

# **The Likelihood of Human Casualty in Highway Crashes**

**A Briefing for the NHTSA Office of Crashworthiness**

**Based on an Investigation Conducted for  
the FHWA/NHTSA Crash Analysis Center  
at George Washington University, Virginia**

**March 19, 1996  
DeBlois Associates  
Washington, D.C.**

## "The Likelihood of Casualty in Highway Crashes"

Many outcomes and their severity may be considered individually or in combinations for the purpose of casualty prediction.

In this briefing: Casualty = Fatality or MAIS 3+

Other possibilities to be addressed and evaluated later include:

Severe Injury, Irrespective of Fatality,  
Extensive Hospitalization, Irrespective of Other Factors,  
Post Crash Fatalities, in Addition to All Fatalities,  
The Injury Severity Score, etc.  
Most Severe Injury or Injuries and Accompanying Attributes

Predictors Selected for this Briefing:

Delta V in Planar Crashes,  
Direction of Force in Planar Crashes,  
Rollover Occurrence, by Quarter Turns,  
Occupant's Age,  
Restraint Use, and  
Seating Position.

Additional Predictors to be Addressed and Evaluated Later,  
Especially with the Benefit of Crash Scene Observables:

Door Opening,  
General Area of Damage, to Supplement the Direction of Force,  
Size, Shape, and Rigidity of Collision Partner,  
Extent of Damage,  
Specific Horizontal and Vertical Location of the Crush,  
Crush Distribution,  
Roadway Class, for Possible Resolution of R/O Severity,  
Occupant Gender, Size, and Shape, and  
Make, Model, and Model Year as Surrogates  
of Many Non Observables.

Processing of Raw Data from the NASS/CDS 1988-1994

In view of the dichotomous outcome under consideration (i.e. "Yes" or "No" Fatality or MAIS 3+) a maximum likelihood procedure, specifically a logistic regression with weighing factors, is used to fit various models to the raw data. Essentially, the probability of casualty is modeled as:

$$P = 1 / [1 + \exp(-w)]$$

where  $w = A + B*x + C*y + \text{etc}$   
where  $x, y, \text{etc}$  are the selected predictors.

Specifically, the procedure estimates the coefficients: A, B, C, etc, and their standard errors.

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Programmable Algorithms

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For Planar Crashes, the probability of fatality or MAIS 3+ is given (in 0 to 100%) by:

$$P = 100 / [1 + \exp(-w)] \quad \text{where}$$

$$w = A + B \cdot \Delta V + C \cdot \text{Age} + D + E + F$$

A	= -8.65 +/- 0.43;	
B	= 0.13	0.00 if $\Delta V$ in mph;
C	= 0.03	0.00 if Occupant's Age in Years;
D	= 2.18	0.33 if DOF=Frontal;
	2.57	0.34 if DOF=Left;
	2.66	0.39 if DOF=Right;
	0.00	0.00 if DOF=Rear;
E	= -0.94	0.15 if Occupant is Restrained;
	0.00	0.00 if Occupant is Unrestrained;
F	= -0.13	0.23 if Occupant is the Driver;
	0.17	0.24 if Occupant is Front Passenger;
	0.00	0.00 if Occupant is Rear Seated.

With Rollover Occurrence the probability of fatality or MAIS 3+ is given (in 0 to 100%) by:

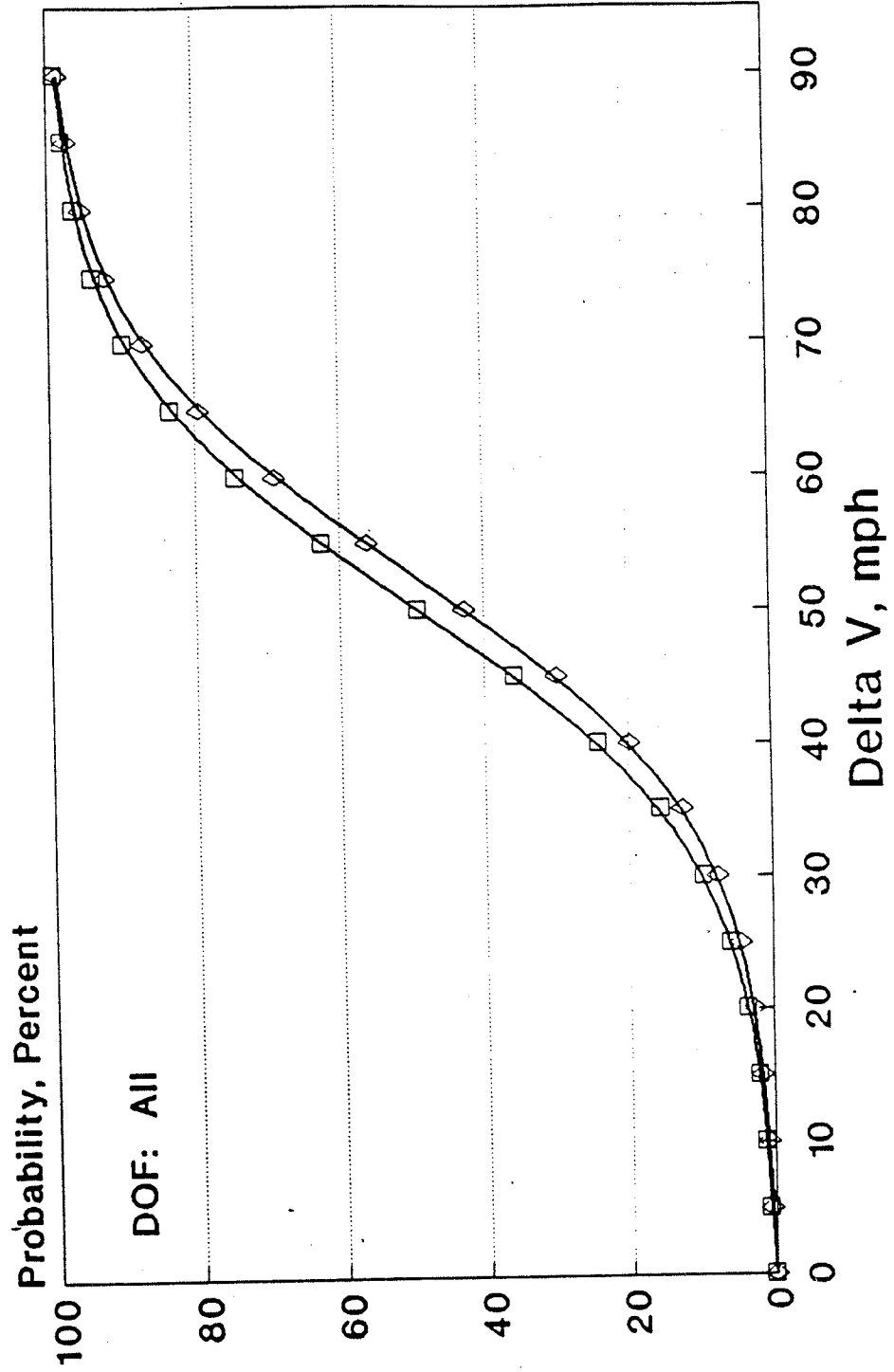
$$P = 100 / [1 + \exp(-w)] \quad \text{where}$$

$$w = A + B + C \cdot \text{Age} + D + E$$

A	= -4.07 +/- 0.11;	
B	= 0.77	0.19 if One Quarter Turn Rollover;
	0.67	0.17 if Two or Three Quarter Turns Rollover;
	1.44	0.11 if Four or More Quarter Turns Rollover;
	0.00	0.00 if No Rollover;
C	= 0.02	0.00 if Occupant's Age in Years;
D	= -1.07	0.08 if Occupant is Restrained;
	0.00	0.00 if Occupant is Unrestrained;
E	= 0.18	0.11 if Occupant is the Driver;
	0.23	0.12 if Occupant is Front Passenger;
	0.00	0.00 if Occupant is Rear Seated.

Applications are illustrated in attached Figures 1 to 11. More detail may be found in Tables I and II.

Fig. 1. Probability of Fatality or  
MAIS 3+, +/- Standard Error, v. Delta V  
for All Planar Car Crashes



The NASS/CDS 1988-1994

Fig. 2. Crash Frequency & Probability of Fatality or MAIS 3+, as a Function of Delta V for Planar Car Crashes

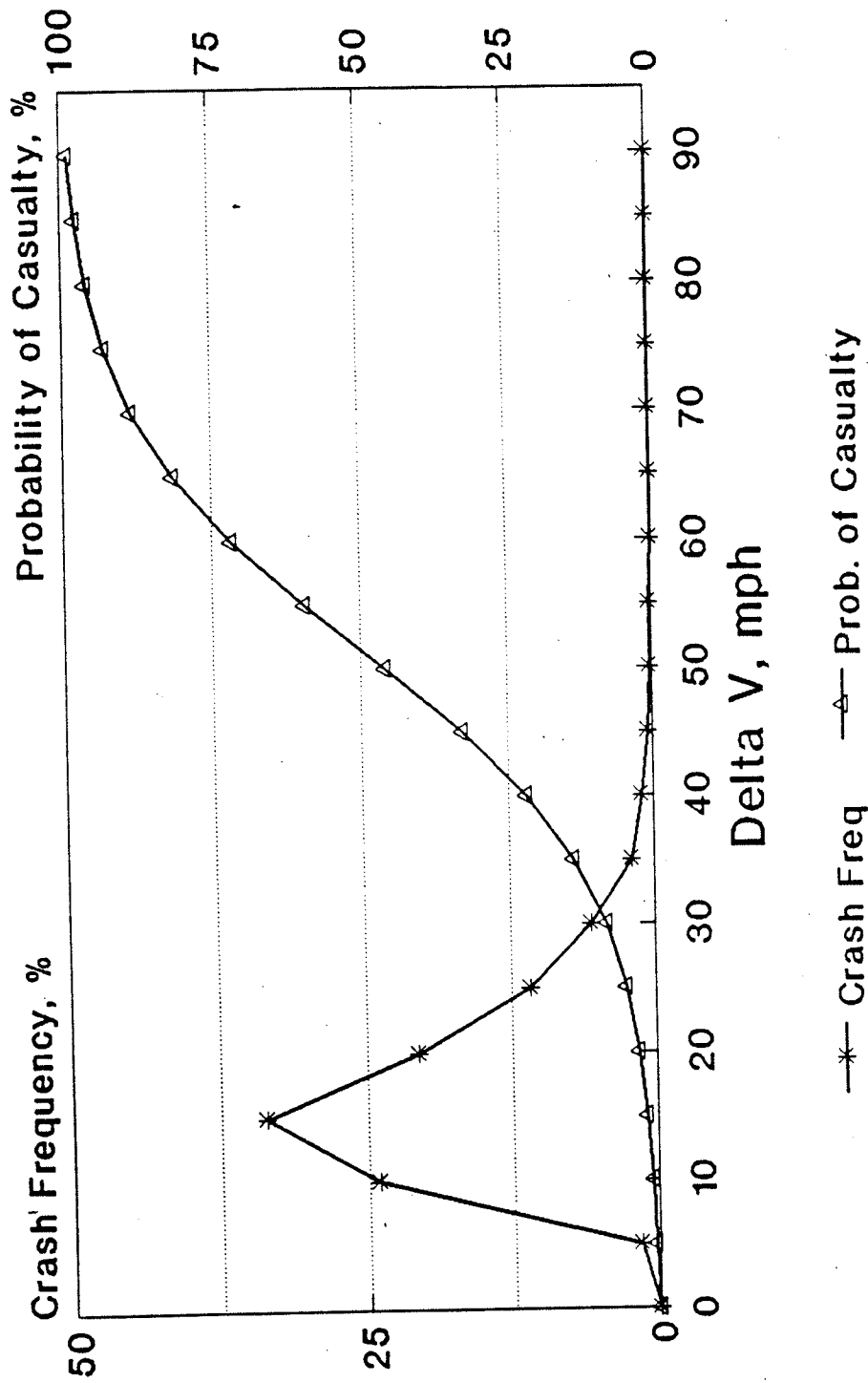


Fig. 3. Cumulative Crash Frequency and Cumulative Fatalities or MAIS 3+, as a Function of Delta V

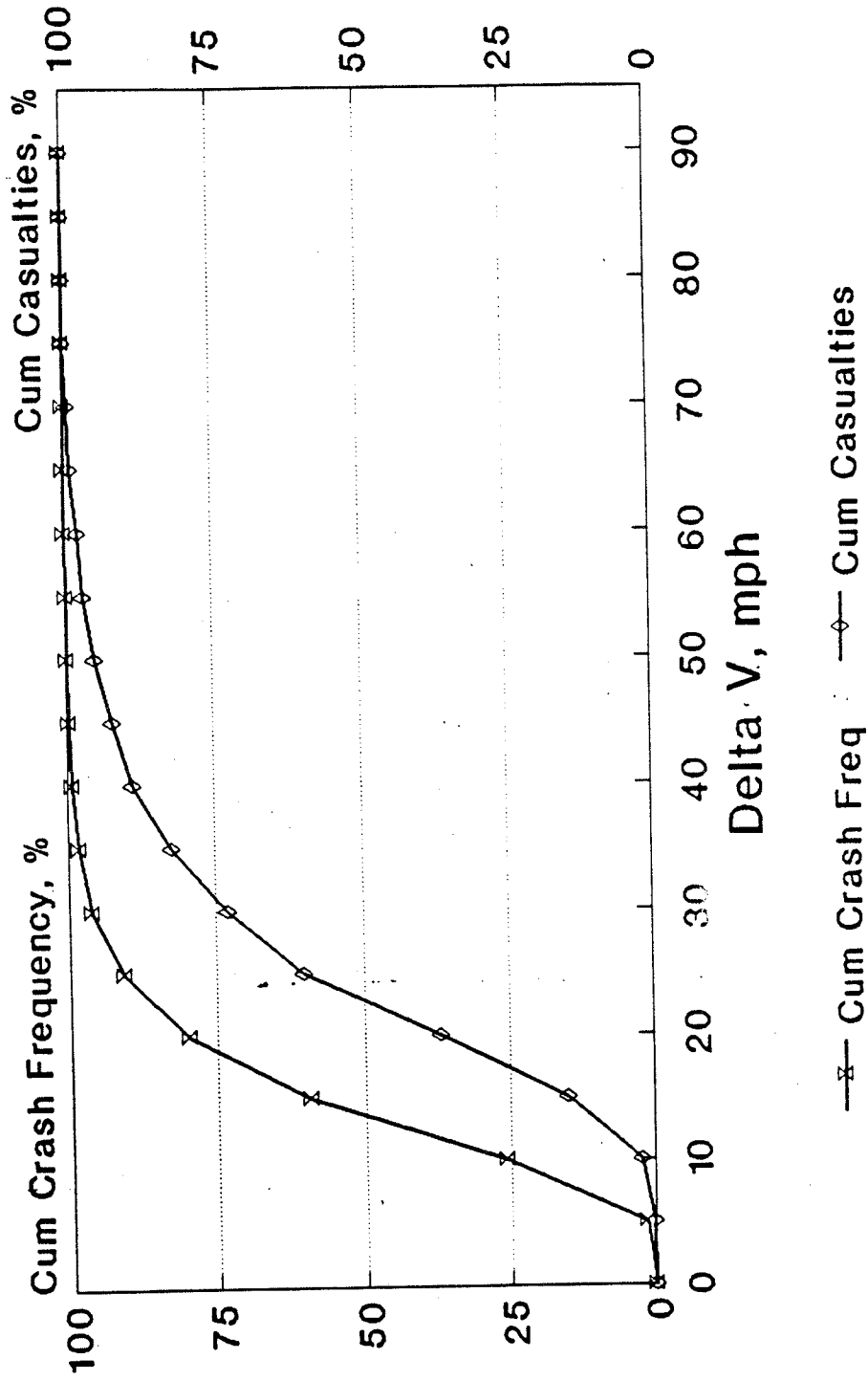


Fig. 4. Probability of Car Occupant Fatality or MAIS 3+, as a Function of Delta V for Shown Planar Car Crashes

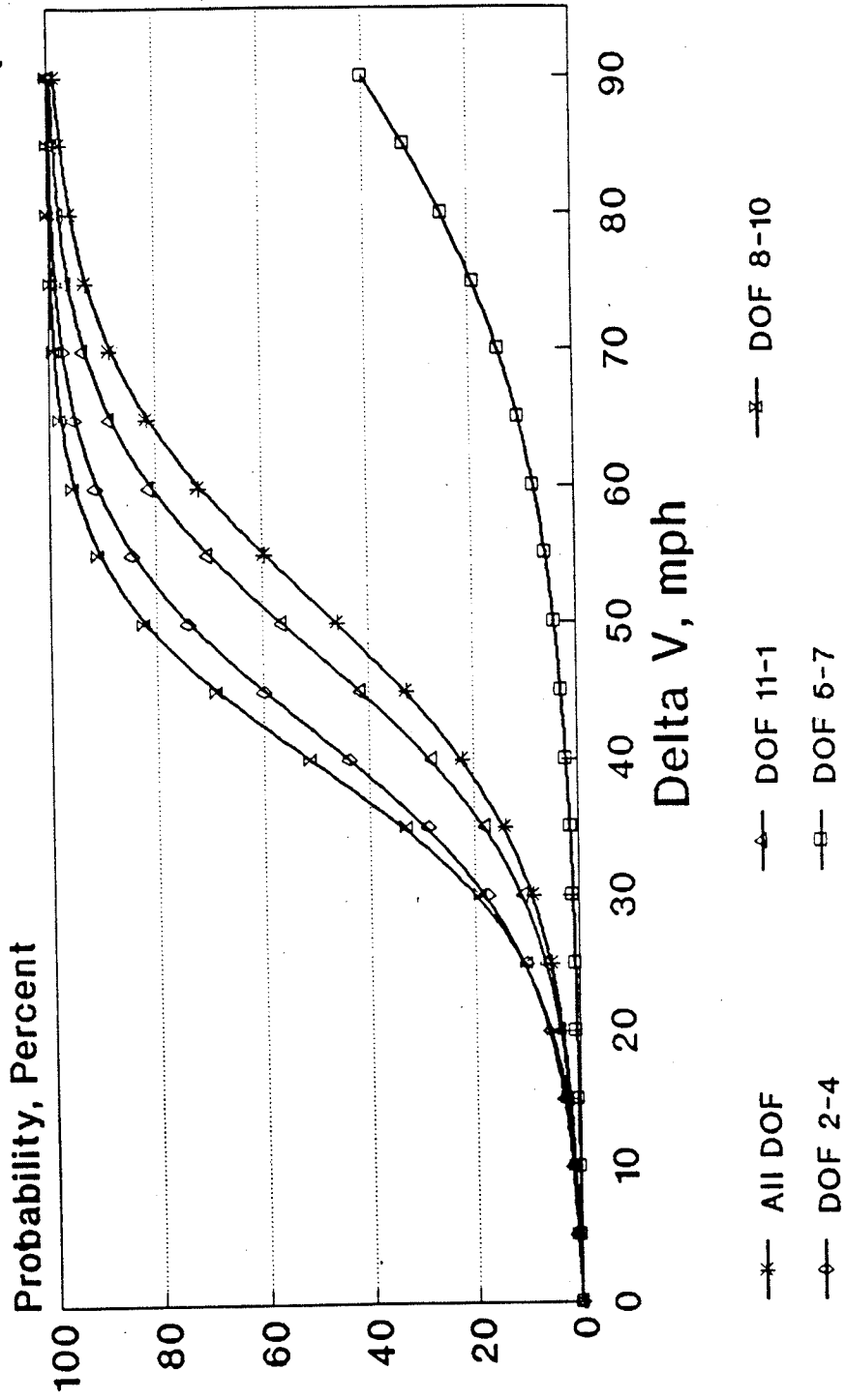


Fig. 5. Probability of Car Occupant Fatality or MAIS 3+, as a Function of Delta V for Shown Occupant Age.

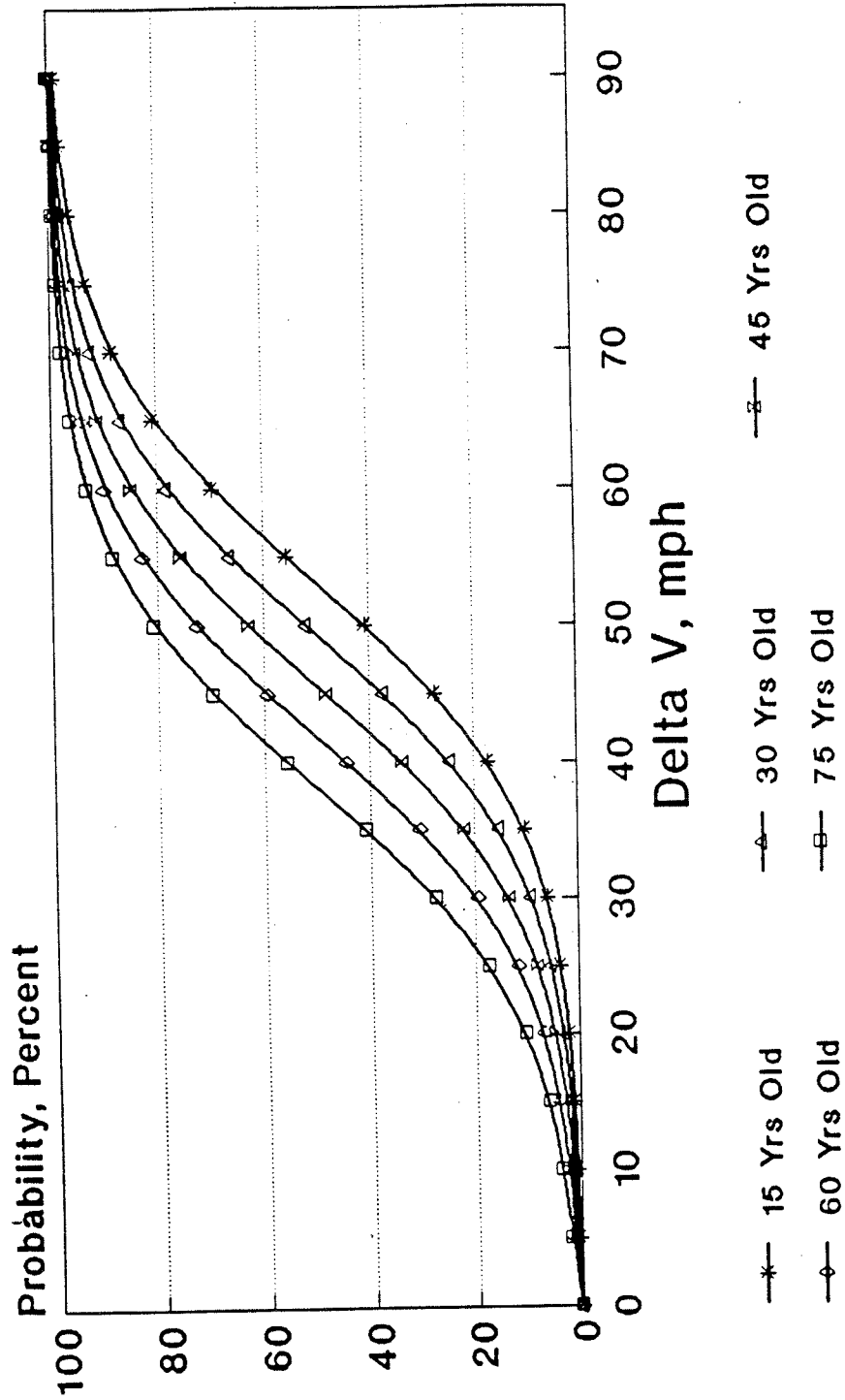




Fig. 6. Probability of Car Occupant Fatality or MAIS 3+, as a Function of Delta V for Shown Restraint Use

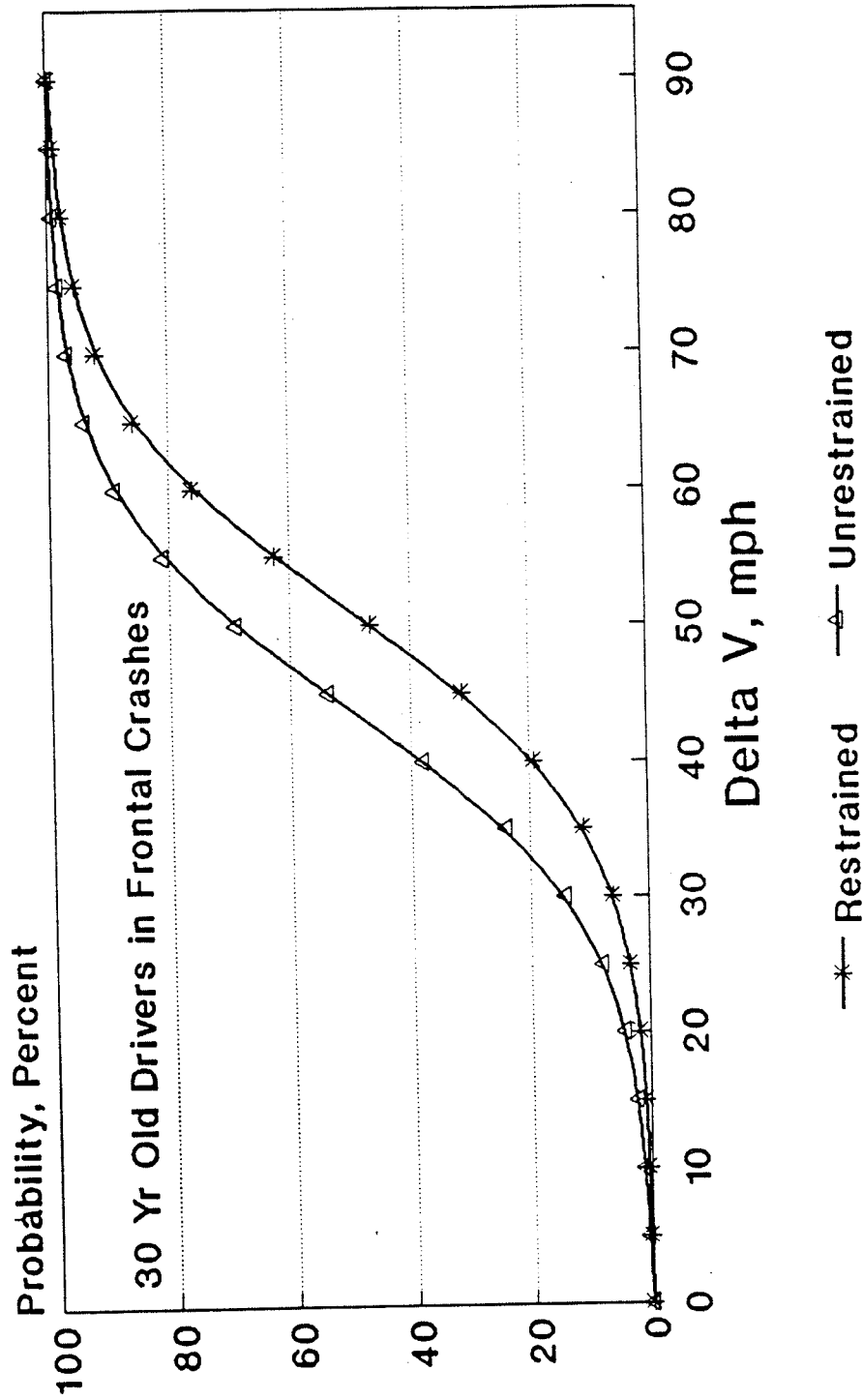


Fig. 7. Probability of Car Occupant Fatality or MAIS 3+, as a Function of Delta V for Shown Seating Positions

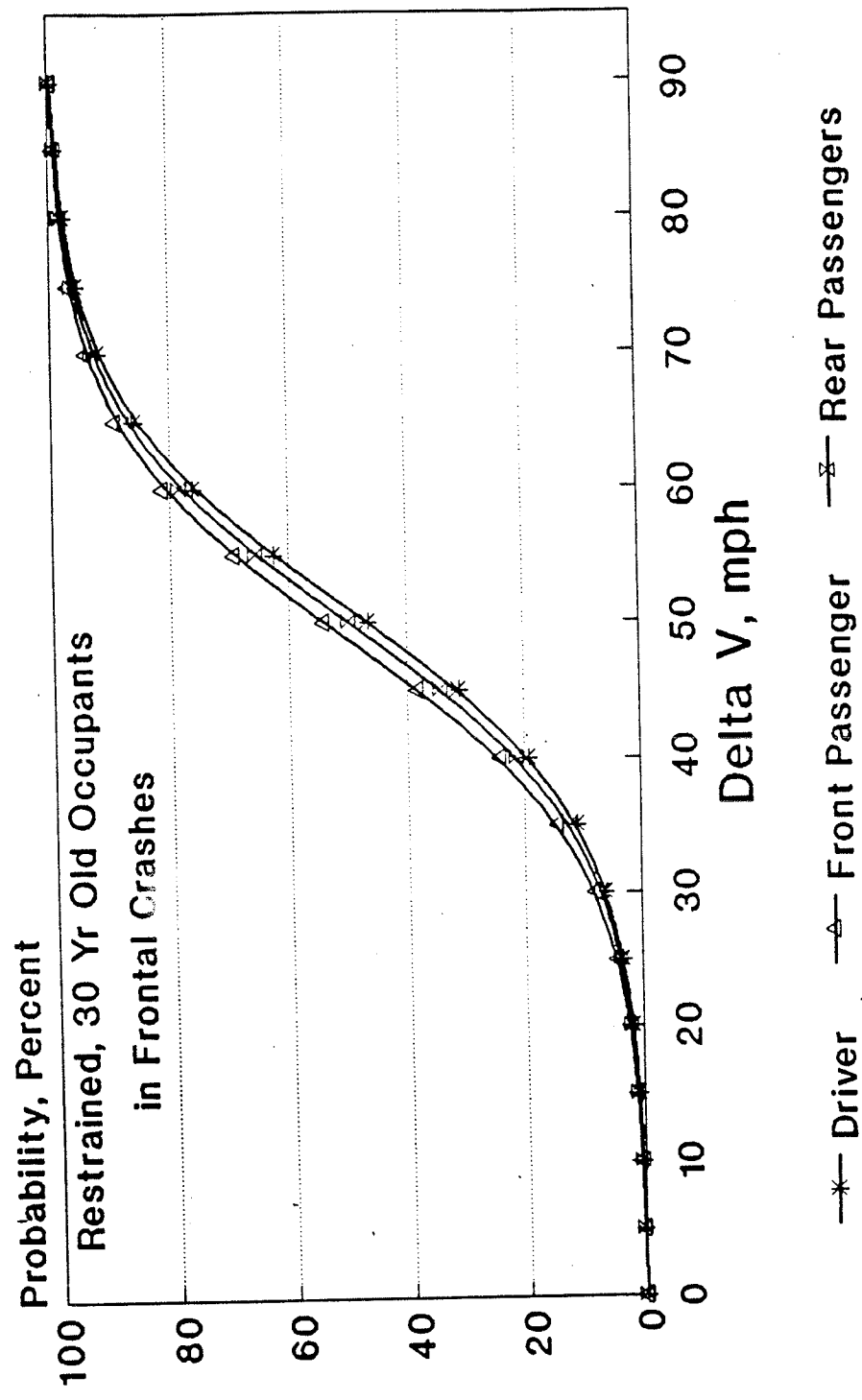
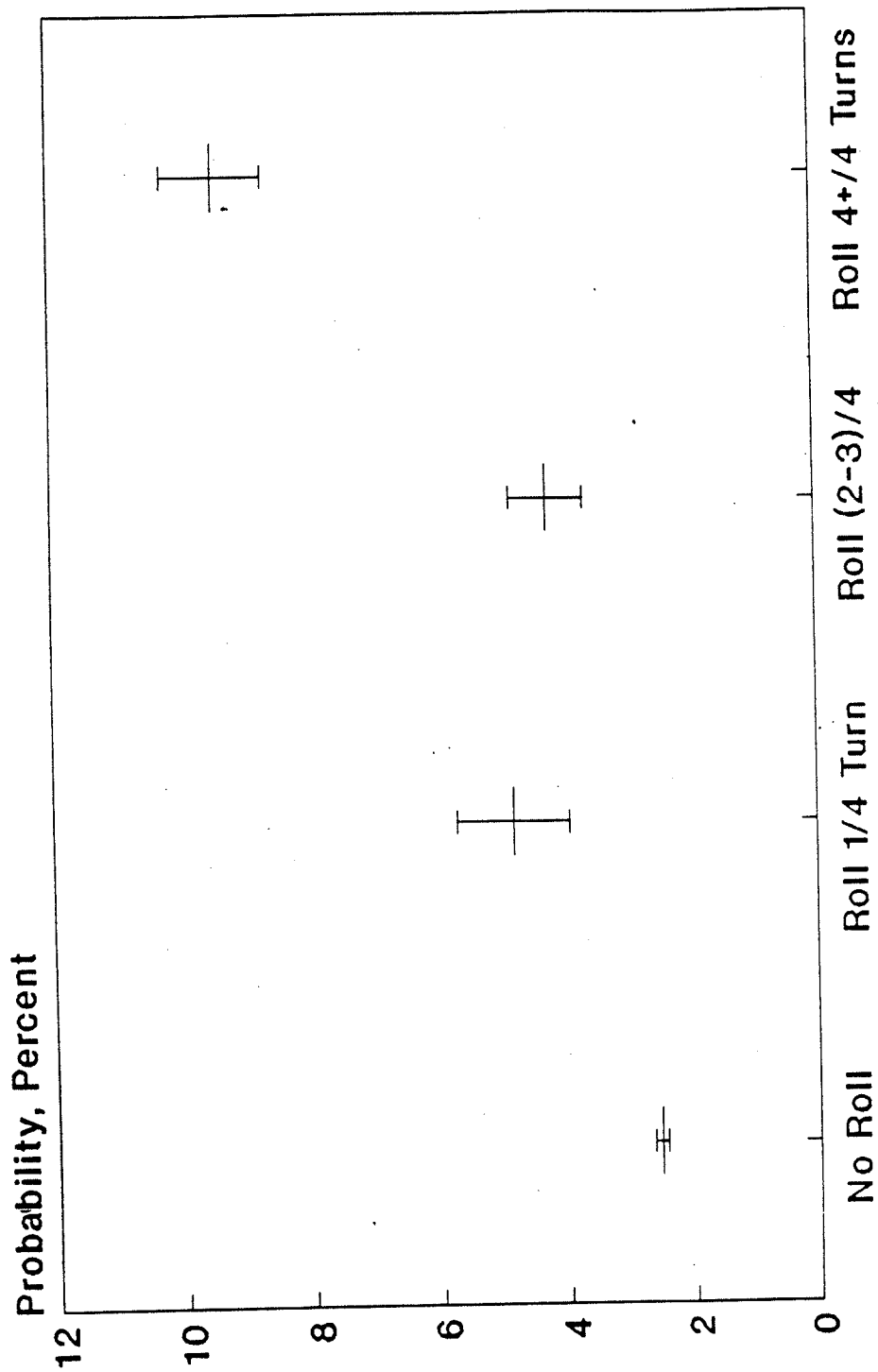


Fig. 8. Probability of Fatality or  
MAIS 3+, +/- Standard Error, versus  
Rollover Quarter Turns for Car Crashes



The NASS/CDS 1988-1994

Fig. 9. 95% Confidence Bounds for  
Probability of Fatality or MAIS 3+  
v. Delta V for All Planar Car Crashes

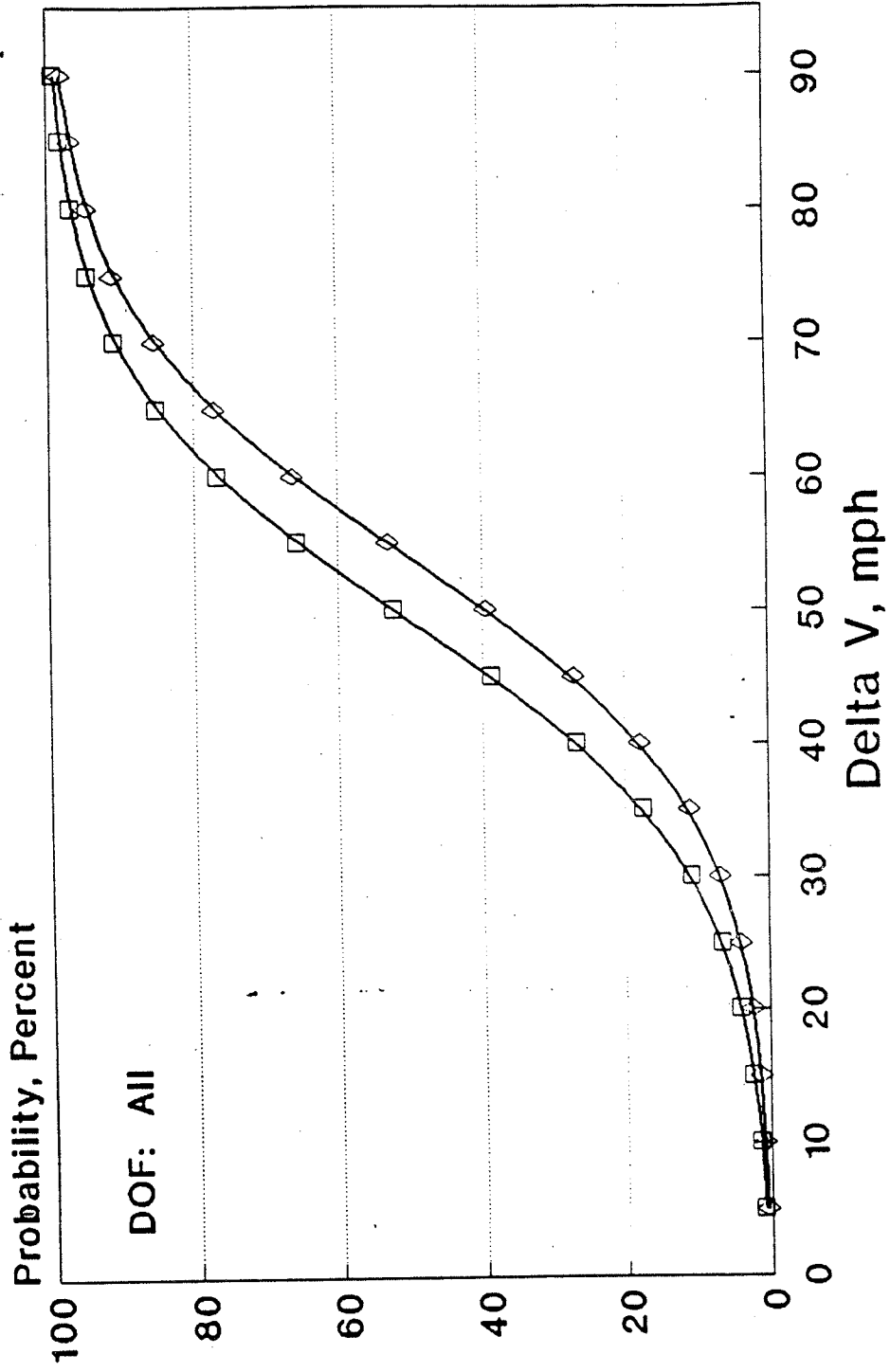


Fig. 10. 95% Confidence Bounds for  
Probability of Fatality or MAIS 3+  
v. Delta V for Front Planar Car Crashes

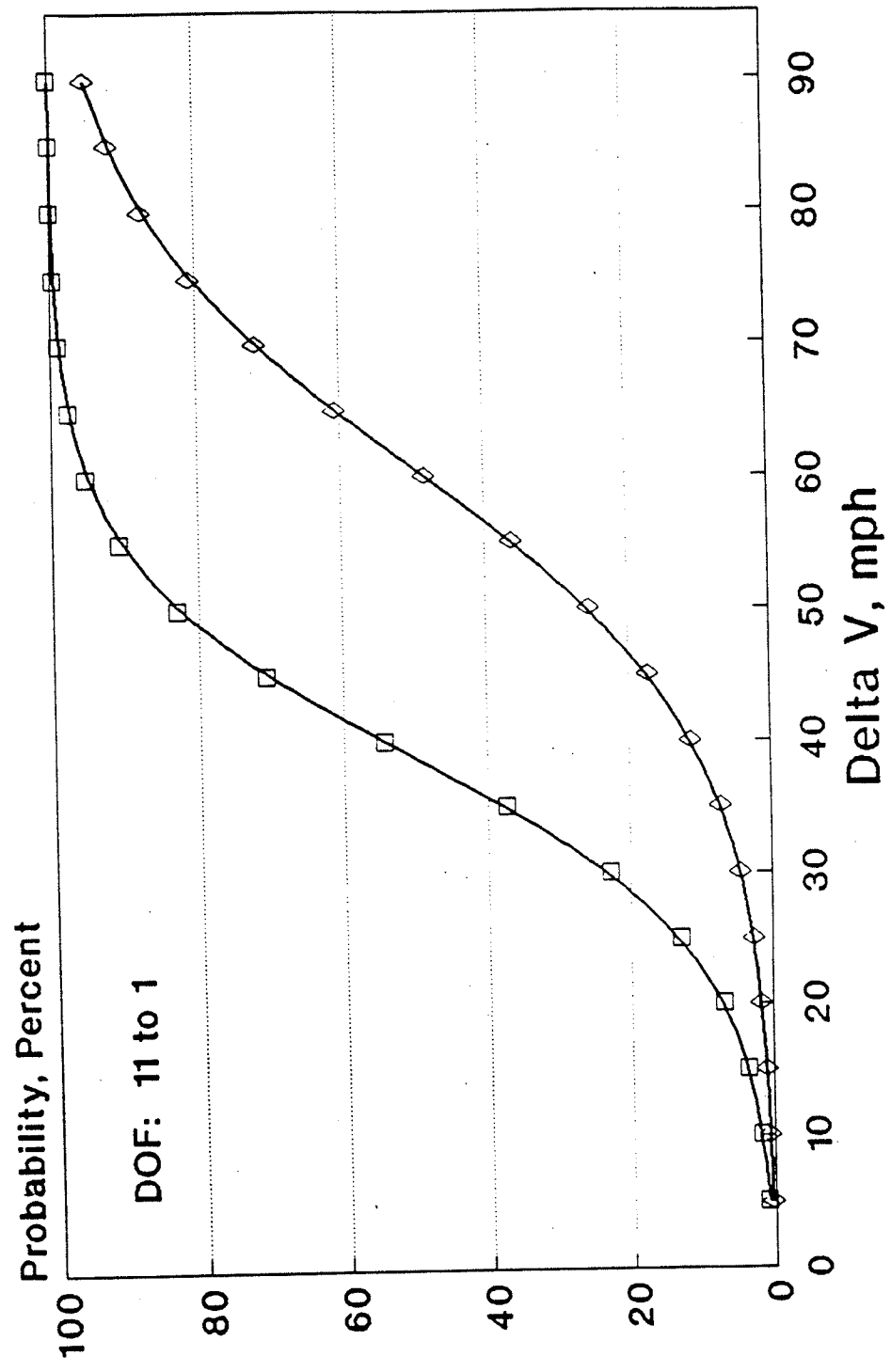


Fig. 11. 95% Confidence Bounds for  
 Probability of Fatality or MAIS 3+,  
 v. Delta V for Left Planar Car Crashes

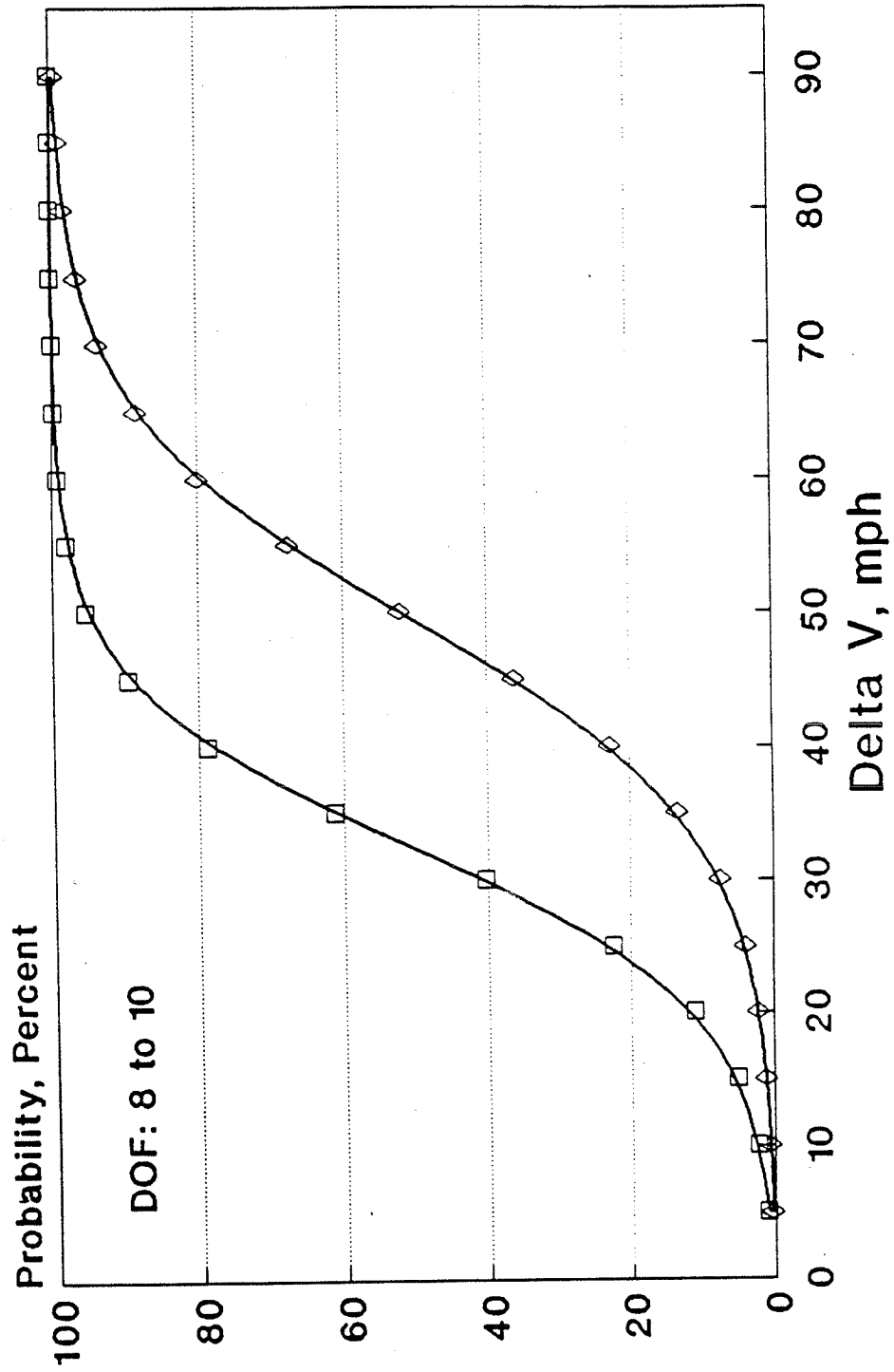


Table I. Concerning Planar Crashes

Case	SEAT	OCCRE	AGE	DOF	DV	P	+/-
1	Driver	Restrained	30	Front	5	0.2	0.0
2	Driver	Restrained	30	Front	10	0.5	0.0
3	Driver	Restrained	30	Front	15	0.9	0.0
4	Driver	Restrained	30	Front	20	1.7	0.1
5	Driver	Restrained	30	Front	25	3.3	0.3
6	Driver	Restrained	30	Front	30	6.1	1.0
7	Driver	Restrained	30	Front	35	11.0	3.4
8	Driver	Restrained	30	Front	40	19.2	10.8
9	Driver	Restrained	30	Front	45	31.2	24.5
10	Driver	Restrained	30	Front	50	46.5	33.7
11	Driver	Restrained	30	Front	55	62.5	28.9
12	Driver	Restrained	30	Front	60	76.1	15.8
13	Driver	Restrained	30	Front	65	85.9	6.0
14	Driver	Restrained	30	Front	70	92.1	1.9
15	Driver	Restrained	30	Front	75	95.7	0.6
16	Driver	Restrained	30	Front	80	97.7	0.2
17	Driver	Restrained	30	Front	85	98.8	0.1
18	Driver	Restrained	30	Front	90	99.4	0.0
19	Driver	Restrained	30	Left	5	0.4	0.0
20	Driver	Restrained	30	Left	10	0.7	0.0
21	Driver	Restrained	30	Left	15	1.3	0.1
22	Driver	Restrained	30	Left	20	2.5	0.2
23	Driver	Restrained	30	Left	25	4.7	0.5
24	Driver	Restrained	30	Left	30	8.7	2.0
25	Driver	Restrained	30	Left	35	15.4	6.9
26	Driver	Restrained	30	Left	40	25.9	18.4
27	Driver	Restrained	30	Left	45	40.1	31.2
28	Driver	Restrained	30	Left	50	56.2	32.1
29	Driver	Restrained	30	Left	55	71.1	20.9
30	Driver	Restrained	30	Left	60	82.5	8.9
31	Driver	Restrained	30	Left	65	90.0	3.0
32	Driver	Restrained	30	Left	70	94.5	0.9
33	Driver	Restrained	30	Left	75	97.1	0.3
34	Driver	Restrained	30	Left	80	98.4	0.1
35	Driver	Restrained	30	Left	85	99.2	0.0
36	Driver	Restrained	30	Left	90	99.6	0.0
37	Driver	Restrained	30	Right	5	0.4	0.0
38	Driver	Restrained	30	Right	10	0.8	0.0
39	Driver	Restrained	30	Right	15	1.5	0.1
40	Driver	Restrained	30	Right	20	2.8	0.2
41	Driver	Restrained	30	Right	25	5.2	0.7
42	Driver	Restrained	30	Right	30	9.4	2.5
43	Driver	Restrained	30	Right	35	16.7	8.4
44	Driver	Restrained	30	Right	40	27.7	21.0
45	Driver	Restrained	30	Right	45	42.3	32.8
46	Driver	Restrained	30	Right	50	58.4	31.7

47	Driver	Restrained	30	Right	55	72.9	19.5
48	Driver	Restrained	30	Right	60	83.8	8.1
49	Driver	Restrained	30	Right	65	90.8	2.7
50	Driver	Restrained	30	Right	70	95.0	0.8
51	Driver	Restrained	30	Right	75	97.3	0.3
52	Driver	Restrained	30	Right	80	98.6	0.1
53	Driver	Restrained	30	Right	85	99.3	0.0
54	Driver	Restrained	30	Right	90	99.6	0.0
55	Driver	Restrained	30	Rear	5	0.0	0.0
56	Driver	Restrained	30	Rear	10	0.1	0.0
57	Driver	Restrained	30	Rear	15	0.1	0.0
58	Driver	Restrained	30	Rear	20	0.2	0.0
59	Driver	Restrained	30	Rear	25	0.4	0.0
60	Driver	Restrained	30	Rear	30	0.7	0.0
61	Driver	Restrained	30	Rear	35	1.4	0.1
62	Driver	Restrained	30	Rear	40	2.6	0.2
63	Driver	Restrained	30	Rear	45	4.9	0.5
64	Driver	Restrained	30	Rear	50	8.9	1.8
65	Driver	Restrained	30	Rear	55	15.8	6.3
66	Driver	Restrained	30	Rear	60	26.5	17.2
67	Driver	Restrained	30	Rear	65	40.9	29.5
68	Driver	Restrained	30	Rear	70	57.0	29.7
69	Driver	Restrained	30	Rear	75	71.7	18.3
70	Driver	Restrained	30	Rear	80	82.9	7.5
71	Driver	Restrained	30	Rear	85	90.3	2.5
72	Driver	Restrained	30	Rear	90	94.7	0.7
73	Driver	Unrestrnd	30	Front	5	0.6	0.0
74	Driver	Unrestrnd	30	Front	10	1.2	0.1
75	Driver	Unrestrnd	30	Front	15	2.3	0.1
76	Driver	Unrestrnd	30	Front	20	4.3	0.4
77	Driver	Unrestrnd	30	Front	25	7.9	1.3
78	Driver	Unrestrnd	30	Front	30	14.2	4.7
79	Driver	Unrestrnd	30	Front	35	24.0	13.8
80	Driver	Unrestrnd	30	Front	40	37.8	26.7
81	Driver	Unrestrnd	30	Front	45	53.7	30.0
82	Driver	Unrestrnd	30	Front	50	69.0	20.1
83	Driver	Unrestrnd	30	Front	55	81.0	8.7
84	Driver	Unrestrnd	30	Front	60	89.1	2.9
85	Driver	Unrestrnd	30	Front	65	94.0	0.9
86	Driver	Unrestrnd	30	Front	70	96.8	0.3
87	Driver	Unrestrnd	30	Front	75	98.3	0.1
88	Driver	Unrestrnd	30	Front	80	99.1	0.0
89	Driver	Unrestrnd	30	Front	85	99.5	0.0
90	Driver	Unrestrnd	30	Front	90	99.8	0.0
91	Driver	Unrestrnd	30	Left	5	0.9	0.0
92	Driver	Unrestrnd	30	Left	10	1.3	0.1
93	Driver	Unrestrnd	30	Left	15	3.4	0.2
94	Driver	Unrestrnd	30	Left	20	6.2	0.7
95	Driver	Unrestrnd	30	Left	25	11.3	2.8
96	Driver	Unrestrnd	30	Left	30	19.6	9.1
97	Driver	Unrestrnd	30	Left	35	31.9	21.5



98	Driver	Unrestrnd	30	Left	40	47.3	30.2
99	Driver	Unrestrnd	30	Left	45	63.2	24.8
100	Driver	Unrestrnd	30	Left	50	76.7	12.5
101	Driver	Unrestrnd	30	Left	55	86.3	4.5
102	Driver	Unrestrnd	30	Left	60	92.3	1.4
103	Driver	Unrestrnd	30	Left	65	95.9	0.4
104	Driver	Unrestrnd	30	Left	70	97.8	0.1
105	Driver	Unrestrnd	30	Left	75	98.8	0.1
106	Driver	Unrestrnd	30	Left	80	99.4	0.0
107	Driver	Unrestrnd	30	Left	85	99.7	0.0
108	Driver	Unrestrnd	30	Left	90	99.8	0.0
109	Driver	Unrestrnd	30	Right	5	1.0	0.0
110	Driver	Unrestrnd	30	Right	10	1.9	0.1
111	Driver	Unrestrnd	30	Right	15	3.7	0.3
112	Driver	Unrestrnd	30	Right	20	6.8	1.0
113	Driver	Unrestrnd	30	Right	25	12.2	3.5
114	Driver	Unrestrnd	30	Right	30	21.1	10.9
115	Driver	Unrestrnd	30	Right	35	33.8	24.0
116	Driver	Unrestrnd	30	Right	40	49.5	31.0
117	Driver	Unrestrnd	30	Right	45	65.2	23.7
118	Driver	Unrestrnd	30	Right	50	78.2	11.4
119	Driver	Unrestrnd	30	Right	55	87.3	4.0
120	Driver	Unrestrnd	30	Right	60	93.0	1.3
121	Driver	Unrestrnd	30	Right	65	96.2	0.4
122	Driver	Unrestrnd	30	Right	70	98.0	0.1
123	Driver	Unrestrnd	30	Right	75	98.9	0.1
124	Driver	Unrestrnd	30	Right	80	99.4	0.0
125	Driver	Unrestrnd	30	Right	85	99.7	0.0
126	Driver	Unrestrnd	30	Right	90	99.8	0.0
127	Driver	Unrestrnd	30	Rear	5	0.1	0.0
128	Driver	Unrestrnd	30	Rear	10	0.1	0.0
129	Driver	Unrestrnd	30	Rear	15	0.3	0.0
130	Driver	Unrestrnd	30	Rear	20	0.5	0.0
131	Driver	Unrestrnd	30	Rear	25	1.0	0.0
132	Driver	Unrestrnd	30	Rear	30	1.8	0.1
133	Driver	Unrestrnd	30	Rear	35	3.5	0.2
134	Driver	Unrestrnd	30	Rear	40	6.4	0.7
135	Driver	Unrestrnd	30	Rear	45	11.6	2.5
136	Driver	Unrestrnd	30	Rear	50	20.1	8.3
137	Driver	Unrestrnd	30	Rear	55	32.5	19.9
138	Driver	Unrestrnd	30	Rear	60	48.0	27.9
139	Driver	Unrestrnd	30	Rear	65	63.9	22.0
140	Driver	Unrestrnd	30	Rear	70	77.2	10.6
141	Driver	Unrestrnd	30	Rear	75	86.6	3.7
142	Driver	Unrestrnd	30	Rear	80	92.6	1.2
143	Driver	Unrestrnd	30	Rear	85	96.0	0.4
144	Driver	Unrestrnd	30	Rear	90	97.9	0.1
145	Frnt Pax	Restrained	30	Front	5	0.3	0.0
146	Frnt Pax	Restrained	30	Front	10	0.6	0.0
147	Frnt Pax	Restrained	30	Front	15	1.2	0.0
148	Frnt Pax	Restrained	30	Front	20	2.3	0.1

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149	Frnt Pax	Restrained	30	Front	25	4.4	0.4
150	Frnt Pax	Restrained	30	Front	30	8.0	1.3
151	Frnt Pax	Restrained	30	Front	35	14.3	4.5
152	Frnt Pax	Restrained	30	Front	40	24.2	13.6
153	Frnt Pax	Restrained	30	Front	45	38.0	27.6
154	Frnt Pax	Restrained	30	Front	50	54.0	33.8
155	Frnt Pax	Restrained	30	Front	55	69.2	26.1
156	Frnt Pax	Restrained	30	Front	60	81.2	12.9
157	Frnt Pax	Restrained	30	Front	65	89.2	4.6
158	Frnt Pax	Restrained	30	Front	70	94.0	1.4
159	Frnt Pax	Restrained	30	Front	75	96.8	0.5
160	Frnt Pax	Restrained	30	Front	80	98.3	0.1
161	Frnt Pax	Restrained	30	Front	85	99.1	0.1
162	Frnt Pax	Restrained	30	Front	90	99.5	0.0
163	Frnt Pax	Restrained	30	Left	5	0.5	0.0
164	Frnt Pax	Restrained	30	Left	10	0.9	0.0
165	Frnt Pax	Restrained	30	Left	15	1.8	0.1
166	Frnt Pax	Restrained	30	Left	20	3.4	0.2
167	Frnt Pax	Restrained	30	Left	25	6.3	0.7
168	Frnt Pax	Restrained	30	Left	30	11.4	2.7
169	Frnt Pax	Restrained	30	Left	35	19.8	8.9
170	Frnt Pax	Restrained	30	Left	40	32.1	21.8
171	Frnt Pax	Restrained	30	Left	45	47.5	32.8
172	Frnt Pax	Restrained	30	Left	50	63.4	30.3
173	Frnt Pax	Restrained	30	Left	55	76.9	17.7
174	Frnt Pax	Restrained	30	Left	60	86.4	7.1
175	Frnt Pax	Restrained	30	Left	65	92.4	2.3
176	Frnt Pax	Restrained	30	Left	70	95.9	0.7
177	Frnt Pax	Restrained	30	Left	75	97.8	0.2
178	Frnt Pax	Restrained	30	Left	80	98.8	0.1
179	Frnt Pax	Restrained	30	Left	85	99.4	0.0
180	Frnt Pax	Restrained	30	Left	90	99.7	0.0
181	Frnt Pax	Restrained	30	Right	5	0.5	0.0
182	Frnt Pax	Restrained	30	Right	10	1.0	0.0
183	Frnt Pax	Restrained	30	Right	15	2.0	0.1
184	Frnt Pax	Restrained	30	Right	20	3.7	0.3
185	Frnt Pax	Restrained	30	Right	25	6.8	0.9
186	Frnt Pax	Restrained	30	Right	30	12.3	3.3
187	Frnt Pax	Restrained	30	Right	35	21.2	10.7
188	Frnt Pax	Restrained	30	Right	40	34.1	24.4
189	Frnt Pax	Restrained	30	Right	45	49.8	33.9
190	Frnt Pax	Restrained	30	Right	50	65.5	29.5
191	Frnt Pax	Restrained	30	Right	55	78.4	16.4
192	Frnt Pax	Restrained	30	Right	60	87.4	6.3
193	Frnt Pax	Restrained	30	Right	65	93.0	2.0
194	Frnt Pax	Restrained	30	Right	70	96.2	0.6
195	Frnt Pax	Restrained	30	Right	75	98.0	0.2
196	Frnt Pax	Restrained	30	Right	80	98.9	0.1
197	Frnt Pax	Restrained	30	Right	85	99.4	0.0
198	Frnt Pax	Restrained	30	Right	90	99.7	0.0
199	Frnt Pax	Restrained	30	Rear	5	0.0	0.0

200	Frnt Pax	Restrained	30	Rear	10	0.1	0.0
201	Frnt Pax	Restrained	30	Rear	15	0.1	0.0
202	Frnt Pax	Restrained	30	Rear	20	0.3	0.0
203	Frnt Pax	Restrained	30	Rear	25	0.5	0.0
204	Frnt Pax	Restrained	30	Rear	30	1.0	0.0
205	Frnt Pax	Restrained	30	Rear	35	1.9	0.1
206	Frnt Pax	Restrained	30	Rear	40	3.5	0.2
207	Frnt Pax	Restrained	30	Rear	45	6.5	0.7
208	Frnt Pax	Restrained	30	Rear	50	11.7	2.5
209	Frnt Pax	Restrained	30	Rear	55	20.3	8.2
210	Frnt Pax	Restrained	30	Rear	60	32.7	20.4
211	Frnt Pax	Restrained	30	Rear	65	48.3	30.9
212	Frnt Pax	Restrained	30	Rear	70	64.1	27.7
213	Frnt Pax	Restrained	30	Rear	75	77.4	15.3
214	Frnt Pax	Restrained	30	Rear	80	86.8	5.9
215	Frnt Pax	Restrained	30	Rear	85	92.6	1.9
216	Frnt Pax	Restrained	30	Rear	90	96.0	0.6
217	Frnt Pax	Unrestrnd	30	Front	5	0.9	0.0
218	Frnt Pax	Unrestrnd	30	Front	10	1.6	0.1
219	Frnt Pax	Unrestrnd	30	Front	15	3.1	0.2
220	Frnt Pax	Unrestrnd	30	Front	20	5.7	0.5
221	Frnt Pax	Unrestrnd	30	Front	25	10.4	1.8
222	Frnt Pax	Unrestrnd	30	Front	30	18.2	6.2
223	Frnt Pax	Unrestrnd	30	Front	35	29.9	16.8
224	Frnt Pax	Unrestrnd	30	Front	40	45.0	28.7
225	Frnt Pax	Unrestrnd	30	Front	45	61.1	28.6
226	Frnt Pax	Unrestrnd	30	Front	50	75.0	17.2
227	Frnt Pax	Unrestrnd	30	Front	55	85.2	6.8
228	Frnt Pax	Unrestrnd	30	Front	60	91.7	2.2
229	Frnt Pax	Unrestrnd	30	Front	65	95.5	0.7
230	Frnt Pax	Unrestrnd	30	Front	70	97.6	0.2
231	Frnt Pax	Unrestrnd	30	Front	75	98.7	0.1
232	Frnt Pax	Unrestrnd	30	Front	80	99.3	0.0
233	Frnt Pax	Unrestrnd	30	Front	85	99.6	0.0
234	Frnt Pax	Unrestrnd	30	Front	90	99.8	0.0
235	Frnt Pax	Unrestrnd	30	Left	5	1.3	0.0
236	Frnt Pax	Unrestrnd	30	Left	10	2.4	0.1
237	Frnt Pax	Unrestrnd	30	Left	15	4.5	0.3
238	Frnt Pax	Unrestrnd	30	Left	20	8.2	1.0
239	Frnt Pax	Unrestrnd	30	Left	25	14.7	3.7
240	Frnt Pax	Unrestrnd	30	Left	30	24.8	11.5
241	Frnt Pax	Unrestrnd	30	Left	35	38.7	24.4
242	Frnt Pax	Unrestrnd	30	Left	40	54.7	30.2
243	Frnt Pax	Unrestrnd	30	Left	45	69.8	22.0
244	Frnt Pax	Unrestrnd	30	Left	50	81.6	10.1
245	Frnt Pax	Unrestrnd	30	Left	55	89.5	3.5
246	Frnt Pax	Unrestrnd	30	Left	60	94.2	1.1
247	Frnt Pax	Unrestrnd	30	Left	65	96.9	0.3
248	Frnt Pax	Unrestrnd	30	Left	70	98.4	0.1
249	Frnt Pax	Unrestrnd	30	Left	75	99.1	0.1
250	Frnt Pax	Unrestrnd	30	Left	80	99.5	0.0

251	Frnt Pax	Unrestrnd	30	Left	85	99.8	0.0
252	Frnt Pax	Unrestrnd	30	Left	90	99.9	0.0
253	Frnt Pax	Unrestrnd	30	Right	5	1.4	0.1
254	Frnt Pax	Unrestrnd	30	Right	10	2.6	0.1
255	Frnt Pax	Unrestrnd	30	Right	15	4.9	0.3
256	Frnt Pax	Unrestrnd	30	Right	20	8.9	1.3
257	Frnt Pax	Unrestrnd	30	Right	25	15.8	4.6
258	Frnt Pax	Unrestrnd	30	Right	30	26.5	13.6
259	Frnt Pax	Unrestrnd	30	Right	35	40.9	26.7
260	Frnt Pax	Unrestrnd	30	Right	40	57.0	30.5
261	Frnt Pax	Unrestrnd	30	Right	45	71.7	20.8
262	Frnt Pax	Unrestrnd	30	Right	50	82.9	9.2
263	Frnt Pax	Unrestrnd	30	Right	55	90.3	3.1
264	Frnt Pax	Unrestrnd	30	Right	60	94.7	0.9
265	Frnt Pax	Unrestrnd	30	Right	65	97.2	0.3
266	Frnt Pax	Unrestrnd	30	Right	70	98.5	0.1
267	Frnt Pax	Unrestrnd	30	Right	75	99.2	0.0
268	Frnt Pax	Unrestrnd	30	Right	80	99.6	0.0
269	Frnt Pax	Unrestrnd	30	Right	85	99.8	0.0
270	Frnt Pax	Unrestrnd	30	Right	90	99.9	0.0
271	Frnt Pax	Unrestrnd	30	Rear	5	0.1	0.0
272	Frnt Pax	Unrestrnd	30	Rear	10	0.2	0.0
273	Frnt Pax	Unrestrnd	30	Rear	15	0.4	0.0
274	Frnt Pax	Unrestrnd	30	Rear	20	0.7	0.0
275	Frnt Pax	Unrestrnd	30	Rear	25	1.3	0.0
276	Frnt Pax	Unrestrnd	30	Rear	30	2.5	0.1
277	Frnt Pax	Unrestrnd	30	Rear	35	4.6	0.2
278	Frnt Pax	Unrestrnd	30	Rear	40	8.5	1.0
279	Frnt Pax	Unrestrnd	30	Rear	45	15.1	3.3
280	Frnt Pax	Unrestrnd	30	Rear	50	25.4	10.5
281	Frnt Pax	Unrestrnd	30	Rear	55	39.4	22.6
282	Frnt Pax	Unrestrnd	30	Rear	60	55.0	27.7
283	Frnt Pax	Unrestrnd	30	Rear	65	70.5	19.3
284	Frnt Pax	Unrestrnd	30	Rear	70	82.1	8.4
285	Frnt Pax	Unrestrnd	30	Rear	75	89.8	2.8
286	Frnt Pax	Unrestrnd	30	Rear	80	94.4	0.9
287	Frnt Pax	Unrestrnd	30	Rear	85	97.0	0.3
288	Frnt Pax	Unrestrnd	30	Rear	90	98.4	0.1
289	Rear Pax	Restrained	30	Front	5	0.3	0.0
290	Rear Pax	Restrained	30	Front	10	0.5	0.0
291	Rear Pax	Restrained	30	Front	15	1.0	0.0
292	Rear Pax	Restrained	30	Front	20	2.0	0.1
293	Rear Pax	Restrained	30	Front	25	3.7	0.3
294	Rear Pax	Restrained	30	Front	30	6.8	0.8
295	Rear Pax	Restrained	30	Front	35	12.3	3.0
296	Rear Pax	Restrained	30	Front	40	21.2	9.7
297	Rear Pax	Restrained	30	Front	45	34.1	22.3
298	Rear Pax	Restrained	30	Front	50	49.8	30.4
299	Rear Pax	Restrained	30	Front	55	65.5	24.2
300	Rear Pax	Restrained	30	Front	60	78.4	12.0
301	Rear Pax	Restrained	30	Front	65	87.4	4.3

302	Rear Pax	Restrained	30	Front	70	93.0	1.3
303	Rear Pax	Restrained	30	Front	75	96.2	0.4
304	Rear Pax	Restrained	30	Front	80	98.0	0.1
305	Rear Pax	Restrained	30	Front	85	98.9	0.1
306	Rear Pax	Restrained	30	Front	90	99.4	0.0
307	Rear Pax	Restrained	30	Left	5	0.4	0.0
308	Rear Pax	Restrained	30	Left	10	0.8	0.0
309	Rear Pax	Restrained	30	Left	15	1.5	0.1
310	Rear Pax	Restrained	30	Left	20	2.9	0.2
311	Rear Pax	Restrained	30	Left	25	5.4	0.5
312	Rear Pax	Restrained	30	Left	30	9.8	1.8
313	Rear Pax	Restrained	30	Left	35	17.2	6.1
314	Rear Pax	Restrained	30	Left	40	28.5	16.6
315	Rear Pax	Restrained	30	Left	45	43.3	28.4
316	Rear Pax	Restrained	30	Left	50	59.4	27.9
317	Rear Pax	Restrained	30	Left	55	73.7	16.5
318	Rear Pax	Restrained	30	Left	60	84.3	6.5
319	Rear Pax	Restrained	30	Left	65	91.1	2.1
320	Rear Pax	Restrained	30	Left	70	95.2	0.6
321	Rear Pax	Restrained	30	Left	75	97.4	0.2
322	Rear Pax	Restrained	30	Left	80	98.6	0.1
323	Rear Pax	Restrained	30	Left	85	99.3	0.0
324	Rear Pax	Restrained	30	Left	90	99.6	0.0
325	Rear Pax	Restrained	30	Right	5	0.5	0.0
326	Rear Pax	Restrained	30	Right	10	0.9	0.0
327	Rear Pax	Restrained	30	Right	15	1.7	0.1
328	Rear Pax	Restrained	30	Right	20	3.1	0.2
329	Rear Pax	Restrained	30	Right	25	5.8	0.6
330	Rear Pax	Restrained	30	Right	30	10.6	2.2
331	Rear Pax	Restrained	30	Right	35	18.5	7.4
332	Rear Pax	Restrained	30	Right	40	30.4	19.1
333	Rear Pax	Restrained	30	Right	45	45.5	30.0
334	Rear Pax	Restrained	30	Right	50	61.5	27.4
335	Rear Pax	Restrained	30	Right	55	75.4	15.2
336	Rear Pax	Restrained	30	Right	60	85.4	5.8
337	Rear Pax	Restrained	30	Right	65	91.8	1.8
338	Rear Pax	Restrained	30	Right	70	95.6	0.6
339	Rear Pax	Restrained	30	Right	75	97.6	0.2
340	Rear Pax	Restrained	30	Right	80	98.8	0.1
341	Rear Pax	Restrained	30	Right	85	99.3	0.0
342	Rear Pax	Restrained	30	Right	90	99.7	0.0
343	Rear Pax	Restrained	30	Rear	5	0.0	0.0
344	Rear Pax	Restrained	30	Rear	10	0.1	0.0
345	Rear Pax	Restrained	30	Rear	15	0.1	0.0
346	Rear Pax	Restrained	30	Rear	20	0.2	0.0
347	Rear Pax	Restrained	30	Rear	25	0.4	0.0
348	Rear Pax	Restrained	30	Rear	30	0.8	0.0
349	Rear Pax	Restrained	30	Rear	35	1.6	0.1
350	Rear Pax	Restrained	30	Rear	40	3.0	0.1
351	Rear Pax	Restrained	30	Rear	45	5.5	0.4
352	Rear Pax	Restrained	30	Rear	50	10.1	1.6

353	Rear Pax	Restrained	30	Rear	55	17.7	5.5
354	Rear Pax	Restrained	30	Rear	60	29.1	15.3
355	Rear Pax	Restrained	30	Rear	65	44.0	26.3
356	Rear Pax	Restrained	30	Rear	70	60.1	25.2
357	Rear Pax	Restrained	30	Rear	75	74.3	14.1
358	Rear Pax	Restrained	30	Rear	80	84.7	5.4
359	Rear Pax	Restrained	30	Rear	85	91.4	1.7
360	Rear Pax	Restrained	30	Rear	90	95.3	0.5
361	Rear Pax	Unrestrnd	30	Front	5	0.7	0.0
362	Rear Pax	Unrestrnd	30	Front	10	1.4	0.0
363	Rear Pax	Unrestrnd	30	Front	15	2.6	0.1
364	Rear Pax	Unrestrnd	30	Front	20	4.9	0.3
365	Rear Pax	Unrestrnd	30	Front	25	8.9	1.1
366	Rear Pax	Unrestrnd	30	Front	30	15.8	4.1
367	Rear Pax	Unrestrnd	30	Front	35	26.5	12.1
368	Rear Pax	Unrestrnd	30	Front	40	40.9	23.7
369	Rear Pax	Unrestrnd	30	Front	45	57.0	25.6
370	Rear Pax	Unrestrnd	30	Front	50	71.7	15.6
371	Rear Pax	Unrestrnd	30	Front	55	82.9	6.3
372	Rear Pax	Unrestrnd	30	Front	60	90.3	2.0
373	Rear Pax	Unrestrnd	30	Front	65	94.7	0.6
374	Rear Pax	Unrestrnd	30	Front	70	97.2	0.2
375	Rear Pax	Unrestrnd	30	Front	75	98.5	0.1
376	Rear Pax	Unrestrnd	30	Front	80	99.2	0.0
377	Rear Pax	Unrestrnd	30	Front	85	99.6	0.0
378	Rear Pax	Unrestrnd	30	Front	90	99.8	0.0
379	Rear Pax	Unrestrnd	30	Left	5	1.1	0.0
380	Rear Pax	Unrestrnd	30	Left	10	2.0	0.1
381	Rear Pax	Unrestrnd	30	Left	15	3.8	0.2
382	Rear Pax	Unrestrnd	30	Left	20	7.0	0.7
383	Rear Pax	Unrestrnd	30	Left	25	12.7	2.4
384	Rear Pax	Unrestrnd	30	Left	30	21.8	7.9
385	Rear Pax	Unrestrnd	30	Left	35	34.8	19.0
386	Rear Pax	Unrestrnd	30	Left	40	50.5	26.3
387	Rear Pax	Unrestrnd	30	Left	45	66.2	19.9
388	Rear Pax	Unrestrnd	30	Left	50	78.9	9.2
389	Rear Pax	Unrestrnd	30	Left	55	87.8	3.2
390	Rear Pax	Unrestrnd	30	Left	60	93.2	1.0
391	Rear Pax	Unrestrnd	30	Left	65	96.3	0.3
392	Rear Pax	Unrestrnd	30	Left	70	98.1	0.1
393	Rear Pax	Unrestrnd	30	Left	75	99.0	0.0
394	Rear Pax	Unrestrnd	30	Left	80	99.5	0.0
395	Rear Pax	Unrestrnd	30	Left	85	99.7	0.0
396	Rear Pax	Unrestrnd	30	Left	90	99.9	0.0
397	Rear Pax	Unrestrnd	30	Right	5	1.2	0.0
398	Rear Pax	Unrestrnd	30	Right	10	2.2	0.1
399	Rear Pax	Unrestrnd	30	Right	15	4.1	0.2
400	Rear Pax	Unrestrnd	30	Right	20	7.7	0.9
401	Rear Pax	Unrestrnd	30	Right	25	13.7	3.0
402	Rear Pax	Unrestrnd	30	Right	30	23.3	9.6
403	Rear Pax	Unrestrnd	30	Right	35	36.8	21.4

404	Rear Pax	Unrestrnd	30	Right	40	52.7	27.0
405	Rear Pax	Unrestrnd	30	Right	45	68.1	19.0
406	Rear Pax	Unrestrnd	30	Right	50	80.4	8.3
407	Rear Pax	Unrestrnd	30	Right	55	88.7	2.8
408	Rear Pax	Unrestrnd	30	Right	60	93.8	0.9
409	Rear Pax	Unrestrnd	30	Right	65	96.6	0.3
410	Rear Pax	Unrestrnd	30	Right	70	98.2	0.1
411	Rear Pax	Unrestrnd	30	Right	75	99.1	0.0
412	Rear Pax	Unrestrnd	30	Right	80	99.5	0.0
413	Rear Pax	Unrestrnd	30	Right	85	99.7	0.0
414	Rear Pax	Unrestrnd	30	Right	90	99.9	0.0
415	Rear Pax	Unrestrnd	30	Rear	5	0.1	0.0
416	Rear Pax	Unrestrnd	30	Rear	10	0.2	0.0
417	Rear Pax	Unrestrnd	30	Rear	15	0.3	0.0
418	Rear Pax	Unrestrnd	30	Rear	20	0.6	0.0
419	Rear Pax	Unrestrnd	30	Rear	25	1.1	0.0
420	Rear Pax	Unrestrnd	30	Rear	30	2.1	0.1
421	Rear Pax	Unrestrnd	30	Rear	35	3.9	0.2
422	Rear Pax	Unrestrnd	30	Rear	40	7.2	0.6
423	Rear Pax	Unrestrnd	30	Rear	45	13.0	2.1
424	Rear Pax	Unrestrnd	30	Rear	50	22.3	7.1
425	Rear Pax	Unrestrnd	30	Rear	55	35.4	17.2
426	Rear Pax	Unrestrnd	30	Rear	60	51.2	23.7
427	Rear Pax	Unrestrnd	30	Rear	65	66.8	17.2
428	Rear Pax	Unrestrnd	30	Rear	70	79.4	7.6
429	Rear Pax	Unrestrnd	30	Rear	75	88.1	2.5
430	Rear Pax	Unrestrnd	30	Rear	80	93.4	0.8
431	Rear Pax	Unrestrnd	30	Rear	85	96.4	0.3
432	Rear Pax	Unrestrnd	30	Rear	90	98.1	0.1

Table II. Concerning Rollover Occurrence

Case	ROLL	SEAT	OCCRE	AGE	P	+/-
1	R/O, 1 Qrtr	Driver	Restrained	15	2.0	1.0
2	R/O, 2 or 3 Qrtrs	Driver	Restrained	15	1.8	0.9
3	R/O, 4+ Qrtrs	Driver	Restrained	15	3.8	1.6
4	No Rollover	Driver	Restrained	15	0.9	0.3
5	R/O, 1 Qrtr	Driver	Restrained	30	2.7	1.3
6	R/O, 2 or 3 Qrtrs	Driver	Restrained	30	2.4	1.2
7	R/O, 4+ Qrtrs	Driver	Restrained	30	5.1	2.0
8	No Rollover	Driver	Restrained	30	1.3	0.4
9	R/O, 1 Qrtr	Driver	Restrained	45	3.6	1.8
10	R/O, 2 or 3 Qrtrs	Driver	Restrained	45	3.3	1.5
11	R/O, 4+ Qrtrs	Driver	Restrained	45	6.8	2.7
12	No Rollover	Driver	Restrained	45	1.7	0.5
13	R/O, 1 Qrtr	Driver	Restrained	60	4.8	2.3
14	R/O, 2 or 3 Qrtrs	Driver	Restrained	60	4.4	2.0
15	R/O, 4+ Qrtrs	Driver	Restrained	60	8.9	3.4
16	No Rollover	Driver	Restrained	60	2.3	0.7
17	R/O, 1 Qrtr	Driver	Restrained	75	6.4	3.0
18	R/O, 2 or 3 Qrtrs	Driver	Restrained	75	5.8	2.6
19	R/O, 4+ Qrtrs	Driver	Restrained	75	11.7	4.3
20	No Rollover	Driver	Restrained	75	3.0	0.9
21	R/O, 1 Qrtr	Driver	Unrestrnd	15	5.6	2.2
22	R/O, 2 or 3 Qrtrs	Driver	Unrestrnd	15	5.1	2.0
23	R/O, 4+ Qrtrs	Driver	Unrestrnd	15	10.4	3.1
24	No Rollover	Driver	Unrestrnd	15	2.7	0.6
25	R/O, 1 Qrtr	Driver	Unrestrnd	30	7.4	2.9
26	R/O, 2 or 3 Qrtrs	Driver	Unrestrnd	30	6.8	2.5
27	R/O, 4+ Qrtrs	Driver	Unrestrnd	30	13.6	3.9
28	No Rollover	Driver	Unrestrnd	30	3.6	0.8
29	R/O, 1 Qrtr	Driver	Unrestrnd	45	9.8	3.7
30	R/O, 2 or 3 Qrtrs	Driver	Unrestrnd	45	8.9	3.3
31	R/O, 4+ Qrtrs	Driver	Unrestrnd	45	17.5	4.8
32	No Rollover	Driver	Unrestrnd	45	4.8	1.0
33	R/O, 1 Qrtr	Driver	Unrestrnd	60	12.8	4.6
34	R/O, 2 or 3 Qrtrs	Driver	Unrestrnd	60	11.7	4.1
35	R/O, 4+ Qrtrs	Driver	Unrestrnd	60	22.3	5.7
36	No Rollover	Driver	Unrestrnd	60	6.4	1.3
37	R/O, 1 Qrtr	Driver	Unrestrnd	75	16.5	5.7
38	R/O, 2 or 3 Qrtrs	Driver	Unrestrnd	75	15.2	5.1
39	R/O, 4+ Qrtrs	Driver	Unrestrnd	75	27.9	6.6
40	No Rollover	Driver	Unrestrnd	75	8.4	1.7
41	R/O, 1 Qrtr	Frnt Pax	Restrained	15	2.1	1.1
42	R/O, 2 or 3 Qrtrs	Frnt Pax	Restrained	15	1.9	0.9
43	R/O, 4+ Qrtrs	Frnt Pax	Restrained	15	4.0	1.7
44	No Rollover	Frnt Pax	Restrained	15	1.0	0.3
45	R/O, 1 Qrtr	Frnt Pax	Restrained	30	2.8	1.5



46	R/O, 2 or 3 Qrtrs	Frnt Pax	Restrained	30	2.6	1.3
47	R/O, 4+ Qrtrs	Frnt Pax	Restrained	30	5.4	2.2
48	No Rollover	Frnt Pax	Restrained	30	1.3	0.4
49	R/O, 1 Qrtr	Frnt Pax	Restrained	45	3.8	1.9
50	R/O, 2 or 3 Qrtrs	Frnt Pax	Restrained	45	3.4	1.7
51	R/O, 4+ Qrtrs	Frnt Pax	Restrained	45	7.1	2.8
52	No Rollover	Frnt Pax	Restrained	45	1.8	0.6
53	R/O, 1 Qrtr	Frnt Pax	Restrained	60	5.0	2.5
54	R/O, 2 or 3 Qrtrs	Frnt Pax	Restrained	60	4.6	2.2
55	R/O, 4+ Qrtrs	Frnt Pax	Restrained	60	9.4	3.6
56	No Rollover	Frnt Pax	Restrained	60	2.4	0.7
57	R/O, 1 Qrtr	Frnt Pax	Restrained	75	6.7	3.2
58	R/O, 2 or 3 Qrtrs	Frnt Pax	Restrained	75	6.1	2.8
59	R/O, 4+ Qrtrs	Frnt Pax	Restrained	75	12.2	4.6
60	No Rollover	Frnt Pax	Restrained	75	3.2	1.0
61	R/O, 1 Qrtr	Frnt Pax	Unrestrnd	15	5.9	2.4
62	R/O, 2 or 3 Qrtrs	Frnt Pax	Unrestrnd	15	5.4	2.1
63	R/O, 4+ Qrtrs	Frnt Pax	Unrestrnd	15	10.9	3.4
64	No Rollover	Frnt Pax	Unrestrnd	15	2.8	0.6
65	R/O, 1 Qrtr	Frnt Pax	Unrestrnd	30	7.8	3.1
66	R/O, 2 or 3 Qrtrs	Frnt Pax	Unrestrnd	30	7.1	2.7
67	R/O, 4+ Qrtrs	Frnt Pax	Unrestrnd	30	14.2	4.2
68	No Rollover	Frnt Pax	Unrestrnd	30	3.3	0.9
69	R/O, 1 Qrtr	Frnt Pax	Unrestrnd	45	10.2	3.9
70	R/O, 2 or 3 Qrtrs	Frnt Pax	Unrestrnd	45	9.4	3.5
71	R/O, 4+ Qrtrs	Frnt Pax	Unrestrnd	45	18.2	5.1
72	No Rollover	Frnt Pax	Unrestrnd	45	5.0	1.1
73	R/O, 1 Qrtr	Frnt Pax	Unrestrnd	60	13.4	4.9
74	R/O, 2 or 3 Qrtrs	Frnt Pax	Unrestrnd	60	12.2	4.4
75	R/O, 4+ Qrtrs	Frnt Pax	Unrestrnd	60	23.1	6.0
76	No Rollover	Frnt Pax	Unrestrnd	60	6.7	1.4
77	R/O, 1 Qrtr	Frnt Pax	Unrestrnd	75	17.2	6.0
78	R/O, 2 or 3 Qrtrs	Frnt Pax	Unrestrnd	75	15.8	5.4
79	R/O, 4+ Qrtrs	Frnt Pax	Unrestrnd	75	28.9	7.0
80	No Rollover	Frnt Pax	Unrestrnd	75	8.8	1.9
81	R/O, 1 Qrtr	Rear Pax	Restrained	15	1.7	0.6
82	R/O, 2 or 3 Qrtrs	Rear Pax	Restrained	15	1.5	0.6
83	R/O, 4+ Qrtrs	Rear Pax	Restrained	15	3.2	1.0
84	No Rollover	Rear Pax	Restrained	15	0.8	0.2
85	R/O, 1 Qrtr	Rear Pax	Restrained	30	2.3	0.9
86	R/O, 2 or 3 Qrtrs	Rear Pax	Restrained	30	2.0	0.8
87	R/O, 4+ Qrtrs	Rear Pax	Restrained	30	4.3	1.3
88	No Rollover	Rear Pax	Restrained	30	1.1	0.2
89	R/O, 1 Qrtr	Rear Pax	Restrained	45	3.0	1.2
90	R/O, 2 or 3 Qrtrs	Rear Pax	Restrained	45	2.7	1.0
91	R/O, 4+ Qrtrs	Rear Pax	Restrained	45	5.7	1.7
92	No Rollover	Rear Pax	Restrained	45	1.4	0.3
93	R/O, 1 Qrtr	Rear Pax	Restrained	60	4.0	1.5
94	R/O, 2 or 3 Qrtrs	Rear Pax	Restrained	60	3.7	1.3
95	R/O, 4+ Qrtrs	Rear Pax	Restrained	60	7.6	2.2
96	No Rollover	Rear Pax	Restrained	60	1.9	0.4

97	R/O, 1 Qtrtr	Rear Pax	Restrained	75	5.4	2.0
98	R/O, 2 or 3 Qtrtrs	Rear Pax	Restrained	75	4.9	1.7
99	R/O, 4+ Qtrtrs	Rear Pax	Restrained	75	10.0	2.7
100	No Rollover	Rear Pax	Restrained	75	2.6	0.5
101	R/O, 1 Qtrtr	Rear Pax	Unrestrnd	15	4.7	1.4
102	R/O, 2 or 3 Qtrtrs	Rear Pax	Unrestrnd	15	4.3	1.2
103	R/O, 4+ Qtrtrs	Rear Pax	Unrestrnd	15	8.9	1.8
104	No Rollover	Rear Pax	Unrestrnd	15	2.3	0.3
105	R/O, 1 Qtrtr	Rear Pax	Unrestrnd	30	6.3	1.8
106	R/O, 2 or 3 Qtrtrs	Rear Pax	Unrestrnd	30	5.7	1.5
107	R/O, 4+ Qtrtrs	Rear Pax	Unrestrnd	30	11.6	2.3
108	No Rollover	Rear Pax	Unrestrnd	30	3.0	0.4
109	R/O, 1 Qtrtr	Rear Pax	Unrestrnd	45	8.3	2.3
110	R/O, 2 or 3 Qtrtrs	Rear Pax	Unrestrnd	45	7.6	2.0
111	R/O, 4+ Qtrtrs	Rear Pax	Unrestrnd	45	15.1	2.8
112	No Rollover	Rear Pax	Unrestrnd	45	4.0	0.5
113	R/O, 1 Qtrtr	Rear Pax	Unrestrnd	60	10.9	3.0
114	R/O, 2 or 3 Qtrtrs	Rear Pax	Unrestrnd	60	10.0	2.6
115	R/O, 4+ Qtrtrs	Rear Pax	Unrestrnd	60	19.3	3.5
116	No Rollover	Rear Pax	Unrestrnd	60	5.4	0.6
117	R/O, 1 Qtrtr	Rear Pax	Unrestrnd	75	14.2	3.7
118	R/O, 2 or 3 Qtrtrs	Rear Pax	Unrestrnd	75	13.0	3.2
119	R/O, 4+ Qtrtrs	Rear Pax	Unrestrnd	75	24.4	4.1
120	No Rollover	Rear Pax	Unrestrnd	75	7.1	0.8