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Supplemental Report: U.S. Fatal Accidents on High-Speed Roadways Involving Guardrails

Specialist's Factual Report
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1. TRUCK ACCIDENT DATA GROUP

In support of the accident investigation, the Division of Safety Research and Statistical Analysis (RE-10) within the Office of Research and Engineering was asked to extract data from the National Highway Traffic Safety Administration (NHTSA) Fatality Analysis Reporting System (FARS), which includes fatal accident data from public roads in the United States. The objective was to count the number of fatal accidents involving heavy vehicles on high-speed roadways and describe some characteristics of these accidents. Specific focus was placed on the interaction between heavy vehicles and guardrails.

2. METHODS

Data Source and Variables Used

Data were extracted from FARS, a census of fatal crashes on U.S. public roads in which at least one person died within 30 days of the event. FARS data are obtained

from police reports, driver records, vehicle records, and death certificates. NHTSA does not conduct independent crash investigations in support of FARS.

This supplemental report to the Bronx, New York, accident investigation focuses on fatal crashes involving heavy vehicles—such as large buses, truck-tractors, and single-unit trucks—on public high-speed roadways, *including interstates, expressways, freeways, and other principal arterials*. The majority of these roadways are on the National Highway System. In FARS, the accident-level variable road function (Road_Fnc) is used to identify roadways as high-speed roadways, while the vehicle-level variable body type (Body_typ) is used to classify vehicles into large bus, truck-tractor, single-unit truck, and passenger vehicle. To provide long-term historical perspective, the data analysis spans 1994–2010, the last calendar year of available FARS data.

A specific interest of this data report is vehicle collisions with guardrails. FARS data offer three variables—one at the accident level and two at the vehicle level. The accident-level variable "First Harmful Event (Harm_Ev)" does not identify which vehicle collides with the guardrail when more than one vehicle is involved. The vehicle-level variable "Most Harmful Event (M_Harm)" is specific to the individual vehicle; however, it records only the event that is deemed the most harmful—most likely causing the fatal or severe injury. The second vehicle-level variable was introduced in 2004 by NHTSA as a set of six variables, referred to as "sequence of events (SEQ1–SEQ6)," to capture up to six sequential events for each vehicle involved in a crash. The FARS codes relevant to this data report are 24 (guardrail face) and 52 (guardrail end).

FARS also records police-related factors for vehicles that may have contributed

to the crash. Of more than 90 driver-related factors, up to four can be coded (DR_CF1–DR_CF4). Fatigue (drowsy, sleepy, asleep) is coded as "1." Cell phones are coded as "93" (presence) or "94" (in use at time of accident) if police decide that the use or presence of a cell phone may have been a contributing factor.

In 2010, the FARS "sequence of events" was expanded to include more than six events. However, in this data report, to preserve consistency in the analyses, only the first six events were studied. There are also now two new data sets of interest, the DISTRACT and DRIMPAIR data sets—which replace the driver-related factors (DR_CF1–DR_CF4, discussed earlier) and are used to evaluate cell phone use and fatigue.[1]

[1] *Fatality Analysis Reporting System (FARS) Analytical Reference Guide*, DOT HS 811 529 (Washington, DC: U.S. Department of Transportation, National Highway Traffic Safety Administration, 2011), <http://www-nrd.nhtsa.dot.gov/Pubs/811529.pdf>, accessed April 2, 2012.

3. FINDINGS

Key findings are summarized below. All supporting tables and figures are placed at the end of this report (tables 1–11 and figures 1 and 2).

Counts of Vehicles Involved in Fatal Crashes on High-Speed Roadways

Passenger vehicles represented the majority of vehicles involved in fatal crashes on U.S. public roads from 1994–2010 (table 1).

- On average 55,640 vehicles were involved in fatal crashes each year. Of these, 45,822 were passenger vehicles (82%), 3,223 truck-tractors (6%), 1,286 single-unit trucks (2%), and 283 large buses (0.5%).

Compared to truck-tractors and single-unit trucks, large buses were less frequently involved in fatal crashes on high-speed roadways from 1994–2010 (table 1).

- About 41% of all large bus fatal crashes occurred on high-speed roadways. For other vehicle types, 68% of truck-tractor, 47% of single-unit truck, and 43% of passenger vehicle fatal crashes occurred on high-speed roadways.

From 1994–2010, the number of vehicles involved in fatal crashes on all U.S. public roads decreased. However, large buses showed the smallest percentage decrease (table 1).

- When all vehicle types are considered, there was a 19% decrease in vehicle involvement in fatal crashes over this 17-year period. The percentage decreases were 27% for truck-tractors, 26% for single-unit trucks, 24% for passenger vehicles, and only 4% for large buses.

The percentage of passenger vehicles, truck-tractors, and single-unit trucks involved in fatal crashes on high-speed roadways from 1994–2010 declined significantly when compared to that of large buses (table 1).

- Over this period, the number of fatal crashes involving large buses dropped from 108 to 103 (5% decrease); this percentage decline was considerably less than that of passenger vehicles (23%), truck-tractors (22%), and single-unit trucks (21%) (table 1).

However, according to the Federal Highway Administration Highway Statistics Series, bus travel on interstate highways grew considerably faster than other vehicle types. In terms of fatal crash involvement per 100 million vehicle-miles, large buses, therefore, observed the most notable decline (figure 1).[2]

- In 1994, the fatal crash involvement rate for large buses was 8.2 crashes per 100 million vehicle-miles on U.S. interstates, approximately twice as high as the rates for single-unit trucks (4.3), passenger vehicles (4.0), and truck-tractors (3.9). By 2010, the involvement rates were much more similar—2.9 for large buses, 2.3 for passenger vehicles, 1.8 for truck-tractors, and 1.8 for single-unit trucks.

- Figure 1 also shows (in the legend) the annual rates of decrease for the four vehicle body types. From 1994–2010, the fatal crash involvement rate for

[2] Motor-vehicle travel data (in million vehicle-miles) were obtained directly from FHWA Highway Statistics Series table VM-1 (see: <http://www.fhwa.dot.gov/policyinformation/statistics/2010/vm1.cfm>). In the computation of fatal crash involvement rates, only vehicle-mile values for rural and urban interstate travels were used.

large buses declined by 0.42 crash per 100 million vehicle-miles every year, whereas the other three body types observed declining rates of 0.12–0.15 crash per 100 millions vehicle-miles. These declining rates were all statistically significant at the 99% confidence level.

Occupant Deaths on High-Speed Roadways

On average, 24 occupants of large buses involved in fatal crashes on high-speed roadways were killed each year from 1994–2010. Occupant deaths for other vehicle types each year were 12,326 for passenger vehicles, 332 for truck-tractors, and 99 for single unit trucks (table 2).

For the 4 years 1994–1997, fewer than 10 occupants of large buses died in high-speed roadway crashes. These numbers increased considerably in recent years and have stayed above 20 since 2002, peaking at 51 in 2005 (table 2). Comparatively, occupant deaths in truck-tractors and passenger vehicles declined (table 2).

On average, 17% of deaths in crashes on high-speed roadways involving large buses were the occupants in the large buses. Similarly, the percentages were 15% and 14% for single-unit trucks and truck-tractors, respectively. However, 80% of crash deaths involving passenger vehicles were the occupants of passenger vehicles (table 3).

Involvement in Multivehicle Crashes on High-Speed Roadways

Large buses, truck-tractors, and single-unit trucks were much more likely to be involved in multivehicle fatal crashes than passenger vehicles. From 1994–

2010, 68% of fatal crashes involving large buses on high-speed roadways involved multiple vehicles. Correspondingly, the percentages were 83% for truck-tractors, 82% for single-unit trucks, and only 53% for passenger vehicles (table 4).

Collision With Guardrails on High-Speed Roadways

From 1994–2010, "collision with guardrail" was infrequently attributed as the most harmful event to the heavier vehicles (table 5).

- "Collision with guardrail" was assigned as the most harmful event for 3,861 crashes involving passenger vehicles (resulting in 4,160 deaths), 204 crashes involving truck-tractors (230 deaths), 53 crashes involving single-unit trucks (56 deaths), and 4 crashes involving large buses (8 deaths).

From 2004–2010, "collision with guardrail" was one of six sequence of events assigned to the vehicles (table 6).

- In 6,132 crashes during this 7-year period, a passenger vehicle collided with a guardrail at some point of the event sequence, resulting in a total of 6,935 deaths.
- In 749 crashes, a truck-tractor collided with a guardrail in the event sequence, resulting in 870 deaths.
- In 189 crashes, a single-unit truck collided with a guardrail in the event sequence, resulting in 206 deaths.
- In 23 crashes, a large bus collided with a guardrail in the event sequence, resulting in 51 deaths.

Comparing the two variables (most harmful event and sequence of event) from 2004–2010, significantly larger numbers of crashes were identified using sequence of event (tables 5 and 6).

- For passenger vehicles over this 7-year period, 1,394 crashes were identified using most harmful event, while 6,132 crashes were identified using sequence of event—for a ratio of 1:4.
- For truck-tractors, 63 and 749 crashes were identified using most harmful event and sequence of events, respectively—for a ratio of 1:12.
- For single-unit trucks, 23 and 189 crashes were identified using most harmful event and sequence of events, respectively—for a ratio of 1:8.
- Over these 7 years, no crash involving large buses was identified using most harmful event.
- Compared to passenger vehicles, heavier vehicles (large buses, truck-tractors, and single-unit trucks) were more likely to collide with a guardrail and subsequently be involved in another event (such as a collision with another vehicle) that was identified as the most harmful.

From 2004–2010, the majority of fatal crashes involving guardrails occurred on high-speed roadways (tables 7 and 13).

- Of all 373,484 vehicles involved in fatal crashes on U.S. public roads, about 4% (13,112 vehicles) involved collisions with guardrails at one point during the fatal crash sequence (table 7).

- Of vehicle collisions involving guardrails, about 66% (8,630) occurred on high-speed roadways (table 7).
- Heavy vehicles (figure 2) accounted for about 11% (991 vehicles) of all vehicles involved in fatal crashes involving guardrail collisions on high-speed roadways. This vehicle count included 23 large buses, 758 truck-tractors, and 190 single-unit trucks (table 6), in addition to 20 other large trucks (including unknown truck types).

From 2004–2010, "collision with guardrail" was not typically the first event in fatal crashes on high-speed roadways (table 8).

- For all vehicles, 52% of "collision with guardrail" events occurred as the second in a sequence of up to six events.
- "Collision with guardrail" most likely occurred second to another event for truck-tractors, single-unit trucks, and passenger vehicles.
- For large buses, however, "collision with guardrail" was more likely to occur as the third event (44%).
- On high-speed roadways, very few fatal crashes had "collision with guardrail" coded as the first event.
- These observations indicate that one or more precipitating events led to "collision with guardrail."

In fatal crashes on high-speed roadways from 2004–2010, "collision with guardrail" was most likely secondary to "collision with moving vehicle on same road" (table 9).

- "Ran-off-road," either to the left or right, was the event most often cited as the preceding event to "collision with guardrail"—which is not surprising because most guardrails on high-speed roads are set back a distance from the traveling lanes.
- Excluding the "ran-off-road" event, the most frequently cited event for all vehicle types was "collision with moving vehicle on same road" (27%), followed by "rollover" (21%).
- For heavy vehicles, "collision with moving vehicle on same road" was the leading preceding event for single-unit trucks (38%), truck-tractors (31%), and large buses (25%). For large buses, "rollover" also accounted for 25% of all preceding events.

In fatal crashes on high-speed roadways from 2004–2010, "collision with guardrail" was most often followed by "rollover" (table 10).

- For all vehicle types, the overwhelming majority of events (35%) following "collision with guardrail" were "rollover" events.
- "Rollover" was particularly prevalent after single-unit truck collisions with guardrails (41%), while "rollover" represented 28% of subsequent events for truck-tractors.
- For large buses, however, a "ran-off-road" event after collision with guardrail was more frequent (19%) than "rollover" (13%).

With regard to fatal crashes involving guardrails on high-speed roadways from 2004–2010, fatigue was more frequently a driver-related factor than cell phone use/presence (table 11).

- Heavy vehicles involved in “collision with guardrail” fatal crashes were more likely to have “fatigue” cited as one driver-related factor. Specifically, 13% of large buses, 9% of single-unit trucks, and 8% of truck-tractors had “fatigue” assigned as a driver-related factor. In comparison, the same factor was cited for only 5% of passenger vehicles.
- When compared to “fatigue,” overall lower percentages were observed for cell phone use or presence.
- Heavy vehicles were more likely to have “cell phone use/presence” cited as one driver-related factor—for example, 4% of large buses, 4% of truck-tractors, and 3% of single-unit trucks, as compared to only 2% of passenger vehicles.

4. LIMITATIONS OF DATA

This report provides a national perspective on fatal crashes involving heavy vehicles, specifically large buses, truck-tractors, and single-unit trucks. The use of the variable sequence of events provides a way to identify fatal crashes involving “collision with guardrail.” However, because the sequence of event variable was introduced in 2004, only 7 years of data can be so analyzed. Additionally, there were considerable changes in the FARS data sets in 2010. Sequence of event became a separate data

set, and some vehicles now have more than six events. Distraction (which includes cell phone) and impairment (which includes fatigue) have also become separate data sets.[3]

The discussion in this report regarding cell phone use requires the most caution. The citation of "cell phone use" or "cell phone presence" prior to 2010 was highly subjective. It is believed that FARS data largely underestimate the prevalence of cell phone distraction. Furthermore, the distraction data set in 2010 now includes three elements that can be used to imply cell phone distraction ("while talking or listening to cellular phone," "while dialing cellular phone," and "other cellular phone related"). In this report, no attempt is made to present year-to-year trends with respect to "fatigue" and "cell phone."

This report considers fatal crashes on U.S. high-speed roadways—which include interstates, expressways, and freeways, as well as primary arterials—where guardrails are likely to be present. The estimates of vehicle-mile travel by body types are limited to interstates.

[3] The distraction and impairment data sets in the 2010 FARS data are "DISTRACT" and "DRIMPAIR."

Table 1. Vehicles involved in fatal crashes by body type, road type, and year, 1994-2010, Fatality Analysis Reporting System

	All Vehicles			Large Buses			Passenger Vehicles			Truck-tractors			Single Unit Trucks		
	On all roads	On high-speed roads		On all roads	On high-speed roads		On all roads	On high-speed roads		On all roads	On high-speed roads		On all roads	On high-speed roads	
Year	No.	No.	%	No.	No.	%	No.	No.	%	No.	No.	%	No.	No.	%
1994	54,911	23,991	43.7	258	109	42.2	46,240	19,816	42.9	3,264	2,140	65.6	1,306	585	44.8
1995	56,524	24,026	42.5	271	100	36.9	48,178	20,036	41.6	3,189	2,097	65.8	1,232	560	45.5
1996	57,347	25,524	44.5	326	143	43.9	48,621	21,124	43.4	3,415	2,323	68.0	1,295	609	47.0
1997	57,060	25,083	44.0	297	126	42.4	48,343	20,744	42.9	3,535	2,381	67.4	1,328	611	46.0
1998	56,922	25,367	44.6	289	120	41.5	48,146	20,989	43.6	3,560	2,434	68.4	1,354	635	46.9
1999	56,820	25,063	44.1	319	127	39.8	47,755	20,557	43.0	3,504	2,408	68.7	1,377	649	47.1
2000	57,594	24,702	42.9	325	128	39.4	48,047	20,235	42.1	3,540	2,315	65.4	1,418	664	46.8
2001	57,918	25,314	43.7	292	120	41.1	48,172	20,747	43.1	3,377	2,286	67.7	1,379	631	45.8
2002	58,426	25,197	43.1	274	95	34.7	48,832	20,719	42.4	3,288	2,209	67.2	1,252	546	43.6
2003	58,877	25,531	43.4	291	114	39.2	48,647	20,708	42.6	3,346	2,315	69.2	1,307	634	48.5
2004	58,729	25,479	43.4	279	106	38.0	47,966	20,558	42.9	3,466	2,360	68.1	1,373	634	46.2
2005	59,495	26,087	43.8	280	122	43.6	47,946	20,796	43.4	3,442	2,351	68.3	1,443	675	46.8
2006	58,094	25,158	43.3	305	124	40.7	46,514	19,910	42.8	3,289	2,217	67.4	1,405	674	48.0
2007	56,253	24,349	43.3	281	118	42.0	44,559	18,996	42.6	3,208	2,180	68.0	1,314	650	49.5
2008	50,660	22,109	43.6	251	110	43.8	39,590	17,148	43.3	2,817	1,919	68.1	1,153	542	47.0
2009	45,540	20,251	44.5	221	96	43.4	36,321	16,032	44.1	2,155	1,493	69.3	953	464	48.7
2010	44,713	19,766	44.2	249	106	42.6	35,102	15,313	43.6	2,395	1,665	69.5	973	460	47.3
Total	945,883	412,997		4,808	1,964		778,979	334,428		54,790	37,093		21,862	10,223	
Mean	55,640	24,294	44	283	116	41	45,822	19,672	43	3,223	2,182	68	1,286	601	47
% Change (1994-2010)															
	-18.6	-17.6		-3.5	-2.8		-24.1	-22.7		-26.6	-22.2		-25.5	-21.4	

Figure 1. Fatal crash involvement rates on high-speed roadways by body type and year, 1994-2010, Fatality Analysis Reporting System

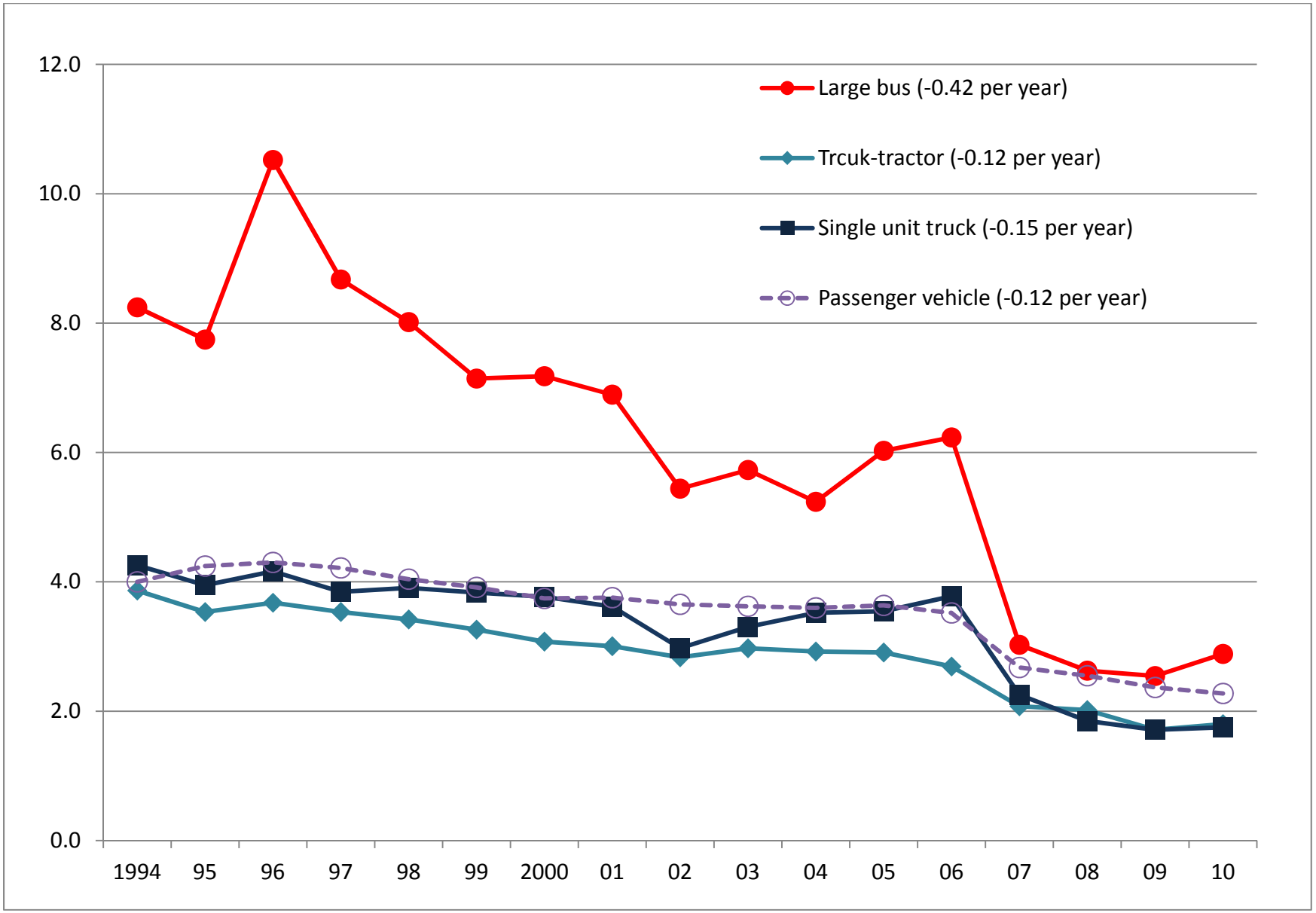

Table 2. Fatal crashes and fatalities on high-speed roadways by body type and year, 1994-2010, Fatality Analysis Reporting System

	Crash count				Crash death				Death in vehicle			
year	Large Bus	Passenger Vehicle	Truck-Tractor	Single Unit Truck	Large Bus	Passenger Vehicle	Truck-Tractor	Single Unit Truck	Large Bus	Passenger Vehicle	Truck-Tractor	Single Unit Truck
1994	108	13,466	1,995	573	126	15,480	2,377	674	8	12,500	320	69
1995	100	13,537	1,948	547	107	15,477	2,332	629	8	12,484	315	88
1996	141	14,170	2,120	596	162	16,330	2,513	683	9	13,396	295	81
1997	125	14,080	2,202	599	149	16,247	2,643	697	9	13,315	346	99
1998	120	14,056	2,196	619	146	16,100	2,675	699	27	13,266	357	110
1999	123	13,891	2,177	635	163	16,023	2,660	750	38	13,316	391	108
2000	127	13,664	2,083	639	148	15,697	2,453	742	7	12,967	336	112
2001	119	14,004	2,070	616	144	15,942	2,411	685	17	13,062	335	81
2002	95	13,964	1,974	532	135	16,000	2,410	621	32	13,141	331	104
2003	111	13,903	2,080	608	148	15,926	2,483	688	30	13,020	359	101
2004	104	13,963	2,103	614	138	16,046	2,537	744	35	13,120	364	112
2005	121	14,165	2,135	647	176	16,162	2,504	741	51	12,967	384	134
2006	123	13,759	1,969	648	139	15,577	2,341	721	20	12,318	358	121
2007	118	13,097	1,912	625	151	14,848	2,276	712	27	11,603	370	127
2008	110	11,994	1,728	531	138	13,401	1,995	602	40	10,210	318	98
2009	96	11,232	1,356	455	116	12,638	1,566	518	22	9,704	223	75
2010	103	10,865	1,531	450	132	12,123	1,786	492	33	9,145	246	64
Total	**1,944**	**227,810**	**33,579**	**9,934**	**2,418**	**260,017**	**39,962**	**11,398**	**413**	**209,534**	**5,648**	**1,684**
Mean	**114**	**13,401**	**1,975**	**584**	**142**	**15,295**	**2,351**	**670**	**24**	**12,326**	**332**	**99**
% change (1994-2010)												
% Chg	**-4.6**	**-19.3**	**-23.3**	**-21.5**	**4.8**	**-21.7**	**-24.9**	**-27.0**	**312.5**	**-26.8**	**-23.1**	**-7.2**

Table 3. Percent of crash death occurring in vehicle on high-speed roadways by body type and year, 1994-2010, Fatality Analysis Reporting System

year	Large Bus	Passenger Vehicle	Truck-tractor	Single Unit Truck
1994	6.3	80.7	13.5	10.2
1995	7.5	80.7	13.5	14.0
1996	5.6	82.0	11.7	11.9
1997	6.0	82.0	13.1	14.2
1998	18.5	82.4	13.3	15.7
1999	23.3	83.1	14.7	14.4
2000	4.7	82.6	13.7	15.1
2001	11.8	81.9	13.9	11.8
2002	23.7	82.1	13.7	16.7
2003	20.3	81.8	14.5	14.7
2004	25.4	81.8	14.3	15.1
2005	29.0	80.2	15.3	18.1
2006	14.4	79.1	15.3	16.8
2007	17.9	78.1	16.3	17.8
2008	29.0	76.2	15.9	16.3
2009	19.0	76.8	14.2	14.5
2010	25.0	75.4	13.8	13.0
Yearly Average	**16.9**	**80.4**	**14.2**	**14.7**

Table 4. Multiple-vehicle fatal crash on high-speed roadways by body type and year, 1994-2010, Fatality Reporting System

	Large Buses		Passenger Vehicle		Truck-tractor		Single Unit Truck	
Year	Crash	% of all Crash	Crash	% of all Crash	Crash	% of all Crash	Crash	% of all Crash
1994	65	60.2	7,244	53.8	1,630	81.7	487	85.0
1995	64	64.0	7,049	52.1	1,614	82.9	455	83.2
1996	91	64.5	7,623	53.8	1,776	83.8	494	82.9
1997	89	71.2	7,623	54.1	1,815	82.4	502	83.8
1998	76	63.3	7,522	53.5	1,845	84.0	513	82.9
1999	89	72.4	7,444	53.6	1,818	83.5	533	83.9
2000	94	74.0	7,294	53.4	1,757	84.3	538	84.2
2001	83	69.7	7,417	53.0	1,732	83.7	514	83.4
2002	67	70.5	7,371	52.8	1,674	84.8	431	81.0
2003	82	73.9	7,536	54.2	1,741	83.7	502	82.6
2004	76	73.1	7,471	53.5	1,761	83.7	523	85.2
2005	85	70.2	7,559	53.4	1,778	83.3	505	78.1
2006	80	65.0	7,242	52.6	1,653	84.0	515	79.5
2007	80	67.8	6,811	52.0	1,571	82.2	485	77.6
2008	65	59.1	6,172	51.5	1,402	81.1	432	81.4
2009	70	72.9	5,675	50.5	1,113	82.1	375	82.4
2010	68	66.0	5,572	51.3	1,277	83.4	365	81.1
Total	1,324	68.1	120,625	52.9	27,957	83.3	8,169	82.2
Mean	78	68.1	7,096	52.9	1,645	83.2	481	82.2

Table 5. Fatal crashes and fatalities on high-speed roadways with most harmful event to vehicle attributed as "collision with guardrail face or end, by body type and year, 1994-2010, Fatality Analysis Reporting System

	Large bus			Passenger vehicle			Truck-tractor			Single unit truck		
Year	No. of crash	Death in vehicle	Crash death	No. of crash	Death in vehicle	Crash death	No. of crash	Death in vehicle	Crash death	No. of crash	Death in vehicle	Crash death
1994	0	0	0	255	271	281	13	13	16	0	0	0
1995	2	1	2	228	234	242	12	11	13	4	4	4
1996	0	0	0	253	263	272	14	13	15	2	2	2
1997	0	0	0	269	280	294	19	20	22	4	3	4
1998	0	0	0	239	255	263	13	14	14	2	2	2
1999	0	0	0	216	219	232	16	16	20	4	4	4
2000	0	0	0	262	269	285	7	6	7	6	5	6
2001	0	0	0	257	263	273	18	15	25	2	1	2
2002	1	5	5	230	239	250	17	17	18	4	3	6
2003	1	0	1	258	246	284	12	10	14	2	2	2
2004	0	0	0	205	210	220	9	8	9	4	2	5
2005	0	0	0	203	200	216	16	11	17	3	3	3
2006	0	0	0	210	215	224	10	9	12	1	1	1
2007	0	0	0	213	219	230	5	5	5	2	2	2
2008	0	0	0	198	194	207	9	6	9	5	4	5
2009	0	0	0	176	176	186	4	3	4	3	3	3
2010	0	0	0	189	188	201	10	10	10	5	4	5
Total	4	6	8	3861	3941	4160	204	187	230	53	45	56
Mean	0.2	0.4	0.5	227.1	231.8	244.7	12.0	11.0	13.5	3.1	2.6	3.3

Table 6. Crashes and fatalities involving vehicle colliding with guardrails as one of six events in crash sequence on high-speed roadways (2004-2010).

	Large Bus		Passenger Vehicle		Truck-tractor		Single Unit Truck	
	Crashes	Deaths	Crashes	Deaths	Crashes	Deaths	Crashes	Deaths
2004	3	6	918	1,062	123	148	30	35
2005	4	7	984	1,122	131	154	35	38
2006	5	6	760	1,079	106	128	26	28
2007	2	2	942	1,073	123	144	29	31
2008	2	18	847	942	103	119	30	32
2009	5	9	749	840	86	92	18	19
2010	2	3	732	817	77	85	21	23
Total	23	51	6,132	6,935	749	870	189	206
Mean	3.3	7.3	876.0	990.7	107.0	124.3	27.0	29.4

Table 7. Vehicles colliding with guardrail during sequence of events in fatal crashes by road types in 2004-2010, Fatality Analysis Reporting System

Road Functions	Collided with guardrail	All crashes	Percent of all vehicles	Percent of all guardrail vehicles
High-speed Roadways	8,630	163,199	5.3	65.8
Minor Arterials	1,760	73,171	2.4	13.4
Collectors	1,690	71,042	2.4	12.9
Local Road	950	62,389	1.5	7.2
Unknown	82	36,83	2.2	0.6
All Road Types	13,112	373,484	3.5	100.0

Table 8, Relative distribution of the sequential order at which "collision with guardrails" occurred by body type on high-speed roadways (2004-2010)

	Large bus	Truck-tractor	Single unit truck	Passenger vehicle	All vehicle
First	0.0	4.2	4.7	4.5	4.6
Second	30.4	47.1	47.4	50.7	51.9
Third	43.5	30.1	28.4	27.6	27.4
Fourth	21.7	12.4	12.1	11.7	11.0
Fifth	4.3	4.5	4.2	4.3	3.9
Sixth	0.0	1.7	3.2	1.3	1.2

Figure 2. Distribution of all vehicles colliding with guardrail on high-speed roadways by vehicle types (2004-2010)

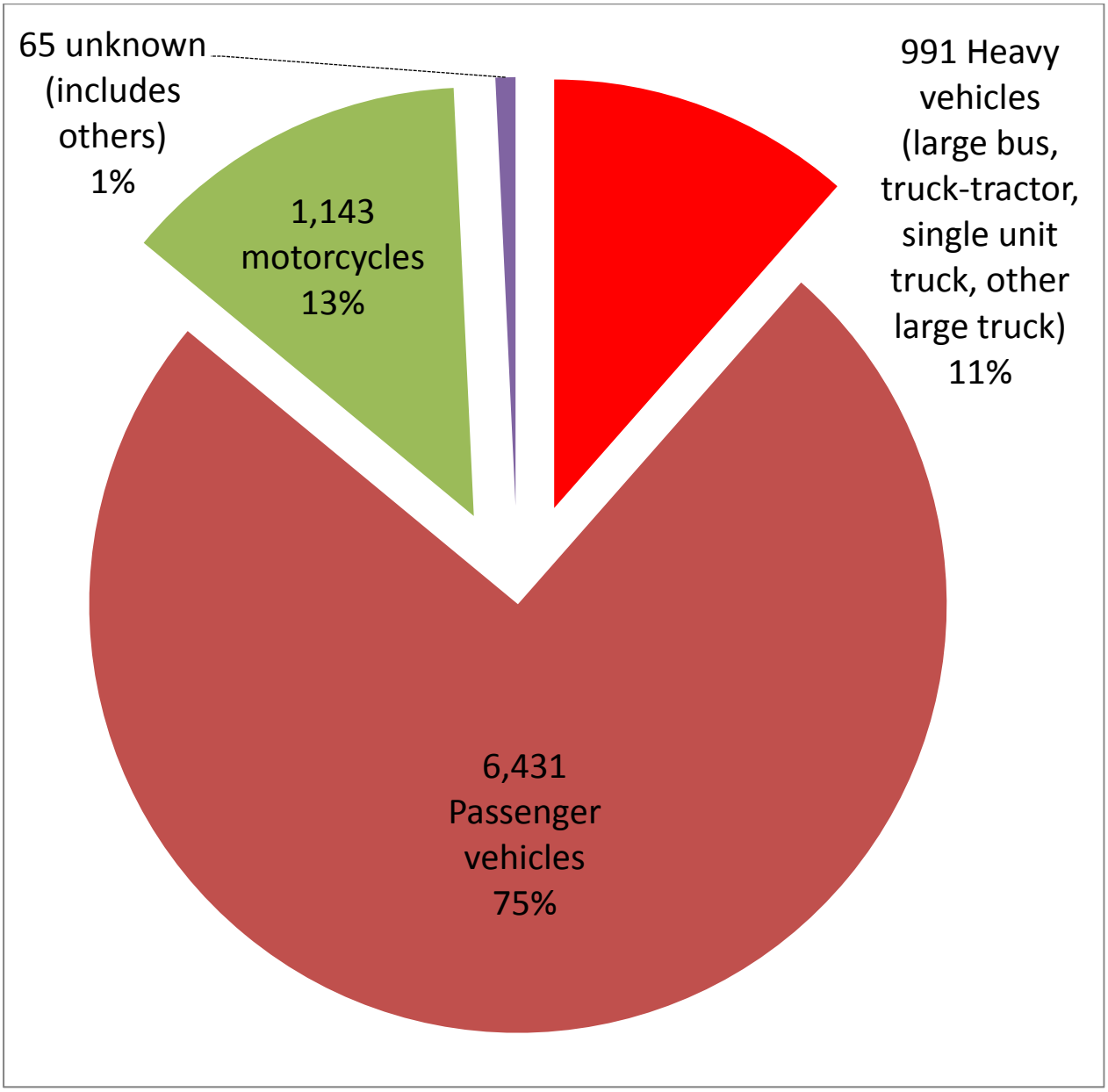

Table 9, Frequency by event type preceding the "collision with guardrail" event (excluding "ran-off-road" event) on high-speed roads by body type (2004-2010).

	Large bus		Truck-track		Single unit truck		Passenger vehicle		All vehicle	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Collided with moving vehicle on same road	2	25.0	77	31.4	28	37.8	532	27.5	680	26.5
Rollover	2	25.0	47	19.2	14	18.9	380	19.6	528	20.5
Crossed median or centerline	1	12.5	25	10.2	10	13.5	220	11.4	281	10.9
Collided with guardrail (face and end)	0	0.0	10	4.1	3	4.1	195	10.1	260	10.1
Collided with highway hardware (e.g. cushion, culvert, curb, ditch)	10	12.5	8	3.3	3	4.1	119	6.2	172	6.7
Collided with support (e.g. highway sign, overhead sign, light, traffic sign)	0	0.0	6	2.4	2	2.7	118	6.1	144	5.6
All others	2	25.0	72	29.4	14	18.9	370	16.1	505	19.6
Total event	8	100.0	245	100.0	74	100.0	1934	100.0	2570	100.0

Table 10, Frequency by event type following the "collision with guardrail" event on high-speed roads by body type (2004-2010).

	Large bus		Truck-track		Single unit truck		Passenger vehicle		All vehicle	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Rollover	2	12.5	155	27.9	55	40.7	1630	35.6	2006	34.6
Ran off Road (to left and right)	3	18.8	17	3.1	1	0.7	458	10.0	511	8.8
Vehicle event (e.g. jackknife, cargo loss, separation of units, airborne)	1	6.3	58	10.5	7	5.2	362	7.9	444	7.7
Collided with fixed object other than support (e.g. tree, wall, building)	3	18.8	49	8.8	6	4.4	296	6.5	387	6.7
Collided with moving vehicle on same road	1	6.3	27	4.9	4	3.0	311	6.8	381	6.6
Crossed median or centerline	0	0.0	13	2.3	5	3.7	321	7.0	355	6.1
Collided with support (e.g. highway sign, overhead sign, light, traffic sign)	3	18.8	23	4.1	10	7.4	232	5.1	307	5.3
All others	3	18.8	971	38.4	47	34.8	971	21.2	1406	24.3
Total event	16	100.0	4581	100.0	135	100	4581	100.0	5797	100.0

Table 11. Vehicles colliding with guardrail during sequence of events in fatal on high-speed roadways by body type and driver-related factor (2004-2010), Fatality Analysis Reporting System

		Fatigue as a factor		Cell phone use/presence as factor	
	All vehicles	Vehicles	% of all vehicles	Vehicles	% of all vehicles
Large Bus	23	3	13.0	1	4.3
Truck-tractor	758	63	8.3	29	3.8
Single Unit Truck	190	17	8.9	5	2.6
Passenger Vehicle	6,431	312	4.9	148	2.3