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PRELIMINARY REGULATORY IMPACT ANALYSIS

Effectiveness IV-19
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REAR SEAT LAP SHOULDER BELTS IN PASSENGER VEHICLES UNDER 10,001 LBS. GVWR

OFFICE OF REGULATORY ANALYSIS
PLANS AND POLICY
NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

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SUMMARY

Following is a summary of the findings of this preliminary examination of rear seat lap shoulder belts:

- At current rear seat lap belt usage rates (9.5 percent for passenger cars, 6-18 percent for trucks and MPVs) rear seat lap/shoulder belts in passenger cars would prevent 10 fatalities and 330 moderate to critical injuries annually. In light trucks and multipurpose vehicles (MPVs), rear seat lap/shoulder belts could prevent 55 moderate to critical injuries.

- If current usage rates were to double, rear seat lap/shoulder belts in passenger cars could prevent 22 fatalities and 695 moderate to critical injuries annually. In light trucks and multipurpose vehicles, rear seat lap/shoulder belts could prevent 3 fatalities and 110 moderate to critical injuries annually.

- If 70 percent of all rear seat occupants wore their safety belts in passenger cars, lap/shoulder belts could prevent 76 fatalities and 2430 moderate to critical injuries annually. A 70 percent usage rate in light trucks and MPVs would prevent 8 fatalities and 280 moderate to critical injuries annually.

- For passenger cars, roughly 90 percent of all safety benefits occur from outboard seating positions. For light trucks and MPVs, roughly 70 percent of all safety benefits occur from outboard seating positions.

- About 90 percent of the potential rear seat safety benefits for light trucks and vans occurs from the second seat (the first rearward seat).

- Additional safety benefits may occur to front seat passengers through a reduction in force loading on front seats caused by rear seat passengers, or to rear seat passengers if lap/shoulder belts in themselves cause an increase in rear seat belt usage.

- Installing lap/shoulder belts in the rear outboard seats of passenger cars would increase per vehicle costs by $12. Installing lap/shoulder belts in the center seating position would increase costs by an additional $20.

- Component costs of outboard rear seat lap/shoulder belts in light trucks and multipurpose vehicles would range from $7-$33 depending on vehicle type. The total cost for all rear seating positions (including center seats) would range from $13-$190.

- o Limiting the requirements for lap/shoulder belts to second seats only would reduce per vehicle costs of light trucks and MPVs to $7-$13 for outboard seats only and $13-$65 for all rear seating positions.

- o The added weight from lap/shoulder belts will have a minor effect on lifetime fuel costs, increasing passenger car costs by $1-$4 and light trucks and multipurpose vehicle costs by $1-$12.

- o Installing lap/shoulder belts in the rear outboard seats of passenger cars would result in total annual costs of $139 million. The inclusion of center seats as well could increase total costs by nearly 80 percent to $248 million.

- o Installing lap/shoulder belts in all rear outboard seats of light trucks and MPV's would result in total annual costs of $21 million. The inclusion of center seats as well would increase total costs by over 200 percent to $63 million.

- o Limiting the requirements for lap/shoulder belts to second seats only would reduce total annual costs for light trucks and MPVs to $16 million for outboard seats only and $56 million for all rear seating positions.

- Because of limited incidence of rear seat injury in buses, there is very little potential for safety improvement in these vehicles. Total annual costs for buses could range from $68,000 for second seat, outboard positions only installation to $804,000 for all rear seats, all positions.

I. INTRODUCTION & BACKGROUND

Federal Motor Vehicle Safety Standard (FMVSS) No. 208 currently requires that all passenger cars except convertibles come equipped with Type 2 safety belts (lap and shoulder belts) at all front seat outboard seating positions. For all other positions, Type 1 belts (lap belts only) are required but Type 2 belts may be installed at the manufacturers' discretion. This same requirement applies to the rear seats of trucks, school buses and multipurpose passenger vehicles with a gross vehicle weight rating (GVWR) of 10,000 lbs. or less. Non-school buses in this same category are not required to have rear seat lap belts but lap belts are currently supplied by all manufacturers.

When it was first issued in 1967, FMVSS No. 208 required only lap belts in all rear seating positions. At that time rear outboard seats were excluded from the Type 2 requirement because the reduction in the relatively small number of injuries that occurred in rear seats (over 90 percent of all occupant fatalities occur in the front seat) did not appear to justify the significant cost increase (essentially a doubling of the front seat only cost) that would have been incurred. Although Type 2 belts are not required in rear seats, FMVSS No. 210 requires that all passenger cars have anchorage points with sufficient reinforcement to enable the voluntary installation of a Type 2 belt by either the manufacturer or vehicle owner.

In 1982, Kathleen Weber and John Melvin petitioned the agency to amend FMVSS No. 208 to require the installation of Type 2 safety belts in the rear outboard seating positions in passenger cars. The basis for their petition was that the shoulder harness could be used to secure child restraint systems and children on booster seats and would provide additional protection for other rear seat occupants as well. NHTSA denied the petition in 1984 (49 FR 15241), citing the superiority of the harness system already available in child restraints and the potential for misuse of these systems with the shoulder harness. The agency did agree with the petitioners that Type 2 belts in rear seats might give some added degree of protection to adults. However, the agency believed that the additional cost ($20 for a non-detachable Type 2 belt with emergency locking retractor) could not be justified by the relatively minor benefits that would result due to the marginal increase in belt effectiveness or usage.

Over the last several years, there have been significant developments which argue for a reexamination of this issue. At present 24 states and the District of Columbia have enacted seat belt use laws (26 were originally enacted but 2 were rescinded in state-wide referendums; in addition, Virginia has passed, but not yet enacted a law). Although most of these laws apply only to front seat passengers, it is anticipated that the usage habits developed in response to state laws and increased public awareness of the importance of belt use will improve rear seat belt usage to some extent as well.

In August 1986, the agency granted a petition from the Los Angeles Area Child Passenger Safety Association requesting the agency to require the installation of rear seat lap/shoulder belts. The agency decided to grant the petition and re-examine whether to require the installation of rear seat lap/shoulder belts because of the widespread adoption of state safety belt use laws as a result of the Department's July 1984 decision on occupant crash protection (July 17, 1984, 49 FR 28962).

Recently the major domestic manufacturers (GM, Ford and Chrysler) have announced their intentions to voluntarily install rear seat outboard lap and shoulder belts on most or all of their vehicles over the next few years. Currently, at least thirteen foreign manufacturers (Audi, BMW, Honda, Jaguar, Mercedes, Mitsubishi, Nissan, Peugeot, Rolls Royce, SAAB, Volvo, VW, and Ford Merkur) are installing Type 2 safety belts in the rear seats of some of their passenger cars. Toyota, however, installed Type 2 belts in the 1981-82 Cressida but deleted them in 1983. Therefore, despite the encouraging trend towards voluntary installation, there is already a precedent for subsequent removal of these systems. A reexamination of the issue will therefore be made to determine whether a requirement for Type 2 belts in rear seats is warranted under current circumstances.

II. THE SAFETY NEED

The vast majority of occupant fatalities and injuries (over 90 percent) occur in the front seats of passenger vehicles. Although rear seats account for a small percentage of total injuries, in absolute terms they still represent a significant safety problem. Tables II-1, II-2 and II-3 list the 1985 fatality and injury experience in passenger cars, light trucks and MPV's and in buses for all age groups except children aged 0-4, most of whom would be placed in child restraints and who would not benefit from shoulder belts. Rear seat occupants accounted for nearly 1,700 fatalities and over 190,000 injuries in 1985. Roughly 99 percent of these fatalities and injuries occurred in second seats with the remainder occurring in vehicles with multiple rear seats such as vans or station wagons. Outboard seats accounted for roughly 85 percent of all fatalities and injuries with less than 15 percent occurring in center seating positions.

Historically, front and rear seat occupant fatalities have followed a roughly similar pattern, with fatalities rising in the late 1970's and then declining during the economic recession of the early 1980's. In 1984 with the economy picking up, driving increased and fatalities rose as well (see Figures II-1 and II-2). In 1985, front seat fatalities declined but rear seat fatalities continued to increase. This may have been partially due to safety belt use laws that became effective in several states in

1985. These laws typically applied to front seat passengers only. Surveys conducted by NHTSA indicate that belt use in the front seats of vehicles increased from 14.4 to 21.7 percent in 1985 while rear seat usage increased from 5.8 to 9.5 percent over the same period.

Rear seat fatalities and injuries are thus expected to continue to represent a significant and possibly increasing share of the overall occupant safety problem.

TABLE II-1

1985 REAR SEAT FATALITIES BY VEHICLE TYPE AND SEAT LOCATION* AGES 5 AND OVER

	Second Seat			Other Rear Seats			All Rear Seats		
	Outboard	Center	Total	Outboard	Center	Total	O	C	T
Passenger Cars	1315	207	1522	0	0	0	1315	207	1522
Pickups**	23	5	28	0	0	0	23	5	28
Vans***	21	31	52	1	1	2	22	32	54
Truck Based Station Wagons	6	0	6	0	0	0	6	0	6
On/Off Rd.****	62	15	77	0	0	0	62	15	77
Light Truck Total	112	51	163	1	1	2	113	52	165
Buses	0	0	0	0	0	0	0	0	0
TOTAL	1427	258	1685	1	1	2	1428	259	1687

* Unknowns distributed proportionally. "Other" seating positions (e.g., riding on someone's lap) ignored as not being eligible for benefit from belts.

** The portion of these pickup fatalities that fall under 10,001 lbs. GVW is unknown.

*** The distribution of fatalities in the second seat of vans was actually 38 in outboard seats and 14 in center seats. However, as discussed in Chapter V, most right rear seats in vans are considered to be center seats for purposes of safety belt requirements (due to the aisle on the right side of vans). The numbers listed in the above table conform to this definition. Vans with more than 10 person seating capacity are classified as buses for safety standard purposes. Data on the number of seating positions in vans is not available in the FARS data base. No rear seat fatalities were recorded in vans with more than 10 seats in the NASS file.

**** Some on/off road vehicles would be exempt by being either a convertible or open-body type vehicle.

SOURCE: Fatal Accident Reporting System (FARS)

TABLE II-2

1985 REAR SEAT AIS 2-5 INJURIES BY VEHICLE TYPE AND SEAT LOCATION* AGES 5 AND OVER

	Second Seat			Other Rear Seats			All Rear Seats		
	Outboard	Center	Total	Outboard	Center	Total	O	C	T
Passenger Cars	17772	2028	19800	0	0	0	17772	2028	19800
Pickups**	308	0	308	0	0	0	308	0	308
Vans***	310	394	704	92	118	210	402	512	914
Truck Based Station Wagons	0	0	0	0	0	0	0	0	0
On/Off Rd.****	976	29	1005	0	0	0	976	29	1005
Light Truck total	1594	423	2017	92	118	210	1686	541	2227
Buses*****	29	105	134	72	0	72	101	105	206
TOTAL	19395	2556	21951	164	118	282	19559	2674	22233

* Unknowns distributed proportionally. "Other" seating positions ignored as not being eligible for benefit from belts.

** The portion of these pickup injuries that fall under 10,001 lbs. GVWR is unknown.

*** The distribution of injuries in the second seat of vans was actually 694 in outboard seats and 10 in center seats. In third seats injuries were 181 in outboard seats and 29 in center seats. However, as discussed in Chapter V, the right rear seats in vans are considered to be center seats for purposes of safety belt requirements (due to the aisle on the right side of vans). The numbers listed in the above table conform to this definition. No AIS 2-5 injuries were recorded in vans with more than 10 person seating capacity (which would be classified as buses).

**** Some on/off road vehicles would be exempt by being either a convertible or open-body type vehicle.

***** The portion of these injuries sustained in buses under 10,001 lbs. GVWR is unknown. Injuries clearly coded as being sustained in vehicles >10,000 lbs. GVWR are excluded. No bus AIS 2-5 injuries were coded as being <10,000 lbs. GVWR. The injuries shown here were coded as unknown GVWR. Center seat numbers include all "other" designations in NASS.

SOURCE: National Accident Sampling System (NASS)

TABLE II-3

1985 REAR SEAT AIS 1 INJURIES BY
VEHICLE TYPE AND SEAT LOCATION*
AGES 5 AND OVER

	Second Seat			Other Rear Seats			All Rear Seats		
	Outboard	Center	Total	Outboard	Center	Total	O	C	[illegible]
Passenger Cars	136073	12290	148363	146	0	146	136219	12290	148509
Pickups**	23	0	23	0	0	0	23	0	23
Vans***	1506	2957	4463	549	1067	1616	2055	4024	6079
Truck Based Station Wagons	618	0	618	0	0	0	618	0	618
On/Off Rd.****	8550	230	8780	0	0	0	8550	230	8780
Light Truck Total	10697	3187	13884	549	1067	1616	11246	4254	15500
Buses*****	198	2845	3043	298	0	298	496	2845	3341
TOTAL	146968	18322	165290	993	1067	2060	147961	19389	167350

* Unknowns distributed proportionally. "Other" seating positions ignored as not being eligible for benefit from belts.

** The portion of these pickup injuries that fall under 10,000 lbs. GVWR is unknown.

*** The distribution of injuries in the second seat of vans was actually 3860 in outboard seats and 621 in center seats. In third seats AIS 1 injuries were 2072 in outboard seats and 1418 in center seats. However, as discussed in Chapter V, the right rear seats in vans are considered to be center seats for purposes of safety belt requirements (due to the aisle on the right side of vans). The numbers listed in the above table conform to this definition. Vans exceeding 10 person seating capacity are considered to be buses and are reflected in that category.

**** Some on/off road vehicles would be exempt by being either a convertible or open-body type vehicle.

***** The portion of these injuries sustained in buses under 10,001 lbs. GVWR is unknown. Center seat numbers include all "other" designations in NASS.

SOURCE: National Accident Sampling System (NASS)

FIGURE II-1

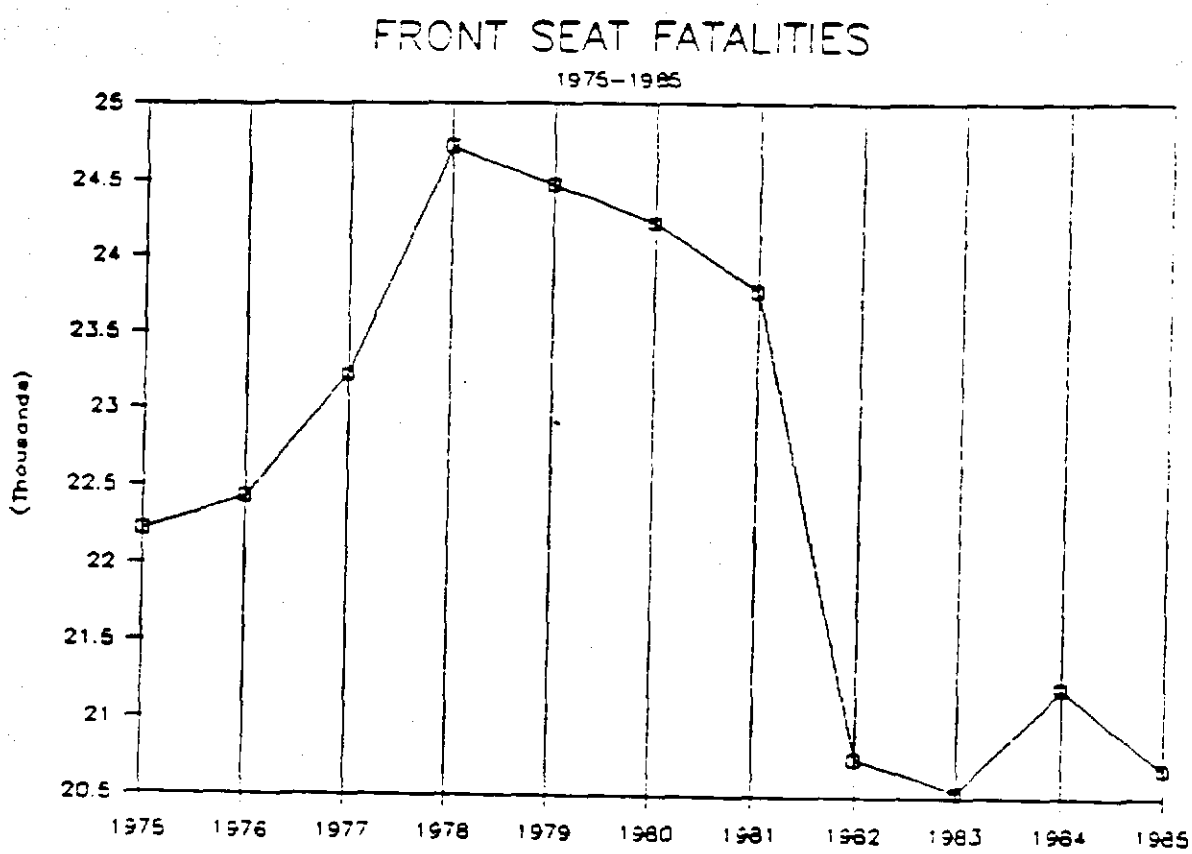
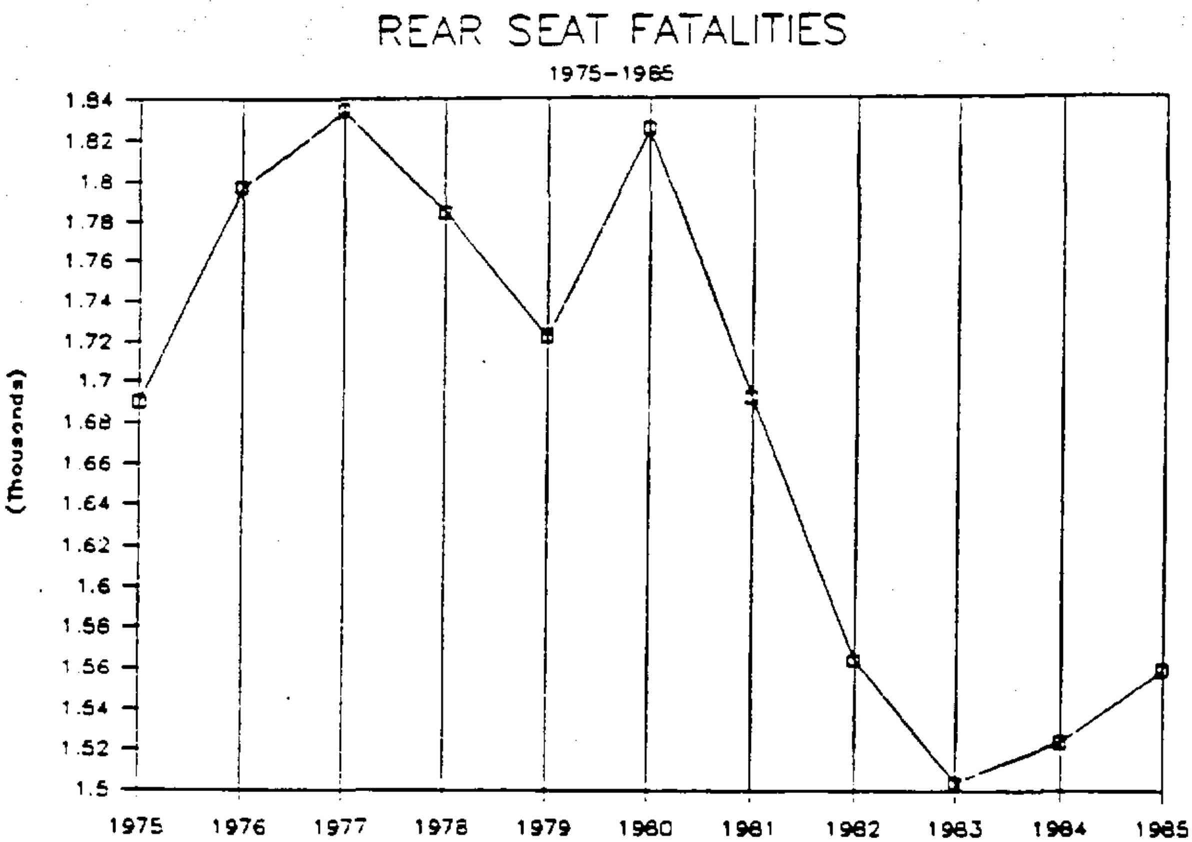

FRONT SEAT FATALITIES
1975–1985
(Thousands)
25
24.5
24
23.5
23
22.5
22
21.5
21
20.5
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985

FIGURE II-2


REAR SEAT FATALITIES
1975–1985
(Thousands)
1.84
1.82
1.8
1.78
1.76
1.74
1.72
1.7
1.68
1.66
1.64
1.62
1.6
1.58
1.56
1.54
1.52
1.5
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985

III. ALTERNATIVES

In addressing the issue of requiring lap and shoulder belts in the rear seat of passenger vehicles, a variety of alternative approaches are possible. Specifically, requiring Type 2 belts may be appropriate in certain types of vehicles but not others, and in certain, but not necessarily all seating positions. This analysis separately examines the costs and benefits associated with standards applicable to the following categories:

Vehicles:

Passenger Cars

Light Trucks and Multipurpose Vehicles

Buses under 10,001 lbs. GVWR

Seating Positions:

Second seat -- outboard seat only

Second seat -- all positions

All other rear seats

Each vehicle category will be examined for each set of possible seating position categories.

In addition, the analysis will consider whether it is appropriate to extend existing requirements for seat belt comfort and convenience and dynamic testing to any new rear seat belt requirements. A discussion of these issues will be presented separately in Section VI.

IV. Benefits

The benefits that can be derived from rear seat Type 2 safety belts are a function of both the level of protection that is provided by these systems or their effectiveness, and of the willingness of consumers to actually use the belts. In the following sections these variables will be estimated and combined with injury and fatality rates to provide an estimate of potential safety benefits for each alternative and vehicle type.

A. Effectiveness

The effectiveness of a safety belt system is defined as the percentage reduction in fatalities or injuries for restrained occupants compared to unrestrained occupants. In the Final Regulatory Impact Analysis (FRIA) amending FMVSS 208 to require automatic restraints,[1/] NHTSA provided an extensive analysis of the effectiveness of safety belts in front seating positions. Table IV-1 lists the results of this analysis.

TABLE IV-1

Percent Effectiveness of Front Seat Safety Belts

	Manual Lap Belt	Manual Lap/Shoulder Belt
Fatalities	30-40	40-50
AIS 2-5 injuries	25-35	45-55
AIS 1 injuries	10	10

These estimates were based on a combination of statistical analyses of real world accident experience and laboratory testing. Although they are judged to be fairly accurate estimates of belt effectiveness in front seats, they may not be applicable to similar systems in rear seats because front seating positions involve potential occupant collisions with different vehicle structures. Front seat occupants, for example, are more likely to impact the steering wheel, dashboard or windshield, while rear seat occupants are more likely to impact front seat backs. In addition, in a frontal collision, the distance to initial impact of front and rear passengers is likely to be different depending on the adjusted position of the front seat. In any given vehicle, these distances would be inverse i.e: the further back a front seat is pushed the closer the rear seat occupant is to the seat back and vice-versa. Overall, the effect of crash dynamics for rear seat occupants could differ significantly from front seat occupants.

There have been a number of attempts made to estimate the effectiveness of rear seat lap belts; NHTSA knows of no existing estimates of the effectiveness of rear seat lap-shoulder belts. This is probably due to the fact that they are currently found on only 1.5% of the existing passenger car fleet. Table IV-2 summarizes the existing analyses[2/] of rear seat lap belt effectiveness and their results. Where the estimates for fatalities and serious injuries noted in this table are identical, the specific study lumped both categories together and separate estimates are not available.

TABLE IV-2

ESTIMATES OF REAR SEAT LAP BELT EFFECTIVENESS

Author	Basis	Effectiveness: Fatality	Effectiveness: Serious Injury	Effectiveness: Minor or All Injury
National Ctr for Statistics and Analysis (NCSA), NHTSA	North Carolina Accident Data	41-49%*	41-49%*	17-18%*
NCSA, NHTSA	Maryland Accident Data	30-59%*	30-59%*	9-22%*
Transport Canada	Canadian Accident Data	41%	41%	-----
NCSA-NHTSA Partyka	NCSS & NASS Data	39%	57%	23%
NCSA-NHTSA Najjar	NCSS	59%	59%	-----
Campbell	North Carolina Accident Data	25-30%	50%	------
Evans-GM	FARS	18%	-----	-----
Kahane-NHTSA	FARS & Penn. Accident Data	17-26%	37%	11%

*Effectiveness rates for persons age 15 or greater

These results are also listed in Table IV-9. When all seats are considered, statistically significant results are found for pickups, vans, truck based station wagons and buses. When second seats only are considered, a statistically significant result is found for vans, truck based station wagons and buses only.

Noticeable discrepancies exist between relative estimates based on second seats and estimates based on all seats. A Z test was therefore run between seat locations as well. The result of these tests are shown in the last column of Table IV-9. The tests confirm that the large differences between all seat and second seat only usage estimates for passenger cars and buses are significant. The smaller differences found in other types of vehicles are not significant. The higher relative usage levels that result from second seat only data thus appear to be a valid function of the lower usage rates found in rear seats of passenger cars and buses while the validity of higher rear seat rates in other vehicles is uncertain.

A comparison between Tables IV-8 and IV-9 reveals a significant discrepancy between estimates of passenger car restraint use. The 19 city survey indicates a usage rate of 21.1 percent in 1985 for all seating positions and a rate of 9.5 percent for rear seat positions. The NASS accident files, on the other hand, indicate usage rates of 42 percent for all seats and 30 percent for rear seats.

TABLE IV-9
Restraint Usage of Occupants Aged 5 and Over
1985 NASS File

	All Seats			Second Seats			
	Usage	Usage Relative to P.C.	Z Test Relative to P.C.	Usage	Usage Relative to P.C.	Z Test Relative to P.C.	Z Test, Second Seat vs. Front Seats
Passenger Cars	41.7	1.0	-	29.6	1.0	-	3.59**
Pickups	27.7	.66	4.49*	ID	ID	ID	ID
Vans	51.2	1.23	-2.93*	55.1	1.86	-2.70*	-0.59
Truck Based Station Wagons	53.0	1.27	-3.45*	55.3	1.87	-2.84*	0.86
On/Off Rd. Vehicles	37.7	0.90	1.21	38.3	1.29	-0.84	-0.28
Buses	8.7	0.21	12.43*	6.2	0.21	3.00*	5.03**

ID = Insufficient data
* = Usage level is significantly different from that of passenger cars at .05 confidence level
** = Usage level is significantly different from that of front seats at .05 confidence level

It is likely that this discrepancy reflects an over-estimation of belt usage in NHTSA's accident files. Estimates of restraint usage in these files are derived from interviews with accident victims and police reports (which are often themselves based on occupant testimony). In recent years, with the passage of safety belt use laws in many states, NHTSA has been concerned that some unbelted occupants may claim to have been wearing a seat belt in order to avoid conflict with state laws. Similarily, false usage claims could be motivated by concerns about insurance coverage, contributory liability or negative social image. Preliminary results from an internal study by NHTSA's National Center for Statistics and Analysis (NCSA) indicate that usage estimates derived from 1985 NASS data are overstated by as much as 150 percent in areas where state belt use laws are in effect and 50 percent in areas with no laws. This phenomenon is confirmed by a Florida study[5/] of reported and observed seat belt use in which it was found that 41 percent of survey respondents claimed to wear seat belts regularly while only 22 percent usage was found in the observation survey. The results of a similar survey in Ohio[6/] found that adults claimed belt usage exceeded observed usage by roughly 100 percent.

Usage estimates from the 19 city survey, on the other hand, are based on observed usage rather than occupant testimony. They are therefore not subject to over-estimation due to false usage claims by vehicle occupants.

Estimates of belt usage in non-passenger cars are also available in observational surveys conducted by states,[7/] primarily to determine the effect of their safety belt use laws. Table IV-10 summarizes the results of these surveys from 5 states in which usage by vehicle type was examinec.

TABLE IV-10
Usage by Vehicle Type Derived from State Observational Surveys

	USAGE			USAGE RELATIVE TO PASSENGER CARS	
State/Date	Passenger Cars	Pickup Trucks	Vans	Pickup Trucks	Vans
Illinois					
4/85	17.2	6.6	-	.38	-
4/86	38.9	21.9	-	.56	-
7/86	41.8	25.6	-	.61	-
Michigan					
7/85	60.4	45.8	53.1	.76	.88
12/86	44.6	30.3	38.2	.68	.86
4/86	45.0	33.2	39.5	.74	.88
Minnesota					
1983	13.8	5.1		.37	
1984	15.1	8.6		.57	
1985	17.8	10.0		.56	
Texas					
12/85	14.8	11.8		.80	
12/86	64.9	65.5		1.01	
Wisconsin					
1986	34.3	22.7*	22.7*	.66*	.66*

*Includes pickups and vans

The results of these surveys vary dramatically by state and time period. Variation between time periods often reflects the initiation of safety belt use laws and their aftermath. The high usage rate recorded in the 7/85 Michigan study for example, reflects the publicity and enforcement associated with the initial months of the state law. Usage declined to a level of roughly 45 percent in passenger cars and 30 percent in trucks shortly thereafter. Similarily, the dramatic differences found in the two Texas reports reflect pre and post law periods.

For the reasons previously discussed, observational surveys are considered to provide the most accurate estimates of actual restraint usage. The 19 city survey summarized in Table IV-8 is the most comprehensive, and therefore the most nationally representative of the available surveys and it will be used to establish baseline (1985) usage rates for passenger cars. 1985 rear seat passenger car usage is therefore estimated to be 9.5 percent. Baseline usage for all other vehicles will be established relative to this level.

From Tables IV-9 and IV-10 there are 13 different estimates of relative usage rates for pickup trucks. None of these are specific to the second seat. A simple unweighted arithmetic average of these estimates yields a relative of .64. With the exception of 3 outliers, the second Texas survey and the 2 earliest surveys, all estimates lie between roughly 55 and 80 percent and the midpoint of these boundry estimates is 67.5, a result almost indentical with 3 of the surveys, including NASS, the largest one. Although the absolute usage rates derived from NASS are believed to be overstated, there is no evidence for a similar conclusion regarding the relative usage rates of different vehicles. Overestimation may, in fact, be larger for some vehicles, but it is assumed that this effect is minor. The relative consistency of results from the various surveys supports this assumption. Overall, it appears reasonable to assume that usage for light trucks is roughly 2/3 of that of passenger cars or 6.4 percent.

The two sources of data on the relative usage rates of vans produced contradictory results. The 3 Michigan observational surveys found van usage rates to be just under 90 percent of passenger car rates. (The Wisconsin study lumped vans with light trucks and is thus not useful). NASS data, on the other hand, found van usage rates that were 23 percent higher than passenger cars in all seats and 86 percent higher in second seats. Although the Michigan studies are probably accurate for that state, it is questionable whether they would accurately reflect usage habits nationwide.

As previously noted, the higher usage relatives found for van second seats primarily result from lower usage rates found in the rear seats of passenger cars. The most appropriate estimate for vans would therefore appear to be 86 percent greater than the passenger car rate or 17.7 percent.

It is unclear whether the rear seat estimate for vans is an accurate reflection of equality in both front and rear seat usage rates. The estimate is based on a fairly small sample (154 cases) and the usage rate based on the raw data (before ratio-weighting it to the national level) is only 38 percent (rather than 55 percent after weighting). This fact combined with the contradictory results noted in the Michigan studies leave considerable doubt about the validity of the NASS usage estimates for vans. However, given the lack of a more reliable nationwide measure, it will be used here with the caveat that it may result in an overly optimistic estimate of potential benefits to van occupants under current usage rates.

For truck based station wagons, the only specific estimate is from NASS files. As was the case with vans, this estimate is based on a very small number of cases and, although the Z test indicates that it does differ from passenger car usage, the accuracy of the estimate is subject to a large standard error. Nonetheless, this estimate will be used bearing in mind the fact that it may result in an optimistic benefit result. Usage for truck based station wagons is therefore estimated to be 87 percent higher than that of passenger cars or 17.7 percent.

Similarly the NASS estimate for on/off road vehicles is of suspect significance but will be used as the only available estimate keeping in mind its likely optimistic nature. Usage rates for on/off road vehicles are therefore estimated to be 29 percent higher than passenger cars or 12.3 percent.

Finally, the NASS bus estimate was found to vary significantly from that of passenger cars. A factor of .21 will be used, resulting in an estimated bus usage rate of 2.0 percent.

Table IV-11 summarizes the baseline 1985 usage rates that will be estimated in computing benefits for each vehicle type.

TABLE IV-11

Baseline Rear Seat Belt Usage Estimates
by Vehicle Type
(Percent)

Vehicle Type	1985 Rear Seat Belt Usage
Passenger Cars	9.5
Pickup Trucks	6.4
Vans	17.7
Truck Based Station Wagons	17.7
On/Off Road Vehicles	12.3
Buses	2.0

C. Calculation of Benefits

As previously mentioned, benefits for each alternative are a function of the effectiveness rates and usage levels that were calculated in the 2 previous sections. Net benefit calculations consist of 3 basic steps. First, effectiveness estimates and usage levels for the current manual lap belt system will be used to estimate the base number of fatalities and injuries that would have occurred had no one used the current systems. This is done using the following formula:

$$BI = \frac{CI}{1 - U \times E}$$

Where:

BI = Base fatalities or injuries
CI = Current fatalities or injuries (1985)
U = Current usage level (1985)
E = Effectiveness of current (lap belt only) system

For example, from Table II-1 (Chapter II), there were 1315 fatalities in the back outboard seats of passenger cars in 1985. From Table IV-7, manual lap belts were estimated to be 25 percent effective against fatalities and were estimated to be used by 9.5 percent of rear seat occupants (Table IV-11). The number of fatalities that would have occurred had no one worn their lap belts is therefore:

$$BI = \frac{1315}{1 - (.095 \times .25)} = 1348$$

VI. OTHER ISSUES

If Type 2 belts are required on vehicles, there are several related issues which must be resolved as a part of the final rule. Specifically NHTSA must decide whether it is appropriate to extend the comfort and convenience requirements of FMVSS 208 to rear seats as well and whether to require dynamic testing of rear seat Type 2 belts.

Standard 208 requires that by September 1, 1989, manual belts in front seating positions installed in any vehicle with a GVWR of 10,000 pounds or less meet requirements for belt contact force, latch plate access, retraction and seat belt guides and hardware characteristics. The use of an anthropomorphic dummy is necessary to determine compliance with all of these requirements except for seat belt guides and hardware requirements. Since dummy positioning procedures have not been developed for the rear seating positions, compliance with belt contact force, latch plate access and retraction requirements cannot yet be ascertained. Once rear seat positioning procedures have been developed, an NPRM can be issued proposing the appropriate requirements for these areas. FMVSS 208 currently requires that all manual belt systems meet seat belt guide and hardware requirements, which do not require anthropomorphic dummies for compliance verification. NHTSA anticipates that this requirement would remain in effect for rear seat lap/shoulder belts.

Dynamic testing for FMVSS 208 will be required for all outboard seating positions in the front seat of passenger cars as of September 1, 1989 if two-thirds of the population is not covered by state belt usage laws (i.e., if automatic restraints requirements are rescinded). NHTSA has estimated that these requirements will increase testing costs by about $8500 per test. Application of dynamic testing to rear seats should be somewhat less expensive because much of this cost is not variable with the number of seating positions tested. Assuming that rear seat tests could be run concurrent with front seat tests, NHTSA's preliminary estimate of incremental costs associated with rear seat testing is $4,000-$5,000 per test. This includes the added costs of recording and processing data, certifying test dummies and installing additional outboard cameras. Costs could be considerably lower for some large manufacturers that run their own full time testing labs. Additional costs could be incurred if additional test dummies are purchased. Part 572 dummies currently cost roughly $12,000 each and Hybrid III dummies, which will be required after 1991, cost $30,000 each. This cost would be spread over a large number of tests.

A potential problem with running concurrent front and rear seat tests is that the added weight of the rear seat crash dummies (roughly 165 lbs per dummy) could result in added vehicle crush which could adversely impact test results. Therefore, unless some way was found to adjust for the effect of the added weight, extension of this requirement to rear seats would have the unintended effect of making it harder to comply with existing dynamic test requirements. The effect of added weight could be minimized by requiring that tests be conducted in only one position, but this could skew the impact load to one side of the vehicle and alter crash test results as well. In addition, it would not necessarily reflect adequate compliance at the other seating positions. Running separate rear seat compliance tests is another option; however, this would result in significant additional costs (such as additional prototype crash vehicles).

NHTSA is seeking public comment on both dynamic testing and seat belt comfort and convenience issues.

APPENDIX A. SENSITIVITY ANALYSIS, ALTERNATE EFFECTIVENESS RATES

The effectiveness estimates used in the body of this analysis to estimate benefits were derived from studies using the "double pair" comparison method. As noted in Chapter IV, this method is thought to provide more reliable estimates of effectiveness than more conventionally derived studies because it provides an automatic control for differences in crash severity and it can utilize FARS files, the best source of data for analyzing rear seat lap belt effectiveness against fatalities.

Studies based on double pair methodology, however, are relatively recent, and there are numerous studies based on more conventional methodology which produce consistently higher effectiveness estimates for rear seat lap belts. This appendix will examine benefit estimates based on these higher effectiveness estimates.

In Table IV-2 (see Chapter IV), these studies, as well as the two "double pair" based studies were summarized. The first 5 studies were based on the conventional approach which essentially examines the rate of injury for restrained occupants compared to unrestrained occupants as a group. Most of these studies lumped fatalities and serious injuries together but the one that did separate them (Partyka), found a higher rate of effectiveness against serious injuries that against fatalities. This is consistent with the findings of Kahane's "double pair" estimate. A simple average of all the conventional fatality estimates is roughly 42 percent. Since injuries, which are expected to have a higher effectiveness rate, were included in most of these estimates, the actual average fatality effectiveness is probably somewhat lower and actual injury effectiveness is probably higher. For this analysis we will examine a base lap belt fatality effectiveness of 40 percent and a serious injury effectiveness of 55 percent. These numbers are similar to the results of Partyka's study, one of the two that produced separate fatality and injury estimates. Campbell's study produced somewhat lower estimates but the higher estimates will be used to examine a wider range in the sensitivity analysis.

The incremental effectiveness of lap/shoulder belts will be based on the point differences found in front seat systems (see Table IV-1). Given the high base effectiveness rates examined here, use of percent rather than point increments would produce judgmentally absurd results (i.e., 90 percent effectiveness against injuries). Even the point based injury effectiveness estimate (75%) appears highly optimistic. The effectiveness estimates examined here are summarized below:

	Manual Lap Belts	Manual Lap/ Shoulder Belts
Fatalities	40	50
AIS 2-5 Injuries	55	75

Tables A-1, A-2 and A-3 summarize the benefits that would accrue under these effectiveness rates at current usage rates at double current usage rates and at 70 percent usage respectively. A comparison of these results with Tables IV-12, IV-13 and IV-14 indicates that these conventionally derived estimates of effectiveness produce benefits that are roughly one-third higher (injuries) to double (fatalities) those derived in the body of this analysis. Even so, benefits for all truck and bus categories remain modest even under the more optimistic usage assumptions of Table A-2. At 70 percent usage rates, truck and MPV categories show more significant benefits but buses benefits remain low, due to the low incidence of injury in these vehicles.

TABLE A-1

SENSITIVITY ANALYSIS
POTENTIAL BENEFITS FROM TYPE 2 BELTS BY
VEHICLE TYPE AND SEAT LOCATION
(AT CURRENT USAGE RATES)

	Second Seat			Other Rear Seats			All Rear Seats		
	Outboard	Center	Total	Outboard	Center	Total	O	C	T
Passenger Cars									
Fatalities	13	2	15	0	0	0	13	2	15
AIS 2-5	356	41	397	0	0	0	356	41	397
Pickups									
Fatalities	0	0.	0	0	0	0	0	0	0
AIS 2-5	4	0	4	0	0	0	4	0	4
Vans									
Fatalities	0	1	1	0	0	0	0	1	1
AIS 2-5	12	15	27	4	5	9	17	19	36
Truck Based Stn. Wgn.									
Fatalities	0	0	0	0	0	0	0	0	0
AIS 2-5	0	0	0	0	0	0	0	0	0
On/Off Road									
Fatalities	1	0	1	0	0	0	1	0	1
AIS 2-5	26	1	27	0	0	0	26	1	27
Light Truck Total									
Fatalities	1	1	2	0	0	0	1	1	2
AIS 2-5	42	16	58	4	5	9	47	20	67
Buses									
Fatalities	0	0	0	0	0	0	0	0	0
AIS 2-5	0	0	0	0	0	0	0	0	0

TABLE A-2

SENSITIVITY ANALYSIS
POTENTIAL BENEFITS FROM TYPE 2 BELTS BY
VEHICLE TYPE AND SEAT LOCATION
(AT DOUBLE 1985 USAGE RATES)*

	Second Seat			Other Rear Seats			All Rear Seats		
	Outboard	Center	Total	Outboard	Center	Total	O	C	T
Passenger Cars									
Fatalities	27	4	31	0	0	0	27	4	31
AIS 2-5	750	86	836	0	0	0	750	86	836
Pickups									
Fatalities	0	0	0	0	0	0	0	0	0
AIS 2-5	10	0	10	0	0	0	10	0	10
Vans									
Fatalities	0	1	1	0	0	0	0	1	1
AIS 2-5	24	31	55	7	9	16	31	40	71
Truck Based Stn. Wgn.									
Fatalities	0	0	0	0	0	0	0	0	0
AIS 2-5	0	0	0	0	0	0	0	0	0
On/Off Road									
Fatalities	2	0	2	0	0	0	2	0	2
AIS 2-5	52	2	54	0	0	0	52	2	54
Light Truck Total									
Fatalities	3	1	4	0	0	0	3	1	4
AIS 2-5	86	33	119	7	9	16	93	42	135
Buses									
Fatalities	0	0	0	0	0	0	0	0	0
AIS 2-5	0	1	1	0	0	0	0	2	2

* Rates were doubled and rounded. Assumed usage rates were 20 percent for passenger cars, 15 percent for pickups, 35 percent for vans and truck based station wagons, 25 percent for on/off road vehicles, and 4 percent for buses.

TABLE A-3

SENSITIVITY ANALYSIS
POTENTIAL BENEFITS FROM TYPE 2 BELTS BY
VEHICLE TYPE AND SEAT LOCATION
(AT 70% USAGE RATES)

	Second Seat			Other Rear Seats			All Rear Seats		
	Outboard	Center	Total	Outboard	Center	Total	O	C	T
Passenger Cars									
Fatalities	96	15	111	0	0	0	96	15	111
AIS 2-5	2625	300	2925	0	0	0	2625	300	2925
Pickups									
Fatalities	2	2.	2	0	0	0	2	0	2
AIS 2-5	45	0	45	0	0	0	45	0	45
Vans									
Fatalities	2	2	4	0	0	0	2	2	4
AIS 2-5	48	61	109	14	18	32	62	79	141
Truck Based Stn. Wgn.									
Fatalities	0	0	0	0	0	0	0	0	0
AIS 2-5	0	0	0	0	0	0	0	0	0
On/Off Road									
Fatalities	5	1	6	0	0	0	5	1	6
AIS 2-5	147	4	151	0	0	0	147	4	151
Light Truck Total									
Fatalities	9	3	12	0	0	0	9	3	12
AIS 2-5	240	65	305	14	18	32	254	83	337
Buses									
Fatalities	0	0	0	0	0	0	0	0	0
AIS 2-5	4	15	19	10	0	10	14	15	29

An examination of Table IV-2 reveals a wide divergence in effectiveness estimates ranging from 17 to 59 percent against fatalities and serious injuries. There are several reasons, aside from obvious sample differences (e.g. size of sample, quality of data, controls for crash severity), that account for this difference. The first of these is that the 4 studies with the highest estimates (the 2 NCSA state data studies, the Transport Canada study and the NCSA study by Najjar), lumped fatalities and serious injuries together. In the three studies that did break out fatalities separately (Campbell, Partyka & Kahane), the fatality effectiveness estimate is significantly lower than the injury estimate (all three estimates for serious injury include fatalities as well but the fatality estimate is separate). This implies that an estimate specific to fatalities derived in the other studies may be lower than the grouped estimates they provided. Conversely, it also implies that their estimate of the effectiveness of safety belts in reducing serious injury might be somewhat higher, although probably by a minor amount due to the predominate incidence of non-fatal injuries.

A second, and probably more significant reason for the wide range of effectiveness estimates is that two fundamentally different methodologies were used to estimate effectiveness. The 5 earliest studies, (the 2 NCSA state studies, Transport Canada, and the 2 NCSA national studies and Campbell) all utilized an approach which basically estimates effectiveness by examining the rate of injury for restrained occupants. This "conventional" approach yielded relatively consistent group estimates clustered around the high end of the range, varying from 30-59% (an exception was Campbells' low end estimate of 25 percent). A simple average of these estimates yields an estimate of about 42 percent, which would probably be somewhat lower for fatalities and somewhat higher for serious injuries.

The two latest reports, Evans and Kahane, both utilize the "double pair" comparison method, in which the injury risk for back seat occupants is compared to that of other occupants of the same vehicle. The results of these analyses indicate significantly lower effectiveness estimates at all injury levels with fatality effectiveness of between 17 and 26 percent.

Kahane cites two advantages of this technique over the conventional method used in the other analyses. First, the conventional approach cannot be used with FARS, since calculation of unbiased casualty rates requires nonfatal as well as fatal crashes. FARS, which contains records of nearly 500 rear seat occupants age 5 and older who wore belts and were fatally injured, is the best source of data for analyzing rear seat lap belt effectiveness against fatalities.

Secondly, double pair comparison provides an automatic control for differences in the severity of crashes involving belted and unrestrained populations - both the subject and control occupants are in the same vehicle.

Analysts in NHTSA's National Center for Statistics and Analysis (NCSA) confirm that the double pair comparison method has theoretical advantages over the conventional method - especially with regard to its access to FARS data. For this preliminary analysis therefore, an effectiveness estimate based on the most recent reports will be used. However, because the conventional method resulted in consistently higher estimates despite a wide variety of data sources, higher effectiveness estimates will be examined as well through a sensitivity analysis.

The range of fatality estimates shown for Kahane's study (17-26%) reflects two different samples of FARS data. Using FARS data from 1975-1986, Kahane's calculation resulted in an estimate of only 17 percent. However, when he examined estimates based on individual years, he found that the years 1975-1982 produced individual estimates that averaged only 6 percent. These estimates were inconsistent (with range of 72 points) and some years even indicated negative effectiveness. Results from the 1983-1986 were more consistent and averaged 26 percent. Kahane speculates that the strange results from the early FARS files may reflect underreporting of back seat lap belt usage in those years due to the generally minimal use of rear seat belts. In the early 1980's, many states added belt use for all occupants to their accident reporting requirements for the first time and public awareness of the importance of belt use also began to increase. These factors could eventually lead to more accurate rear seat belt use estimates in state reports. On the other hand, these is some evidence that belt use laws which were effective in a number of states in 1985, have resulted in an overreporting bias in police accident reports (see Section IV-B). However, since most laws apply only to front seats, this bias would not neassarily extend to rear seat belt usage.

Regardless of the reason, estimates based on early years of FARS data are clearly counter-intuitive and grossly inconsistent. FARS data from 1983-86 are consistent and could logically reflect the more accurate state reporting practices that have developed in recent years. Moreover, partially because of this improved reporting and partially because more people used belts in recent years, 1983-86 FARS contains more than 1/2 of the sample of belted back seat occupants. It thus appears likely that the most accurate estimate of rear seat lap belt effectiveness against fatalities was derived from the last 4 years of FARS data.

Evans' original analysis used the same basic approach as Kahane but was based on FARS from 1975-1983. Based on these years, he estimated rear seat lap belt effectiveness to be 7 percent. He later incorporated 1984 and 1985 data in his analysis and derived an estimate of 18 percent - similar to Kahane's estimate of 17 percent based on 1975-1986. Since it was derived from the same data base, the Evans estimate would be affected by the same reporting problems as Kahane's, and would reflect the same inconsistent results for early years of FARs data. Kahane's estimate of 26 percent based on 1983-1986 data is judgmentally the most reliable estimate of rear seat lap belt effectivenss against fatalities.

Kahane supplies the only "double pair" estimate for injury effectiveness. Based on data from the state of Pennsylvania, he estimates effectiveness rates of 37% against serious or fatal injuries, 33% against moderate, serious or fatal injuries, and 11% against all injuries. For purposes of this analysis, it is desirable to develop effectiveness estimates specific to injury severity categories rather than overlapping estimates. These categories are defined in the Abbreviated Injury Scale (AIS) as follows: AIS 1 (minor), AIS 2 (Moderate), AIS 3 (Serious), AIS 4 (Severe), AIS 5 (Critical). AIS 2-5 injuries will be lumped together to allow continuity with data developed in previous NHTSA analyses. The breakout of data available in Kahane's report and in the Pennsylvania data base provides an analytical basis for deriving estimates of effectiveness against both AIS 1's and AIS 2-5's.

Kahane's analysis provides tables listing the incidence of back seat injuries by restraint use for each of the above mentioned overlapping categories. The incremental number of injuries found in the "all injuries" category compared to the "Moderate, Serious or Fatal Injuries" category essentially represents minor injuries. Although the injury definitions in Pennsylvania state data are not identical to those of the Abbreviated Injury Scale (AIS), minor injuries are the closest proxy for AIS 1 injuries available from this data source.

Table IV-3 illustrates the calculation of effectiveness against minor injuries.

TABLE IV-3
ESTIMATION OF REAR SEAT LAP BELT EFFECTIVENESS
AGAINST MINOR INJURIES BASED ON PAIRED COMPARISON
(OCCUPANTS AGE 5 OR MORE)

Back Seat Restr. Use	Back Seat Injuries	Driver injuries Unrestr.	Driver injuries Belted	Risk Factor	Lap Belt Inj. Red.
Unrestrained	12,506	12,136	---	1.030	----
Lap Belts	414	476	---	.870	15.5%
Unrestrained	1,306	---	1,179	1.108	----
Lap Belts	1,493	----	1,366	1.093	1.4%

Weighted average injury reduction for lap belted vs. unrestrained back seat occupants:

$$1-\left[\frac{414 + 1,493}{414(1.030/.870) + 1,493\ (1.108/1.093)}\right] = 4.8 \text{ percent}$$

TABLE IV-4
ESTIMATION OF REAR SEAT LAP BELT EFFECTIVENESS AGAINST MODERATE OR SERIOUS INJURIES BASED ON PAIRED COMPARISON
(OCCUPANTS AGE 5 OR MORE)

Back Seat Restr. Use	Back Seat Injuries	Driver injuries Unrestr.	Driver injuries Belted	Risk Factor	Lap Belt Inj. Red.
Unrestrained	4,541	5,548	---	.818	----
Lap Belts	78	156	---	.500	38.9%
Unrestrained	377	---	293	1.287	----
Lap Belts	306	---	346	.884	31.3%

Weighted average injury reduction for lap belted vs. unrestrained back seat occupants:

$$1 - \left[\frac{78 + 306}{78(.818/.500) + 306(1.287/.884)}\right] = 33.0\%$$

In Table IV-4, data from the Pennsylvania accident files for level A and B injuries are combined to produce a paired comparison estimate of effectiveness for moderate and serious injuries.

The Pennsylvania accident files are classified according to an A, B, C injury scale with A injuries representing the most serious and C the least serious injury types. Fatalities are classified in their own grouping. The Abbreviated Injury Scale uses a six category numeric scale to define injury severity. Although there will inevitably be some overlap and inconsistency between injury classifications in each respective scale, judgmentally, the most equivalent injury groupings would be C injuries in the Pennsylvania data with AIS 1 injuries in the AIS scale and A and B injuries in the Pennyslvania data with AIS 2-5 in the AIS scale. These groupings are to some extent confirmed by the relative incidence of injury severity in each category. For the 1982-1985 period (the period for which Pennsylvania data were examined), NASS data indicate that 15 percent of all injured occupant survivors were AIS 2-5 and 85 percent were AIS 1. In the Pennsylvania accident files, 27 percent were rated as A and B while 73 percent were C level injuries. Although not identical, given the parallel order of severity rank in the 2 data bases, the similarity of these percentages confirms the rough equivalency of the groupings discussed above.

Overall, the double pair comparison method yields effectiveness estimates of 26 percent against fatalities, 33 percent against moderate to serious injuries (proxy for AIS 2-5 injuries) and 4.8 percent against minor injuries (proxy for AIS 1 injuries).

The FARS data used in Kahane's analysis support the conclusion that, all other things being equal, the rear seat is a safer crash environment than the front seat, especially in frontal crashes. The added safety results from the softer surfaces offered by rear seat backs compared to the instrument panel, steering wheel or windshield that are more frequently impacted by front seat occupants. This added protection reduces expected injury levels and allows less room for improvement from belts in rear seats. This implies an expected decrease in rear seat belt effectiveness relative to front seat effectiveness. When comparing our rear seat results with previous effectiveness estimates for front seat lap belts in Table IV-1, it is apparent that the fatality and AIS 1 injury estimates are consistent with this expectation. However, the AIS 2-5 estimate is actually 3 points higher than the average estimate for front seat belts. It is unclear whether this is due to a bias in samples used to derive either estimate, to variation within statistical confidence levels, or whether it actually reflects characteristics of AIS 2-5 injuries in front vs. rear seat crash environments.

As previously mentioned, rear seat lap shoulder belts are currently installed in only 1.5 percent of the vehicle fleet and as a result, there is no adequate basis for analyzing their effectiveness statistically. In addition, there are no crash test data available on these systems. An estimate of rear seat Type 2 belt effectiveness will therefore be made based on the improvement experienced in front seat Type 2 belts over front seat lap belts.

Returning again to Table IV-1, in front seats, lap/shoulder belts were estimated to be 10 points or 28 percent more effective then lap belts against fatalities, 20 points or 66 percent more effective against AIS 2-5 injuries, and equally effective against AIS 1 injuries (this equality essentially reflects the fact that belts can cause AIS 1 level bruises while restraining occupants in moderate to severe crashes and that many hand, arm, feet and leg injuries are not sufficiently reduced by belts).

Estimating lap/shoulder belt effectiveness based on the incremental point difference would produce estimates of 36 percent for fatalities and 53 percent for AIS 2-5 injuries. Basing these estimates instead on the percent increments would result in estimates of 33 percent for fatalities and 55 percent for AIS 2-5 injuries. Since development of the original front seat estimates was done independently for each belt system, there is no inherent preference for either method.

Ironically, because of the original inverse relationship between the magnitude of effectiveness rates for lap and lap/shoulder belts (i.e., lap belt effectiveness is higher for fatalities whereas lap/shoulder belt effectiveness is higher for AIS 2-5 injuries), the results of either method are directionally inconsistent. Adding incremental percentage points results in the higher estimate for fatalities but the lower estimate for AIS 2-5 injuries, while reflecting percent increments does the reverse.

There is reason to believe that the incremental effectiveness of Type 2 belts in rear seats is somewhat less than in front seats. This conclusion is supported by past effectiveness studies which indicate that lap/shoulder belts offer more incremental effectiveness over lap belts in frontal collisions than in other types and by accident data which indicate a disproportionate share of injuries to front seat occupants from frontal collisions.

In 1976 as a part of NHTSA's Restraint Systems Evaluation Program (RSEP), a study of restraint system effectiveness was conducted by the Highway Safety Research Center of the University of North Carolina.[3/] The study focused on towaway accidents involving 1973-1975 model passenger cars. Table IV-5 summarizes the incremental effectiveness estimates of lap/shoulder belts compared to lap belts found in that study using 3 different estimation procedures for each impact site.

TABLE IV-5
INCREMENTAL EFFECTIVENESS AGAINST INJURIES ≥ AIS 2 of
LAP/SHOULDER BELTS OVER LAP BELTS BY IMPACT SITE

Impact Site	Unadjusted*	Mantel-Haenszel Estimate	Gencat and Log-Linear Model
Front	.404	.370	.389
Side	.214	.355	.311
Rear	.455	.319	.319

*Adjustments in other methods account for crash configuration, vehicle weight, vehicle damage, and age/seating position.

Although estimates differ slightly under each specific procedure, the data consistently show higher incremental effectiveness of Type 2 belts in frontal collisions than in side or rear collisions. The one exception occurs for rear collisions using unadjusted data. Data in the original report however, indicate that all rear seat estimates had high standard errors. There is thus considerable doubt about the accuracy of the rear seat effectiveness estimates.

The RSEP results make sense intuitively. Mechanically, the primary effect of shoulder belts is the restriction of forward upper body movement. This type of motion is most likely to result from a frontal impact where unbelted or lap belted occupants would be thrown forward into steering columns, instrument panels, windshields or seat backs. Restricting upper torso motion has obvious benefits in these cases whereas in side or rear impact the added benefits from upper torso restriction is more subtle or in some instances nonexistant.

Data from both the Fatal Accident Reporting System (FARS) and the National Accident Sampling System (NASS) indicate that frontal collisions cause more injury in front seats than in rear seats. Table IV-6 lists the percent of total passenger car occupant injuries associated with non-rollover frontal impacts for 3 levels of injury severity from 1983-1986 FARS and 1983-1985 NASS files[4/] by seating position.

TABLE IV-6
PERCENT OF TOTAL PASSENGER CAR OCCUPANT INJURIES CAUSED BY NON-ROLLOVER FRONTAL IMPACTS BY INJURY SEVERITY AND SEATING POSITION
(PERCENT)

	Front Seat	Rear Seat	Difference	Percent Difference
Fatalities	51	38	13	34
AIS 2-5 Injuries	60	42	18	42
AIS 1 Injuries	56	48	8	17

Frontal collisions account for between 51 and 60 percent of total front seat injuries but only 38-48 percent of total back seat injuries. The frontal collisions share of total injury is between 17 and 42 percent higher in front seats than in rear seats. The higher rate of injury from frontals in front seats occurs because occupants are closer to the point of impact, and because the front seat offers a more "hostile" impact environment than the rear seat. In a frontal impact accident, front seat occupants are more likely to collide with the steering column, instrument panel, windshield, or A pillars. Rear seat occupants are more likely to collide with the relatively soft front seat back. In fact, Kahane's analysis indicates that in frontal crashes, the natural protection offered by the rear seat environment is equal to or better than that offered by rear seat lap belts or front seat lap and shoulder belts. (In non frontal crashes, however, lap belts were 43 percent effective against fatalities).

Given that the primary benefit of shoulder belts is in frontal accidents and that a larger proportion of front seat occupant injuries occur in frontals than do rear seat occupant injuries, the incremental effectiveness of shoulder belts in rear seats should be less than, or at least should not exceed, that experienced in front seats. To reflect this analytically, the lower of the previously discussed estimates of incremental effectiveness (33%) will be used for fatalities. For AIS 2-5 injuries, the lower incremental effectiveness estimate (53%) is artificially inflated by the high base lap belt effectiveness estimate. This estimate will be judgmentally reduced from 20 points to 17 points to remain consistent with the expectation that shoulder belts are no more effective in rear than in front seats. It is acknowledged that these individual estimates may not be precise, but they appear reasonable in light of existing data. Table IV-7 lists the effectiveness levels that will be used to estimate safety benefits in this analysis. As previously mentioned, a sensitivity analysis will examine alternate effectiveness estimates (see Appendix A).

TABLE IV-7
ESTIMATED PERCENT EFFECTIVENESS OF REAR SEAT
SAFETY BELTS

	Manual Lap Belt	Manual Lap/ Shoulder Belt
Fatalities	26	33
AIS 2-5 Injuries	33	50
AIS 1 Injuries	5	5

B. Usage

Regardless of how effective manual restraint systems may be, they will provide no protection to vehicle occupants unless they are properly used. Historically the general public has resisted the use of safety belts. In recent years, however, a combination of state belt use laws and an increasing public awareness of the importance of belt use has resulted in a dramatic increase in overall usage rates. Table IV-8 lists the trend in belt usage rates by seat location over the last 5 years. Children ages 0-4 are not included because they should be restrained in child safety seats and are too small to benefit from lap shoulder belts; therefore they will not be considered in computing benefits.

TABLE IV-8
Restraint Use in Passenger Cars by
Seat Location, Ages 5 and Over

	Front Seat	Back Seat	Average
1981-1982	10.7	1.7	10.3
1983	13.6	3.7	13.2
1984	14.4	5.8	14.0
1985	21.7	9.5	21.1

Source: Derived from 19 city surveys conducted by Goodell-Grivas in 1983-1985, and by Opinion Research in 1981-1982.

A gradual trend towards improved belt usage rates occurred during the early 1980's but in 1985, when belt use laws first became effective in 9 states, nationwide usage rates increased by 50 percent to over 21 percent. It is significant that although nearly all belt use laws apply only to front seat occupants, restraint usage in rear seats also increased by roughly 60 percent. This could reflect either a continuation of the earlier upward trend due to increased consumer awareness or to a carryover effect from the legal requirements that increases voluntary usage as well. These effects are undoubtedly related since publicity and debate about safety belt use laws has in itself served to educate the general public and may be responsible for much of the voluntary improvement seen in the 1983-1985 period.

The data listed in Table IV-8 were derived from the 19 city survey conducted for NHTSA each year by independent contractors. The survey is based on observed usage in passenger cars; however, other vehicle types such as trucks and vans are not included in the survey. An estimate of current belt usage rates in other vehicles must therefore be derived from other sources.

One readily available source of restraint usage rates by vehicle type is NHTSA's accident reporting systems, FARS and NASS. Both of these data files contain information on occupant restraint usage in motor vehicle accidents that can be broken out by vehicle type. FARS files, however, contain data on serious accidents only and thus would not provide a representative estimate of overall belt usage. NASS files include data from a wide range of accident severities.

In Table IV-9, usage data from 1985 NASS files are listed for a variety of vehicle types. Rates are listed for all seats and for second seats only. The rates for each vehicle type are then expressed as a function of passenger car usage. Thus, based on data for all seats in these files, restraint usage in pickups is estimated to be roughly 2/3 of that in passenger cars while usage in on/off road vehicles is roughly equal to that in passenger cars. Truck based station wagons and vans had usage rates that were 27 percent and 23 percent higher than passenger car rates respectively, while buses had only 20 percent of the passenger car usage rate.

Because the sample size that was used to estimate usage rates for various vehicles varies dramatically, a statistical measure of the significance of their differences (a Z test) was computed.

The Z statistic was computed as follows:

$$Z = (P_1-P_2)/\sqrt{2((n_1 S^2p_1 + n_2 S^2p_2)/(n1 + n_2))}$$

Where:

P_1 = usage rate of 1st variable
P_2 = usage rate of 2nd variable
S^2P1 = standard error for P1 (from Appendix 6 in 1984 NASS)
S^2P2 = standard error for P2 (from Appendix 6 in 1984 NASS)
n_1 = unweighted number of observations for P_1
n_2 = unweighted number of observations for P_2

Therefore, manual lap belts have reduced rear seat fatalities in passenger cars from 1348 to 1315 or by 33 (2.4 percent).

To estimate the expected benefits of Type 2 belts, the effectiveness of these systems (33 percent) is multiplied by the base fatalities and the assumed usage rate. Although usage rates may increase above current levels, this analysis assumes that such increases would not be due to the belt system itself. A common usage rate must therefore be used for both types of belt systems. Gross benefits from Type 2 belts are computed as follows:

Gross benefits = Base fatalities x usage x effectiveness
Gross benefits = 1348 x .095 x .33
Gross benefits = 42

The net benefits of Type 2 belts over the current system is simply the difference between the gross benefits of each system. In this case, 42 - 33 =9 fatalities prevented at current usage rates and accident levels.

Table IV-12 summarizes the net benefits that would result from requiring Type 2 belts in each vehicle type and seat location. For passenger cars, a total of 10 fatalities and 330 moderate to serious injuries could be prevented with roughly 90 percent of these benefits accruing from outboard seats. As a group, light trucks can save only 55 moderate to serious injuries and no fatalities. Roughly 70 percent of these savings are

TABLE IV-12

POTENTIAL BENEFITS FROM TYPE 2 BELTS BY VEHICLE TYPE AND SEAT LOCATION (AT CURRENT USAGE RATES)

	Second Seat			Other Rear Seats			All Rear Seats		
	Outboard	Center	Total	Outboard	Center	Total	O	C	T
Passenger Cars									
Fatalities	9	1	10	0	0	0	9	1	10
AIS 2-5	296	34	330	0	0	0	296	34	330
Pickups									
Fatalities	0	0	0	0	0	0	0	0	0
AIS 2-5	3	0	3	0	0	0	3	0	3
Vans									
Fatalities	1	1	2	0	0	0	1	1	2
AIS 2-5	10	13	23	3	4	7	13	17	30
Truck Based Stn. Wgn.									
Fatalities	0	0	0	0	0	0	0	0	0
AIS 2-5	0	0	0	0	0	0	0	0	0
On/Off Road									
Fatalities	1	0	1	0	0	0	1	0	1
AIS 2-5	21	1	22	0	0	0	21	1	22
Light Truck Total									
Fatalities	0	0	0	0	0	0	0	0	0
AIS 2-5	31	14	45	3	4	7	37	18	55
Buses									
Fatalities	0	0	0	0	0	0	0	0	0
AIS 2-5	0	0	0	0	0	0	0	0	0

associated with outboard seats. Because of their extremely low usage and injury rate, buses currently offer almost no potential for safety benefits. Note that no benefits are listed for AIS 1 injuries because the effectiveness of Type 2 belts against AIS 1 injuries is estimated to be identical to that of Type 1 belts (due to the fact that lap belts can cause AIS 1 level bruises while restraining occupants in moderate to severe crashes and that many hand, arm, feet, and leg injuries are not sufficiently reduced by belts).

The benefits noted in Table IV-12 are based on current (1985) belt usage rates. It is likely that these rates will increase somewhat as more state belt use laws are passed and public awareness of the importance of belt use continues to increase.[8] An increase in usage would result in a proportionate increase in safety benefits. In Table IV-13, the benefits that would result if belt use rates were to roughly double for each vehicle type are shown. Under these circumstances, the potential for safety benefits for passenger cars increases to 22 fatalities and nearly 700 moderate to serious injuries.

Light truck benefits would increase to 3 fatalities and over 100 injuries prevented. Because of their low base usage and injury experience, the potential for safety benefits in buses remains insignificant.

In the FRIA for FMVSS 208, Automatic Restraints, NHTSA examined an upper limit of front seat belt usage of 70 percent. Seventy percent was considered to be the upper bound of probable front seat belt usage under state belt use laws based on experience with these laws in other countries and attitudes towards belt use in the United States. Although rear seat belt use currently lags behind front seat belt use by a significant margin, it is possible that improved public awareness of the importance of safety belt use could result in rear seat usage rates that are close to or equal to front seat rates. In Table IV-14, the benefits would result from a 70 percent rear seat belt usage rate are examined. The importance to automotive safety of increasing belt usage in demonstrated by the dramatic improvement in safety benefits for all vehicle categories that results from this higher rate of usage. Under the 70 percent usage rate, only buses continue to register low safety benefits. This is due to the low rate of injuries currently experienced in this vehicle type.

All of the above estimates were developed using effectiveness estimates derived from the double pair comparison method (see section IV-A). These estimates were chosen because they were judged to be more accurate than those derived using more conventional techniques. However, estimates based on conventional techniques consistently produce effectiveness estimates that are noticeably higher than those adopted here. For this reason, a sensitivity analysis will be performed to estimate benefits that could result under higher effectiveness rates. The results of this analysis are shown in Appendix A.

While rear seat belt improvements have obvious benefits for rear seat occupants, it is possible that front seat occupants could benefit as well through the reduction in force loading on front seats caused by rear seat passengers. Several studies have documented unrestrained rear seat occupants as a cause of front seat occupant injury.[9] It is possible that in smaller vehicles, with limited space between front and rear seats, even a lap belt restrained occupant could increase front seat loading because of contact between the front seat back and the upper torso of the rear seat occupant. Lap/shoulder belts would mitigate this effect. NHTSA is seeking comment on the extent to which Type 2 belts might mitigate injuries to front seat occupants as well as rear seat occupants.

It is also possible that installing lap shoulder belts in the rear seat could in itself improve rear seat belt usage by mitigating the doubts that some consumers might have regarding the safety benefit associated with lap belts in high speed crashes. If this were to occur, additional safety benefits would result. NHTSA in therefore also seeking comment on the extent to which rear seat lap shoulder belts would increase belt usage rates.

TABLE IV-13

SENSITIVITY ANALYSIS
POTENTIAL BENEFITS FROM TYPE 2 BELTS BY VEHICLE TYPE AND SEAT LOCATION
(AT DOUBLE 1985 USAGE RATES)*

	Second Seat			Other Rear Seats			All Rear Seats		
	Outboard	Center	Total	Outboard	Center	Total	O	C	T
Passenger Cars									
Fatalities	19	3	22	0	0	0	19	3	22
AIS 2-5	624	71	695	0	0	0	624	71	695
Pickups									
Fatalities	0	0	0	0	0	0	0	0	0
AIS 2-5	8	0	8	0	0	0	8	0	8
Vans									
Fatalities	1	1	2	0	0	0	1	1	2
AIS 2-5	20	25	45	6	7	13	26	32	58
Truck Based Stn. Wgn.									
Fatalities	0	0	0	0	0	0	0	0	0
AIS 2-5	0	0	0	0	0	0	0	0	0
On/Off Road									
Fatalities	1	0	1	0	0	0	1	0	1
AIS 2-5	43	1	44	0	0	0	43	1	44
Light Truck Total									
Fatalities	2	1	3	0	0	0	2	1	3
AIS 2-5	63	26	89	6	7	13	77	33	110
Buses									
Fatalities	0	0	0	0	0	0	0	0	0
AIS 2-5	0	1	1	0	0	0	0	1	1

* Rates were doubled and rounded. Assumed usage rates were 20% for passenger cars, 15% for pickups, 35% for vans and truck based station wagons, 25% for on/off road vehicles and 4% for buses.

TABLE IV-14

SENSITIVITY ANALYSIS
POTENTIAL BENEFITS FROM TYPE 2 BELTS BY
VEHICLE TYPE AND SEAT LOCATION
(AT 70% USAGE RATES)

	Second Seat			Other Rear Seats			All Rear Seats		
	Outboard	Center	Total	Outboard	Center	Total	O	C	T
Passenger Cars									
Fatalities	66	10	76	0	0	0	66	10	76
AIS 2-5	2183	249	2432	0	0	0	2183	249	2432
Pickups									
Fatalities	1	0	1	0	0	0	1	0	1
AIS 2-5	37	0	37	0	0	0	37	0	37
Vans									
Fatalities	1	2	3	0	0	0	1	2	3
AIS 2-5	39	50	89	12	15	27	51	65	116
Truck Based Stn. Wgn.									
Fatalities	0	0	0	0	0	0	0	0	0
AIS 2-5	0	0	0	0	0	0	0	0	0
On/Off Road									
Fatalities	3	1	4	0	0	0	3	1	4
AIS 2-5	121	4	125	0	0	0	121	4	125
Light Truck Total									
Fatalities	5	3	8	0	0	0	5	3	8
AIS 2-5	197	54	251	12	15	27	209	69	278
Buses									
Fatalities	0	0	0	0	0	0	0	0	0
AIS 2-5	3	13	16	9	0	9	12	13	25

FOOTNOTES
Chapter 4

1 Final Regulatory Impact Analysis, Amendment to Federal Motor Vehicle Safety Standard 208, Passenger Car Front Seat Occupant Protection, DOT HS 806-572 July, 1984.

2 The studies referred to in Table IV-2 are as follows:

"Injury Rates and Belt Effectiveness in Car Front and Rear Seats-North Carolina Data," National Center for Statistical Analysis, Internal Study.

"Injury Rates and Belt Effectiveness in Car Front and Rear Seats - Maryland Data," National Center for Statistical Analysis, Internal Study.

"Current Activities in Canada Relating to the Protections of Children in Automobile Accidents," Road Safety and Motor Vehicle Regulation Directorate, Transport Canada.

"Note on Rear Seat Belt Use and Usefulness Estimated from Automated Accident Data," S. Partyka, March 1986.

"Restraint Use and Effectiveness for Rear Seat Occupants," Daniel Najjar, March, 1980.

"The Effectiveness of Rear-Seat Lap-Belts in Crash Injury Reduction", B.J. Campbell, University of North Carolina, Highway Safety Research Center.

"Rear Seat Restraint System Effectiveness in Preventing Fatalities," Leonard Evans, June 24, 1986.

"Fatality and Injury Reducing Effectiveness of Lap Belts for Back Seat Occupants," Charles J. Kahane, SAE Paper no. 870486.

3 A Statistical Analysis of Seat Belt Effectiveness in 1973-1975 Model Cars Involved in Towaway Crashes, September 1976, DOT HS 802 031.

4 1986 NASS data are not yet available.

5 Reported and Observed Seat Belt Usage Levels of Motor Vehicle Occupants in Florida, Communication Research Center, Florida State University, March 31, 1985.

6 Implementation of Ohio's Mandatory Use Law, First Quarterly Report, Office of the Governor's Highway Safety Representative, 9/30/86.

7 The surveys noted in Table IV-10 are as follows:

"Welcome to Life in Illinois, Occupant Restraint Usage in Illinois," Illinois Department of Transportation. Surveys for April 1985, July 1985 and April 1986 published in June 1985, November 1985, and September 1986 respectively.

"Direct Observation of Seat Belt Use in Michigan," The University of Michigan Transportation Research Institute. Survey for July 1985, December 1985 and April 1986 published in August 1985, February 1985 and May 1986 respectively.

"1985 Minnesota Safety Restraint and Helmet Use Study with Driver Attitude Survey," Minnesota Occupant Restraint Program and the Minnesota Department of Public Safety.

"Observed Pre-Law Safety Belt Use of Adult Front Seat Occupants in Twelve Texas Cities," Texas Department of Highway and Public Transportation, December 1985.

"Observed Front Seat Occupant Restraint Use in Fourteen Texas Cities Before and After Safety Belt Use Legislation," Texas Department of Highway and Public Transportation, September 1986.

Wisconsin passenger restraint use survey, Wisconsin Department of Transportation August 18, 1986.

8 Note however that preliminary data from the 1986 19 city survey show no appreciable increase in rear seat usage rates from 1985. Rear seat usage in passenger cars during the last 6 months of 1986 was 9.5 percent, identical to 1985.

9 Car Occupant Fatalities and the Effects of Future Safety Legislation, D.K. Griffiths, H.R.M. Hayes, P.F. Gloyns, S.J. Rattenbury, and G.M. MacKay, Twentieth STAPP Car Crash Conference.

The Effect of Rear Seat Passengers on Front Seat Occupants in Frontal Impacts, A.K. Roberts, 1983

V. COSTS

The costs associated with a requirement for rear seat lap and shoulder belts would potentially involve both increased vehicle costs and increased operating costs due to the added fuel burned because of additional weight. The following sections will examine the magnitude of these costs under the variety of alternatives discussed in Chapter III.

A. Vehicle Price Increases

NHTSA is not aware of any studies that specifically address the cost of rear seat safety belts. However, these systems are sufficiently similar to front seat systems to allow reasonable estimates of their cost to be derived from available front seat cost data.

There are 3 basic types of component changes that could be applicable to the various vehicle types and seating positions that are under consideration. As noted in section I, FMVSS No. 210 already requires that all forward facing outboard seats in passenger cars (other than convertibles) be equipped with anchorages for a Type 2 seat belt assembly. "Anchorage" is defined as the provision for transferring seat belt assembly loads to the vehicle structure. Therefore, no additional structural reinforcement should be necessary at these positions. The added components needed for the installation of Type 2 belts in the rear