is actually supplying this material and is the principal supplier for Talley Industries. Several other domestic companies are developing materials for possible use in air bag systems but as yet are not involved in actual production. These include Nylco Corporation of Clinton, Massachusetts and Milliken and Co. of Spartanburg, South Carolina. Takata Kojyo of Japan is currently supplying this material in completed modules to Romeo Kojyo.

Assemblers

Normally, an assembler will either assemble the three components of an air bag in its own facility or subcontract to another company. Currently there are two principal assemblers in the U.S., Romeo Kojyo and Talley Industries.

Romeo Kojyo of Tempe, Arizona, is an example of a manufacturing company which buys components and does its own assembly. It was formed to develop and manufacture air bag restraint components and systems. Romeo Kojyo is affiliated with Takata Kojyo, Japan. Takata Kojyo is supplying to Romeo Kojyo the air bag module, the steering wheel and hub adaptor, and the device connecting the entire system to the steering column. Romeo Kojyo is a small business with less than 10 employees.

Talley Industries of Phoenix, Arizona manufactures its own inflators but purchases fabric and other components from suppliers. It then sews the bag and assembles a completed air bag module. Talley is currently supplying air bags to both Ford and Breed for demonstration and experimental development programs, and has a production line order of 5,000 units from Ford Motor Co. for use in the GSA fleet air bag program. Talley is a fairly large firm with roughly 3,800 employees.

2. Potential Effects of an Automatic Restraint Rule on the Air Bag Industry

In this section, the labor requirements in the air bag industry are estimated from unit costs and labor costs. According to one supplier, a rule of thumb in the air bag industry is that cost can be divided approximately into one-third for labor, one-third for materials and one-third for overhead.[3] This will vary somewhat according to the number of units produced. In the following table, consumer cost per unit comes from Chapter VIII. The percent cost of labor is based on industry sources for 1,000, 10,000 and 1,000,000 units.[4] The other labor cost percentages have been assumed.

TABLE X-4

No. of Air Bag Systems	Consumer Cost Per Unit (incl. Driver+Passenger Side)	Wholesale Cost Per Unit* (incl. Driver+ Passenger Side)	% Cost of Labor	No. of Employees
1,000	---	---	50-60	---
10,000	$1,500	$1,320	33.3	165
100,000	$600	$528	25	495
300,000	$350	$308	20	693
1,000,000	$320	$282	20	2,116
2,500,000	$310	$273	20	5,120

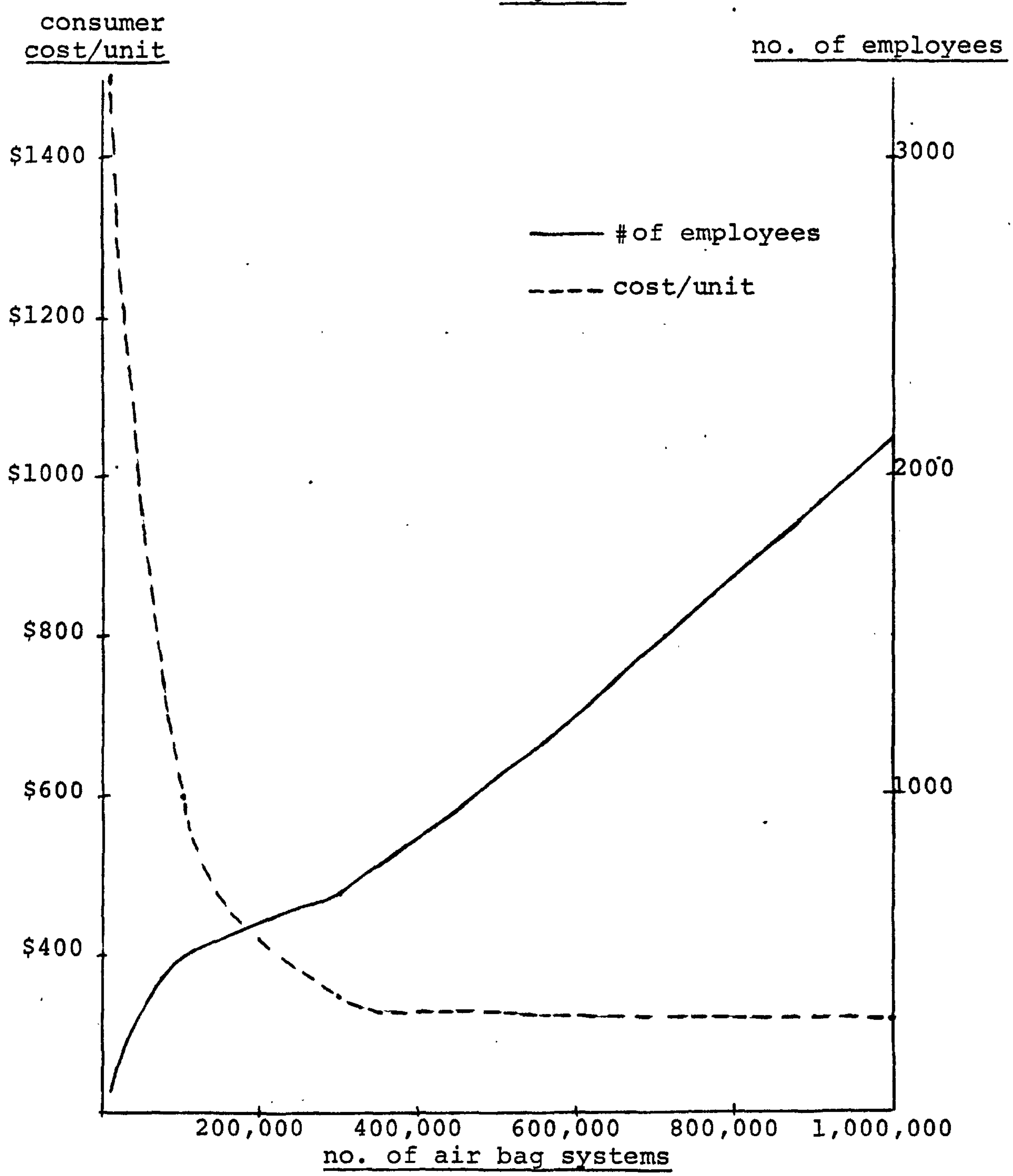
* Wholesale cost is derived by multiplying consumer cost by 88 percent.

3 David Romeo, Romeo Kojyo, Tempe, Arizona.
4 Ibid.

LABOR REQUIREMENTS

IN THE AIR BAG INDUSTRY

Figure 1



The table shows that cost per unit and the cost of labor decline as the operation becomes larger. The consumer cost is reduced by 12 percent to provide wholesale costs. The percent cost of labor must be applied to wholesale costs. The number of employees increases as production increases.

To derive an estimate for labor requirements, for example, we begin with a wholesale cost of $282 million for one million air bags. Assuming a 20 percent labor requirement, the cost for labor would be $56.4 million. ($282 mill. x .20=$56.4 million). Based on discussions with current air bag manufacturers,[5] we assume that $10 is the hourly wage rate for air bag production. This rate, however, must be marked up to reflect non-wage compensation such as employer contributions to health and life insurance plans, unemployment insurance, retirement plans, etc. These forms of compensation are estimated to be 25 percent of total compensation. (This NHTSA estimate is based on a 1977 report prepared by the Bureau of Labor Statistics.) The hourly wage rate of $10 is 75 percent, (1-.25) of the total hourly wage rate. Thus, the hourly compensation rate that includes wage and non-wage compensation is $13.33 (.75 x total hourly wage rate = $10; total hourly wage rate = $10/.75 = $13.33).

Thus, 4.231 million are the number of hours spent per year producing air bags (56.4 million/13.33 = 4.231 million). Assuming the average person works 2,000 hours/year, there would be 2,116 employees making one million air bags (4,231,000/2,000=2,116). The change in labor requirements as the number of air bag systems change has been derived and is shown in Table X-4

[5] David Romeo, Romeo Kojyo, Temple, Arizona.

and in Figure 1. It should be remembered that these numbers are an approximation. While only 165 employees would be required to produce 10,000 units, 5,120 would be required to produce 2.5 million.

C. New Car Dealers and Auto Repair Establishments

A major concern for automobile dealers is that fewer cars will be sold as automobile prices rise with automatic restraints. According to Chapter IX, a price increase of $320 due to air bags might reduce sales from approximately 20 to 80 thousand. There were about 25,000 franchised new car dealerships in the U.S. in 1983.[6] The following calculation determines the average number of sales lost at each dealership:

$$\frac{20{,}000 \text{ to } 80{,}000}{25{,}000} = .8 \text{ to } 3.2$$

Thus, there could be approximately 1 to 3 car sales lost on an annual basis per dealership. In 1982, the average new car dealer sold roughly 320 vehicles valued at $3.5 million.[7] The additional price for automatic restraints, therefore, does not result in a significant decline in sales per dealership.

As discussed in the introduction to this chapter, a significant number of dealers were found to be small businesses. This finding was based on 13 CFR 121.2 which defined dealers as a small business based on annual receipts. In addition, auto repair shops and gasoline service stations are involved in the servicing and supplying of new automatic restraint equipment. According to 13 CFR 121.2, an auto repair shop is considered to

6 NADA Data for 1983, NADA Industry Analysis Department.
7 Source for Vehicle Sales, Automotive News 1984 Market Data Book.
Source for Value of Sales, NADA Data for 1983.

be a small business if its annual receipts do not exceed $3.5 million, and a gasoline service station is a small business if its annual receipts do not exceed $4.5 million. In 1982, auto repair shops (independent and franchised) sales were $20.8 billion based on 177,000 establishments. Thus, the average sales per shop were $117,514 ($20,800,000,000/177,000 = $117,514) which is well below $3.5 million.[8] In 1982, gasoline service station sales were $7.2 billion and there were 72,000 stations. Again, for each service station, the sales are well below $4.5 million ($7,200,000,000/72,000 = $100,000).[9] Thus, the auto repair shops and the gasoline service stations would include a significant number of small entities.

Automobile dealers are also concerned about increasing service and parts supply system costs, including the training of those personnel involved with fixing or selling the new part. Auto repair shops and gasoline service stations face the same concerns to the degree that they will be servicing and supplying new passive restraint equipment. The current manual belt occupant protection system is fairly simple and is treated like any other repair or replacement item. Even the automatic belt systems that exist today are not overly complicated from a mechanic's standpoint and, as such, offer little problem to dealers in a repair or maintenance situation. While replacement of a manual belt system is not a common occurrence, parts are available if needed. Any dealer costs associated with these systems are generally considered as normal operating or overhead costs.

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8 NADA Data for 1983, p. 10.
9 NADA Data for 1983, p. 10. 72,000 includes only those outlets that perform "significant" repair work (i.e. those establishments that perform work beyond simple oil change or lube jobs and/or those establishments that receive at least 2% of total dollar revenue from service labor).

Several additional operating costs related to the use of air bags could be incurred by dealers, repair shops, and service stations. Because air bag systems are more sophisticated than belt systems, specialized technician training and education programs will be necessary for dealership personnel. The dealers expressed concerns at the recent hearings in Los Angeles, Kansas City, and Washington, D.C. about whether technicians could be promptly and effectively retrained to service, repair, and replace the more complicated automatic restraint systems.

Other air bag associated costs to dealers and automotive repair shops are the need for special tools, diagnostic equipment and remote detonating devices for scrappage of air bag units; fire-proof, lockable storage facilities; and the cost of compliance with additional environmental and safety requirements. These costs, in addition to those two discussed above, are, in part, associated with the potential concerns associated with sodium azide, the most common air bag propellant.[10] (See Chapter III for a complete discussion on sodium azide.)

Although several dealers voiced concern at the hearings about product liability issues, Chapter III concludes that manufacturers and dealers do not face an increased risk of liability with automatic restraints. Automatic restraints are actually expected to reduce the number of product liability claims as the number of people previously injured or killed in crashes allegedly caused by vehicle manufacturing or design problems will be protected by automatic restraints. Chapter III also explains that information provided by insurers indicates that product liability insurance is available to cover the automatic restraint-related claims experienced by

[10] NADA docket comments, 74-14-N32-1680, p. 9-10.

vehicle manufacturers. Indemnification programs are also offered by vehicle manufacturers and may eliminate some of the dealers' product liability problems resulting from factors beyond their control.

The May 14, 1984, SNPRM included three alternatives that could pose additional problems for automobile dealers. The first alternative would provide a waiver from an automatic restraint requirement for cars sold to residents of a state passing a mandatory use law (MUL). If such an alternative were adopted, dealers could face additional expenses due to an uncertain marketing situation. As several docket commenters point out, there could be an inharmonious patchwork of states thoughout the country regarding MULs. Some states would have waivers while in adjacent states automatic restraints might be required. Still others could have legislation or waivers pending. It could be complicated for a dealer with an interstate market to inventory cars and assure the sale of appropriately configured cars.

Dealers could encounter difficult situations as consumers cross state lines to buy vehicles. One docket comment provided an example of this type of situation with the State of California and its emission control regulation. Californians in major population centers, located at a considerable distance from the border, were crossing the border to buy vehicles. A more intense situation could occur on the East Coast where drivers are more frequently entering and exiting nearby states.[11] However, no data are available to quantify any potential loss of business.

[11] Volkswagen of American, Inc., docket comments, 74-14-N35-046, p.12.

The second alternative that would present problems for the dealer is the mandatory demonstration program which would require automobile companies to equip five percent of their passenger cars with automatic restraints for four years. The dealers, in addition to the automotive companies, could largely bear the cost of such a program. In the case of the 1974-76 air-bag-equipped GM cars and of the 1978-80 automatic-belt-equipped Chevettes, for example, the franchised dealers were apparently adversely affected. At the October 1983 hearings on the NPRM, General Motors dealers testified that the vehicles with automatic restraints often had to be discounted by at least the price of the device in order that such vehicles could be removed from inventory and prevent rising floor plan costs.[12] However, since the demonstration program would only cover a small part of total dealer inventory, such losses are not expected to be significant.

The probability that a similar problem could occur with another alternative raised in the SNPRM, that would rescind automatic restraint requirements if a certain percent of the states passed MULs, was also considered. It is possible that if this alternative was selected and the requirements for rescission were reached only after initial production of automatic restraints was begun, some dealers might have inventories of vehicles equipped with automatic restraints. In the event that consumers considered these vehicles less desirable than vehicles with regular restraint systems, this could result in lost revenue for the affected dealerships. However, no losses would occur if effective marketing programs created a demand for these vehicles.

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[12] National Automobile Dealers Association (NADA) docket comments, 74-14-N35-066, p.9.

Further, any adverse impact of this changeover could be avoided by improving public acceptance of automatic restraints. Public education programs and media advertising aimed at educating the public on the nature and importance of properly used safety devices could play an important role in overcoming any negative perceptions and improving overall market demand for vehicles equipped with automatic restraints. If portions of the vehicle fleet are gradually equipped with automatic restraints, consumers should become accustomed to their operation and effectiveness prior to the point where general unfamiliarity might result in rejection of automatic restraints to the extent that sales would be adversely affected.

D. Automobile Manufacturers

For the automobile manufacturing industry, companies that employ fewer than 1,000 persons are defined as small businesses under 13 CFR 121.2. Currently eleven domestic companies fit this definition. The largest of these companies are Avanti, of South Bend, Indiana, with 150 employees and Excalibur Automobile Corporation in Milwaukee, Wisconsin, with 125 employees. Production for all eleven of these small companies in 1982 totalled 924 vehicles. Typically the vehicles manufactured by these companies are either high performance vehicles, custom or specialty vehicles, or reproductions.

On a per car basis, both development and production costs for small manufacturers are typically much higher than those for larger manufacturers that can mass produce vehicles. In addition, the development time needed to incorporate new safety features into their vehicles may be longer since they may not have current in-house expertise with new technologies. Both of these factors will serve to limit the ability of small automobile manufacturers to incorporate automatic restraints in their vehicles in an efficient and competitive manner. In particular, air bag requirements would result in price increases significantly larger than those that would be needed on mass produced vehicles. It should be noted however, that custom or specialty vehicles are frequently sold primarily to affluent customers and may thus be relatively unaffected by price changes.

E. Conclusions

There are numerous small enterprises involved in the manufacture, sale and maintenance of automatic restraints. While the effect of most alternatives is expected to be minor, there are several exceptions. Potential significant effects are summarized as follows:

Seat Belt Industry

One safety belt manufacturer and 3 independent seat belt webbing suppliers are identified as small businesses. The safety belt manufacturer is engaged solely in seat belt related activities. Automotive safety belt webbing accounts for 10 to 75 percent of the webbing suppliers' production. The estimated 32 percent reduction in seat belt webbing requirements that could result from an all air bag requirement could have a significant adverse impact on these firms, with possible losses averaging up to 1/3 of current revenue derived from seat belt related activities. The exact number of employees that are involved with seat belt production for these firms is unknown, but with roughly 1300 jobs potentially involved, it appears that up to several hundred jobs could be eliminated from small businesses in this industry, if air bags were required on all cars and lap belts replaced three point belts in front outboard seating positions. Alternatives requiring air bag installation in fewer positions or fewer vehicles would have proportionally smaller effects on this industry. Further, a requirement for 3-point belts rather than lap belts with air bags would completely eliminate any potential adverse effects on this industry.

Air Bag Industry

At this time, domestic air bag production is limited primarily to small fleet purchases and research efforts. Although several small firms are involved in this area, with one exception, they do not appear to be financially dependent on air bag production. Further, none of the alternatives under consideration by DOT would require limits on air bag production. Therefore, no adverse effects are anticipated for this industry as a result of this rulemaking. Selection of an alternative that requires air bags, however, would cause tremendous growth in this industry, involving potential revenues of roughly three billion dollars annually. It is likely that most of this growth would go to existing producers, but that a significant share would be taken by other companies that are currently producing related products.

New Car Dealers

Many new car dealers qualify as small businesses. Concerns were expressed by dealer organizations about a number of issues including lost sales, maintenance problems, and product liability. As previously discussed, these are not expected to be significant problems. However, the alternative which would require waivers of automatic restraint requirements for residents of states with mandatory belt use laws could present significant, though unquantifiable problems for new car dealers in terms of inventory control, distribution, and sales imbalances near state lines. The alternative which would rescind automatic restraint requirements if a certain percent of all states passed MULs could result in some losses to dealerships if consumers rejected the automatic restraints already installed on large inventories of passenger cars. Such losses, of course, would not occur if sufficient consumer demand was generated for automatic restraint equipped cars through effective public information and education programs.

Automobile Manufacturers

Potentially, the eleven automobile manufacturers that qualify as small businesses could be adversely affected by any alternative that requires air bag installation in their vehicles. The high cost of these devices, when installed in low volume production vehicles, could adversely affect either sales or profit margins. However, it should be noted that many of the vehicles sold by these companies are specialty vehicles, custom vehicles, or reproductions and such vehicles, which are often sold to affluent customers, are relatively unaffected by price changes. The extent of the adverse effect on this industry is therefore uncertain.

Repair Shops and Garages

No significant effects are expected to result from this rulemaking. If air bags are required, repair establishments will need to purchase tools, equipment, and storage facilities for air bag removal and replacement. However, as with all other capital investments needed to properly service today's sophisticated passenger vehicles, these costs would ultimately be recouped through charges for the service they are intended to provide.

XI. PUBLIC OPINION AND MARKET ACCEPTANCE

Public acceptability of automatic restraint systems is an important issue in this rulemaking, as it has been throughout the history of the automatic occupant protection standard. As stated in the NPRM, public acceptance is important to the success of Federal efforts to increase automotive safety. Temporary safety gains are possible with unpopular and restrictive safety regulations, but if a sufficient number of people dislike a device enough not to use it, the potential safety benefits of the rule will not be realized.

That the agency must consider public acceptance in this rulemaking is beyond question. According to a ruling by the D.C. Court of Appeals, NHTSA cannot fulfill its statutory requirements unless it considers popular reaction; without public cooperation there can be no assurance that a safety system can "meet the need for motor vehicle safety" and "it would be difficult to term 'practicable' a system, like the ignition interlock, that so annoyed motorists that they deactivated it."[1] However, there is considerable controversy concerning the proper interpretation of public acceptance. In a memorandum filed after the NPRM comment period closed, State Farm Mutual Automobile Insurance Company argued that public opinion data are largely irrelevant, and that public acceptability is only to be considered to the extent that people will render any automatic restraint system useless by disabling it. In an effort to clarify the issue, the

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1 Pacific Legal Foundation et al. v. Department of Transportation, 593 F. 2d 1338 (D.C. Cir. 1979).

Department sought additional comments on this issue in the SNPRM on State Farm's intepretation of public acceptability.

Docket Comments

In response to the NPRM, the Department received an overwhelming number of comments from the public - over 8000. The vast majority of these comments were from individuals, expressing strong views about automatic restraints, primarily air bags. While many of these comments were inspired by news releases or mailings from interested groups, such as automobile manufacturers, consumer groups, etc., there were still substantial numbers of individual commenters registering their own opinion. Most of the comments against automatic restraints, the bulk of which were against air bags, were based on perceptions of system malfunction (inadvertent deployment), fear of injury/entrapment and high cost. They indicate a substantial lack of information and understanding among the public of the characteristics of automatic restraint systems and, more importantly, of the significant role of restraints in preventing fatalities and injuries.

On the issue of interpretation of public acceptance in the SNPRM, 29 of the 130 commenters submitted their views. The insurance companies concurred with State Farm's interpretation. Of the responding manufacturers, one (Renault) accepted the State Farm interpretation, four rejected it, and five expressed no opinion. Two of the responding states endorsed the State Farm position and two were opposed.

State Farm reiterated its position that "public reaction...has regulatory significance only if it is ranslated into behavior" and automatic restraints are disabled. Until this occurs, any activity--or lack thereof--should be considered as acceptance. The lack of widespread resistance would thus be a "tacit vote of public approval". It argued further that the legislative history of the Vehicle Safety Act made it clear that safety was the overriding consideration in implementing the Act. Thus, more weight should be given to the safety benefits of a contemplated safety requirement than to the public acceptability of the devices used to comply with that requirement.

Allstate, the Insurance Institute for Highway Safety (IIHS), the Institute of Transportation Engineers (ITE), the State of Washington and the American Insurance Association (AIA) supported the State Farm interpretation of acceptabilty as being relevant only to the extent it resulted in fewer benefits. Allstate noted that if public acceptance is to be a deciding factor in this rulemaking, then DOT should repeal the requirement for manual belts since nearly 90 percent of the population "rejects" them. The State of Washington doubts that more than a few people will take the time to render passive restraints inoperable and the IIHS reviewed prior studies to show the extent of the public's desire for passive restraints. The ITE agreed that complying with public opinion polls should not be the agency's goal while the AIA claimed the proper standard of interpretation is public acquiesence, not public preference. AIA also argued that automatic restraints only require toleration, not action (as do manual belts) and that their purpose is to be effective, not popular.

Auto manufacturers characterized State Farm's view of the subject as too narrow an oversimplification (National Automobile Dealers Association); not consistent with legislative history, judicial precedent or prior positions of DOT (Motor Vehicle Manufacturers Association); an unacceptably narrow interpretation (Chrysler, American Motors); and [should be] broader (Ford). Volkswagen stated that public acceptability is two-faceted, with both the State Farm position and the public popularity issue being equally important. Ford stated that public acceptance involves far broader issues than disabling unwelcome equipment. The Pacific Legal Foundation (PLF) and Consumer Alert stated that the issue of public acceptance is not limited to the sole question of deactivating mandatory automatic restraints; it encompasses all factors which may affect DOT's performance of its statutory duties. Several commentors (Chrysler, Toyota, VW, NADA, and PLF) believe the interlock analogy is valid in the case of FMVSS 208. They claim that the interlock requirement probably had a favorable benefit/cost ratio and was only "rejected" by 33 percent of the people; yet a consumer backlash resulted in the defeat of the rule through legislation. Chrysler argues that in the narrow sense of the State Farm interpretation of public acceptability the interlock was a success: belt use increased and traffic safety improved. However, in the broader sense it failed since it was repealed by the Congress.

This position was also argued by PLF which stated that DOT, when prescribing rules, must consider the statutory mandate of whether the rule "will contribute to carrying out the purposes of [the] Act." They contend that another interlock-type rule, with subsequent rejection, does not comply with this criterion. Honda cites consumer acceptance as a key factor. In urging a broader interpretation of public acceptability, commentors cited factors such as the actual deactivation or disabling of devices (PLF, NADA, MVMA); a delay in purchasing or a change in purchasing decisions (PLF, NADA, MVMA, American Motors); risk compensation (PLF); expressions of opposition (NADA); and advocating legislative recission (Toyota, Motor Voters). Motor Voters, a California consumer group, expressed concern that given an option, manufacturers would elect to install cumbersome automatic belts with the intent of defeating the standard legislatively, and that this outcome would be particularly likely if the belt design made disconnection difficult. MVMA submitted a memorandum of law, and stated that public acceptability is part of the "all relevant factors" considered under the Act. Two 1974 congressional actions are cited as illustrating what is acceptable: the interlock ban, and the congressional review of a mandatory automatic restraint rule (Senate debate on 1974 Federal highway bill). MVMA further stated that the State Farm interpretation includes an "erroneous view": future consequences "cannot be ignored simply because they are matters of future probability that do not admit of precise measurement."

The manufacturers stated that nondetachable belts would raise consumer acceptance problems because they are more coercive than are current belts. This expectation is based in part on the interlock experience. NADA stated that the experience with VW Rabbits, Toyota Cressidas and GM Chevettes indicates a lack of consumer acceptance of automatic belt systems and that the GM experience with air bag cars shows a similar lack of consumer acceptance. NADA argued further that the Breed airbag inflator, because of its ease of installation, will encourage deactivation while Mercedes claimed they are unaware of any instances of deactivation o: their airbag system (34,500 vehicles with airbags have been sold).

Various findings were provided on the attitude of the public toward automatic restraints. Consumer Alert provided a public opinion poll showing that fewer than 15 percent of the respondents wanted mandatory automatic restraints. Public Citizen submitted a public opinion poll which it viewed as showing a clear preference for automatic restraints, especially air bags. IIHS cited a recent public opinion poll indicating that 56 percent of the respondents favored requiring automatic restraints on new cars as standard equipment and 37 percent favored requiring that that type of restraint be offered as an option. The American Automobile Association stated that while consumers may not rush to purchase automatic restraints as options where manual belts were original equipment, they would accept automatic restraints as original equipment, particularly if they could choose between the various types of automatic restraints. Other groups argued that the increased protection against facial, spinal and head injuries afforded by air bags would result in consumers choosing air bags as the preferred automatic restraint, it they are allowed to make the choice. Most of these groups indicated that air bags are less intrusive than automatic belts, and would therefore be more readily accepted by the public.

The SNPRM raised a second public acceptability issue: assuming that the relevant factor is the number of people defeating the automatic restraints, will enough people do this to preclude the achievement of the necessary safety benefits to outweigh the costs? While not all commenters addressed this issue, the responses received tended to fall again along two sides. State Farm cited that "the standards' huge potential net social benefits will be realized," while NADA cited the record that many "Americans have disabled and will disable, devices...[;] such evidence clearly establishes the lack of consumer acceptance...and the resultant lack of safety benefits...."

The extensive public comments to the docket indicate that informed opinion is strongly divided on the proper interpretation of what constitutes public acceptance of automatic restraints for the purpose of this rulemaking. On the other hand, the great majority of individuals commenting on automatic restraints based their comments on insufficient information about the benefits as well as the effectiveness and special features of the different systems. Data and analyses that are germane to the various interpretations are presented in this chapter and Chapter V. Chapter V presents data on usage of manual and automatic restraints and estimates a range of possible future usage of automatic belts based on the public's demonstrated degree of acceptance of manual belts, characteristics of manual and automatic systems, and public attitudes toward them.

Public Opinion Surveys

A number of surveys have been conducted over the last several years in order to gain information concerning public attitudes on voluntary or mandated automatic restraints. The issues or questions addressed by these surveys which are covered in this section are pertinent to broad considerations of public acceptance of automatic restraints, such as the extent of public knowledge about automatic restraints; how the public feels about the Federal government mandating automatic restraints in new cars or state governments mandating the use of belts that are already in cars; how much the public would be willing to pay for restraints; public attitudes and preferences for alternative restraint systems; and restraint system marketability.

In assessing the significance of survey responses on automatic restraint issues, the fact that the driving public has little direct experience with automatic restraints on which to base responses and form its views, should be kept in mind. (Approximately 500,000 cars have been sold in the U.S. with automatic belts, and about 12,000 cars have been sold with air bags. The size of the current fleet is approximately 120 million passenger cars.) Also, it should be emphasized that the current relevance of some of the studies is uncertain. Depending on the issue and subject matter, consumer and public attitudes may change to greater or lesser degrees over time. Responses to what are essentially philosophical questions such as whether automatic restraints should be required equipment or whether use of manual seat belts should be mandatory are likely to be influenced over time by the level of public information and education and the publicity disseminated as well as by general trends in public opinion. On the other hand, attitudes on more concrete subjects or on issues with which respondents have had direct experiences, while still subjective, might remain more relevant over a longer period of time. For example, the attitude of people who have used automatic restraints toward the comfort of their automatic system, would probably remain relevant over time for that particular system. These points concerning the relevance of past surveys on public attitudes should be kept in mind.

Data gathering techniques used in the surveys whose results are presented, included telephone, home, and workplace interviews; discussion groups; and clinics. Information obtained varied from simple "yes" or "no" answers to single questions to numerous and detailed responses to lengthy questionnaires. While respondents who were surveyed were typically randomly selected, nationally representative samples of licensed drivers or heads of households, some surveys contacted owners of specific make and model vehicles. Others contacted individuals in given geographical areas. The reader is referred to individual survey reports for details on survey methodologies and findings on facets of the surveys on automatic restraint issues not covered herein.

The main issues considered here are the following:

1) The extent of the public's awareness and knowledge of automatic restraint systems;

2) Whether automatic restraints should be required through regulation or whether it should be left to consumer choice;

3) How much the public is willing to pay for air bags;

4) Attitudes toward alternative systems - manual belts, automatic belts, and air bags;

5) Attitudes toward mandatory safety belt usage laws; and

6) Marketing of air bags as optional equipment.

The methodologies and results of two recently performed surveys that were provided to the docket are discussed at the end of this chapter. The results of surveys on restraint usage are presented in Chapter V.

A. Awareness/Knowledge of Automatic Restraint Systems

Information on the degree to which the public is familiar with and knowledgeable about automatic restraints is essential for gauging whether results of public opinion surveys on automatic restraint issues are valid indicators of public attitudes toward automatic restraints. Survey responses, however, must be used with caution if the respondents have little knowledge of or experience with the systems about which they are being questioned.

Compared with other issues, only a limited number of past surveys included questions on public awareness/knowledge of automatic restraints. The results of information gathered are presented below.

1. Air Bags

Considerably higher percentages of the interviewees reported awareness/knowledge of air bags than automatic seat belts.

o 1976 Yankelovich[2]--". . . 62 percent of drivers (interviewed) indicate they know what an air bag is when the term is mentioned to them."

o 1976 Market Research Group, Survey Data Research[3] -- 83 percent of owners of new GM cars without air bags knew or had heard of air bags.

o 1978 Hart[4]--79 percent reported they had heard about the air bag system. Of these respondents, 70 percent could volunteer at least one substantive statement about their knowledge of the air bag system. That is, 55 percent had some knowledge about the air bag system.

o 1978 Teknekron[5]--When asked if they had heard of air bags or air cushions, 93 percent of the respondents replied affirmatively. Of those who heard of air bags, nearly 72 percent correctly described how air bags worked.

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2 "Driver Attitudes Toward Restraints," Yankelovich, Skelly, and White, Inc., September 1976, p. 21.

3 "A Passive Occupant Restraint System Study," Market Research Group, Inc., and Survey Data Research, Inc., December 1976.

4 "Public Attitudes Toward Passive Restraint Systems," DOT-HS-803-570, Peter D. Hart Research Associates, Inc., August 1978, p. 41.

5 "1978 Survey of Public Perceptions on Highway Safety," Teknekron, Inc., November 1978, p. 67.

As noted above, the percentage of respondents reporting that they "knew" or "heard of" air bags ranges from 62 to 93 percent.

2. Automatic Seat Belts

There were five surveys that asked about awareness/knowledge or experience with automatic seat belt systems (ASB). In two of the surveys (1978 Hart[6] and 1983 Insurance Institute for Highway Safety (IIHS[7])) the respondents consist of the general public (adult Americans who are either licensed drivers or who live in households with at least one automobile). The format of the Hart survey was a personal interview, that of the IIHS survey was a telephone interview. The other three surveys were telephone interviews of owners of specific vehicle models that were equipped with automatic seat belts or manual belts.

o 1978 Hart[8] -- In comparison to 79 percent for air bags, "only 15 percent say that they have heard anything about automatic seat belts."

o 1980 Opinion Research[9]--80 percent of ASB-equipped Chevette owners and 61 percent of ASB-equipped VW Rabbit owners first "found out about the ASB system" after the purchase of their cars or through dealers/salespersons.

o 1981 Opinion Research[10]--74 percent of ASB-equipped Chevette owners and 65 percent of ASB Rabbit owners "first heard of or became aware of" the ASB system at the dealers where the car was purchased.

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6 Op. Cit.

7 "Public Opinion About Automobile Occupant Restraint," Insurance Institute for Highway Safety, December 19,1983.

8 Op. Cit., p. 48.

9 "Automatic Safety Belt Systems Owner Usage and Attitudes in GM Chevettes and VW Rabbits (1980 models)," DOT-HS-805-797 Opinion Research Corp., February 1981, p. 10.

10 "Automatic Safety Belt Systems: Changes in Usage Over Time in GM Chevettes and VW Rabbits," DOT-HS-806-058, Opinion Research Corp., August 1981, p. 13.

o 1981 JWK International[11]--76 percent of ASB equipped Toyota owners "first heard of or became aware of" the ASB system at the dealers where the car was purchased.

o 1983 IIHS[12] -- 4 percent indicate that they presently or in the past have owned a car with an ASB system. An additional 10 percent indicate they have been in someone else's car equipped with ASB.

From the above, it is clear that only a small percentage of the driving public is familiar with the ASB system.

B. Government's Role in Making Automatic Restraints Available

This section summarizes survey findings on the question of whether the public favors the Federal Government's requiring manufacturers to install automatic restraint systems in all new cars. It also summarizes the limited information available on the public's desire to have a choice of purchasing vehicles equipped with either automatic or manual restraints, depending on individual preferences. Surveys did not address other possibilities, such as a mandated demonstration program in which a percentage of cars would be produced with automatic restraints, or a phase-in of a limited number of automatic restraint-equipped vehicles each year.

This review of public opinion on whether the government should mandate automatic restraints should not be interpreted as indicating that this issue, *per se*, is important to the decision on an automatic restraint rule. Costs and benefits of the options are the critical inputs to the

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[11] "Automatic Safety Belt Usage in 1981 Toyotas," DOT-HS-806-146, JWK International Corp., February 1981, p. 16.

[12] Op. Cit.

decision. However, this information is one indicator of the degree to which the public would accept and use automatic restraint systems, and this latter consideration is germane to the final decision.

Before discussing survey results, it should be emphasized that the Department held public hearings on this rulemaking on occupant crash protection in Washington, D.C., Kansas City, and Los Angeles at which testimony was heard from individuals, representatives from the automobile and insurance industries, consumer organizations, government officials, and others. In addition, more than 8,000 comments were received in the docket. While witnesses and commenters do not represent a randomly selected cross-section of the American population, their points of view span all sides of the issues and enable the Department to not only consider the arguments supporting various positions but also to gain some appreciation of the depth of feeling of those that testified and commented. It is typically not possible to obtain such depth of information in public opinion surveys.

Of the surveys reviewed, 12 asked respondents whether they favored or opposed a requirement that air bags/automatic restraints be required in new cars, with no option being provided the respondents for indicating opinions that new car purchasers should have a choice of buying cars with or without automatic restraints. Only 2 of 12 surveys included a cost figure for respondents to consider in answering the question on a government requirement for automatic restraints. Most surveys did nothing to ascertain the degree of knowledge respondents had about automatic restraints, nor did they provide them with much, if any, information about the systems. Table XI-1 indicates the public's response on surveys on whether the Federal Government should require automatic restraints in all new cars. Of the 12 surveys included in the table, 8 found the respondents to be in favor of the Government's requiring automatic restraints. The deficiencies in survey methodologies not withstanding, these results indicate that while many people do not favor a government mandate for automatic restraints on all new cars (as many people do not favor any type of mandated piece of equipment), there is also a substantial number who state they are willing to purchase cars with automatic restraints. This suggests that public reaction to the concept of automatic restraints can initially be expected to be mixed. Since many people either are unaware of, or have not personally experienced such restraint systems, public information and education efforts that describe the automatic systems -- how they operate and their advantages -- and how they have successfully worked during actual crashes, might increase the degree to which the public favors automatic restraints and their mandated installation. Public education, enhanced by the availability of the devices to demonstrate their performance, will be the ultimate factors affecting the public's reaction.

TABLE 'I-1

RESULTS OF SURVEYS ASKING WHETHER RESPONDENTS FAVORED REGULATIONS REQUIRING AUTOMATIC RESTRAINTS IN ALL NEW CARS

SURVEY CONDUCTED BY	SPONSORED BY	YEAR OF SURVEY	GOVERNMENT REGULATION REQUIRING AUTOMATIC RESTRAINTS			RESTRAINT SYSTEM QUESTIONED ABOUT	COST INFORMATION PROVIDED	COMMENTS
			Favor %	Oppose %	No Opinion %			
McGinley	NHTSA	1984	41	36	23	Air Bags	$300	
Maritz Market Research	GM	1983	51	49	--	Air Bags	$100	
			35	65	--	Air Bags	$320	
			19	81	--	Air Bags	$500	
J. D. Power	NHTSA	1982	23	53	22	Air Bags	None	
Market Opinion Research	New York Times	1980	45	32	23	Air Bags	None	
Area Market Research Associates	Arkansas Dept. of Pub. Saf.	1979	72	28	—	Air Bags	None	
VA. Hwy. Board of Trans. Research Council	VA. Dept. of Public Safety	1978	55	41	4	Air Bags or Auto Belts	None	
Caddell		1978	47	44	9	Air Bags	None	
Hart	NHTSA	1978	58	28	14	Air Bags or Auto Belts	None	Cost information part of another question.
Teknekron	NHTSA	1978	73	24	11	Air Bags or Similar Device	None	
Gallup Poll	-----	1977	46	37	17	Air Bags	None	
Market Research Group, Survey Data Research	GM	1976	39	54	7	Air Bags	"Significant increase in car prices".	1st line -- owners of air bag equipped cars.
			15	70	15			2nd line -- owners of cars without air bags.
Yankelovich	MVMA	1976	29	62	9	Air Bags	None	Based on 62% of respondents who knew what an air bag was.

References to Table XI-1.

1. McGinley Marketing Research, Inc., "Trends in Public Knowledge and Attitudes Toward Occupant Restraint Systems," Monthly Report, February 1984.

2. Maritz Market Research, "Passive Restraint Study," November 30, 1983.

3. J.D. Power and Associates, "1982 Automotive Consumers Profile," January 1982.

4. Market Opinion Research, Inc., Detroit, Poll on Automotive Issues, April 1980.

5. Area Market Research Associates, "Arkansas Motorists: The 55 mph Speed Limit and Safety Devices," July 1979.

6. Virginia Highway and Transportation Research Council, Poll of Virginia Drivers, 1979.

7. Patrick Caddell, Poll of U.S. Drivers, 1978.

8. Peter D. Hart, Research Associates, Inc., "Public Attitudes Toward Passive Restraint Systems," DOT-HS-803-570, August 1978.

9. Teknekron, Inc., "1978 Survey of Public Perceptions on Highway Safety," DOT-HS-803-179, November 1978.

10. Gallup Poll of U.S. Adults, July 1977.

11. Market Research Group, Inc. and Survey Data Research, Inc., "A Passive Occupant Restraint System Study," December 20, 1976.

12. Yankelovich, Skelly, and White, Inc., "Driver Attitudes Toward Restraints," September 1976.

Of the materials reviewed, two sets of focus group discussions dealt partially with the issue of consumer choice, and one survey directly targeted the issue.[13] A major reason for the dearth of surveys addressing this issue would appear to be that from June 1977 to October 1981 a Federal regulation was in place requiring that automatic restraints be installed in new cars beginning with model year 1982 large cars (later changed to model year 1983). That made consumer choice a moot issue over the period.

A series of focus group discussions in 1979 sponsored by NHTSA and conducted by National Analysts, Inc.,[14] while oriented toward vehicle fuel efficiency issues, arrived at the following conclusion on discussions of the automatic restraint topic: ". . . most of those expressing an opinion on passive restraints opposed the Government making them mandatory, and many asked for a choice between passive belts and air bags" (p. 42). Focus group discussions led by Market Facts, Inc.[15] in 1980 reached the consensus that both air bags and automatic belts should be available. Acceptance of the requirement for automatic restraints was divided between those who felt that the safety benefits would outweigh the increase in cost and the possible loss of the freedom to choose, and those who questioned the effectiveness and reliability of automatic restraints and opposed increased costs and loss of freedom.

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13 Implicit in the concept of consumer choice is that the option of purchasing new cars with automatic restraints will be available, as the result of regulation or otherwise.

14 "Consumer Orientation Toward Fuel Efficient Vehicles: Fourth Cycle," National Analysts, Inc., March 1980.

15 "A Study of Consumer Behavior Toward Fuel Efficient Vehicles, Interim Report," Market Facts, Inc., July 1980.

A survey focusing directly on the consumer choice issue was commissioned by Consumer Alert, Inc., and conducted by Finkelstein and Associates in 1978.[16] Respondents' opinions on the consumer choice issue were as follows:

- Air bags seem to be an effective automobile safety system and the government is right to require that all new cars have them, even though consumers will loose their freedom of choice.	15.2%
- Air bags have not been shown to be the most efficient or effective safety system, and for this reason the government is premature in requiring that all new cars have them.	19.7%
- Regardless of the merits or the faults of the air bag, the government has no right to require consumers to pay for this automobile safety system, if they don't want it.	58.5%
- Don't know.	6.5%

In the above survey, the respondent was informed that the air bag option on a new car would cost $200 ($304 in 1982 dollars), the replacement cost for an air bag that deployed would be $500 ($760), and that air bags were ineffective in certain types of crashes. The survey did not point out to respondents that insurance would, in most instances, probably cover air bag replacement costs. It also did not address the potential magnitude of safety benefits--and assumed car, health, and life insurance cost reductions--associated with air bags.

[16] "National Attitudinal Survey -- Air Bags," Arthur J. Finkelstein and Associates, July 1978.

C. How Much Would the Public Pay for Air Bags?

Several surveys have inquired about the extra cost the public would be willing to incur in purchasing a car with an air bag. Answers to this question to some extent act as gauges of the public's interest and commitment to air bag systems. Of course, implicit in the relevance of this question of willingness to pay is that the new car purchaser will have a choice of whether to purchase an air bag equipped car; otherwise, the question would be moot since purchasers would have to pay the extra cost for the system if they wanted a new car. In addition, the cost of mandated safety equipment is part of the base price of a new car and is thus not known to consumers and may be unlikely to engender any adverse reaction. If the price of the car increases significantly over the prior year, with no apparent improvement other than the installation of air bags, some adverse reaction is possible.

Table XI-2 summarizes surveys that addressed the issue of how much the public would be willing to pay for an air bag system. While surveys varied to some extent on how this question was put to the public, the degree of attention and depth of probing devoted to this issue, and the particular cost categories specified in the questioning, the table attempts to summarize survey findings in a consistent fashion while recognizing that in some instances data are not strictly comparable. Surveys included, while spanning the 1971-1983 period, are clustered in the 1976-1978 time frame.

TABLE XI-2

PERCENT OF THE PUBLIC WILLING TO PAY GIVEN
AMOUNTS FOR AIR BAG SYSTEMS

SURVEY CONDUCTED BY	GROUP SURVEYED	YEAR OF SURVEY	(1982 Dollars) $0	$100	$200	$300	$400	$500	$600	$700	$800	$900
IIHS	Adult Drivers	1983		55%	47%	42%						($1000) 18
J. D. Power 2/	U.S. Households	1982	100%	80%		54%		26%(>$400)				
VA. Hwy and Transp. Res. Council	Virginia Drivers	1979				56%						
Hart 3/	U.S. Drivers	1978		57%		52%	45%		41%			
Finkelstein	U.S. Drivers	1978				41%						
Allstate	U.S. Metro. Residents	1977			56%							
Washington Traffic Safety Comm.	Washington Residents	1977				56%						
General Motors	GM Small Car Owners	1976-77	68% 4/		40%	19%		11%				
	GM Large Car Owners	1977	80% 4/		51%	26%		14%				
	Owners of Large GM Cars with Bags	1976	96% 4/		87%	71%		58%				
Yankelovich, et al 5/	U.S. Drivers	1976	100%		49%	29%		14%	7%		4%	
Market Research Group	Oldsmobile Owners	1976			33% 6/ 35% 7/	6% 6/ 32% 7/		1% 6/ 18% 7/				
General Motors	GM Car Owners	1971				50% 8/						

1/ The question of what the public would be willing to pay for air bags was asked in several different ways in the surveys reviewed. For example, some surveys asked what respondents would be willing to pay, others whether they would be willing to buy the system at given costs; some studies offered a choice of opting for no automatic restraint systems, while one sought public preference for air bag versus automatic belt systems given a set of cost differentials between the two systems. This table attempts to summarize somewhat disparate surveys in a useful fashion, while recognizing that in some instances data are not strictly comparable.

2/ Eleven percent of the respondents could not provide a cost estimate. These 11 percent of the responses were allocated based on the 89 percent responses.

3/ Respondents were asked to choose between air bag or automatic belt systems at various differences in cost for the two systems. For this summary it is assumed that automatic belts cost $80.

4/ Twenty percent of large car, 32 percent of small car owners, and 4 percent of owners of large cars with air bags said they would not have air bags in their next cars even at no cost.

5/ The question on the maximum amount drivers would be willing to pay for air bags was summarized in the survey report only for the 62 percent of drivers who knew what an air bag was. And of this 62 percent, 61 percent were uncertain or did not know what they would be willing to pay. The data presented herein, therefore, represent only 24 percent of the total sample. Also, to a limited degree, certain assumptions had to be employed to sub-divide the distribution of costs in the report.

6/ Percentages shown are for responses to the question of whether the respondent felt the public would be "greatly interested" in the air bag option at given prices.

7/ Percentages shown are for responses to the question of whether the respondent felt the public would be "somewhat interested" in the air bag option at given prices.

8/ Air bag selected over alternative systems with specified prices: No restraint @ $0 -- 5%, manual belt system @ $25-30 -- 20%, automatic belt @ $20-$25 -- 25% (1971$).

References to Table XI-2

1. Insurance Institute for Highway Safety, "Public Opinion About Automobile Occupant Restraint," December 19, 1982.

2. J.D. Power and Associates, "1982 Automotive Consumer Profile," January 1982.

3. Virginia Highway and Transportation Research Council, Poll of Virginia Drivers, 1979.

4. Peter D. Hart Research Associates, Inc., "Public Attitudes Toward Passive Restraint Systems," DOT-HS-803-570, August 1978.

5. Arthur J. Finkelstein and Associates, "National Attitudinal Survey -- Air Bags," July 1978.

6. Allstate Insurance Co., "1977 National Images Survey," November 1977.

7. Washington Traffic Safety Commission, "Air Bag Demonstration Survey," October 1977.

8. General Motors Corporation, Market Research Group, Inc., Survey Data Research, Inc., "Passive Occupant Restraint System Study," 1976-1977.

9. Yankelovich, Skelly, and White, Inc., "Driver Attitudes Toward Restraints," September 1976.

10. Market Research Group, Inc., "Air Cushion Restraint System, National Consumer Research Study," May 1975.

11. General Motors Corporation, "Consumer Opinions Relative to Automotive Safety Restraint Systems -- Pilot Study," May 1971.

Survey dollar values reported in the table are updated to 1982 dollars for consistency and purposes of comparison. It should be recognized, however, that this conversion of responses to 1982 dollars does not create strictly comparable values, given the disproportionate increases in the prices of various goods and services and fluctuations in real disposable and, particularly, discretionary income over the period.

The disparate results of the GM surveys indicate that greater differences in responses will be attained when surveying groups of owners of different sized cars than when surveying the general population of drivers. Owners of small GM cars indicate they would be willing to pay less than owners of larger GM cars for air bags. This may reflect the fact that the cost of air bags would constitute a larger portion of the small car purchase price than for large cars. This is not an unexpected response as purchasers of small, less expensive cars would be expected to react in this manner to relatively high priced options, be they air bags or air conditioners. Their reaction also may reflect the somewhat greater usage of existing manual belt systems by small car owners. Toward the upper end of the scale, owners of large GM cars with air bags expressed strong support for the system with 58 percent willing to pay over $500. Also, the Hart Study found that 41 percent of those surveyed would be willing to pay over $600 (1982$) for an air bag system, but in this survey respondents were given the option of selecting either air bags or automatic belts at several cost differentials; therefore, results place a value on respondents' preference for air bags compared to automatic belts but do not place a value on the air bag system, per se. The IIHS survey found that less than half (47%) would be willing to pay $200 for air bags; however, 18 percent indicated they would pay as much as $1,000.

While the table shows these and some other disparities in survey findings on the percentage of respondents who indicate they would pay given amounts, due in part to how the questions were phrased and the options presented the respondents, some general conclusions can be drawn. Only a small percentage appears willing to pay more than $400 or would expect to pay less than $100 for an air bag system. The majority of responses in most surveys are clustered around the $200 and $300 cost categories, covering a range of approximately $150-$350. Toward the upper end of this cost range the driving public is roughly evenly divided in its willingness to buy an air bag system, as an option. This suggests that a substantial, potential market for air bags exists and that a significant portion of the public would opt for them if they were priced within the $150-$350 range and available in sufficient quantities. Again, it must be pointed out that these results are only relevant to the above-mentioned surveys, all but two of which are at least six years old, and to the information on benefits (generally sparse) and costs provided by the survey instrument. As experience with child restraint laws demonstrates--48 states passing such laws within six years--"public acceptance" can change rather quickly.

D. Attitudes Toward Alternative Restraint Systems -- Manual Belts, Automatic Belts, and Air Bags

This section summarizes survey findings on individuals' preferences among restraint systems, the reasons they give for favoring or opposing the three types of systems, and the feelings and evaluations of those who have actually tried the various systems. Findings on what are felt to be key issues are presented. The reader is referred to the individual survey reports for discussions of survey methodologies and results on facets of the surveys not presented below.

1. Inter-system Comparisons

Several surveys questioned respondents directly on their choice of restraint system. An early survey was conducted by General Motors Corporation in 1971, in which new car owners were invited to a clinic in Chicago, provided an increasing amount of information on various restraint systems, and requested to state their preference among systems.[17]

Clinic participants were provided the following sequence of information on the various systems: descriptive information, vehicle system inspection, film demonstration, and costs. Cost information provided was manual belts -- $25-$30 ($61-$74 in $1982), automatic belts -- $20-$25 ($49-$61), and air cushion -- $130-$160 ($319-$392). Respondents' preference of restraint system after receiving this information broke down as follows:

[17] "Consumer Opinion Relative to Automatic Safety Restraint Systems -- Pilot Study," General Motors Corporation, May 1971.

Manual Belts	20%
Automatic Belts	25%
Air Cushion	50%
No Restraint System	5%
	100%

Respondents were also shown news stories that were favorable, unfavorable, and balanced about the performance of air bags. Following are respondents' preferences for automatic belts versus air bags:

Automatic Belts	44%
Air Cushion	56%
	100%

This survey is most interesting as it demonstrates how "acceptance" changes as additional information is supplied.

More recent telephone surveys asking respondents to choose between air bags and automatic belts at specified cost differentials were conducted by Teknekron[18] and Automated Services.[19]

18 "1979 Survey of Public Perceptions on Highway Safety," Teknekron, Inc., July 1979, DOT-HS-805-165.

19 "1980 Survey of Public Perceptions on Highway Safety," Automated Services, Inc., September 1980, DOT-HS-805-702.

	Air Bags	Automatic Belts	Doesn't Matter/No Opinion
Teknekron (1979) (air bag cost: $100-$200 more than automatic belt)	50.7%	38.5%	10.8%
Automated Services (1980) (air bag cost: $200-$300 more than automatic belt)	39.0	49.2%	11.8%

In 1979, respondents were told air bags would cost $100-$200 more than automatic belts; in 1980, they were told they would cost $200-$300 more. Results indicate that consumer preference is sensitive to price. It appears that at an air bag cost of around $200 ($288 in $1982) higher than for automatic belts respondents would have been approximately evenly split in their preference for air bags or automatic belts.

A 1978 telephone survey by Finkelstein and Associates[20] queried respondents' preference for air bags versus the standard manual belt system. As additional information on the cost and performance of air bags was provided respondents, preference for air bags decreased from an initial 47 percent to a final 14 percent:

[20] "National Attitudinal Survey -- Air Bags," Arthur J. Finkelstein and Associates, July 1978.

Information Provided	Favor Air Bags
Initial Question	47% (+15% unsure)
Air Bag Cost -- $200 ($304 in $1982)	41% (+7% unsure)
Replacement Cost if Deployed -- $500 ($760)	25% (incl. unsure)
Safety, Fuel Economy, Emission Control Already Cost $666 ($1,013)	23% (incl. unsure)
Information on Air Bag and Seat Belt Effectiveness	14%

The Hart 1978 home interview survey[21] asked respondents, after they were shown pictures of automatic restraint systems, to rate on a scale of 1 to 7 (1= poor, 7= excellent) the quality of air bags, automatic belts, and manual belts with respect to four criteria. The results are presented in Table X-3.

TABLE XI-3
ATTITUDES TOWARD ALTERNATIVE
RESTRAINT SYSTEMS -- MEDIAN SCORES

	AIR BAG			AUTO BELT			MANUAL BELT		
		BELT USE[22]			BELT USE			BELT USE	
CRITERIA	TOTAL	FREQ.	INFREQ.	TOTAL	FREQ.	INFREQ.	TOTAL	FREQ.	INFREQ.
SAFETY	5.4	5.5	5.4	4.8	5.5	4.1	4.9	5.8	3.8
APPEARANCE	4.5	4.7	4.2	3.6	4.3	3.1	4.0	4.6	3.2
EASE OF USE	5.5	5.7	5.3	5.0	5.4	4.5	3.7	5.2	3.1
COMFORT	5.3	5.6	5.3	3.2	4.3	1.8	2.6	4.7	1.3

21 "Public Attitudes Toward Passive Restraint Systems," Peter D. Hart Research Associates, Inc., August 1978, DOT-HS-803-570.

22 Frequent and infrequent manual belt usage.

As indicated, air bags ranked highest in all categories. Note cost was not considered in these ratings. In another question, respondents were asked to choose between air bags and automatic belts at several price differentials. At an airbag cost of $200 more than for automatic belts, 38 percent preferred air bags, 46 percent preferred automatic belts, and 16 percent were not sure. At a cost differential of $350, the preference was 35 percent for air bags, 50 percent for automatic belts, and 15 percent not sure.

2. Reasons for Preference Among Systems

a. Manual Belts

Table XI-4A summarizes the reasons people give for not wearing seat belts, as ascertained in surveys conducted by Teknekron and Automated Services. As shown, not wanting to be bothered and being lazy and forgetful are on average the single most popular reasons given. While automatic belts could obviate these reasons, this does not mean that other reasons would not preclude these people from using their belts. Seat belts being uncomfortable and inconvenient to use are other frequently stated reasons for not using them. Note that the reasons provided of fear of entrapment, doubting value, and not wanting to be restrained, are also pertinent to automatic belts. By far the most frequent response given in these studies for wearing manual belts is the obvious one, it enhances occupant safety.

TABLE XI-4A
Reasons for Disliking or Not Using Manual Belts
(Percent)

Reason	Teknekron[23] (1979)	Automated[24] Services (1980)
Don't want to be bothered, lazy, forgetful	13.9	21.7
Uncomfortable	13.2	15.5
Inconvenient	15.1	17.2
Fear of being trapped in vehicle	10.7	11.0
Doubt value	4.5	5.8
Don't want to be restrained	7.7	8.8
No reason (users)	17.1	13.8
Other	17.9	6.1

Table XI-4B summarizes findings reported by Newport and Tarrance on responses to the question: "Why is it that so many people don't wear their seat belts?"

TABLE XI-4B
Why People Don't Wear Seat Belts (1981)[25]

	PERCENT
Too much time/hassle	25%
Not in habit/don't think about it/ lazy	22%
Uncomfortable/too confining	20%
Scared of being trapped	7%
Think won't be in accident	6%
Other	15%
Don't know/not sure	5%
	100%

23 Op. Cit.
24 Op. Cit.
25 "National Safety Belt Study," Frank M. Newport and V. Lance Tarrance, Jr., September 4, 1981.

Note that the inconvenience factor is incorporated primarily in category number one. A review of selected individual responses indicates that some of the responses counted in category two could possibly be better categorized as questioning the safety benefits of safety belts, e.g., "they think it has no bearing on their safety," "lack of care for their lives," "their laziness thinking seat belts wouldn't do much good, except in a real bad accident."

Reasons for not wearing a seat belt ascertained in the 1983 IIHS survey are reported in Table XI-4C.[26] The percentages shown are based on the main reasons provided by 195 respondents.

Table XI-4C
Main Reason For Not Wearing A Seat Belt

	Percent
Uncomfortable/inconvenient	26
Forget/not in the habit	22
Only take short trips/unnecessary for short distances	13
Lazy/dislike taking the time	22
Fear of entrapment	8
Other	5
Don't know/refused to answer	4
	100

[26] Insurance Institute for Highway Safety, November 1983, Op. Cit.

Note that the combined response for categories two and four account for 44 percent. This contrasts to the average 17.8 percent response for category one, "don't want to be bothered/lazy/forgetful," of the Teknekron and Automated Services surveys. A portion of the difference is likely attributable to inclusion of "not in the habit responses" in the IIHS tabulations.

b. Automatic Belts

Respondents to the 1978 Hart Study[27] volunteered perceived advantages and disadvantages of automatic belts. Following are listed the more frequent responses. The percentages shown indicate the proportion that each listed advantage is of all stated advantages, and that each listed disadvantage is of all stated disadvantages. Since respondents likely had little or no knowledge (they were shown a diagram and given a verbal description of the system) or experience with automatic belts, a public or industry information campaign that focuses on these perceived disadvantages could undoubtedly increase acceptance.

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27 Peter D. Hart Research Associates, Inc., Op. Cit

TABLE XI-5

VOLUNTEERED ADVANTAGES AND
DISADVANTAGES OF AUTOMATIC BELTS

Advantages	Percent[28]
Have to Use Them, Greater Use Thereof	35
Easy to Use, Convenient, Don't Have to Remember	34
Prevent Injury	22
Disadvantages	**Percent**
Might Get Trapped	23
Too Confining, Restraining	13
Uncomfortable	11
A Nuisance, in the Way	11
No Freedom of Choice	10
Getting In and Out Is Inconvenient	10
Might Not Work Properly	9

[28] Some respondents volunteered more than one response. Twenty two percent of the respondents could think of no advantage to automatic belts; 14 percent could think of no disadvantage.

The Hart study also provided a list of advantages and disadvantages of automatic belts from which respondents were to select their top choice. Following are the top four selections in each category.

TABLE XI-6

SELECTED LIST OF ADVANTAGES
AND DISADVANTAGES OF AUTOMATIC BELTS

Advantages	Percent
Don't Have to Remember to Buckle Up	48
Driving Safer -- Will Always Have Belt On	29
Because They are Simple, They Will Work	14
Not Very Expensive	12
Disadvantages	
Might Trap You In Car After Accident	39
Too Constraining and Uncomfortable	25
Inconvenient, Irritating To Be Strapped In Even For Short Ride	17
Uncomfortable, Especially For Overweight People or Pregnant Women	17

Opinion Research Corporation surveyed owners of 1975 Volkswagens, some with automatic belts and some with manual. Of those surveyed, those owners of automatic belts and manual belts who had a choice of systems when they purchased their vehicles were asked to provide their reasons for choosing or not choosing the automatic system. As indicated in Table XI-7, the major factor for choosing automatic belts was ease and convenience of use. The main reason for not selecting the automatic system was the added expense. While the added expense disadvantage is not germane to the issue of automatic belts if individuals would not be given a choice of systems under an automatic restraint rule, it would be if consumers were given an option and indicates that some would forego the advantages of the automatic belt system because of the extra cost. Most of the other disadvantages, of much smaller magnitude than the price issue, would also apply to usage. The advantages related to choice of system would also be expected to be advantages related to increased usage.

TABLE XI-7

REASONS FOR CHOICE OF BELT SYSTEM[29]

Reasons for Choosing Automatic System	Percent
Easy/convenient to use	73
Forces one to use belt	14
Safer than conventional system	10
Wanted to try it/read about it	9
More comfortable	6
Offers greater freedom of movement	4
Like the knee pad	3

(Principal answers. Percentages add to more than 100 percent due to multiple answers)

[29] "Passive vs. Active Safety Belt Systems in Volkswagen Rabbits: A Comparison of Owner use Habits and Attitudes;" Opinion Research Corporation, August 1976. DOT-HS-801-958.

Reasons for not Choosing Automatic System

Too expensive/extra cost	47
Dislike the knee pad	13
Inconvenient to use	7
Less safe than conventional	5
Too long a delivery time	5
Prefer conventional safety belt	3
Don't use safety belts	3
Decision made by another family member	3
Less comfortable	2

(Principal answers)

Opinion Research surveyed owners of 1978-79 MY Chevettes and 1978 MY Rabbits, equipped with automatic belt systems[30]. Forty-one percent of the Chevette and 80 percent of the Rabbit owners said they would choose an automatic belt system if purchasing a new car. The principal reasons stated are shown below. Safety and convenience were the primary factors. Comfort did not figure prominently as a factor.

	1978-79 Automatic Chevette Owners	1978 Automatic Rabbit Owners
Safety-related factors	51%	40%
Convenience Factors	39%	56%
More Comfortable	5%	11%

30 Automatic Safety Belt Systems Owner Usage and Attitudes in GM Chevettes and VW Rabbits," Opinion Research Corporation, May 1980, DOT-HS-805-399.

Following are the principal reasons given in the same survey by the 49 percent of Chevette owners and 12 percent of Volkswagen owners for why they would not purchase an automatic belt system in their next new car. (Some Chevette and Volkswagen owners were uncertain whether they would purchase automatic systems in their next new car.)

	1978-79 Automatic Chevette Owners	1978 Automatic Rabbit Owners
Convenience Factors	33%	25%
Comfort Factors	18%	17%
No Interlock	16%	17%
Freedom to Wear/Not Wear	16%	17%

Opinion Research Corporation also conducted a 1980 survey of owners of 1980 MY Rabbits and Chevettes equipped with automatic belts. Opinion Research queried respondents on their reactions to the automatic belt system both initially and after a period of time. Following are results from the 1979 and 1980 surveys.[31]

[31] Opinion Research Corporation, May 1980, Ibid. "Automatic Safety Belt Systems Owner Usage and Attitudes in GM Chevettes and VW Rabbits (1980 Model Year)," Opinion Research Corporation, February 1981, DOT-HS-805-797.

TABLE XI-8

REACTIONS OF AUTOMATIC BELT OWNERS

------------INITIAL REACTIONS---------------

	1979 Survey		1980 Survey	
	Chevette	Rabbit	Chevette	Rabbit
Favorable	45%	67%	39%	61%
Unfavorable	41	22	54	32
No Opinion	14	11	7	7

REACTIONS "AFTER OWNING CAR AWHILE"

	1979 Survey		1980 Survey	
	Chevette	Rabbit	Chevette	Rabbit
Favorable	51%	84%	49%	77%
Unfavorable	43	13	44	18
No Opinion	6	3	7	5

The above response indicates a significant increase over time in the percentage of owners having a favorable impression about automatic belts. This favorable opinion on the automatic belt systems suggests the possibility that they could be successfully marketed on a wider scale and that actual familiarity, rather than breeding contempt, results in greater acceptance than the concept itself.

Respondents were also questioned about what they liked most and least about their automatic belt systems. Note the change in response for features liked least between 1979 MY and 1980 MY Chevettes. The 1979 Chevette has a detachable automatic belt with an interlock, while the 1980 model has what is in effect a non-detachable system with no starter interlock. Entering and exiting problems are much more prevalent in 1980 Chevettes.

TABLE XI-9

AUTOMATIC BELT FEATURES LIKED MOST AND LEAST

	Features Liked Most			
	1979 Survey		1980 Survey	
	Chevette	Rabbit	Chevette	Rabbit
Convenience	39%	82%	45%	62%
Safety	24	17	31	36
Comfort	6	14	9	15
Nothing	30	8	29	12

	Features Liked Least			
	1979 Survey		1980 Survey	
	Chevette	Rabbit	Chevette	Rabbit
Entering/Exiting	18%	20%	41%	21%
Poor Belt Fit	16	11	16	21
Retractor Problems	9	5	7	11
Interlock or Warning System	26	12	3	14
Mounting on Door	8	1	5	2

Information was gathered comparing automatic and manual belt systems. In its 1976 survey,[32] Opinion Research asked owners of VW Rabbits with automatic or manual belt systems their respective impressions of the two systems. Table XI-10 summarizes general impressions about the two systems and about the more specific issue of comfort.

TABLE XI-10

AUTOMATIC AND MANUAL BELT SYSTEM OWNERS' IMPRESSIONS

	Impressions of Owners of Respective Systems	
General Impressions	Automatic Belts	Manual Belts
Favorable	83%	67%
Unfavorable	13	20
No Impression	4	13
Comfort		
Comfortable	73%	45%
Fairly Comfortable	19	35
Not Comfortable	7	16
Other	1	4

[32] Opinion Research Corporation, August 1976, Op. Cit.

As shown, automatic belts were thought of more favorably in general and were felt to be comfortable by a much larger percentage of owners. The fact that the automatic system consists of a shoulder belt (plus knee bolster), while the manual system consists of a lap and shoulder belt, likely accounts for some of the difference in the perceived level of comfort in the two systems.

Opinion Research asked respondents to evaluate their experience with specific comfort and convenience problems associated with use of their respective automatic and manual belt systems.

TABLE XI-11

COMFORT AND CONVENIENCE OF AUTOMATIC AND MANUAL BELT SYSTEMS

	-------PERCENT WITH PROBLEM------	
ISSUE	Owners of Cars With Automatic Belts	Owners of Cars With Manual Belts
Jewelry Lost, or Damaged	10%	14%
Belt Falls off Shoulder	10	19
Belt Hard on Clothing	16	36
Belt Rubs on Face or Neck	19	42
Belt Exerts Pressure on Chest	19	39
Belt Chafing or Rubbing Chest	23	38
Belt Hinders Reach for Glove Compartment or Controls	25	43
Padded Knee Panel (Auto)	16	--
Belt Interferes with Entering Car (Auto)	37	--
Belt Interferes With Exiting Car (Auto)	38	--
Fastening or Buckling Belt (Manual)	--	38
Belt Retractor Locks When Buckling (Manual)	--	42
Belt Interferes With Entering Back Seat (Manual)	--	50
Belt Attachments Inaccessible (Manual)	--	56

Except for problems associated with entering and exiting and the knee bolster, the automatic belt system was rated higher in comfort by its users than was the manual system by its users. There was no indication whether the presence of a lap belt in the 3-point manual belt system made their comparison to the automatic belt system less favorable.

Clinical evaluations of the comfort and convenience of safety belt systems in 1980 and 1981 model vehicles revealed that automatic safety belt systems were more comfortable than manual systems in identical vehicles. The study, conducted by Verve Research Corporation, produced the results shown in Table XI-12. Systems were rated for comfort based on belt fit and belt pressure on the occupant. The rankings shown indicate where each vehicle's system ranked among the 55 that were tested. As indicated, automatic systems ranked well ahead of manual systems in terms of comfort, with the exception of the VW Rabbit, for which the rankings were close. Three of the vehicles (BMW 320i, Chevy Chevette, Ford LTD) had lap belt portions to their automatic systems; these systems thus corresponded to the 3-point manual belt systems to which they were compared.

Table XI-12[33]

Comfort Rankings for Automatic and Manual Belt Systems

Vehicle and Safety Belt System	Average Comfort Ranking Among 55 Vehicles Tested	
	Belt Fit	Belt Pressure
BMW 320i (Auto) continuous loop	16	17
BMW 320i (Manual)	37	47
Chevy Chevette (Auto) continuous loop	17	8
Chevy Chevette (Manual)	53	54
Ford LTD (Auto) continuous loop	2	1
Ford LTD (Manual)	30	34
VW Jetta (Auto) 2-point	26	28
VW Jetta (Manual)	40	52
VW Rabbit (Auto) 2-point	39	46
VW Rabbit (Manual, Veh.#1)	41	45
VW Rabbit (Manual, Veh.#2)	25	33

3. Air Bags

The 1978 Hart survey queried respondents on their impression of air bags (respondents were provided verbal and visual descriptions). Following are the top four volunteered perceived advantages and disadvantages of air bags:

[33] "Evaluation of the Comfort and Convenience of Safety Belt Systems in 1980 and 1981 Model Vehicles, "Verve Research Corporation, March 1981, DOT-HS-805-860.

TABLE IX-13

VOLUNTEERED ADVANTAGES AND DISADVANTAGES OF AIR BAGS

Advantages	Percent
Protect from injuries, death, offer protection	44
Protect driver from windshield, steering wheel, dashboard	36
Automatic, work without driver involvement	8
Cushion impact in collision, front end crashes	7
Disadvantages	
Might not inflate, accidentally inflate	19
Expensive to install, maintain, restore	14
Might not inflate when they should	12
Might obstruct vision	11

Following are the top four reasons for favoring and opposing installation of air bags in new cars as selected by respondents from lists.

TABLE XI-14

Selected Reasons for Favoring and Opposing Air Bags[34]

Reasons for Favoring Installation	Percent
Provide most safety in a front end collision	34
Work automatically in a crash	33
Provide most safety for little children	30
Don't have to think about them, hidden	22

Reasons for Opposing Installation	Percent
Might inflate by mistake	47
Can't be sure they will work	25
Cost more than other safety systems	13
Air bag system uses toxic chemicals	12
Air bags might surround you or hit you too hard	12
Only effective in front end crashes, still have to wear lap belt	12
Can't trust auto companies to do a good enough job in making such complicated equipment	12

Reasons given for opposing or favoring air bags, by those opposing and favoring their required installation, respectively, in a 1979 telephone survey of Arkansas drivers, are summarized below:

[34] The percentages shown indicate the percentage of respondents selecting given reasons. Some respondents selected two best reasons.

TABLE X-15[35]

REASONS FOR FAVORING AND OPPOSING AIR BAGS

Reasons for Favoring Air Bags	Percent
Safety	87.4
Convenience	9.1
Other	3.5

Reasons for Opposing Air Bags	Percent
Fear Early Inflation	18.2
Fear Loss of Control	4.6
Still Unproven	31.7
Fear Entrapment	7.2
High Cost	16.4
Other	21.9

Respondents who favor mandatory air bags logically perceive safety benefits therefrom, while those opposed expressed concern about air bags not working when needed, inflating unnecessarily, and being too costly. The perceived reliability of air bags was most often mentioned and dominates the list of stated disadvantages.

[35] "Arkansas Motorists: The 55 mph Speed Limit and Safety Devices," Area Market Research Associates, July 1979.

Respondents who preferred air cushions in the 1971 GM clinic were asked to provide reasons for their choice.[36] Although the safety effectiveness of air cushions was by far the primary concern, as indicated in Table XI-16, it is also obvious that comfort, convenience and appearance played an important role.

TABLE XI-16

REASONS FOR AIR BAG PREFERENCE

Safest and most practical injury-free system	93%
More freedom of movement -- less confining than belt	26
"Automatic" nature of the system is good -- protects people who usually don't buckle up	8
Looks nicer than falling straps -- neater	6
Makes easier entry and exit possible	4
I don't like belts	3
Prevents injuries arising from hitting steering wheel	2
Miscellaneous comments	8

(Percentage over 100% due to multiple comments)

In 1977 GM sponsored a survey of owners of GM cars equipped with an Air Cushion Restraint System (ACRS).[37] Opinions and attitudes were not specifically requested; however, 475 owners offered comments, which are summarized below:

[36] General Motors Corporation, 1971, Op. Cit.
[37] Air Cushion Restraint System: A survey of Owners' Opinions," University of North Carolina, May 1978.

TABLE XI-17

POSITIVE AND NEGATIVE COMMENTS ON AIR BAGS

Positive Comments	No.	Percent
No problems with ACRS	30	6
Good feeling toward ACRS	64	14
Feeling of safety and confidence	57	12
Prefer ACRS over belts	35	7
Would purchase another ACRS	85	18
ACRS should be in all cars	29	6
	---	---
	300	63
Negative Comments		
Problems with horn	21	4
Problems with checklight	19	4
Problems with servicing	28	6
Discouraged by dealers to buy ACRS	5	1
Other negative comments	41	9
	---	---
	114	24
All other ACRS comments	36	8
Comments irrelevant to ACRS	25	5
Total comments	475	100

Findings of the Hart and GM surveys indicate that the safety value of air bags is clearly perceived, although questions exist about their reliability. The majority of owners of GM air bag equipped cars had favorable reactions to the system.

In 1976, General Motors sponsored a survey of owners of 1976 GM cars with and without air bags.[38] The following responses were provided when the air bag owners were asked their reasons for purchasing a car with air bags:

[38] "A Passive Occupant Restraint System Study," Market Research Group, Inc., and Survey Data Research, Inc., December 1976.

Car came equipped with air bags; car I wanted just had them already	45%
Wanted safest car -- just safer than belts	22%
Don't like seat belts and wanted protection	16%

Only 4 percent of air bag owners said they would not purchase air bags (again), even at no added cost, compared to 30 percent of the non-owners.

To summarize, surveys generally indicate that automatic belt systems are superior to manual systems in comfort and convenience, depending of course on the design of a particular system, and that these characteristics would appear to over-ride some of the reasons respondents give for not using manual belts and therefore increase usage. Of course, a degree of comfort and convenience is lost whenever a manual or automatic belt is utilized. Differences in convenience of use between automatic and manual belts are important to deciding which system to purchase, while differences in system comfort have little bearing thereon. Respondents perceive some degradation in vehicle appearance from automatic belts.

Air bags are rated highest on comfort, convenience, and appearance and are perceived to be safer by infrequent belt users. Primary concerns expressed about air bags relate to reliability, whether they will work when needed or deploy accidentally, and cost. Again, it must be emphasized that in evaluating results of public surveys, it should be understood that respondents generally have at best very little knowledge about or experience with air bags, and not much more with automatic belts.

E. Public Attitudes Toward A Mandatory Safety Belt Usage Law

This section summarizes past and recent state and nationwide surveys on public opinion concerning mandatory safety belt usage laws. Eighteen of these surveys have employed reasonable methodologies to gain representative opinions. Nine of the state surveys, either conducted or commissioned by state agencies, were conducted from 1977-79 and a single state survey was conducted in Michigan in 1983.

Results of the above 18 state and nationwide surveys are reported on separate tables. The table summarizing the nationwide surveys is divided into two parts; those surveys that in their articulation of the question on mandatory safety belt usage were silent on whether a penalty would be imposed, and those that stipulated a fine for non-usage. One state, New Jersey, incorporated the consideration of a penalty in its survey, and results are included in the table summarizing the state surveys.

As shown on Table XI-18, 6 of the 10 state surveys found public opinion against a mandatory usage law, with the strongest vote against being in North Carolina with a ratio of over 4:1. Two states had a majority favoring a mandatory usage law, with the strongest vote in favor being in Michigan with a ratio of 62:38 in favor. Two state surveys showed a virtual deadlock on the issue. A survey in the Grand Rapids area of Michigan in 1977, demonstrated the effect of a safety belt usage campaign by reversing a 52 percent to 34 percent vote against mandatory usage before the campaign to a 44 percent to 38 percent vote in favor after the campaign. In New Jersey, when the stipulation of a $10 fine for non-compliance was introduced, opinion against mandatory usage increased from 52 percent to 63 percent.

Table XI-19 summarizes the results of the nationwide surveys on the issue of mandatory usage. Of the five surveys that did not stipulate a penalty for non-compliance, three indicate public preference in favor of mandatory usage and two indicate preference against it. The three surveys in favor of mandatory use laws were more recent.

TABLE XI-18

STATE SURVEYS ON A MANDATORY SAFETY BELT USE LAW

YEAR	STATE	------PERCENT----- FAVOR	AGAINST	UNDECIDED	COMMENT
1977	New Jersey	39	52	9	
		30	63	7	with $10 fine
1977	Michigan; Grand Rapids and surrounding area	34	52	14	Pre media campaign
		42	42	16	During media campaign
		44	38	18	Post media campaign
1977	VIRGINIA	38	58	4	
1977	KENTUCKY	32	33	35	
1978	CALIFORNIA	--	65	--	
1978	NEBRASKA	42.2	42.5	15.3	
1978	NORTH CAROLINA	14	62	23	
1979	ARIZONA	30	61	29	
1979	ARKANSAS	54	46	--	
1983	MICHIGAN	62	38	--	

TABLE XI-19

NATIONWIDE SURVEYS ON A MANDATORY SAFETY BELT USE LAW

YEAR	CONDUCTED BY	PERCENT FAVOR	PERCENT AGAINST	PERCENT UNDECIDED	SANCTION
1977	Insurance Institute for Highway Safety	47	50	3	
1977	American Automobile Association	41	48	11	
1978	Teknekron	54	45	1	
1979	Teknekron	52	47	1	
1983	Yankelovich, Skelly, and White[39]	65	35		
	(SURVEYS STIPULATING SANCTION)				
1976	Yankelovich, Skelly, and White[40]	29	66	5	"Summons and fine"
1977	Gallup Poll	17	76	7	"$25 fine"
1978	Hart	21	57	22	"fines"

[39] Conducted for the All-Industry Research Advisory Council, an organization formed by the property-casualty insurance industry; docket entry 74-14-N35-067.

[40] Conducted for the Motor Vehicle Manufacturers Association.

The three nationwide surveys addressing the mandatory usage issue and stipulating a sanction against non-compliance show a stronger opinion against such laws than do the surveys that did not stipulate sanctions. This suggests that a portion of the public does not associate the concept of enforcement and sanctions with mandatory use laws - or at least they did not 6-8 years ago. However, a number of recent state surveys suggest that public opinion is shifting on the issue of state mandatory safety belt use laws. Although these surveys, due to some methodological deficiencies, are not representative of the public-at-large, their results do provide an indication of recent public attitudes toward mandatory use laws.

Two attitude surveys conducted in the State of New York last year provide a case in point. The first, conducted in Nassau County in the Spring of 1983, asked licensed drivers, "Are you in favor of mandatory seat belt legislation (requiring everyone to wear seat belts)?" This questions was posed as a potential countermeasure to mitigate the consequences of drunk driving. The responses were 56 percent yes; 39 percent no; and 5 percent don't know. Later in 1983, the New York State Medical Society surveyed visitors at the 1983 State Fair. Sixty seven percent indicated they would be in favor of a law requiring the use of safety belts by adults. In June 1984 the state legislature of New York passed a mandatory use law.

The Ohio State Highway Patrol conducted a survey of publi: attitudes during June and July 1983. Patrol officers asked a set of questions of drivers and passengers stopped for various reasons. Ninety five percent said they favored a child restraint law; 56 percent favored a mandatory safety belt law for adults, and 88 percent said they would obey a mandatory law if it were passed. Similar results were obtained in a representative survey conducted in Michigan in 1983 (see Table XI-18). Eighty five percent of the respondents in the Michigan survey said they would comply with a state law requiring the wearing of safety belts for all front seat occupants. Sixty two percent said that they favored a mandatory law.

F. Marketing of Air Bags as Optional Equipment

The U.S. automotive industry provides only one example of an attempt to market air bags. General Motors (GM) offered the Air Cushion Restraint System (ACRS) option from 1974 through 1976 on Cadillac DeVille and Eldorado models; Buick Electra, LeSabre, and Riviera models; and Oldsmobile 98, 88, and Toronado models. GM built and sold only 10,243 ACRS equipped cars over the three-year period compared to an ACRS production capacity of 300,000 units over that period and a total sales volume of 2,208,354 vehicles in which the ACRS was available. This computes to a three-year installation rate of 0.46 percent and a total utilization of less than 3.5 percent of GM's ACRS production capacity.

In 1982, NHTSA sponsored a study[41] to examine the GM marketing effort of air bags in the mid-1970's to try to determine whether any or all of the factors that limited GM's sales could be corrected or overcome in future marketing efforts. The study also identified the types of information that would be needed in order to effectively plan and implement a marketing program for air bags.

The results show that much can be learned from a retrospective analysis of GM's marketing of air bags. The study identified three problems in the market which affected the demand for ACRS.

[41] "A Retrospective Analysis of the General Motors Air Cushion Restraint System Marketing Effort, 1974 to 1976," National Analysts, July 1983.

1. Lack of dealer commitment -- The initial attitude of the dealer towards ACRS is strongly linked to the dealership's ACRS performance. Those dealers who had positive selling experiences saw ACRS as a positive marketing advantage. Those dealers that had neutral or negative selling experiences often shared the same doubts and fears about ACRS as consumers. The correlation is not absolute. Some dealers started out enthusiastically but wound up regretting the decision to stock ACRS cars. However, no dealers started out skeptical and later became enthusiastic about ACRS.

2. Unanticipated consumer concerns -- In marketing ACRS, GM positioned the option as a "comfort and convenience" item (ACRS would eliminate the need for cumbersome and troublesome shoulder belts). However, consumers had serious concerns over the technical operation of air bags -- inadvertent deployment, blocked vision, cost and inconvenience of replacing an ACRS unit, etc. These concerns apparently were not ameliorated by the various marketing materials developed by GM.

Another unanticipated concern, which appears to have been of significant importance, was the unavailability of the tilt steering wheel option if ACRS was ordered. This was especially important because tilt wheel was (and is) a high installation-rate option on the relatively expensive cars on which GM offered ACRS.

Failure to satisfy these consumer concerns, particularly the safety fears over ACRS' operation, resulted in the ACRS being viewed as both expensive (ACRS price ranged from $225 in MY '74 to $315 in MY '76 --$453 to $549 in $1982) and of doubtful efficacy -- a fatal combination.

3. Installation of ACRS on full-size vehicles -- While GM's logic in offering ACRS first on full-size, upmarket vehicles appeared sound at the time, there is evidence which suggests that ACRS' demand grows as vehicle size drops. This demand in smaller cars is linked directly to safety concerns. Thus, if air bags had been offered on smaller cars, they would have had to be positioned more as a safety item and less as a comfort and convenience item. While ACRS would have undoubtedly met with strong price resistance among small car buyers, the air bag concept probably would have made more immediate sense to small car owners. On the other hand, the ACRS was not developed for small cars in the mid-70's -- and still is not. Also, the price increase for an ACRS is more negatively perceived by small car buyers than by large car buyers (see Section C).

The retrospective air bag marketing study also contains a number of recommendations for developing a marketing strategy. Three specific areas of concentration are mentioned:

1. Consumers -- The overriding need in marketing air bags to consumers is to create a totally positive view of the system before price enters into the equation. This means that an intensive probing

of consumer attitudes, particularly negative attitudes, towards the air bag system should be undertaken before any new marketing effort. Additionally, a marketing strategy should identify the most likely prospective buyers of air bags and the promotional themes to which they will best respond. In addition to these research efforts, the GM air bag experience argues strongly for the pretesting of merchandising materials and even sales techniques.

2. Technical Research -- A major drawback of the ACRS, from both a customer and dealer standpoint, was that there was little indication of its presence and thus it did not become a selling point. It is imperative to find some way to dramatize the presence of the air bag to the point where it is an attention grabber, a visible source of pride, and perhaps of some "bragging" value.

Also, there is a need for some sort of credible, and most likely tangible, assurance that the air bag is ready to go into action when it is needed. GM used a dashboard indicator light; however, that in itself did not appear to be sufficient.

3. Dealers -- While a positive attitude and commitment by manufacturers to market air bags is essential, it is the dealers and sales personnel who provide the direct link to the consumers. The critical role played by dealers' and sales personnels' attitudes in shaping the ACRS' selling experience demands that future air bag marketing strategies take their concerns into account. A better understanding is needed of: (1) the extent of dealer fear or

skepticism about air bags; (2) the types of consumers to whom dealers would and would not attempt to sell air bags; and (3) the conditions required to motivate dealers to market air bags.

As a result of the retrospective GM air bag marketing study, it appears reasonable to assume that air bags could be successfully merchandised as an option, if an effective marketing strategy were developed and pursued by the manufacturer(s). To be effective, the consumer and dealer concerns must be addressed and resolved.

G. Public Opinion Surveys -- Docket Submissions

In addition to the above surveys, the results of two new public opinion surveys on vehicle occupant restraint issues were submitted to the docket. One was commissioned by General Motors Corporation, the other by the Insurance Institute for Highway Safety (IIHS). Both surveys include some questions which the Department believes influenced the answers; consequently, the agency believes that some responses do not accurately reflect current consumer/public attitudes with respect to automatic restraint systems.

The General Motors survey (Docket No. 74-14-N32-1666), conducted by Maritz Market Research of Detroit, consisted of telephone interviews over the November 14-22, 1983 period with 1,101 new car buyers. It is essentially designed to measure attitudes on government regulation of safety technology and vehicle operation.

The IIHS survey (Docket No. 74-14-N32-1667), also a telephone survey, was conducted by the National Center for Telephone Research during the period November 14-17, 1983. In this survey, 1,254 heads of households at least 21 years of age with valid drivers licenses were interviewed. The IIHS survey attempts to measure attitudes on different safety technologies, divorced for the most part from the issue of government regulation. However, as discussed below, the notion of government regulation becomes intertwined with the issue of automatic restraint availability.

The representativeness and validity of the overall survey results are discussed below. This is followed by presentation, evaluation, and discussion of survey results on a few key issues.

1. Representativeness and Validity of the Surveys

Before discussing the individual surveys, an initial comment is warranted: It is questionable whether either survey could obtain useful or accurate information on automatic belts over the phone. It is too difficult to conceptually understand the system without first-hand experience. Therefore, responses to questions containing such terms as "automatic restraints" or "automatic belts" are of dubious value.

a) General Motors surveyed owners of recent model cars who stated they would be buying a new car in the future, i.e., new car buyers. No information is provided on the universe from which the sample was drawn nor on sample selection procedures. Because only new car buyers are surveyed, results cannot be considered nationally representative of all those that would be affected by a FMVSS 208 decision -- all automobile owners and operators. However, while survey questions relating to whether automotive restraints should be mandated should be directed to the motoring public at large, questions on what the public would be willing to pay for them are appropriately addressed to new car buyers.

The response options in the questionnaire do not provide for the "unsure" and "does not matter" type of response. It is unreasonable to assume that all respondents had a firm opinion on each of the issues addressed in the questionnaire; the size of the unsure response is important in assessing public attitudes.

Some deficiencies in question wording are discussed below in the section summarizing results on specific questions.

b) The IIHS survey begins by giving each respondent a brief introduction to the Nation's highway safety problem -- "40-50 thousand people are killed," "tens of thousands are severely injured," "federal government has acted to reduce deaths and injuries by requiring . . . protective features," "one of these protective features is the seat belt," "about one out of 10 Americans wear seat belts." The respondents were then asked, "how often do you wear a seat belt when you drive your car?"

The response to this first question produced the results of "twenty-eight percent of respondents reported always wearing their seat belts, while an additional 12 percent reported wearing them almost always." Obviously, these respondents either overrepresent safety-conscious people, or their responses are biased by the so called "acquiescence effect," a phenomenon encountered in survey research which manifests itself as a tendency to show support for whatever it is that appears to be of importance to the interviewer, and the "social desirability effect," which manifests itself by a tendency to support positions which one feels that one should support as a good citizen. The latter two phenomena are most likely the case, since the survey's introduction talks of death and injury, protective features, federal government, and poor belt usage rates; and then the respondent is immediately asked if he/she wears his/her seat belt. Many respondents can be expected to answer positively to such a question, since they would not wish to appear to be against safety.

If the sample is overrepresented by seat belt users, it biases the applicability to all consumers. Also, if the "acquiescence" and "social desirability" biases exist in this response, then their existence in other responses is highly probable.

Some explanatory information and questions are phrased in such a manner as to almost certainly bias results; for example, the question on whether automatic restraints should be required in new cars. The responses to this and selected other questions are presented and discussed below:

2. Results and Analysis of Specific Survey Questions

a. Should air bags/automatic restraints be available in new cars?

(1) The General Motors survey addressed this issue with the following explanatory statement and question. The results follow:

"In the event of an accident at 12 miles per hour or more, air cushions in your steering wheel and dashboard would rapidly inflate, forming a restraining bag for driver and passenger. Air bags would add $320 to the cost of a car."

"Would you favor a government regulation requiring the installation of air bags on your next new car at an additional cost of $320?" This question was also asked for costs of $100 and $500.

	Yes	No
@ Cost of $100	51%	49%
@ Cost of $320	35%	65%
@ Cost of $500	19%	81%

As stated above, addressing the question of a regulatory requirement to new car buyers does not produce results representative of the driving public. In addition, phrasing the question in terms of government regulations introduces a bias against the acceptability of air bags, since it is well known that a certain segment of the population is against practically any and all types of government regulation. It is impossible to determine the degree to which the air bag issue or the regulatory issue influenced responses.

The air bag being described as a "restraining bag" might convey the image of a bag which holds and suffocates the occupants; this description may tend to reinforce rather than dispel any existing consumer concerns over the performance and reliability of air bags.

The survey contained a similar statement and question on automatic belts:

"Now, a few questions about automatic seat belts. Cars would be equipped with lap and shoulder belts which automatically "belt-in" seat passengers as they sit down. Automatic seat belts would add $100 to the cost of a car."

"Would you favor a government regulation requiring the installation of automatic seat belts on your next new car at an additional cost of $100?"

Yes	No
38%	62%

While General Motors directly addresses the issue and appropriately includes cost figures for respondents' consideration, belts being described in terms of their ability to "belt-in" the occupants might reinforce any exisiting fear of entrapment among respondents.

The question of acceptable cost is appropriately addressed to new car owners. However, since the survey merges this i sue with the issue of restraint/regulation, which is not appropriately addressed only to new car buyers, opinions on each cannot be assessed, and results addressing the two jointly cannot be considered appropriately nationally representative.

Also, the GM survey did not discuss any potential benefits of belts/bags. If respondents were told the expected safety benefits associated with the additional cost, the answers might have been different.

(2) The IIHS survey addressed the issue in two parts -- a statement and then a question. These are shown below:

"Currently automatic seat belts are available only to buyers of some Volkswagen cars and more expensive Toyota cars, while air bags are available only to buyers of some Mercedes cars. If these new features were standard on all new cars, the cost of these features to each buyer would be substantially lower than if purchased as an option and more people would be protected automatically in crashes."

Question: "Do you think that air bags and automatic belts should be standard equipment for everyone or do you think that they should be optional for those people who want and can afford them?"

Should be standard	56%
Should be optional	40%
No preference	2%
Don't know/not sure	2%

The IIHS survey is biased toward automatic restraints being standard equipment in new cars for the following reasons:

o The phrasing of the question on whether automatic restraints should be standard equipment or "optional for those people who want and can afford them" likely does not make clear to the respondent that automatic restraints could be required as an option in less expensive cars. While a close reading of the explanatory statement preceding the question by respondents might preclude this ambiguity for most, it appears likely that many respondents hearing the statement read over the phone followed by the question would construe "those people who want and can afford" optional equipment to mean purchasers of the Mercedes and other expensive cars.

o Respondents were told that "substantially lower" costs would result from automatic restraints being produced in large quantities and installed in all new cars. "Substantially lower" likely means different and imprecise amounts to various respondents. The absence of restraint system cost estimates for respondent consideration denigrates response validity.

o Survey results on this question are contradicted by results on a question about preference for an air bag or a current manual belt at various costs for an air bag. At a cost of $350 for an air bag, 55 percent of the respondents preferred a manual belt compared to 42 percent preferring the air bag. Were an air bag standard equipment, their preference would not be satisfied.

The IIHS survey then asks the 44 percent of respondents who did not indicate that automatic restraints should be standard equipment whether they felt "car manufacturers should be required to at least make air bags or automatic belts available as options so that those that want them can buy them."

The notion of a requirement is thus introduced in considering the merits of availability of automatic restraints as options. The issue of regulation was not introduced for respondent consideration in voting on whether automatic restraints should be standard equipment, a situation which is more likely to be achieved only through regulation.

The distribution of responses must be questioned because of this inconsistency in incorporating the notion of regulation.

Of the 44 percent of total respondents asked, 84 percent stated that automatic restraints should be made available, 9 percent said they should not, and 6 percent had no preference or did not know. Combining the results of this question with the preceding one, the IIHS survey produces the following summary results.

Automatic restraints should be standard equipment	56%
Manufacturers should be required to make automatic restraints at least available as options	37%
Automatic restraints should be neither standard equipment nor required to at least be available as options	4%
No preference/don't know	3%

Shortcomings concerning the validity of the 56 percent preference indicated for automatic restraints as standard equipment are discussed above. Regarding indicated preference for automatic restraints being made available as options, the question as read to respondents, "car manufacturers should at least make air bags or automatic belts available as options . . .," could imply that this is the least manufacturers should do, when in fact it would entail considerable cost to manufacturers. The agency believes the response may well have been lower had the question been put in a more straight forward manner.

b. <u>How much are people willing to pay for automatic restraints?</u>

(1) The General Motors survey combines or incorporates the willingness to pay issue with the issue of a government regulation requiring installation of automatic restraints and therefore does not address the willingness to pay issue, per se. Results are presented in Section (a) above. Respondents willing to pay specified amounts for restraints may be against government mandating their installation and respond in the negative to a question incorporating both issues; therefore, their responses cannot be used to strictly gauge their willingness to pay.

(2) The IIHS survey ascertained the amounts respondents were willing to pay for both automatic belts and air bags. The following two tables indicate respondents' preference for automatic restraint systems or the manual lap and shoulder belt system that is currently standard equipment in cars, at various costs for the automatic system.

PREFERENCE FOR AUTOMATIC AND MANUAL BELTS AT DIFFERENT PRICES

	Prefer Automatic	Prefer Manual	No Pref.	Neither/ Unsure
Ignoring Price	33%	34%	29%	4%
$100 for automatic belts	30%	53%	11%	6%
$150 for automatic belts	25%	57%	14%	4%

PREFERENCE FOR AIR BAGS AND MANUAL BELTS AT DIFFERENT PRICES

	Prefer Air Bags	Prefer Man. Belts	No Pref.	Neither/ Unsure
Ignoring Price	41%	27%	28%	4%
$100 for air bags	55%	42%		3%
$200 for air bags	47%	50%		3%
$350 for air bags	42%	55%		3%
$1,000 for air bags	18%	79%		3%

The results on how much respondents are willing to pay for air bags are reasonably consistent with results of other studies on this issue that are summarized above.

c. Preference among alternative regulations

(1) The General Motors survey asked respondents which of five government regulations they would "like most" and "like least" to see enforced:

	Government Regulation "Like Most" To See Enforced
Mandatory seat belt law, 65 mph on Interstate System	28%
Air bags in all new cars	24%
Automatic seat belts in all new cars	21%
Mandatory seat belt law	16%
Starter Interlock	11%
	100%

	Government Regulation "Like Least" To See Enforced
Air bags in all new cars	44%
Starter Interlock	18%
Mandatory seat belt law	14%
Automatic seat belts in all new cars	13%
Mandatory seat belt law, 65 mph on Interstate Systems	11%
	100%

As shown, respondents most liked a mandatory seat belt law in conjunction with increasing the speed limit on the Interstate System to 65 mph. However, since the extent to which those selecting the seat belt law and 65 mph were simply voting for a higher speed limit is unknown, none of the responses is useful in gauging opinion on relevant alternatives. The table showing the distribution of responses on least liked alternatives indicates that a requirement that air bags be installed in all new cars is by far the least liked alternative. Both tables show comparative choices among the alternatives listed and do not indicate the degree to which respondents favor each of the individual alternatives.

(2) In the IIHS survey, respondents were told that "some states are considering seat belt use laws that would impose fines on motorists who don't wear their seat belts." They were then asked the following question: "If you had to choose between a seat belt law or automatic protection such as air bags or automatic belts, which would you prefer?"

Prefer law	21%
Prefer automatic protection	48%
No preference	25%
Neither/don't know/ not sure	5%

As shown, respondents voted a more than 2 to 1 preference for automatic restraints. The agency believes, however, that the response for automatic restraints was likely inflated due to the information presented to respondents and how the question was worded. The explanation of seat belt use laws seems to convey a certainty that fines, of some unknown magnitude, would be levied if the seat belt is not worn. The acceptability of a seat belt use law alternative is then weighed against the acceptability of automatic protection to which no cost is assigned. The results, therefore, are based on these assumptions.

d. Mandatory Seat Belt Use Law

Of the two surveys, only the GM survey directly addressed the issue of a mandatory seat belt use law. Respondents were asked if they would be in favor of a mandatory seat belt use law making them subject to a traffic violation ticket if they don't buckle up. Results:

In favor of	35%
Not in favor of	65%

These results can be considered representative of new car buyers.

Both the GM and IIHS surveys contained several other questions. The reader is directed to the respective surveys for the participants' responses.

In summary, the data derived from public opinion surveys, information and material submitted to the docket, and public opinions expressed at the public hearings and in response to the NPRM and SNPRM, all clearly point to the need for public education on the subject of occupant protection. The public generally seems to lack sufficient information on the importance of occupant restraints in preventing deaths and injuries and has very little or no information on automatic restraint systems. There are also indications that educational efforts have positive effects in influencing public attitudes toward programs designed to enhance occupant crash protection.

XII. ALTERNATIVES

The October 1983 Notice of Proposed Rulemaking proposed a broad range of possible alternative approaches for the resolution of the automatic restraint issue. The Notice solicited public comments on each of these proposals, as an important aid in considering the comparative merits of each proposal. Docket commenters were also encouraged to and subsequently provided additional alternatives including the possibility of combining some of the alternatives, e.g., a mandatory belt use law with an automatic restraint requirement.

After reviewing the extensive comments (over 7,800) received at the public hearings and in the docket, the Department identified four additional alternatives in the Supplemental Notice of Proposed Rulemaking (SNPRM) of May 1984 and requested further comments. Thus, the Department has a large list of possible alternatives to consider. These are shown in Table XII-1.

TABLE XII-1
ALTERNATIVES

Alternative	
#1	Require air bags
#2	Require automatic restraints, disallowing detachable belts
#3	Require automatic restraints, allowing detachable belts
#4	Rescind the standard
#5	Center seating position and driver only sub-alternatives

#6	Require air bags for drivers in small cars
#7a	Mandatory use laws, in general
#7b	If any state passed a mandatory use law, a waiver from the automatic restraint requirements would be granted for cars sold to residents of that state
#7c	Automatic occupant restraints would be required in all cars manufactured after a set date unless 75 percent of the states passed mandatory use laws
#8	A mandatory consumer option
#9a	Government subsidized demonstration program
#9b	The government would seek an agreement with automobile manufacturers to provide a fleet of vehicles equipped with automatic restraints
#9c	Mandatory demonstration program
#10	Retrofit Program

This chapter presents a comprehensive summary of the major issues surfaced in comments at the 12/83 public hearings, in docket responses to both the 10/83 NPRM and the 5/84 SNPRM, as well as in the Department's examination of these proposals. For each alternative, a brief description of arguments both in favor of and against its selection is presented, followed by a summary of the positions taken by interested parties in their public comments.

Alternative #1: Require Air Bags for All Front Seat Occupants

Pros:

o Would ensure a usage rate of near 100 percent for drivers and passengers. Even those hard core non-users of belts, who may be overinvolved in serious accidents, would be protected in frontal crashes. (Note that this "usage" rate is for air bags, not lap belts or lap/shoulder belts which would accompany an air bag system and which we have assumed would be used at a level near the current level of belt usage.)

o Significant safety benefits. Would save 4,410-8,960 fatalities and 83,480-152,550 moderate to critical injuries per year, assuming 12.5 percent usage of lap belts with the air bag systems.

o Insurance premium reductions are estimated to be $76-158 over the car's lifetime (present discounted value).

o In frontal crashes, provides protection at higher speeds than safety belts and protects against some injuries that are particularly costly and debilitating (e.g., brain and facial injuries) which belts may not be as effective in preventing.

o Encourages continued development of air bag technology, which could result in more effective and less costly air bags.

o Avoids objections about obtrusiveness of alternatives under which continuous automatic belts would be installed and avoids objections to the government mandating the use of safety belts.

Cons:

o Increase in retail price, $320, might adversely affect auto sales, profits and employment in the short run. Net lifetime consumer cost is estimated to be $206-288.

o Surveys indicate a significant degree of fear or misunderstanding among those parts of the public that oppose air bags.

-- People have fears about alleged hazards associated with air bags, e.g., inadvertent activation. Repair personnel also fear inadvertent deployment while they are working on car interior.

-- People are concerned about reliability of air bags.

-- The cost could create a negative attitude towards air bags and government regulation.

-- Equity argument for current belt users -- very little additional protection is achieved at much greater cost.

o Questionable authority to mandate air bags given statutory requirement for performance standards.

o Necessary Leadtime longer for this alternative than for other automatic restraint alternatives.

o Possible technological problems with air bags in small cars and with out-of-position occupants.

o Some manufacturers believe that air bag tests are not sufficiently repeatable to enable manufacturers to assure themselves of compliance.

o Must use lap or lap/shoulder belts for the most effective occupant protection. When belts are not used in conjunction with air bags, air bags provide less protection than manual three-point belts (when used).

o Repair shops are concerned about potential liability for failure of a car's air bags after repair work on car.

o Possible dangers posed by persons tampering with unfired sodium azide canisters and by scrapping cars with unfired canisters.

Generally, this alternative is supported by the insurance industry, medical and health organizations, and many consumer groups. Support from these groups stems primarily from the feeling that it offers the highest potential safety benefits. Both health and insurance organizations point out that air bags are the most effective safety device in the more serious accidents, and that they would be the most effective way of combatting the most debilitating forms of injury, such as head and spinal column injuries. Especially strong support was indicated by Allstate Insurance, The Center for Auto Safety, Joan Claybrook--of Public Citizen, The Insurance Institute for Highway Safety, Ralph Nader--of Center for the Study of Responsive Law, National Head Injury Foundation, and Nationwide Insurance. Many supporters of air bags also support requirements for automatic restraints in other forms such as automatic belts. Commenters that supported air bags but focused their support primarily on automatic restraints in general include Consumers Union, James P. Corcoran (Superintendent of Insurance, NY), National Safety Council, Dr. William Nordhaus--Professor of Economics at Yale University--commissioned by a group of insurance companies, and State Farm Insurance. Some individual consumers also commented in favor of air bags.

Opposition to an air bag requirement was expressed by the automobile industry, automobile dealers, and one consumer group. The basis for this opposition is primarily the contention that higher costs associated with these devices will have adverse impacts on sales and employment, that the devices are untested and may create hazards of their own, and that much cheaper ways are available for achieving the same safety benefits. Numerous comments from individual consumers also express fear and insecurity about air bag performance. Commenters including GM, Ford, Chrysler, Nissan, Honda, VW, the National Automobile Dealers Association, the Automobile Importers of America, the Motor Vehicle Manufacturers Association, and the Pacific Legal Foundation submitted arguments against requiring air bags. Most groups opposing air bags favored mandatory belt use laws as an alternative method of achieving improvements in highway safety. Notably, Ford Motor Company supports the idea of equipping a test fleet with automatic restraints, including air bags, in order to determine both consumer acceptance and performance of these devices.

Alternative #2. Require Automatic Protection for All Front Seat Occupants However, Detachable Belts are Not Allowed

Pros and Cons assume non-detachable belts will be used in most cars.

Pros:

o Eliminates detachable automatic belts, whose usage rate is the most uncertain.

o Compared to the air bag only alternative, would be less expensive to manufacturers and consumers. Also would avoid possible problems associated with developing air bags for small cars.

o Insurance premium reductions of $7-22 over the car's lifetime, assuming belt usage of 20 percent, and $100-144 assuming usage of 70 percent.

o Could result in significant safety benefits, depending upon belt usage. At 20 percent usage, 520 to 980 fatalities and 8,740 to 15,650 AIS 2-5 injuries could be reduced. At 70 percent usage, 5,030 to 7,510 fatalities and 86,860 to 124,570 AIS 2-5 injuries could be reduced.

Cons:

o Air bags would probably be installed in a low percentage of cars, with the result that economies of scale could not be achieved and high prices would be charged for air bags.

o Public acceptance:

-- Some people may find non-detachable automatic belts uncomfortable, inconvenient, and obtrusive.

-- Obtrusiveness of non-detachable automatic belts might hamper car sales.

-- Some people may fear entrapment by non-detachable automatic belts.

-- Defeat by hard core non-users (e.g., cutting the belt) could result in original and subsequent owners and passengers being deprived of the opportunity to use belts.

o Public clamor about non-detachable automatic belts, the most coercive type of automatic restraint, could damage other safety initiatives.

o Public unfamiliarity with egress mechanisms may result in some cases of entrapment.

o Current manual belt users might argue that automatic belts offer no additional protection, but could cost more over the car's lifetime and might be inconvenient and obtrusive.

o Opponents might argue that it is improper for the government to coerce citizens into saving their own lives. Similar arguments have been used to overturn motorcycle helmet laws.

o Might lead manufacturers to eliminate center front seat because there is no commercially developed technology to provide an automatic belt for that seat. Even if front center seat is exempt from the standard, manufacturers may eliminate this seating position since there is no easy way of entering this seating position with a non-detachable belt.

o No way to be certain how much usage would increase.

Requirements for automatic belts are generally favored by the insurance industry, medical and health organizations, and most consumer groups. Some of these organizations expressed a preference for air bags over automatic belts, but most favored automatic belts over the status quo or State use laws. Generally, supporters of automatic belts view these devices as an effective and inexpensive method of reducing fatalities and injuries. The issue of belt detachability was only addressed by a few supporting commenters. Overall it appears that supporters view automatic belts as effective safety measures in either detachable or non-detachable versions.

Requirements for automatic belts are opposed by the automobile industry, automobile dealers, and one consumer group. As with air bags, these groups contend that automatic belts will raise costs unnecessarily, and that there is a more effective method of improving highway safety; i.e., seat belt usage laws. A further contention of opponents is that automatic belts will be rejected by consumers for either convenience considerations, fear of entrapment, or philosophical objections and therefore, will not result in significant safety improvements. On the question of belt detachability, opponents of automatic belt systems generally felt that non-detachable belts might offer some short term usage improvement over detachable belts, but that there could be more adverse public reaction to the nature of non-detachable belts and the increased difficulty of emergency egress with such systems. Over the long-run they believe usage rates would be roughly the same for either system. For these reasons many manufacturers indicated that they would not equip their cars with non-detachable automatic belts if they were free to choose between detachable and non-detachable automatic belts.

Alternative #3: Require Automatic Protection for All Front Seat Occupants Detachable Belts Are Allowed

(This is a reinstatement of the existing standard.)

Pros and Cons assume detachable belts will be used in most cars.

Pros:

o Could result in significant safety benefits, depending upon belt usage. At 20 percent usage, 520 to 980 fatalities and 8,740 to 15,650 AIS 2-5 injuries would be reduced. At 70 percent usage, 5,030 to 7,510 fatalities and 86,860 to 124,570 AIS 2-5 injuries would be reduced.

o Should be the least objectionable automatic restraint requirement to those who oppose automatic restraints. Over the long run, would provide greatest flexibility for manufacturers and consumers in selecting type of automatic restraint systems.

o Detachability should alleviate some consumer concern about automatic belts and governmental involvement in the consumer's decision about belt usage.

o Would result in real-world data to evaluate usage and effectiveness of detachable automatic belts.

o Would be less expensive to manufacturers and to consumers than would an all air bag rule.

o Insurance premium reductions of $7-22 over the car's lifetime, assuming belt usage of 20 percent, and $100-144 assuming usage of 70 percent.

Cons:

o Could result in consumers only being offered detachable automatic belts, the type of automatic restraint with the most uncertain usage. (It is estimated that nearly all manufacturers would meet the standard with belts if required in the near future.) Additional lifetime expenditures ($51 per car) would be made for what may be relatively small safety benefits.

o Current manual belt users could argue that automatic belts would offer no additional protection, but would cost more.

A discussion of the positions taken by interested parties is included under Alternative #2.

Alternative #4: Rescind the Requirements for Automatic Restraints

Pros:

o Avoids requiring an increase in cost to manufacturers and price to consumers.

o Public acceptance:

- Avoids government forcing public to buy automatic restraints.

-- Avoids forcing current manual belt user to pay more for little, if any additional protection.

o Allows manufacturers choice of whether and when to introduce automatic restraints on any of their models.

o When used, manual belts are as effective (or even more effective) than air bags or automatic belts.

Cons:

o Would not decrease deaths and injuries.

o In view of the State Farm, Supreme Court decision, requires better justification than was used in 1981 for rescission; the Department did not obtain data to support such justification during the public comment period.

o Public acceptance:

-- Consumers wishing to purchase automatic restraints likely to have more limited range of models to choose from, especially in the case of air bags.

o Would lessen incentives to pursue the development and marketing of automatic restraint technology.

Rescission of the automatic restraint standard was generally favored by the automobile manufacturers, automobile dealers, and one consumer group. In most cases, support for rescission was based on the contention that the effectiveness of regulatory solutions has not been adequately proven, that such requirements would be costly and ineffective and that they would be rejected by consumers and that satisfactory procedures for determining compliance did not exist. Criticism of regulatory solutions was, in many instances, coupled with support for other non-vehicular actions, especially for State laws mandating the use of existing belts. Many opponents of regulatory solutions view this as the most efficient and effective way of achieving improvements in highway safety. Numerous consumer comments were also received favoring rescission of the standard.

Generally, the same commenters that opposed automatic restraints supported the rescission option (although support for rescission was frequently implicit rather than the focus of comments). However, Ford Motor Co. argued for a suspension of several years, rather than a rescission of the standard. Under Ford's proposal, during the suspension a test fleet would be equipped with automatic restraints to determine consumer acceptance and performance of these devices. The ultimate decision to rescind or regulate would then be made in light of the experience of the test fleet.

Opposition to rescission was implicit in arguments favoring various forms of automatic restraints. Overall, opposition was expressed by the insurance industry, medical and health organizations, most consumer groups and numerous individuals. These groups cite the potential injury and loss of life that could be prevented by automatic restraints as arguments against rescinding FMVSS 208. They tend to view mandatory State usage laws as inadequate due to the uncertainty over their passage and enforcement.

Alternative #5: Center Seating Position and Driver Only Sub-Alternatives

Pros of Requiring Automatic Protection for Center Seating Position

o Provides all front seat occupants with automatic protection.

o Avoids objections about not providing all front seat passengers with the same type of protection.

Cons of Requiring Automatic Protection for Center Seating Position

o Only 1.5 percent of front seat fatalities and injuries are projected for the center seating position.

o Could result in the elimination of the center seating position if manufacturers did not install air bags. Loss of that position could cause consumer backlash. Air bags would raise costs.

o Ford indicated the center seat may be eliminated even in air bag cars due to problems with out-of-position occupants.

As discussed previously, comments to the Docket on the center seating position by Ford, AMC, Consumer's Union, and the American Automobile Association, favored exempting the center seat position from the standard in order to retain six-seat cars. One commenter argued that the center seat position should not be exempt from the standard since young children were frequently injured in this seating position. While this is true, Child Restraint Laws are now in place in 46 states and have already started to reduce the high percentage of young child fatalities in the center seat position.

Pros of Requiring Driver Only Automatic Restraints

o Is the most cost beneficial approach since 73 percent of the fatalities occur to drivers while only 50 percent of automatic belt costs and 64 percent of air bag costs are attributable to the driver.

Cons of Requiring Driver Only Automatic Restraints

o All front seat occupants might not be protected by similar restraint systems.

There were very few comments to the docket regarding driver only alternatives. Professor Nordhaus (74-14-N35-079) concluded in his analysis that any automatic restraint in any seating position would be cost beneficial. Thus, all seating positions should be covered. John Graham, of Carnegie Mellon University, (74-14-N35-063) favored the driver only alternatives because they were the most cost beneficial. Others suggested the driver only alternatives might be a good way to introduce air bags initially without the full cost.

Alternative # 6 -- Driver-side Only Air Bags for Small Cars: One of the alternatives proposed by the SNPRM would require that air bags be installed on the driver side of small cars only. It assumes that air bags would be the basis for compliance in these positions and vehicles, rather than a supplemental system to the safety belt. Under this alternative, the final rule could prescribe either manual belts or any type of automatic restraint for the other seating position in small cars and all seating positions in all other cars. The basis for proposing this alternative is the perception that small cars are less safe than larger vehicles and the fact that drivers account for three-fourths of all front seat fatalities in automobile accidents. By requiring air bags only in those vehicles and positions where potential safety benefits are maximized, significant cost savings can be accomplished. The SNPRM did not define "small cars," however, and asked for comment as to which criteria would be appropriate for this purpose.

Pros:

- o Would provide a high level of potential protection for those vehicles and seating locations that are most likely to involve injury to occupants.

- o Relative to full frontal air bag requirement for all cars would allow significant cost savings to consumers.

- o Would assure that new vehicle fleets have a variety of driver restraint systems, thus allowing consumers to choose the restraint system they prefer.

- o Would accelerate air bag development by improving public awareness of air bags and providing additional information on effectiveness.

Cons:

- o Would not assure automatic protection for other front seat occupants, accounting for a quarter of all small car front seat fatalities.

- o Would not provide automatic protection for larger cars.

- o May result in higher per unit costs for air bags due to lower production volumes.

- o Would require longer leadtime than automatic restraints, which would delay safety benefits.

- o Added cost of air bag may hurt small car sales and decrease fuel efficiency of the fleet.

This alternative was generally opposed by both the automobile and the insurance industry but for different reasons. The automobile industry was unanimous in its disapproval, citing damage to small car sales and CAFE requirements, limitations in air bag technology, and lack of justification for requiring air bags on any specific kind of vehicle. Opposition from the insurance industry generally focused on the failure of this alternative to provide automatic protection for occupants of large vehicles and for other front seat occupants. Other commenters, including state and local governments, dealer associations, independent researchers, and the general public were overall but not unanimously opposed to this alternative, usually for the reasons cited above by the automobile and insurance industries. Only one commenter, John Graham, a Harvard economist, unequivocally favored this alternative. His reason was that it provided the most favorable benefit/cost ratio.

Alternative # 7a -- Mandatory Seat Belt Usage Laws: This alternative would require action by state legislatures to pass laws requiring that seat belts be used. To be effective, these laws would probably have to be coupled with an effective enforcement program. The Department's role in this alternative would be limited to providing incentives for state action. Because of uncertainty regarding the number of states that would pass such laws and the levels of compliance, the precise level of benefits associated with this alternative cannot be determined.

The Supplemental Notice of Proposed Rulemaking proposed two alternatives relative to mandatory seat belt use laws. These are:

Alternative # 7b -- If any state passed a mandatory use law, a waiver from the automatic restraint requirements would be granted for cars sold to residents of that state.

Alternative # 7c -- Automatic occupant restraints would be required in all cars manufactured after a set date unless 75 percent of the states pass mandatory use laws.

The Department would issue minimum criteria for each state's mandatory use law as follows:

1) A requirement that all front seat occupants in passenger cars be restrained.

2) A prohibition of waivers from the mandatory use law, except for medical reasons.

3) A program that includes such things as:

   a) A penalty of $25 or more.
   b) Civil litigation penalties; a reduction in damages a person may recover from injuries in litigation.
   c) Education programs.

d) The posting of roadside signs notifying motorists of the seat belt use law.

e) An evaluation program.

In addition, the Department indicated that it would be necessary for the manufacturers to submit reports to the Department certifying that they were making steady progress towards the installation of automatic restraints.

Alternative # 7a -- Mandatory Use Laws (MULs), In General.

Pros:

o MULs affect the whole fleet of cars initially rather than just new cars. Thus, MULs would provide more immediate and short term benefits than automatic belts.

o MULs would not raise the price of new cars.

o MULs maximize the use of 3-point manual belts which provide the highest overall level of effectiveness in reducing deaths and injuries.

o MUL's have increased usage considerably in other countries; they should logically increase usage by a large margin in the U.S. as well.

Cons:

o The number of states that would pass a MUL is not certain.

In general, the automobile manufacturers favor MULs as the alternative that is the most effective, in terms of safety, the most cost-effective, and provides the highest benefits in the short run.

MULs are viewed by the automobile manufacturers as a replacement for an automatic restraint requirement. They believe the federal government should provide incentives for state passage of MULs. Ford favored MULs and a demonstration program, saying they are not mutually exclusive. GM favored MULs and proposed a passive interior alternative, discussed earlier in Chapter III--Issues.

The insurance companies, in general, the Institute of Transportation Engineers, Public Citizen, and a number of commenters from state governments believe that automatic restraints and MULs complement each other very well. They favor reinstating FMVSS 208 and then providing incentives for States to enact MULs. Automatic belts could be seen as a method of assisting and ensuring compliance with MULs. Allstate, IIHS, State Farm, and Public Citizen expressed their view that reliance on an MUL alone is contrary to the Department's mandate and statutory authority. Other commenters stated that there were so few states that would pass a MUL that it was not a usable alternative, or that a national MUL would be preferable to state by state MULs.

Alternative # 7b -- States passing MULs would get a waiver from the automatic restraint requirement.

Pros:

- MULs provide immediate benefits for all cars in states that pass these laws rather than just for new cars.

- New car purchasers in states with MULs would save money compared to an automatic restraint requirement.

Cons:

- Manufacturers would have to make the initial investment necessary for automatic restraints, regardless of specific requirements in individual states.

- Would result in a two-car system, increasing costs and administrative burdens for the manufacturers.

- There is no high level cut-off point as in alternative 7c. If 48 states passed MULs, the manufacturers would still have to have two different restraint systems.

- o Dealers with interstate market areas would encounter difficulties in ordering and stocking cars, model availablity, and assuring the sale of properly configured vehicles. Field inventory flexibility may be constrained if cars cannot be moved between states.

- o Changes in buying habits may develop along state lines.

  -- An "almost new" used car market may develop between states. This can be somewhat controlled at the dealer level by defining "new" car as one with up to 3,000 miles on it.

  -- Consumers from a state with a mandatory use law, who want to purchase an automatic restraint car, might have to buy it in another state.

  -- Used manual belt cars might be shipped to automatic restraint states for sales as was prevalent with the California emission standards.

- o It would be difficult to police interstate sales.

While nearly all commenters favor MULs, this particular approach was opposed by almost all commentors.

The automobile manufacturers were generally opposed to this alternative for a number of reasons:

- o Leadtime--Peugeot stated: Because there is no state decision deadline and a two-year leadtime, automatic restraints will be put on all cars initially whatever the states decide.

- o Production, inventory, and sales problems.

- o MVMA stated the effect of incentive or disincentive to MUL state passage is hard to predict. It may result in legislators debating the merits of both systems, resulting in delays in obtaining MULs.

- o Manufacturers' reports are an unnecessary burden--if they don't supply automatic restraints, they can't sell the cars; thus progress is ensured without the need for such reports.

- o GM stated the two car strategy would be extremely costly and disruptive to normal commerce.

The insurance companies also opposed this alternative, some stating that it would violate Congress' mandate to prescribe uniform national standards and that it was unlawful.

The Institute of Transportation Engineers said that state by state MULs would undermine public acceptability of automatic restraints. John Graham indicated that a waiver should be contingent on manual belt usage (however achieved), not passage of a law.

Commenting state representatives generally did not like the way this alternative positioned federal automatic crash protection against state mandatory use laws. This would advance the belief that automatic restraints and seat belt use are mutually exclusive, which is especially damaging for air bags. They also believed that setting federal criteria for state MULs was inappropriate--that the proposed criteria should be guidelines. Generally, they opposed the alternatives on the grounds that the re-imposition of FMVSS 208 and state MULs were not mutually exclusive, that Federal involvement in state MULs is inappropriate, and that specifying criteria would only inhibit passage of such laws.

Alternative # 7c -- Rescission of automatic restraint requirement if 75% of the states enact MULs.

Pros:

- o MULs affect the whole fleet of cars initially rather than just new cars. Thus, MULs would provide more short term benefits and, if all states passed MULs, the same or more long term benefits as automatic belts.

- o If the required number of states passed MULs, manual belts which add no new cost to a car could continue to be installed.

- o This alternative would not result in the two-car system, with the identified problems as discussed in alternative # 7b.

Cons:

- o A short leadtime for FMVSS implementation could force the manufacturers to make the investment necessary for automatic restraints. If 75% of the states then passed MULs, this investment would be wasted.

- o Could result in some states having neither MULs nor automatic restraints.

- o Because states could repeal MULs, a reinstatement of an automatic restraint requirement would involve a long leadtime and would delay potential benefits.

Several manufacturers suggested changes to the leadtime proposed for this alternative. BMW and Ford suggested a separate state decision deadline before tooling commences so that investments would not be wasted. Some manufacturers suggested progress milestones (e.g., if 10% of the states pass an MUL by 1986, the compliance date for manufacturers would be delayed). This progress milestone leadtime alternative was advanced based upon the child restraint experience, which started slowly with Tennessee passing the law in 1977, Rhode Island in 1980, seven more states in 1981 and 46 states as of June 1984. Some of the manufacturers supported a policy of cancelling the automatic restraint requirement if belt use reached a specified level. As with the previous alternative, the manufacturers oppose reporting requirements, oppose federal MUL criteria, and favor federal incentives as proposed in Congressman Dingell's bill.

Several of the insurance companies stated this alternative was contrary to DOT's mandate and authority. Professor Nordhaus argued that the manufacturers would take the least costly approach, hoping that 75% of the states would pass MULs, resulting in poorly designed and under tested systems.

John Graham argued that the 1974-76 experience suggests the states won't be enticed to pass MULs even with incentives. He claims there is no reason to believe that an automatic restraint waiver is more enticing than incentive funds. Also, he claims under the 75% rule that no single state would have an incentive to pass an MUL unless many other states acted first, or enough other states would go along.

Alternative # 8 -- Mandatory Consumer Option: Under this alternative, the Department would seek legislation requiring automobile manufacturers to provide consumers with the option of selecting automatic restraints in some of their models.

Pros:

- Would allow for the development of real world data on both restraint effectiveness and consumer acceptance.

- Would allow consumers the choice of selecting either automatic or manual belts.

Cons:

- Data on restraint effectiveness obtained from this approach would be of limited value because sample of owners would consist of voluntary buyers and would thus be self-selecting towards those members of the public who are more safety conscious.

- Data on public acceptance might similarly be flawed. Because of low volume production, restraint prices would be high and this may discourage many persons who would participate at lower prices.

- Implementation of this approach would be uncertain because Congressional action would be required.

No significant support was expressed for this alternative in the public docket.

Alternative # 9 -- Demonstration Programs: There were three separate demonstration programs considered in the NPRM or SNPRM -- a) the government would subsidize a special fleet of vehicles equipped with automatic restraint systems; b) the government could seek an agreement with automobile manufacturers to provide a fleet of vehicles equipped with automatic restraints; or c) a mandatory demonstration program -- as proposed in the SNPRM based on Ford's proposal.

Alternative # 9a -- <u>Government Subsidized Fleet</u>: Likely participation in a subsidized fleet program would include state and Federal Government agencies, insurance companies, or other corporate fleet operators.

<u>Pros:</u>

- Would allow the public to become more familiar with automatic restraints.

- Would increase field experience and data relevant to public protection.

<u>Cons:</u>

- Information obtained from these groups would not exactly replicate the experience that could be considered typical of the average driver. Even fleet operators would not typically have the high risk night time driving. Thus, this would only provide limited nationally representative data.

Alternative # 9b -- <u>The government would seek an agreement with automobile manufacturers to provide a fleet of vehicles equipped with automatic restraints.</u>

<u>Pros:</u>

- Would allow the public to become more familiar with automatic restraints.

- o Would increase field experience and data relevant to automatic protection.

Cons:

- o Since participation in this program is voluntary, the implementation and adequacy of the program is questionable.

- o If used alone might not satisfy the requirements of the State Farm Supreme Court decision.

Alternative # 9c -- Staged Mandatory Demonstration Program: Manufacturers would be required to equip a fixed percent of their cars sold in the United States with automatic restraints. The requirement would apply for four consecutive model years. Accident and operating experience would be closely monitored over a 5-year period, the principal objectives being to gauge the casualty-reducing effectiveness of air bags, the usage of automatic belts over time, and the operational problems and public reaction to both systems.

Pros:

- o Would resolve many of the uncertainties we now have about air bag effectiveness, automatic belt usage and public acceptance of automatic restraints.

- o Avoids the possibility of another ignition interlock or Standard 121 - the mandate of an insufficiently tested safety device which may turn out to be marginally effective or unacceptable.

Cons:

- o Possible difficulties in selling the cars equipped with automatic restraints, when comparable cars can be bought without them.

- o Unit costs of equipping less than all cars with automatic restraints might be higher than full implementation, especially for manufacturers with low sales volume in the United States.

- o Without assurances that a portion of the cars in the program will have air bags the demonstration will not achieve clear-cut results on air bag effectiveness.

- o Without assurances that a large percent of a particular model would be equipped with automatic belts, the self selection bias may result in the demonstration program not achieving clear-cut results on automatic belt usage (see "guidelines" below).

The proposed demonstration was favored in principle (at 5 percent of each manufacturer's fleet) by many auto manufacturers as providing necessary data on effectiveness and public acceptance and it was opposed by insurance companies as resulting in unnecessary delays.

Although most manufacturers (Ford, AMC, Chrysler, Mazda, Volvo, VW, Peugeot, Mercedes, BMW) favor a demonstration program, at least compared to reinstatement of FMVSS 208, there was widespread opposition to the specifics of the proposal discussed in the SNPRM. Many of the smaller manufacturers did not object to a demonstration program as long as it only applied to larger companies, AMC, Lotus, and Renault took this position. Conversely, Toyota said any demonstration must include all companies.

Many companies (including Ford, BMW, AMC, Chrysler, Volvo, Toyota) favored a demonstration program but only if the choice of automatic restraints was left to the manufacturer and could be limited to the driver side only or if the test procedures were changed as Ford desired or waived altogether.

Nissan, GM and Chrysler questioned whether they could voluntarily sell even 5 percent of their cars with automatic restraints. GM also doubted whether a demonstration would answer the questions of public acceptability and cost. Saab called the program unrealistic, claiming it would only prolong uncertainty while Mazda, Volvo, and Ford favored the program as proposed. However, Ford stated that they envisioned a program that would result in an average of 5 percent of their fleet being equipped with automatic restraints over a 4-year period, not necessarily 5 percent per year. Th type of program may lengthen the evaluation time frame. Nissan could participate if it had 30 months leadtime while Chrysler said it could participate beginning in September 1986 but only for a 2-year (not 4-year) period.

Insurance companies (Allstate, State Farm, NAII) characterized this option as an unnecessary delay and claimed there have already been sufficient "demonstrations" of air bags (GM and Mercedes) and automatic belts (GM, VW, and Toyota). Allstate questioned DOT's authority to deny safety benefits to the car owners not involved in the program. The Insurance Institute for Highway Safety felt the program could be a useful supplement to an automatic restraint rule.

The Institute of Transportation Engineers also called the program unwarranted as did NADA, Professor Nordhaus, and several individual economists. Nordhaus also wondered what, if anything, would be demonstrated by a program with a selection bias (i.e., only those who desire automatic restraints will purchase them).

The State of Washington and the American Seat Belt Council agreed with having a demonstration program but they also supported the implementation of FMVSS 208.

Alternative # 10 -- Require Air Bag Retrofit Ability: This alternative would require that all passenger cars have steering columns and passenger side instrument panels that can be easily modified to accept the aftermarket installation of an air bag system.

Pros:

- Would enable consumers to voluntarily purchase air bag systems and have them installed after vehicle purchase.

- Would make air bags available to those who want them without imposing the full cost of these systems on other buyers.

Cons:

- Would minimize the safety benefits that could result from automatic restraints.

- Since purchase would be voluntary, only the most safety conscious members of society would participate. Drivers who are less concerned with safety, and thus more likely to have a serious accident, would not benefit from this option.

- Installation would be conducted by numerous outlets using personnel with various levels of expertise. This could increase the possibility of improper installation and could result in deployment failures.

- o Prices would increase on all passenger cars, regardless of air bag installation.

- o Aftermarket sales of air bags may be low, resulting in high costs for each driver.

Comment on the retrofit option was limited. Breed Corporation indicated that retrofit would be practical and would allow installation at either the manufacturer, the dealer, or at a service center. Automobile manufacturers pointed out cost problems, especially with low installation rates, and the unproven performance of this type of air bag system.

Selected Alternative

The selected alternative is a reinstatement of the automatic restraint requirements. If mandatory use laws are passed that will cover 67 percent of the population effective September 1, 1989, the rule will be rescinded. In addition, center front seats are exempt from the requirements of the standard.

Following is the implementation schedule:

September 1, 1986	10%
September 1, 1987	25%
September 1, 1988	40%
September 1, 1989 & thereafter	100%

During the MY 1987-89 implementation, manufacturers would be given a credit equal to one and a half car for each car equipped with air bags and other non-belt automatic occupant protection systems.

The selected alternative maximizes the benefits of several major alternatives.

Specifically:

The potential benefits of mandatory use laws (MULs) are substantial. As discussed in Chapter VI of the FRIA, MULs can provide large immediate benefits because they cover the in-use fleet as well as new production vehicles. This alternative encourages passage of MULs and provides the impetus for prompt action by states interested in this approach.

In addition, the benefits of automatic crash protection are realized beginning in MY 1987.

Voluntary use of the manual belts that are already in passenger cars is also expected to rise as a result of growing public understanding of the value of belt use in general and automatic restraints in particular. These same factors, together with additional publicity about automatic restraints and the gradual phase-in of these devices, will allow the public to become more familiar with both the use and importance of automatic restraints. Thus, all three approaches - MULs, voluntary usage and automatic restraints will be influenced by this alternative.

Finally, the standard is written to provide manufacturers with incentives to develop a variety of restraint systems. This will allow consumers to choose from different restraint technologies and will encourage development of unobtrusive occupant protection systems and new occupant safety technologies.

XIII. NET IMPACTS OF AUTOMATIC RESTRAINT DEVICES

This chapter compares the benefits and costs of air bags and detachable and non-detachable automatic belts. It also compares safety benefits and costs by seating position. Insurance premium reductions and dollar costs (retail price and fuel cost increases) are combined to provide a lifetime direct net dollar cost per car to the vehicle owner. As explained previously, total potential "societal" cost savings are not shown in this analysis, but are discussed in Appendix 1.

Table XIII-1 presents the benefits (safety benefits and insurance premium reductions) and costs (retail price increases and fuel costs) of air bags and automatic belts by seating position. Costs and insurance premium reductions are analyzed on a per car basis.

Table XIII-2 presents a breakeven analysis that shows the automatic belt usage levels at which insurance premium reductions offset retail price and fuel costs. The results of these analyses indicate the following:

Air Bags

Air bags for all front seating positions, with lap belts used at current usage rates, are estimated to save 4,410 to 8,960 lives and 83,480 to 152,550 AIS 2-5 injuries per year. Lifetime costs are $364 per car for full front air bags. Lifetime insurance premium reductions (assuming lap belts are used by 12.5% of the occupants) are $76-158. The lifetime net dollar costs after insurance premium reductions are subtracted from air bag costs are $206-288. If installation of air bags caused passengers to ignore their lap belts, safety benefits would be reduced, insurance premium discounts would not be as large, and the net lifetime cost would increase slightly to $210-298.

If air bags were only installed in outboard positions, the slight reduction in both costs and benefits would reduce net lifetime costs slightly to $199-280 at current seat belt usage rates.

Supplying an air bag for the driver position only would cut both costs and benefits dramatically with benefits dropping roughly 27 percent and costs dropping 36 percent (from full front requirements). The net effect would be a drop in lifetime costs to $128-188 at current belt usage rates.

Overall, examining cost and benefits by seating position shows that for air bags, the driver will get 73 percent of the benefits while incurring 64 percent of the net costs. Thus, supplying the driver with an air bag is more cost effective than for the other two positions.

Automatic Belts

Data in Table XIII-1 reflect a range of possible results depending on usage rates for an all-automatic belt equipped fleet (with the center seat exempted). See Chapter V for a discussion of the methodology used to set the bounds of the automatic belt usage range--20% to 70%. At 20 percent usage, an estimated 520 to 980 fatalities and 8,740 to 15,650 AIS 2-5 injuries could be reduced, while at 70 percent usage, an estimated 5,030 to 7,510 fatalities and 86,860 to 124,570 AIS 2-5 injuries could be reduced.

For driver and right front automatic belts (center seat exempted) lifetime costs are $51 per vehicle. At 20 percent usage, lifetime insurance premium reductions are $7-22 per car resulting in a net dollar cost of $29-44 per car. At 70 percent usage there would be a net dollar savings of $49-93 per car.

Supplying an automatic belt for the driver only would have a significant effect on both costs and benefits. Net lifetime costs are $18-26 per car at 20 percent usage, and net lifetime savings are $39-73 at 70 percent usage.

Table XIII-2 shows that for automatic belts (driver and front right passenger -- center seat exempt), the lifetime insurance premium reductions pay for the lifetime costs at 32-44 percent belt usage (32 percent if automatic belts are 50 percent effective, 44 percent if they are 35 percent effective). That is, if automatic belt usage increased to 32-44 percent, or above, there would be a net dollar savings over the lifetime of the car by requiring automatic belts. Air bag systems do not attain similar breakeven points. The estimated lifetime cost of a full front air bag system is $364, while lifetime insurance premium reductions range from $76-158. As discussed in the Summary, these are not "societal" breakeven points as they do not include lost productivity, etc.

TABLE XIII-1

SUMMARY OF SAFETY BENEFITS AND NET DOLLAR COSTS OR BENEFITS FOR AIR BAGS AND AUTOMATIC BELTS (COSTS ON A PER CAR BASIS)

	----SAFETY BENEFITS----				
	FATALS	AIS 2-5 INJURIES	INCREMENTAL LIFETIME COSTS	LIFETIME INSURANCE PREMIUM REDUCTIONS	LIFETIME NET DOLLAR COST OR (BENEFITS)
Full Front Air Bag With Lap Belt					
No Usage of Lap Belt	3,780-8,630	73,660-147,560	$364	$66-154	$210-298
12.5% Usage of Lap Belt	4,410-8,960	83,480-152,550	364	76-158	206-288
Driver and Front Right Air Bag with Lap Belt (Center Seat Exempt)					
No Usage of Lap Belt	3,710-8,490	72,480-145,408	354	64-151	203-290
12.5% Usage of Lap Belt	4,340-8,810	82,260-150,370	354	74-155	199-280
Driver Air Bag with Lap Belt					
No Usage of Lap Belt	2,680-6,250	56,330-114,370	232	36-100	132-196
14.0% Usage of Lap Belt	3,200-6,520	64,820-118,680	232	44-104	128-188
Driver and Right Front Automatic Belt (Center Seat Exempt)					
20% Usage	520-980	8,740-15,650	51	7-22	29-44
70% Usage	5,030-7,510	86,860-124,570	51	100-144	(49)-(93)
Driver Automatic Belt					
20% Usage	270-580	5,260-10,370	26	0-8	18-26
70% Usage	3,610-5,440	67,160-96,770	26	65-99	(39)-(73)

Note: ( ) means dollar benefits (insurance premium reductions) exceed dollar costs.

TABLE XIII-2
BREAKEVEN POINTS ANALYSIS OF
NET DOLLAR COSTS

	---SAFETY BENEFITS---		INCREMENTAL LIFETIME COSTS	LIFETIME INSURANCE PREMIUM REDUCTIONS	LIFETIME NET DOLLAR COST OR (BENEFITS)*
	FATALS	AIS 2-5 INJURIES			
Air Bag with Lap Belt at 12.5% Usage	4,410-8,960	83,480-152,550	$364	$76-158	$206-288
Driver and Right Front Automatic Belt (Center Seat Exempt)					
20% USAGE	520-980	8,740-15,650	51	7-22	29-44
30%	1,420-2,280	24,370-37,440	51	25-46	5-26
40%	2,320-3,590	39,990-59,220	51	43-71	(20)-8
50%	3,230-4,900	55,610-81,000	51	62-95	(11)-(44)
60%	4,130-6,200	71,240-102,790	51	80-120	(29)-(69)
70%	5,030-7,510	86,860-124,570	51	100-144	(49)-(93)

Note: ( ) means dollar benefits (insurance premium reductions) exceed dollar costs.

* The breakeven point range for automatic belt usage is 32-44%. At this point, insurance premium reductions equal lifetime costs.

XIV CONCLUSIONS

After a thorough review of the issue of automobile occupant protection, including the long regulatory history of the matter; the comments on the Notice of Proposed Rulemaking (NPRM) and the supplemental Notice of Proposed Rulemaking (SNPRM); the extensive studies, analyses, and data on the subject; and the court decisions that have resulted from law suits over the different rulemaking actions, the Department of Transportation has reached these conclusions:

- After assessing the data now available to it, the Department has revised its 1981 analysis concerning the likelihood of increased usage if automatic detachable belts are installed to meet FMVSS 208; it cannot project either widespread usage, or a widespread refusal to use such systems by automobile occupants.

- While it is clear that airbags will perform as expected in virtually all cases, it is also clear that the effectiveness of the airbag system is substantially diminished if the occupant does not use a belt. Consumer acceptability is difficult to predict, with the major variable being cost, fear, and the unobtrusiveness of airbags.

- Nondetachable automatic belts may result in sharply increased usage, but there may also be substantial consumer resistance to them.

- The installation of automatic occupant protection in passenger cars may significantly reduce both fatalities and injuries.

- The costs of the existing automatic restraint systems are reasonable, and the potential benefits in lives saved, injuries reduced in severity and costs avoided are substantial.

- Technologically, the systems are feasible and practicable.

- Effectively enforced state mandatory seatbelt use laws (MULS) have the potential for providing the greatest safety benefits of any of the alternatives at little or no additional cost over the current cost of installing occupant restraints (primarily manual belts) in new cars.

- Automatic occupant restraints provide such clear safety benefits that, unless a sufficient number of MULs are enacted, they must be required in all passenger automobiles.

- Certain automatic occupant protection systems, such as airbags or passive interiors, offer such significant potential for preventing fatalities and injuries that their use should be encouraged through appropriate incentives.

As a result of these conclusions, the Department has decided to require automatic occupant protection in all passenger automobiles based on a phased-in schedule beginning on September 1, 1986, with full implementation being required by September 1, 1989, unless before April 1, 1989, two-thirds of the population of the United States are covered by a Mandatory Safety Belt Use Law meeting specified conditions. More specifically, the rule would require the following:

- Passenger cars manufactured for sale in the United States after September 1, 1986, will have to have automatic occupant restraints based on the following phase-in schedule:
    - Ten percent of all automobiles manufactured after September 1, 1986.
    - Twenty-five percent of all automobiles manufactured after September 1, 1987.
    - Forty percent of all such automobiles manufactured after September 1, 1988.
    - One-hundred percent of all automobiles manufactured after September 1, 1989.
- The requirement for automatic occupant restraints will be replaced by allowing the installation of manual or automatic restraints if MULs meeting specified conditions are passed by a sufficient number of States to cover two-thirds of the population of the United States before April 1, 1989.
- During the phase-in period, each passenger automobile that is manufactured with a system other than seatbelts being used to provide the automatic protection to the driver will be given an extra credit equal to one-half of an automobile toward meeting the percentage requirement.
- The front center seat of passenger cars will be exempt from the requirement for automatic occupant protection.