

Front Seat Performance in Rear Impacts: Effect on 1st and 2nd Row Occupant Injury

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ABSTRACT

Purpose: This study analyzes the effect of front seat performance on occupant injury in rear crashes where there is a 2nd row passenger seated behind the front occupant.

Methods: The study was carried out for rear impact crashes in the 1991-2006 NASS-CDS. Only cases where there was a 2nd row occupant seated behind an occupied front seat were chosen. Serious injury (MAIS 3+F) was determined for the front and 2nd row occupants. The performance of the front seat was determined using eight NASS-CDS investigator categories, including no failure, seat failure of the adjuster, seatback or track-anchor and seat deformation by the occupant or intrusion. The rear crashes were subdivided into four severities (<15, 15-25, 25-45 and >45 mph). The risk for serious injury was determined for each category of seat performance. Next, individual cases were reviewed from the online NASS electronic files to better understand the determination of seat performance by the NASS-CDS investigators. The data analysis was then repeated using 1988-1997 NASS-CDS data to match an earlier analysis and publication.

Results: There were 535,953 weighted cases (641 unweighted) of front-outboard occupants with a 2nd row passenger seated behind in a rear crash. 79.9% of the cases had no seatback failure, 3.1% had a seat performance failure and 10.7% were listed as deformed by the front occupant or intrusion. There were 5,338 seriously injured 2nd row occupants (68 unweighted). The risk for serious injury (MAIS 3+F) was 1.00% for 2nd row and 0.43% for front occupants. With no seat failure, serious injury risks were 0.46% for 2nd row and 0.06%

for front occupants. With a failure, they were 7.58% and 2.88%, respectively. With seat deformation, there were 3.33% and 2.54%. Injury risks increased with crash severity. The number of cases of serious injury is limited so no statistical testing was performed. There were only 2 cases with seat failure and 4 with seat deformation in the 25-45 mph category.

Fifteen online cases involving sixteen rear occupants could be downloaded where seat performance was listed as a failure or deformed. In two cases, a seatback failure was noted but the investigators explanations were "the seatback was very reclined at time of inspection" and "seatback reclined when impacted by the occupant." The photos showed the seat reclined but not broken.

Conclusions: Seat failure is infrequent in rear impacts. Seat deformation occurs by occupant loading or intrusion. Seat failure and deformation are associated with a higher risk of injury to the front-seat occupant and the one seated behind. However, miss-coding of seat performance was noted and there are a limited number of NASS-CDS cases. Some NASS-CDS cases were coded as seat failure but involved only a reclined seatback after the crash, not an actual failure of seat structures.

INTRODUCTION

Figure 1 shows the risk for serious and severe injury in rear impacts as a function of crash delta V (Viano, Parenteau 2008a). It is for 1991-2004 NASS-CDS calendar years with rear impacts defined as tow-away vehicles with a rear impact location (GAD1="B") and no rollover (rollover ≤0). For crashes below 30 mph, the risks are extremely low and do not seem to be related to

crash severity. This data suggests that seats are performing well in the field, as found by Partyka (1992). Front seats are designed to protect and contain an occupant while absorbing energy by seatback yielding in rear crashes. In the most severe rear crashes (>30 mph delta V), the risk for serious injury rises. A recent study by Viano, Parenteau (2008a) looked at cases of serious injury in rear crash with delta V above 35 mph. That study showed that intrusion of rear structures and the 2nd row was a significant factor in the increased risk of injury. The intrusion supported the front seatback causing high inertial forces on the occupant and injuries sometimes by impact with component in front of the occupant.

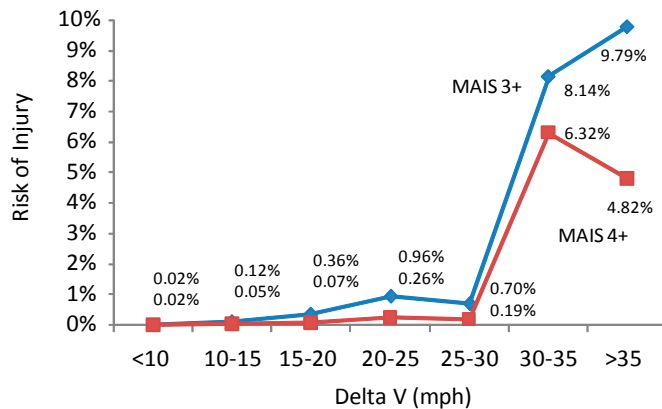


Figure 1: Risk for serious (MAIS 3+) and severe (MAIS 4+) injury to occupants in tow-away rear impacts (from Viano, Parenteau 2008a).

None of the author's previous studies have looked at the seat performance listed by the NASS investigators. This study looks at the NASS data on seat performance by rear crash severity in a subset of field accidents. The subset is rear crashes where there was a 2nd row passenger seated behind an occupied front seat. These data allow analysis of injury risks to the front and 2nd row occupants and the role of the performance of the front seat by crash severity.

While this analysis used 1991-2006 NASS-CDS data, a parallel study was carried out using 1988-1997 NASS-CDS data to evaluate the findings of Friedman et al. (2000). They found that seat "failures" significantly increased the risk for serious injury in 2nd row occupants in 15-25 mph rear impact crashes.

METHODOLOGY

NASS-CDS Data:

NASS-CDS is a stratified sample that includes police-reported crashes involving light vehicles. About 5,000 fatal and injury crashes are prospectively selected each year for investigation. Most of the vehicles are towed from the scene because of damage. The data includes information based on police reports, crash investigation teams, vehicle registration, medical records and interviews. The data is then extrapolated to national

estimates using weighting factors provided by NHTSA. Tow-away rear crashes were included in this study and were defined using the deformation location and rollover variables (GAD1 = 'B' and rollover <=0). The data was analyzed by front seat performance, injury and crash severity.

Front seat performance: The performance of the front-seat occupant was assessed using the "Seatperf" variable. This variable is used by crash investigators to identify whether the seat failed or was deformed. The variable is coded as:

- (1) No failure
- (2) Adjuster failure, includes failure of the height adjustment, longitudinal seat track adjustment, rocker adjustment, swivel/rotational adjustment, or seat back recliner adjustment.
- (3) Seatback failure is when the mechanism designed to lock the seat back in its upright position fails or separates allowing the seatback to move during the collision as a result of occupant loading.
- (4) Tracks-anchors failure is used if the seat separates, to any degree, from a seat track during the crash.
- (5) Deformed by occupant is when the seat form is changed from its original design due to occupant loading during the crash.
- (6) Deformed by intrusion is when the seat is deformed or failed by intrusion of an interior vehicle component(s) or exterior vehicle component(s) into the passenger compartment.
- (7) Combination is when two or more of (2)-(6) occurs.
- (8) Other is used when the only seat failure or deformation is not described above (such as impact forces).

Missing is where there is no entry reported in the seat performance cell. Unknown means the investigator tried to code the performance but was not able to make a determination.

Crash severity: The crash severity was assessed using the "dvtot" variable. The effect of crash severity was analyzed by dividing "dvtot" into >0 to <15 mph, 15 to <25 mph, 25 to <45 mph and ≥45 mph categories.

Injury severity: Injury severity of the occupants was assessed using the Maximum Abbreviated Injury Scale (MAIS) and the "TREATMNT" variable. MAIS represents the assessment of life-threatening injuries at the time of first medical evaluation, and not long-term consequences. It ranges from MAIS = 0-9. MAIS 3-6 represent a serious-unsurvivable injury. Fatality was also used to determine if the occupant died of injuries in the accident. The variable "TREATMNT" was used to define fatality, which is TREATMNT = 1. Because fatalities can occur at any MAIS level, seriously injured occupants are defined as those with MAIS ≥3. The shorthand notation for this is MAIS 3+F.

1991-2006 Analysis: In the first phase of the study, NASS-CDS data for calendar years 1991-2006 was analyzed for 2nd row occupants in rear impacts when the seat in front of them was occupied.

Individual NASS Case Review: Thirty-one cases, involving thirty-three individuals, were identified with seriously-to-fatally injured (MAIS 3+F) 2nd row occupants in rear impacts when the seat in front of them was occupied in 1991-2006 NASS-CDS. Fifteen cases, involving sixteen individuals, were available for downloading from the 1997-2006 NASS-CDS electronic data.

1988-1997 Analysis: In the second phase, NASS-CDS data for calendar years 1988-1997 was analyzed for 2nd row occupants in rear impacts when the seat in front of them was occupied. This phase matched the time period from a study by Friedman et al. (2000).

RESULTS

1991-2006 Analysis

Front and 2nd row occupant injury

Table 1 shows the rear impacts where there was an occupant in the 2nd row behind an occupied front seat. There were 535,953 cases in the 1991-2006 NASS-CDS. The data are organized by the front seat performance determined by the NASS accident investigators. In nearly 80% of the cases, there was no failure or deformation of the seatback. In 10.6% of the cases, the occupant deformed the seat rearward; and, in 0.2% of the cases, intrusion deformed the seat forward. In 3.1% of the cases, there was a failure of the front seat adjuster, seatback or track-anchor.

There were 2,305 (0.43%) front occupants who experienced MAIS 3+F injury in the rear impacts. In contrast, there were 5,338 (1.00%) 2nd row occupants seriously injured. The relative risk was 2.3 times greater for 2nd row occupants. When no seat failure or deformation was noted, the risk for serious injury was 0.06% for front occupants and 0.46% for 2nd row occupant. The relative risk was 7.8 times greater for the 2nd row occupant.

The highest risk for serious injury was in crashes where the front seat was deformed by intrusion. 51.0% of front-seat occupants and 69.9% of 2nd row occupants were seriously injured when intrusion deformed the front seat. When the front seat was deformed by the occupant, the risk was 1.76% for the front occupant and 2.25% for the 2nd row occupant. The relative risk was 1.3 times greater for the 2nd row occupant.

When front seat failure was noted as performance 2-4, the risk for serious injury was 2.9% for the front and 7.6% for the 2nd row occupant. The highest risk was 11.2% for the 2nd row occupant when there was a track-anchor failure of the front seat.

Table 2 gives more information on the front-seat occupants in rear crashes where the seat behind them was occupied. The upper half of the Table gives the exposure data by front seat performance and crash delta V. The data are subdivided by delta V for crash <15 mph, 15-25 mph, 25-45 mph and ≥45 mph. The lower half of the Table gives the incidence of MAIS 3+F injury. 2,305 (0.43%) of the front-seat occupants experienced MAIS 3+F injury.

Table 1: Injury risks in crashes where a front occupant has a 2nd row occupant seated behind in rear impacts.

Front Seat Performance	Exposure		Risk of MAIS 3+F Injury				Risk Ratio
	#	%	Front Occupants # Risk		Rear Occupants # Risk		
No Failure (1)	428,235	79.9%	253 0.06%		1,966 0.46%		7.8
Adjuster Failure (2)	2,265	0.4%	51 2.27%		172 7.59%		3.3
Seatback Failure (3)	10,543	2.0%	351 3.33%		655 6.21%		1.9
Track-Anchor Failure (4)	3,937	0.7%	79 2.00%		442 11.21%		5.6
Deformed by Occupant (5)	56,612	10.6%	994 1.76%		1,275 2.25%		1.3
Deformed by Intrusion (6)	916	0.2%	467 51.0%		640 69.9%		1.4
Combination (7)	1,449	0.3%	0 0.00%		0 0.00%		--
Other (8)	3,016	0.6%	0 0.00%		6 0.20%		--
Missing	24,717	4.6%	70 0.28%		157 0.64%		2.2
Unknown	4,264	0.8%	39 0.91%		25 0.59%		0.6
Total	535,953	100%	2,305 0.43%		5,338 1.00%		2.3

Table 2: Front outboard passengers with 2nd row occupants seated behind (NASS-CDS 1991-2006 weighted).

Delta-V (mph)	Front Occupants (wgt)										Other	Total
	Miss.	Unk.	No Failure	Front Seat Performance			Deformation		Comb. (2-3-4-5-6)			
				Adjuster (2)	Failure Seatback (3)	Track- Anchor (4)	Def. by Occ (5)	Def. by Intrusion (6)				
Driver												
>0-<15	711	400	117,411	725	3,377	213	9,212	0	234	2,753	135,035	
15-<25	2,714	1,229	23,757	841	387	772	6,517	12	0	93	36,321	
25-<45	26	0	1,950	0	2,232	0	4,888	362	0	0	9,458	
≥45	0	0	0	0	0	0	7**	0	0	0	7	
Unknown	3,244	677	30,335	202	767	1,709	15,054	47	0	43	52,077	
Total	6,695	2,306	173,453	1,768	6,763	2,694	35,678	420	234	2,888	232,898	
RFP												
>0-<15	7,720	97	160,740	262	1,184	213	6,468	0	0	0	176,684	
15-<25	7,770	1,116	31,145	115	750	353	5,773	185	966	0	48,171	
25-<45	22	41	4,843	121	560	184	1,016	0	0	128	6,914	
≥45	0	0	0	0	0	0	7***	0	0	0	7	
Unknown	2,510	705	58,054	0	1,286	494	7,669	311	250	0	71,279	
Total	18,022	1,958	254,782	497	3,780	1,244	20,933	496	1,215	128	303,055	
Driver & RFP												
>0-<15	8,431	497	278,151	986	4,561	426	15,680	0	234	2,753	311,718	
15-<25	10,484	2,345	54,902	956	1,137	1,124	12,290	196	966	93	84,492	
25-<45	48	41	6,793	121	2,792	184	5,904	362	0	128	16,372	
≥45	0	0	0	0	0	0	15	0	0	0	15	
Unknown	5,754	1,382	88,389	202	2,053	2,203	22,723	358	250	43	123,356	
Total	24,717	4,264	428,235	2,265	10,543	3,937	56,612	916	1,449	3,016	535,953	
MAIS 3+ F Front Occupants												
Driver												
>0-<15	0	0	0	0	0	0	302	0	0	0	302	
15-<25	0	0	0	0	0	0	31	12	0	0	42	
25-<45	0	0	40	0	0	0	37	362	0	0	439	
≥45	0	0	0	0	0	0	0	0	0	0	0	
Unknown	48	19	33	0	343	0	71	47*	0	0	561	
Total	48	19	73	0	343	0	441	420	0	0	1,344	
RFP												
>0-<15	0	0	0	0	0	0	0	0	0	0	0	
15-<25	0	0	82	51	0	0	0	0	0	0	133	
25-<45	22	0	0	0	0	0	53	0	0	0	75	
≥45	0	0	0	0	0	0	0	0	0	0	0	
Unknown	0	19	99	0	9	79	501	47*	0	0	753	
Total	22	19	180	51	9	79	553	47	0	0	961	
Driver & RFP												
>0-<15	0	0	0	0	0	0	302	0	0	0	302	
15-<25	0	0	82	51	0	0	31	12	0	0	175	
25-<45	22	0	40	0	0	0	90	362	0	0	514	
≥45	0	0	0	0	0	0	0	0	0	0	0	
Unknown	48	39	131	0	351	79	571	94	0	0	1,314	
Total	70	39	253	51	351	79	994	467	0	0	2,305	

*Case 2002-45-105 with 5 seriously injured occupants

**Case 1991-79-155C at 48 mph (no seriously injured driver and left 2nd row passenger)

***Case 2005-50-116B at 83 km/h (no seriously injured RFP and right 2nd row passenger)

Table 3: 2nd row outboard passengers with 1st row occupants seated in front (NASS-CDS 1991-2006 weighted).

2nd Row Occupants (wgt)											
Delta-V (mph)	Miss.	Unk.	Front Seat Performance							Other	Total
			No Failure	Adjuster (2)	Failure Seatback (3)	Track- Anchor (4)	Deformation		Comb. (2-3- 5-6)		
							Def. by Occ (5)	Def. by Intrusion (6)	4-		
2nd row left											
>0-<15	711	400	117,411	725	3,377	213	9,212	0	234	2,753	135,035
15-<25	2,714	1,229	23,757	841	387	772	6,517	12	0	93	36,321
25-<45	26	0	1,950	0	2,232	0	4,888	362	0	0	9,458
≥45	0	0	0	0	0	0	7**	0	0	0	7
Unknown	3,244	677	30,335	202	767	1,709	15,054	47	0	43	52,077
Total	6,695	2,306	173,453	1,768	6,763	2,694	35,678	420	234	2,888	232,898
2nd row right											
>0-<15	7,720	97	160,740	262	1,184	213	6,468	0	0	0	176,684
15-<25	7,770	1,116	31,145	115	750	353	5,773	185	966	0	48,171
25-<45	22	41	4,843	121	560	184	1,016	0	0	128	6,914
≥45	0	0	0	0	0	0	7***	0	0	0	7
Unknown	2,510	705	58,054	0	1,286	494	7,669	311	250	0	71,279
Total	18,022	1,958	254,782	497	3,780	1,244	20,933	496	1,215	128	303,055
2nd Row Left & Right											
>0-<15	8,431	497	278,151	986	4,561	426	15,680	0	234	2,753	311,718
15-<25	10,484	2,345	54,902	956	1,137	1,124	12,290	196	966	93	84,492
25-<45	48	41	6,793	121	2,792	184	5,904	362	0	128	16,372
≥45	0	0	0	0	0	0	15	0	0	0	15
Unknown	5,754	1,382	88,389	202	2,053	2,203	22,723	358	250	43	123,356
Total	24,717	4,264	428,235	2,265	10,543	3,937	56,612	916	1,449	3,016	535,953
MAIS 3+ F Rear Occupants											
2nd row left											
>0-<15	0	0	0	0	0	0	0	0	0	0	0
15-<25	0	0	82	0	56	307	157	0	0	0	601
25-<45	0	0	137	0	12	0	37	362	0	0	547
>45	0	0	0	0	0	0	0	0	0	0	0
Unknown	53	0	647	0	343	22	108	47*	0	0	1,172
Total	53	0	865	0	410	329	302	409	0	0	2,367
2nd row right											
>0-<15	0	0	0	0	0	0	0	0	0	0	0
15-<25	0	0	115	51	11	34	382	185	0	0	778
25-<45	22	0	453	121	0	0	111	0	0	6	713
≥45	0	0	0	0	0	0	0	0	0	0	0
Unknown	82	25	534	0	234	79	480	47*	0	0	1,434
Total	104	25	1,101	172	245	113	973	232	0	6	2,971
2nd Row Left & Right											
>0-<15	0	0	0	0	0	0	0	0	0	0	0
15-<25	0	0	196	51	67	341	539	185	0	0	1,379
25-<45	22	0	590	121	12	0	148	362	0	6	1,260
≥45	0	0	0	0	0	0	0	0	0	0	0
Unknown	135	25	1,180	0	576	101	588	94	0	0	2,699
Total	157	25	1,966	172	655	442	1,275	640	0	6	5,338

* Case 2002-45-105 with 5 seriously injured occupants

**Case 1991-79-155C at 48 mph (no seriously injured driver and left 2nd row passenger)

***Case 2005-50-116B at 83 km/h (no seriously injured RFP and right 2nd row passenger)

Table 4: Individual NASS case review of seriously injured 2nd row occupants with an occupant seated in front.

Case			Vehicle			Front Seat					2nd Row Rear						
Year	PSU	Caseid	Delta V (mph)	MY	Make & Model	Occ.	Age	Restr.	MAIS	Performance	Age	Restr.	MAIS	Region with max injury	Source	Seat Performance	Seatback Intrusion (cm)
1991	76	4B	33	1985	Plymouth Horizon	RFP	57	L/S	2	Adjusters failure	67	L	F	Unk	Unk	Def. by intrusion	
1997	11	22K	21	1991	Plymouth Acclaim	RFP	22	None	3	Adjusters failure	2	None	3	Head	Seatback	Def. by intrusion	54
1999	49	143K	30	1993	Dodge Caravan	Driver	35	L/S	2	Seatback failure	33	L/S	3	UX	Seatback	Deformed by occ	0
2002	75	137K	17	1996	Subaru Impreza	Driver	41	L/S	0	Seatback failure	2	CSS	3	Face	Seatback	No failure	0
1995	48	99B	Unk	1987	Chev. Spectrum	Driver	22	None	4	Seatback failure	1	L+CSS	4	Head	Other veh	Seatback failure	
1995	9	58A	Unk	1992	Chev. G-van	Driver	68	L/S	5 F	Seatback failure	73	None	5 F	Thorax	Seatback	Seatback failure	
1995	49	147B	24	1983	Chev. Camaro	RFP	41	L/S	1	Seatback failure	24	L	4 F	Head	Seatback	Combination	
1993	8	80E	Unk	1990	Chev. Cavalier	RFP	17	Auto belt	1	Seatback failure	17	None	3	UX	Interior	Def. by intrusion	
1996	9	7C	21	1985	Plymouth Reliant	Driver	45	L/S	2	Track-anchor failure	13	None	3	LX	Seatback	Def. by intrusion	
1993	41	37A	Unk	1988	Chev. Beretta	Driver	16	L/S	1	Track-anchor failure	17	None	4	Head	Other pillar	No failure	
1992	75	193J	23	1988	Daihatsu Charade	RFP	Unk	None	Unk	Track-anchor failure	5	L/S	4	Head	Seatback	No failure	
1995	9	58A	Severe	1992	Chev. G-van	RFP	68	L/S	4 F	Track-anchor failure	73	L/S	6 F	Head	Non-contact	Track-anchor failure	
2003	11	193B	27	1995	Saturn SC	Driver	38	L/S+bag	5	Def. by occupant	5	CSS	4 F	Thorax	Seatback	Def. by intrusion	31
2006	74	134K	19	1987	Suzuki Samurai	Driver	27	L/S	1	Def. by occupant	6	L+CSS	3	LX	Seatback	No failure	13
1991	73	97D	20	1983	Mercedes 200	Driver	54	None	2	Def. by occupant	23	L/S	3	Spine	Seatback	Def. by intrusion	
1993	11	10K	24	1986	Dodge Lancer	Driver	68	L/S	1	Def. by occupant	59	L	5	Head	Rear header	Seatback failure	
1992	6	22J	Unk	1989	Ford Mustang	Driver	48	L/S	1	Def. by occupant	76	None	3	Thorax	Seatback	Def. by intrusion	
1993	12	172B	Unk	1985	Mercury Marquis	Driver	35	None	2	Def. by occupant	7	None	5 F	Head	Rear header	Def. by intrusion	
2002	49	123B	Severe	1998	Nissan Sentra	Driver	46	L/S	1	Def. by occupant	11m	Unk**	5 F	Head	Interior	Def. by intrusion	8
2006	75	61K	Unk	1996	Honda Civic	Driver	18	L/S	0	Def. by occupant	17	L/S	3	LX	Hardware	Def. by intrusion	29
2002	9	110J	42	1999	Chev. Malibu	RFP	33	L/S	1	Def. by occupant	5	CSS	3	LX	CSS	Def. by intrusion	67
1997	45	168B	32	1991	Eagle Talon	RFP	16	L/S	1	Def. by occupant	15	L/S*	F	Unk	Unk	Def. by intrusion	43
1996	72	211B	39	1990	Olds Ciera	RFP	56	None	2	Def. by occupant	60	None	4 F	Head	Rear header	Def. by intrusion	
1997	82	76K	22	1991	Geo Metro	RFP	27	L/S	1	Def. by occupant	22	L/S	3	LX	Seatback	Def. by intrusion	79***
1993	75	3K	21	1986	Subaru DL	RFP	51	L/S	1	Def. by occupant	40	L	3	LX	Seatback	Def. by intrusion	
1992	75	169E	15	1979	Mercury Cougar	RFP	82	L/S	1	Def. by occupant	78	None	3	Thorax	S/W	No failure	
2006	49	98B	Severe	1989	Toyota Camry	RFP	41	S	1	Def. by occupant	43	None	5 F	Thorax	Seatback	Def. by intrusion	36
2003	49	160B	Severe	1992	Mitsubishi Eclipse	RFP	47	S	5 F	Def. by occupant	42	None	5 F	Head	Rear header^^	Def. by intrusion	28
1996	48	215A	Unk	1993	Chev. Lumina	RFP	88	None	4 F	Def. by occupant	61	None	F	Unk	Unk	Def. by intrusion	
1999	12	67F	41	1993	Olds Cutlass	Driver	49	L/S	5 F	Def. by intrusion	5	None	3	Abdo/Thorax	Seatback	Def. by intrusion	96
2002	45	103B	Severe	1990	Mercury Sable	Driver	37	L/S	6 F	Def. by intrusion	8	L/S	6 F	Head	Unk	Def. by intrusion	Cat^
1998	43	115E	21	1989	Sterling 827S	RFP	23	L/S	1	Def. by intrusion	21	None	3	Face	Head restr.	Def. by intrusion	
2002	45	103B	Severe	1990	Mercury Sable	RFP	10	L/S	5 F	Def. by intrusion	4	CSS	F	Whole body	Fire	Def. by intrusion	Cat^
* Manuse = 0 unbelted in database, L/S in vehicle inspection notes										*** at middle row seatback		S/W=steering wheel					
** Child listed as unbelted, improperly restrained with L/S and unknown belt use										^^ Catastrophic		^^occupant ejected					

* Manuse = 0 unbelted in database, L/S in vehicle inspection notes

** Child listed as unbelted, improperly restrained with L/S and unknown belt use

*** at middle row seatback

^ Catastrophic

S/W=steering wheel

**occupant ejected

Table 3 gives similar data on the 2nd row occupants in rear crashes where the seat in front of them was occupied. The upper half of the Table gives the exposure by front seat performance and crash severity; and, the lower half gives the incidence of MAIS 3+F injury. 5,338 (1.00%) of the 2nd row occupants experienced MAIS 3+F injury.

Individual NASS Cases

Table 4 lists 31 cases of seat failure or seat deformation involving 33 occupants who were seriously injured in the 2nd row. The information for the cases was obtained from the NASS-CDS database. The performance information is from the NASS-CDS investigator's report. Information about the vehicle and delta V are given with the case identification and year of the crash. Table 4 lists the age, restraint use and injury to the front-seat occupant and similar information on the 2nd row occupant who was seriously injured. Performance is identified for the front seat and 2nd row seats. For the 2nd row occupant, the body region of the most severe injury and injury source are listed. Where noted, the extent of 2nd row seatback intrusion is listed for the seating position of the 2nd row occupant.

Individual NASS Case Review

Fifteen cases in Table 4 with calendar year 1997 and later were downloaded from the NHTSA website involving 16 2nd row MAIS 3+ F occupants. Several of the cases with seat failure and deformation are reported here to see the circumstances of the crash and what

was reported by the NASS-CDS investigating team. An additional case, 2002-49-14E was downloaded. This case involves a seat adjuster failure. The case is not listed in Table 4 since the 2nd row occupant was not seriously injured. Case 1997-11-22K also reports a seat adjuster failure and was downloaded. It is however not clear how the adjuster failed from the photos taken by the investigator. The seatback was noted as "slightly reclined" prior to the crash and moved to "slightly forward position" after the crash. There was no additional indication how the seat track failed. Case 2002-49-14E was reviewed to illustrate a seat adjuster failure.

Seat Adjuster Failure

Case 2002-49-14E involved a failure of the right-front passenger's seat adjuster. Vehicle 1 (1999 Chevrolet Malibu) was traveling north on a 3 lane one way service road. **Vehicle 2** (case vehicle 1992 Nissan Sentra) was traveling north in the second lane of the service road. V1 was fleeing a police vehicle. It exited the highway and ran a red light at the end of the exit service road. It crossed the intersecting road and entered the north bound service road. On the service road, it hit a dip in the road and went airborne. When it came down, it rotated counterclockwise.