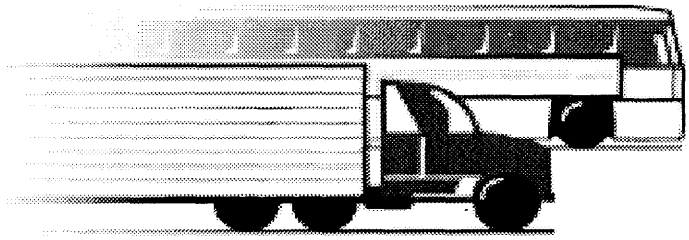

FMCSA

Federal Motor Carrier Safety Administration

The Large Truck Crash Picture

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HIGHLIGHTS

- Almost 3.2 million people were injured and 41,471 were killed in traffic crashes on our nation's roadways in 1998. Thirteen percent or 5,374 of the fatalities and 4 percent or 127,000 of the injuries resulted from traffic crashes involving large trucks.

- Over the past twenty years large trucks accounted for approximately 4 percent of the registered vehicles and 7 percent of the vehicle miles traveled. In terms of crash involvement, trucks were: 8 percent of the vehicles in fatal crashes; 2 percent of the vehicles in injury crashes; and 4 percent of the vehicles in property-damage-only crashes.

- The large truck fatal crash involvement rate (trucks involved in crashes per 100 million vehicle miles of travel) has been consistently higher than the passenger vehicle involvement rate from 1988 to 1998. However, fatal involvement rates for both vehicle types has declined. The truck rate has declined by 32 percent (from 5.4 to 2.5) and the passenger vehicle rate has declined by 29 percent (from 2.8 to 2.0) from 1988 to 1998.

- The large truck injury crash involvement rate (trucks involved in crashes per 100 million vehicle miles of travel) has been consistently lower than the passenger vehicle rate from 1988 to 1998. However, injury crash involvement rates have declined for both vehicle types. The truck rate has declined by 34 percent (from 68 to 45) and the passenger vehicle rate has declined by 26 percent (from 201 to 149) from 1988 to 1998.

- Thirty-eight percent of large truck drivers compared to two-thirds of passenger vehicle drivers involved in fatal crashes from 1994 through 1998 had at least one driver-related factor coded. The most common factors for both types of drivers were running off the road or out of the traffic lane, and driving too fast for conditions or exceeding the posted speed limit.

- Almost three-quarters of the trucks involved in fatal crashes in 1994 to 1998 were combination-unit trucks. Nine times as many combination-unit trucks were involved in fatal crashes than single-unit trucks on a per registered truck basis. On a per 100 million miles of travel basis, an average of 2.8 combination-unit trucks were involved in fatal crashes compared to1.8 single-unit trucks involved in fatal crashes.

I. INTRODUCTION

Almost 3.2 million people were injured and 41,471 were killed in traffic crashes on our nation's roadways in 1998. Thirteen percent or 5,374 of the fatalities and 4 percent or 127,000 of the injuries resulted from traffic crashes involving large trucks. These numbers reflect the major role that commercial vehicles play in our transportation system and underscore the need to improve commercial vehicle safety. Most victims were people in the other vehicles, on bicycles, or pedestrians involved in a crash with a truck. The vast majority of these crashes involve human error by either the commercial vehicle or non-commercial vehicle drivers. In terms of the societal cost, the annual comprehensive cost of crashes involving large trucks was estimated to be over $30 billion (Wang et al.,1999).

Although improving commercial vehicle safety involves preventing crashes involving both trucks and buses, information on bus crashes is limited and, relative to trucks, the safety problem is much smaller. Therefore, this paper focuses on the large truck crash problem, and a brief overview of the commercial bus, or motor coach, crash picture is included in Appendix VII-B.

This paper presents an picture of the large truck highway safety problem in four parts:

- the trends in truck crashes over the past 20 years;
- an overview of truck crashes for 1994 through 1998;
- possible future trends in truck crashes; and
- recent and future research on truck crash causation.

Unless otherwise noted, three data sources were used: the Fatality Analysis Reporting System (FARS), the General Estimates System (GES), and the Motor Carrier Management Information System (MCMIS) crash file. A brief summary description of these databases is included in Appendix VII-A.

II. LARGE TRUCK CRASH TRENDS

Large trucks are vehicles with a gross vehicle weight rating (GWVR) over 10,000 pounds. For the past twenty years large trucks accounted for approximately 4 percent of the registered vehicles and 7 percent of the vehicle miles traveled. In terms of crash involvement, trucks were:

- 8 percent of the vehicles in fatal crashes;
- 2 percent of the vehicles in injury crashes; and
- 4 percent of the vehicles in property-damage-only crashes.

Crashes involving large trucks or any motor vehicles can be analyzed in at least three ways: by the crash event, by the vehicles involved or by the people involved. In the following paragraphs, large truck involvement in traffic crashes is described using all three methods over the past 20 years, 1978 to 1998, (if data were available).

A. Fatal Crashes

The percentage of fatal crashes that involve large trucks has changed very little in the past 20 years. However, the number of trucks involved in fatal crashes, the number of fatalities in truck crashes, and the fatal crash rates for large trucks have changed dramatically.

Table 1. Large Truck Fatal Crashes, 1978-98

YEAR	VEHICLES INVOLVED	TOTAL FATALITIES	VEHICLE MILES OF TRAVEL *	VEHICLE INVOLVEMENT RATE **	FATALITY RATE **	REGISTERED VEHICLES
1978	5,759	6,356	105,739	5.4	6.0	5,859,807
1979	6,084	6,702	109,004	5.6	6.1	5,891,571
1980	5,379	5,971	108,491	5.0	5.5	5,790,653
1981	5,230	5,806	108,702	4.8	5.3	5,716,278
1982	4,646	5,229	111,423	4.2	4.7	5,590,415
1983	4,877	5,491	116,132	4.2	4.7	5,508,392
1984	5,124	5,640	121,796	4.2	4.6	5,401,075
1985	5,153	5,734	123,504	4.2	4.6	5,996,337
1986	5,097	5,579	126,675	4.0	4.4	5,720,880
1987	5,108	5,598	133,517	3.8	4.2	5,718,266
1988	5,241	5,679	137,985	3.8	4.1	6,136,884
1989	4,984	5,490	142,749	3.5	3.8	6,226,482
1990	4,776	5,272	146.242	3.3	3.6	6,195,876
1991	4,347	4,821	149,542	2.9	3.2	6,172,146
1992	4,035	4,462	153,384	2.6	2.9	6,045,205
1993	4,328	4,856	159,888	2.7	3.0	6,088,155
1994	4,644	5,144	170,216	2.7	3.0	6,587,885
1995	4,472	4,918	178,156	2.5	2.8	6,719,420
1996	4,755	5,142	182,971	2.6	2.8	7,012,615
1997	4,917	5,398	191,477	2.6	2.8	7,083,326
1998	4,935	5,374	196,053	2.5	2.7	7,244,135

Notes: A large truck is a truck with a gross vehicle weight rating of 10,001 pounds or more.
* - Millions
** - Per 100 Million large truck Vehicle Miles Traveled
Sources: Vehicle Miles Traveled and Registered Vehicles - Federal Highway Administration
Fatal Crashes, Vehicles Involved, Fatalities - Fatality Analysis Reporting System (FARS)

As illustrated in Table 1, the number of large trucks in fatal crashes and the fatalities resulting from these crashes declined in an irregular pattern in the14 years from 1978 to 1992. The decline for both was 30 percent. After 1992, both numbers increased until 1997. Fatalities decreased slightly in 1998 while truck involvement increased slightly. From 1992 to 1998, large trucks involved in fatal crashes rose 22 percent and fatalities increased by 20 percent.

The pattern for total large truck crash rates for 1978 to 1998 took a different path. After increasing slightly from 1978 to 1979, the vehicle involvement and total fatality rates declined or remained the same for every year from 1979 to 1992. Since then these rates have changed very little. The large truck vehicle involvement rate in fatal crashes dropped 52 percent from 1979 to 1992 (5.6 to 2.6 per 100 million large truck miles of travel); and the 1998 rate of 2.5 is four percent below the 1992 rate. The fatality rate also dropped 52 percent in the 1979-1992 period, and declined another seven percent to 1998 from 2.9 to 2.7.

B. Nonfatal Injury Crashes

Large trucks are involved in many more crashes that result in a nonfatal injury than a fatal injury. Estimates of nonfatal injury crashes involving large trucks are presented in Table 2 for 1988 to 1998. Data were only available for these years. The estimated number of large trucks in injury crashes and people injured in these crashes reached a high in 1989. The vehicle involvement and total injury rates for both also reached their peak in the same year. Over the eleven-year period from 1988 to1998, the estimated number of large trucks involved in injury crashes and people injured in these crashes neither increased nor decreased steadily.

Unlike fatal crashes, injury crashes show some large year-to-year changes. For example, the biggest annual decline in trucks involved in fatal crashes was the 12 percent decline from 1979 to 1980. By contrast the largest change in the number of trucks involved in injury crashes was 29 percent from 1990 to 1991. Since the injury crash estimates are derived from a sample, some of the large annual changes may be due to sampling variation. Considering the sampling variation, no conclusion can be made about the trend in trucks involved or people injured in injury crashes in 1988 to 1998.

The change in injury crash rates, however, has been significant. From the peak rates in 1989 to the low point in 1998, the drop in the vehicle involvement rate (large trucks involved in injury crashes per 100 million truck miles traveled) was 39 percent and the decrease in the injury rate (number of people injured in large truck crashes per 100 million truck miles

traveled) was 38 percent.

Table 2. Large Truck Injury Crashes, 1988-98

YEAR	VEHICLES INVOLVED	INJURED PERSONS*	VEHICLE MILES OF TRAVEL **	VEHICLE INVOLVEMENT RATE ***	INJURY RATE ***	REGISTERED VEHICLES
1988	96,000	130,000	137,985	69.5	94.4	6,136,884
1989	110,000	156,000	142,749	77.2	109.0	6,226,482
1990	107,000	150,000	146,242	73.3	102.6	6,195,876
1991	78,000	110,000	149,542	52.2	73.9	6,172,146
1992	95,000	139,000	153,384	61.8	90.4	6,045,205
1993	97,000	133,000	159,888	60.4	83.2	6,088,155
1994	96,000	133,000	170,216	56.2	78.1	6,587,885
1995	84,000	117,000	178,156	46.9	65.7	6,719,420
1996	94,000	130,000	182,971	51.2	71.1	7,012,615
1997	97,000	133,000	191,477	50.5	69.2	7,083,326
1998	89,000	127,000	196,053	45.2	64.9	7,244,135

Notes: A large truck is a truck with a gross vehicle weight rating of 10,001 pounds or more.
* "Injured Persons" counts all nonfatally injured persons in injury and fatal crashes.
** Millions
*** Per 100 Million Vehicle Miles Traveled
Sources: Vehicle Miles of large truck Travel and Registered Vehicles - Federal Highway Administration
Injury Crashes, Vehicles Involved, Injuries - General Estimates System (GES)

C. Large Truck versus Passenger Vehicle Crash Rates

Seven percent of the miles traveled in this country are traveled by large trucks. Passenger vehicles (passenger cars, pick-up trucks, vans, and sport utility vehicles) travel 92 percent of the vehicle miles traveled. Depending on the severity of the crash, the crash rates using these travel figures for trucks and passenger vehicles differ considerably.

As illustrated in Table 3, the large truck fatal crash involvement rate in 1988 was 32 percent higher than that of passenger vehicles (3.7 large trucks involved in fatal crashes per 100 million vehicle miles traveled vs. 2.8 for passenger vehicles). In 1998, the fatal crash involvement rate for large trucks was 25 percent higher (2.5 per 100 million VMT vs. 2.0 for passenger vehicles). Both rates have declined since 1988, but the decrease for large trucks was greater. A comparison of large truck and passenger vehicle fatal and injury crash involvement rates for the past ten years is presented in Appendix VII-C.

Table 3. Large Truck and Passenger Vehicle Crash Involvement Rates*, 1988 vs.1998

Crash Severity	Vehicle Type	Rate 1988	Rate 1998
Fatal	Large Trucks	3.7	2.5
	Passenger Vehicles	2.8	2.0
Injury	Large Trucks	68	45
	Passenger Vehicles	201	149

* Rates are vehicles involved in crashes per 100 million vehicle miles traveled
Sources: FARS, GES, FHWA Highway Statistics

For injury crashes, the large truck crash rate was considerably lower than the passenger vehicle crash rate for both years. In 1988, the injury crash involvement rate for large trucks was 68 compared to 201 for passenger vehicles. In 1998, the large truck injury crash involvement rate was 45 compared to 149 for passenger vehicles. The rates for both large trucks and passenger vehicles declined from 1988 to 1998, although the decrease for large trucks was greater.

III. LARGE TRUCK CRASH OVERVIEW

This section includes data on the three major elements usually considered in highway safety analyses: drivers, vehicles, and the environment. An additional element, motor carriers, is also discussed.

A. Drivers

Many of the driver factors that occur frequently in passenger vehicle crashes are not as common for drivers of large trucks in crashes. Some of the common driver factors are discussed below for 1994 through 1998:

- Alcohol: 19.7 percent of passenger vehicle drivers involved in fatal crashes had a blood alcohol content (BAC) above 0.10 grams per deciliter, the level determining legal intoxication in most States. Only 1.3 percent of large truck drivers in fatal crashes had a BAC level of 0.10 or more. Although federal regulations sanction truck drivers that drive with a BAC level of 0.02 or greater, crash data on that level of alcohol use are not available.

- Speed: 22.2 percent of passenger vehicle drivers involved in fatal crashes were speeding at the time of the crash. Only 8.8 percent of large truck drivers were speeding at the time of fatal crashes.

- Young Drivers: 27 percent of passenger vehicle drivers in fatal crashes and 21 percent in injury crashes were under the age of 26. Only 6 percent of truck drivers in fatal crashes and 8 percent in injury crashes were under 26 years old.

- Safety Belt Use: 51 percent of passenger vehicle drivers involved in fatal crashes were using their safety belts, compared to 66 percent of large truck drivers involved in fatal crashes.

Large Truck and Passenger Vehicle Driver-Related Crash Factors

Data on driver-related crash factors are coded in FARS from data recorded by police officers at the crash scene. Table 4 presents the percentage of drivers coded for the most commonly coded driver-related crash factors. Since more than one factor can be coded for a driver, the sum of the percentages of drivers with individual factors will exceed the percentage of drivers with factors at the top of the table.

As illustrated in Table 4, 38 percent of large truck drivers involved in fatal crashes from 1994 through 1998 had at least one driver-related factor coded. The most common individual factors cited were running off the road or out of the traffic lane, and driving too fast for conditions or exceeding the posted speed limit. All other factors were coded for less than five percent of the truck drivers.

By contrast, about two-thirds (65 percent) of the passenger vehicle drivers involved in fatal crashes were coded with driver-related factors. Passenger vehicle drivers were recorded with the same factors in almost the same rank order as truck drivers, but the proportions were usually higher.

Truck drivers were recorded at a higher rate than passenger vehicle drivers for two of the twelve most common factors. Following improperly was coded for 1.8 percent of truck drivers compared to 0.8 percent of passenger vehicle drivers. Truck drivers were also cited more often for vision obscured by rain, snow, fog, smoke, sand, or dust.

Related factors do not necessarily indicate who is at fault in a crash or what is the cause of the crash. Related factors are based on the judgment of the officer at the scene and are usually not based on a thorough investigation of the cause of the crash.

Table 4. Large Truck and Passenger Vehicle Driver-Related Factors in Fatal Crashes, 1994-1998

Driver-Related Factors	Large Truck Drivers	Passenger Vehicle Drivers
Driver Factor(s) Recorded?		
Yes	37.5%	65.2%
No	62.5%	34.8%
Total Drivers	**28,478**	**241,757**
Most Common Factors		
Ran Off Road or Out of Traffic Lane	10.9%	30.0%
Driving Too Fast	8.1%	20.8%
Failure to Yield Right of Way	4.9%	9.7%
Inattentive	4.4%	6.7%
Failure to Obey Traffic Signs, Officers	3.0%	5.9%
Erratic/Reckless Driving	2.8%	5.4%
Drowsy, Sleepy, Fatigued	1.8%	2.7%
Following Improperly	1.8%	0.8%
Vision Obscured by Weather Conditions	1.3%	0.7%
Making Improper Turn	1.2%	2.5%
Swerving due to Ice, Snow, Water on Road	1.0%	2.0%
Over Correcting	0.7%	3.0%

Source: FARS, 1994-98

University of Michigan Driver-Related Factors and Crash Configuration

A recent study by the University of Michigan Transportation Research Institute (UMTRI) investigated driver-related crash factors in light of other data available on large truck fatal crashes (Blower, June 1998). The study found evidence that support the accuracy of crash-related factors in fatal crashes involving a large truck and a passenger vehicle.

In one-half of the fatal crashes involving one large truck and one passenger vehicle, physical evidence about each vehicle's maneuver and position prior to the crash was available to help verify the coding of the driver-related factors. In these cases, the driver-related factors appeared to be consistent with the physical evidence. The drivers of vehicles that encroached into the other vehicle's lane in head-on and sideswipe crashes, and drivers of vehicles that struck the other vehicle in rear-end crashes, were assessed driver-related factors or errors more often than the other driver. In the majority of these cases, the passenger vehicle driver was attributed with driver-related factors more often than the driver of the large truck.

For example, 23 percent of the fatal crashes between one large truck and one passenger vehicle were head-on crashes. In 89 percent of these crashes, the passenger vehicle crossed into the large truck's lane of traffic. Passenger vehicle drivers were assessed with driver-related factors in 98 percent of these crashes, and the truck drivers were assessed with factors in 10 percent of these crashes. In those cases where the truck encroached into the lane of travel of the passenger vehicle, the truck driver was coded with driver-related factors in 93 percent of the crashes and the passenger vehicle driver in 9 percent of the crashes.

B. Trucks

Large trucks in FARS, GES and MCMIS are placed into three categories: single-unit or straight trucks (SUT), combination-unit trucks (CUT) or unknown large trucks. Table 5 shows the trucks involved in fatal and nonfatal crashes for all three data sources by truck category. The most important differences between CUTs and SUTs in crashes are:

- Tractors pulling semi-trailers accounted for 62 percent of the trucks involved in fatal crashes in the five years from 1994 through 1998. These tractor semi-trailers accounted for 52 percent of the trucks involved in nonfatal crashes in MCMIS and 48 percent in GES. Both these nonfatal numbers probably would have been higher, if the unknown and missing data could be eliminated.

- The ratio of CUTs to SUTs in fatal crashes is more than 3 to 1. SUTs accounted for

only 20 percent of the trucks involved in fatal crashes, 21 percent of the trucks involved in nonfatal crashes in MCMIS, and 13 percent in GES.

- The differences between CUTs and SUTs are more apparent when examined on a per vehicle basis. Annually, 203 CUTs were involved in fatal crashes per 100,000 registered CUTs, compared to 23 SUTs involved in fatal crashes per 100,000 SUTs, a ratio of nine to one. For injury crashes the rates were 4,230 for CUTs compared to 1,046 SUTs per 100,000 registered vehicles, a ratio of four to one.

- For every 100 million miles traveled by a CUT, an average of 2.8 CUTs were involved in fatal crashes in 1994 to 1998, compared to1.8 SUTs involved in fatal crashes per 100 million miles traveled. On the other hand, 44 CUTs were involved in injury crashes per 100 million miles traveled, compared to 56 SUTs per 100 million miles traveled.

- For the five-year period from 1989 through 1993, the average annual per registered vehicle economic crash cost for CUTs was $13,520, while the cost for SUTs was $2,720, a ratio of five to one (Wang, et al., 1999).

Three other issues concerning the type and cargo of trucks involved in crashes are summarized below:

- Less than five percent of the trucks involved in fatal crashes in 1994 to 1998 were carrying hazardous materials. Less than half of one percent of the fatalities in large truck crashes for these five years were a result of exposure to the hazardous materials in crashes involving interstate motor carriers (RSPA, 2000).

- Eight percent of the trucks involved in fatal crashes had a GWVR between 10,000 and 26,000 pounds. Close to 80 percent had a GWVR over 26,000 pounds. Most, but not all, of the vehicles with a GWVR over 26,000 pounds were combination unit trucks. The remaining trucks had no GVWR listed or were under 10,000 pounds.

- Van cargo bodies (i.e., enclosed boxes that are part of the chassis) accounted for 42 percent of the large trucks involved in fatal crashes and 35 percent involved in nonfatal crashes. Flatbed trucks and dump trucks each accounted for about 10 percent of cargo bodies in fatal and nonfatal crashes. All other individual types accounted for less than 10 percent each.

Table 5. Large Trucks in Crashes by Vehicle Configuration, 1994-1998

Vehicle Configuration	Fatal: FARS	Nonfatal	
		MCMIS	GES
Single Unit Trucks (SUTs)	**19.6%**	**21.4%**	**13.2%**
Single Unit Truck, 2-axle	10.3%	12.3%	13.2%
Single Unit Truck, 3+axle	9.3%	9.1%	
Combination Unit Trucks (CUTs)	**72.1%**	**67.3%**	**52.5%**
Truck/Trailer(s)	3.8%	9.6%	1.4%
Truck Tractor (bobtail)	2.4%	2.9%	2.2%
Tractor/semi-trailer	62.4%	51.8%	47.5%
Tractor/double	3.3%	2.9%	1.4%
Tractor/triple	0.2%	0.1%	0.0%
Unknown	8.3%	5.3%	29.5%
Missing	--	6.1%	--
Total	**28,478**	**444,566**	**2,063,000**

Sources: FARS, MCMIS Crash File, and GES; 1994-1998

Vehicle-Related Crash Factors

In a procedure similar to that for driver factors, FARS analysts code vehicle-related factors based on police crash reports. For the years 1994 through 1998 vehicle-related factors were coded for 8.6 percent of the large trucks and 8.0 percent of the passenger vehicles involved in fatal crashes. These percentages are much smaller than the percentage of drivers coded with driver-related factors. As noted earlier, a higher proportion of passenger vehicle drivers than large truck drivers were coded with driver-related factors in fatal crashes. The opposite is true for vehicle-related factors; however, the difference is not as dramatic.

Brakes and tires were the biggest vehicle problems coded. 2.6 percent of the trucks while only 0.4 of the passenger vehicles involved in fatal crashes were recorded as having a brake-

related factor. One percent of the trucks and 1.1 percent of passenger vehicle were coded as having a tire-related factor. As noted in the discussion on driver factors, related factor does not necessarily mean fault or crash cause.

C. Crash Environment

The key crash environment variables are described in this section.

Roadway Class

Forty percent of large truck miles and 49 percent of CUT miles were driven on interstates from 1994 to 1998 (FHWA, 1998). By contrast only 24 percent of the fatal crashes involving large trucks and 26 percent of fatal crashes involving CUTs occurred on interstates.

More than one-third (37 percent) of fatal truck crashes occurred on principal arterial highways. Some of these highways are high-quality divided highways, but many others, particularly in rural areas are not divided, do not have controlled access and have signalized intersections. These conditions make them more dangerous than interstates.

Roadway Type

Almost three-fifths (59 percent) of large truck fatal crashes, but less that two-fifths of nonfatal crashes (37 percent) took place on undivided highways. Another 30 percent of fatal truck crashes and 23 percent of nonfatal crashes took place on divided highways with no median. The large percentage of fatal crashes on these roadway types may be the result of the increased occurrence of head-on crashes on these roadways.

Location

Almost two-thirds (65 percent) of large truck fatal crashes took place in rural areas. No data are available for nonfatal truck crashes by location.

States

States with the largest populations had the highest number fatal truck crashes. From 1994 through 1998 the ten states with the largest number of people accounted for between 44 to 47 percent of fatal truck crashes each year. These data are presented in Appendix IV-F. With the exception of Michigan and New Jersey, each of the top ten states in population ranked in the top ten in fatal truck crashes in each of these years. Michigan ranked in the top ten in

three of the seven years, and New Jersey never ranked in the top ten.

Weather, Time of Day, and Day of Week

Most fatal and nonfatal truck crashes occur in favorable weather conditions, on dry pavement, during the day, and on weekdays, as illustrated by the following crash data:

- 84 percent took place without any adverse weather conditions;
- 79 percent took place on dry pavement;
- 64 percent took place during the day; and
- 85 percent took place during the work week.

Crash Events

First harmful and most harmful crash events are coded in FARS and GES. MCMIS records the first and up to three subsequent events that happened to the truck involved in the crash. For almost four-fifths (78 percent) of large trucks involved in fatal crashes and almost three-fourths (72 percent) of large trucks involved in nonfatal crashes, the first harmful event was a collision between the truck and another vehicle. Collisions with a fixed object was the next most common first event for both fatal and nonfatal truck crashes. The third most common first harmful event in fatal crashes was collision with a pedestrian (6 percent), and in nonfatal crashes was a collision with a parked motor vehicle (8.9 percent). Truck overturns (i.e., rollovers) were the first harmful events in 4.0 percent of fatal crashes and 2.3 percent of nonfatal crashes.

Initial Point of Impact

The initial point of impact for trucks can vary depending on the severity of the crash. For 62 percent of the trucks involved in fatal crashes, the front of the truck was the initial point of impact. By contrast, for only 30 percent of trucks involved in nonfatal crashes, the front was the initial point of impact. For 15 percent of the trucks involved in fatal crashes, the side of the truck was the initial point of impact. However, the side was the initial point of impact for 47 percent of the trucks in nonfatal crashes. The initial point of impact was the rear of the truck for 15 percent of trucks involved in both fatal and nonfatal crashes.

Manner of Collision

Angle crashes, often where one vehicle hits another going through an intersection, constitute about one-third of both fatal and nonfatal large truck crashes. These crashes may result in

serious injury or minor property damage, depending on the speed of the vehicles and whether the truck is the striking vehicle. By contrast almost one fourth (24 percent) of fatal truck crashes were head-on crashes, while only one percent of nonfatal crashes were head-ons.

D. Motor Carriers

In addition to analyzing of crashes by drivers, vehicles, and crash environment, FMCSA programs assume that motor carriers are an important variable in the crash equation. FMCSA expends considerable resources each year examining the safety performance of individual carriers.

SafeStat

The Motor Carrier Safety Status Measurement System, called *SafeStat*, helps identify motor carriers for potential compliance reviews, as well as trucks and buses and their drivers as candidates for potential roadside safety inspections. FMCSA defines *SafeStat* as a system to provide a rating for motor carriers that will indicate whether a carrier is potentially an unsafe truck or bus operator. The measurement factors and their multiplicative factors are: crashes (2), driver (1.5), vehicle (1) and safety management (1). A more detailed description of the *SafeStat* factors is provided in Appendix VII-F.

SafeStat scores are computed twice a year and used by FMCSA to develop a list of high risk carriers. FMCSA field staff then conduct safety compliance reviews on motor carriers that have the highest scores. Scores are also made available to state agencies that receive FMCSA funding for the conduct of truck and bus roadside inspections. The scores give roadside inspectors the ability to focus inspection efforts on the trucks and buses operated by potentially unsafe motor carriers.

The calculation of *SafeStat* scores is clouded by two factors. FMCSA does not have complete data on all crashes involving interstate motor carriers. Despite progress over the past five years, FMCSA does not receive crash reports on about one-third of the crashes that should be reported by the states for interstate carriers. This lack of complete crash data hampers the calculation of the crash factor in SafeStat. Second, the number of compliance reviews completed each year is less than 10,000. Since this number represents such a small percent of the over 500,000 carriers on the MCMIS Census of carriers, the safety management factor is not calculated on a large majority of carriers.

Industry Segments

Using individual motor carriers as the basic unit of analysis, a recent study examined 10

different segments of the motor carrier industry, and also discriminated between for-hire and private carriers (Corsi et al., 2000). For each of the 20 carrier type segments, the average crash rates were calculated based on safety compliance reviews.

Based on 16 compliance reviews, private moving/household goods carriers had an average crash rate of 0.18 crashes per million vehicle miles traveled (VMT), while 59 private produce carriers subjected to reviews had an average crash rate of 2.89 crashes per million VMT. This rate is 16 times higher than private moving/household goods carriers. In general, five of the 20 groups reviewed by Corsi had crash rates of less than one crash per million VMT, while

four had rates over two crashes per million VMT. The difference between for-hire and private carriers within industry segments was often large.

This study is limited by the same two factors: the lack of complete data on crashes by all motor carriers, and the small the number of motor carrier safety compliance reviews completed each year.

IV. FUTURE TRENDS IN LARGE TRUCK CRASHES

Many variables have an impact on the number and severity of commercial motor vehicle crashes. Key to understanding the number and severity of truck crashes is understanding a truck's exposure to potential crash situations. Truck exposure is impacted by many variables such as the level of economic activity, the availability and relative cost of transporting goods by truck versus train, plane and pipeline, and the changes in the capacity of the highway system compared to the other transportation systems. These variables are then influenced by factors including the price of fuel, the additional cost for trucks to meet more stringent clean air standards and levels of funding to maintain roadways and expand highway capacity. Since most large truck crashes involve a collision with a passenger vehicle, all the factors that influence the presence of other vehicles on roadways play a role in truck crash exposure. The strength of the economy, extent of mass transit use, tolerance for highway congestion, the price of gasoline and the cost of air travel are all factors that impact the amount of passenger vehicle travel.

With so many variables to consider, the task of predicting the future trends in exposure of trucks to danger on the highways is difficult. However, truck travel has increased fairly steadily over the past 20 years. The only time combination truck travel (the greatest share of truck miles) did not increase was between 1978 to 1979. From 1979 to 1980, total truck

miles traveled dropped slightly, and did not exceed the 1979 total again until 1982. During this period the U.S. experienced a gasoline shortage, deregulation of the interstate trucking industry, and the beginning of an economic recession. It is unlikely that there will be any combination of factors in the next decade more dramatic than the events of this period that will reverse the trend in annual increases.

Large truck crash rates that are based on vehicle miles of travel data have changed dramatically over the past 20 years. The 52 percent drop from 1979 to 1992 in the fatal crash involvement was presented in Table 1. In the last six years, however, the decline slowed to about one percent a year. Many factors undoubtedly played a role in the steep drop in rates before 1992, and the subsequent slower decline since then. There is no definitive research to explain these changes.

Given that combination truck traffic has always increased, it seems safe to assume that these increases will continue. Thus, for FMCSA to meet the goal of reducing fatalities in large truck crashes by 50 percent in ten years, the rate of fatalities in large truck crashes must drop by much more than 50 percent.

V. CURRENT AND FUTURE RESEARCH EFFORTS

Current and future FMCSA research efforts focus mainly on large truck crash causation. Two other major areas of research involve the collection of better data on the number of truck crashes and truck exposure.

A. Crash Causation

The law establishing FMCSA provided a mandate and funding to address truck crash causation. Before discussing a study now underway, it is helpful to review recent efforts by FMCSA and other researchers to directly address causation.

FACT Crash Causation Data

In 1996, the Michigan State Police began collecting crash data in a program called the Fatal Accident Complaint Team (FACT). The FACT program collects data on vehicle and driver contribution to crashes. The data are collected by state police officers using a special crash reporting form. They are not trained crash investigators or reconstructionists. By April 2000, data on 332 large truck fatal crashes had been collected.

The results of this analysis are consistent with patterns observed in FARS national data.

Fifty-eight percent of the crashes involve a truck tractor pulling a single semi-trailer, most take place during the day, and 87 percent of the crashes take place during the work week. In the 332 crashes, the actions of the other vehicle involved, including speed and loss of control, were the critical events that caused the crash in 59 percent of the cases. In another 28 percent, the action of the truck driver -- including speed, loss of control, and failure to adjust to road conditions -- was the critical event. Pedestrians and bicyclists caused seven percent of the crashes. Altogether, human factors caused about 94 percent of the crashes. Truck vehicle failure was blamed as the crash cause in only 0.9 percent of the crashes. Factors relating to a previous collision accounted for the remainder of the cases.

Quebec Crash Causation Study

A two year study of truck crashes was recently conducted in the Province of Quebec, Canada by the Road Safety Team from the Ecole Polytechnique de Montreal (Gou et al., 1988) The team of accident reconstruction engineers investigated 195 randomly selected commercial vehicle crashes between May 1995 and June 1997. The causal and contributory factors for each collision were identified and analyzed.

Human direct and indirect factors on the part of the truck drivers and the other drivers were the first cause in about 74 percent of the crashes. Driver recognition and decision errors were most often to blame for the crash. Inattention, improper lookout, excessive speed, and improper maneuver were the major factors found. Other driver factors included distractions inside and outside the vehicle, misjudgements, tailgating, and inadequate directional control or overcorrecting. In nine of the cases, the truck driver was found to be falling asleep, and, in five cases, the passenger vehicle driver was attempting suicide, as confirmed by notes left before the attempt.

Truck mechanical defects were found to be a definite cause of the crash in only 18 cases (9.2 percent) and a contributing factors in 12 (6.1 percent) of the crashes. Truck mechanical conditions were cited in only 4.8 percent of the cases in the police reports of the crashes. This difference may be due to the fact that police officers may not have the expertise to recognize mechanical problems with large trucks. Air brake system failures and improper brake chamber push-rod adjustments were the two leading mechanical problems. Cargo load securement played a role in two percent of the crashes.

FMCSA's Large Truck Crash Causation Study

FMCSA, cooperatively with the National Highway Traffic Safety Administration (NHTSA), has embarked on the first national study of the causes of crashes involving large trucks that

result in a fatality or serious injury. The study will yield data beyond the percentage of crashes that can be attributed to drivers, vehicles, the environment, and the operations of motor carriers. The goal is to collect detailed information on the specific mistakes that drivers make which contribute to crashes, and to determine whether the failure of specific vehicle systems were critical elements in causing the crash.

Nationally representative data on the primary and secondary causes of serious large truck crashes will be collected by teams of trained researchers from NHTSA's National Automotive Sampling System (NASS) and FMCSA-funded truck inspectors. Data collection of the truck's interior and exterior damage, the other vehicle's damage, the injuries of all involved in the crash, the scene investigation and interviews will be the responsibility of the NASS researchers. State inspectors will assist NASS researchers by completing a Level 1 post-crash inspection of the truck and truck driver. FMCSA has contracted with other nationally-recognized truck crash experts to assist with the project. Data for the study will be collected in 24 sites around the country. A pilot test of the study began in June 2000 in four sites: Chicago, Philadelphia, Prince Georges and Charles counties in Maryland, and La Paz and Yuma counties in Arizona. The full study in all 24 sites will begin in 2001. An advisory committee put together by the Transportation Research Board will begin oversight of the study.

Other FMCSA Crash Causation Projects

In addition to the above large truck crash causation study, the FMCSA has several other studies underway or planned to shed light on crash causes and risk factors. These include:

Real-Time Incident Capturing and Analysis Program. This study uses an instrumented vehicle to analyze and classify car-truck proximity-related driver errors for both the large truck and passenger vehicle driver. Planned work will pilot test and implement an instrumented-vehicle observational and incident capturing program employing a full classification taxonomy of driver errors, similar to taxonomies used in crash investigations.

CMV Near-Miss and Other Safety Observational Data Collection. FMCSA plans to work collaboratively with the Bureau of Transportation Statistics to perform a feasibility and design study of a CMV near-miss and other safety observational data collection, perhaps based in one or more large fleets. This program would be modeled after approaches employed in airline and maritime safety to gather data on unsafe incidents and situations not resulting in accidents but with the potential to cause such accidents.

Fleet-Based Case Control Crash Risk Study. FMCSA is considering the feasibility of

performing a large fleet-based study that would compare crash-involved with non-crash-involved drivers and vehicles. This study would determine the relative crash risk associated with driver characteristics (e.g., age, years of experience, training, violations, crash history, physical/medical qualifications, measurements of driving performance), vehicle factors (e.g., vehicle age, design features), and highway/environmental factors (e.g., type of roadway, weather).

Simulator Study of Safe Commercial Vehicle (CMV) Driving Parameters. As the National Advanced Driving Simulator becomes operational, FMCSA will plan, design, and implement basic studies of the safety-related parameters of CMV driving, including the development of standard performance assessment scenarios for CMV drivers, means to identify and classify driver errors, and parallel real-world driving measures. The primary objectives will be to identify the most important CMV driver errors and to develop measures of driving quality and safety.

B. Truck Crash Data Improvement

As noted above, the MCMIS Crash File is intended to be a census of all large truck and bus crashes that result in a fatality, injury, or towaway. However, not all States send FMCSA reports on all trucks and buses involved in crashes that meet the reportable crash criteria. In addition, many of the reports received are incomplete or contain incorrect data. FMCSA and NHTSA have embarked on a cooperative effort to improve crash reporting. The effort will build on NHTSA's successful experience of collection fatal crash data from the States. The effort will involve FMCSA representatives, State agencies that receive truck and bus safety funds from FMCSA, police agencies that collect crash data, and other State and local agencies involved in traffic records collection.

C. Truck Exposure Data

Data for truck vehicle miles of travel (VMT) is currently obtained from two primary sources: the Vehicle Inventory and Use Survey (VIUS) of the Department of Commerce, and the FHWA *Highway Statistics* report. The *Highway Statistics* report is based largely on state-level roadside counts, while VIUS is based on a national sample of registered trucks.

The estimates of VMT in *Highway Statistics* are based on a national sample of roads chosen by the states. States count traffic at sites with automatic vehicle identification or other technology. Sample sites may be recorded either year round, quarterly, or for shorter periods. State level figures are sent to FHWA, which adjusts the figures for annual and between state consistency. The figures are then revised based on VIUS data. Every five

years, VIUS surveys a representative sample of trucks nationwide. Truck owners are asked detailed questions about the use, physical characteristics, and body type of the sampled vehicle. Information collected includes annual mileage, mileage distribution by trip distance, total vehicle mileage, commodities hauled, and hazardous materials transported.

Highway Statistics reports consistently higher VMT than VIUS, on the order of 20 percent in the two most recent years for VIUS, which were 1997 and 1992. However, both sources indicate that large truck travel increased by 3 to 4 percent a year through most of the past decade. Both sources have limitations which hinder their usefulness for crash analysis. VIUS does not provide state-level travel data and, because of unreliability of the figures, FHWA recently decided to discontinue estimating state-level VMT for trucks. Neither source defines trucks in the same manner as FMCSA (over 10,000 pounds GVWR).

Neither data set is likely to be improved dramatically by quick fixes. FMCSA has discussed increasing the sample size of VIUS in order to increase its overall reliability, but this would not remedy the shortcomings mentioned above. Another improvement being considered is obtaining the US DOT number in VIUS, which would allow the agency to merge truck and carrier level information and improve VMT estimates.

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APPENDIX VII - A. Major Data Sources.

Fatality Analysis Reporting System (FARS) – Maintained by NHTSA, the FARS is a census of crashes involving any motor vehicle traveling on a public trafficway, *but only fatal crashes*. The FARS is recognized as the most reliable national crash database. According to FARS, there were 4,935 large trucks involved in fatal crashes in 1998. A large truck is defined in the FARS as a truck with a gross vehicle weight rating (GVWR) of more than 10,000 pounds.

General Estimates System (GES) – Also maintained by NHTSA, the GES is a probability-based, nationally-representative sample of all police-reported fatal, injury, and property-damage-only crashes. The data presented from the GES file are national estimates, calculated using an appropriate weighting variable and are subject to sampling error . The GES data cannot be used for state estimates, since the crash cases drawn are aimed only at obtaining a valid national sample. According to GES, there were an estimated 412,000 large trucks involved in crashes reported to police in 1998. The GES definition of a large truck is the same as FARS.

Motor Carrier Management Information System (MCMIS) Crash File -- Maintained by FMCSA, the MCMIS Crash File includes the National Governors' Association (NGA) recommended data elements collected on trucks and buses involved in crashes that meet the recommended threshold. An NGA reportable crash must involve a truck or a bus, and must result in at least one fatality; one injury where the person injured is taken to a medical facility for immediate medical attention; or one vehicle having been towed from the scene as a result of disabling crash damage. The crashes are reported by States to FMCSA through the *SAFETYNET* computer software. The Crash File is intended to be a census of trucks and buses involved in fatal, injury, and towaway crashes, but some States do not report all NGA-eligible crashes. The MCMIS Crash File is the only large file that collects data on the motor carriers which operate the trucks involved in crashes.

APPENDIX VII-B. Bus Crashes

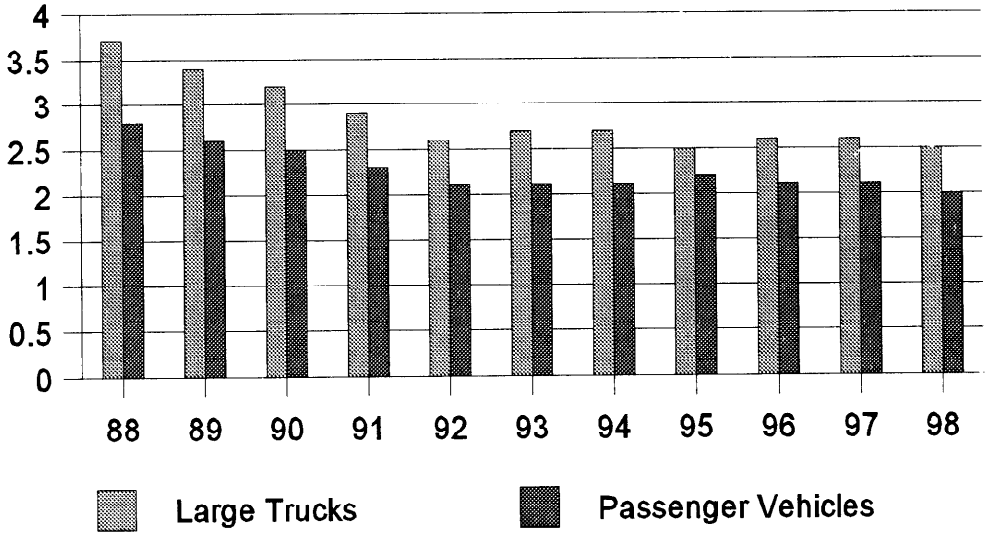
Buses are a relatively small highway safety problem compared to large trucks. In the five years from 1994 through 1998 there were 28,478 large trucks and 1,423 buses involved in fatal crashes. Buses represented only 4.8 percent of the total large trucks and buses involved in fatal crashes.

School buses (554) and transit buses (527) accounted for 76 percent of the bus total in these years. FMCSA does not regulate the transport of school children in school buses or the transport of people by transit buses. Inter-city buses that FMCSA does regulate accounted for only 150 buses involved in fatal crashes during the five year period. This number represents only 11 percent of the buses involved in fatal crashes, and only one-half of one percent of the total large trucks and buses involved in fatal crashes.

FMCSA plans to conduct research into the causes of inter-city bus crashes in the future.

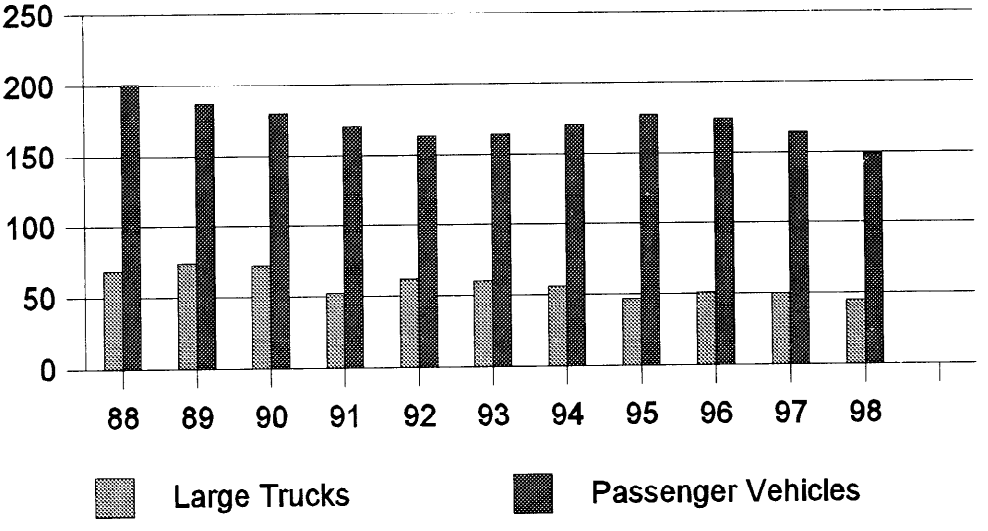
APPENDIX VII-C. Crash Involvement Rates For Large Trucks And Passenger Vehicles

Fatal Crash Involvement Rates for Large Trucks and Passenger Vehicles
(Fatal Crashes per 100 Million VMT)



Injury

Crash Involvement Rates for Large Trucks and Passenger Vehicles
(Injury Crashes per 100 million VMT)



APPENDIX VII-D. List of Driver-Related Crash Factors (as defined in the FARS manual)

- Ran Off Road/Lane -- Failure to keep in proper lane or running off road.
- Driving Too Fast -- Driving too fast for conditions, or in excess of posted maximum speed limit.
- Failure to Yield Right of Way -- Failure to yield to pedestrian, other vehicles, streetcar already in intersection.
- Inattentive -- Driver distracted by cigarette, children, adjusting radio and other devices, reading, talking, television, etc.
- Failure to Obey Traffic Devices -- Failure to obey actual traffic sign, traffic control device, or traffic officer; failure to obey safety zone traffic laws.
- Erratic/Reckless Driving -- Operating a vehicle in an erratic, reckless, careless or negligent manner; operating at erratic or suddenly changing speeds.
- Drowsy/Asleep -- Drowsy, sleepy, asleep, fatigued not due to other factors, such as drugs.
- Following Improperly -- Following too closely; vehicles in caravan too close to allow entry.
- Vision Obscured by Weather -- Vision obscured by rain, snow, fog, smoke, sand, dust.
- Making Improper Turn -- Too wide a right or left turn; unsafe U-turn.
- Ice, Water, Snow on Road -- Swerving to avoid ice, snow, slush, water, sand, dirt, oil, wet leaves on road.
- Over Correcting -- Based on police officer judgment, with knowledge of driver's intention.

APPENDIX VII-E. Trucks Involved in Fatal Crashes by State, 1994-1998.

Fatal Crashes Involving Large Trucks by State, 1994-1998

States by 1996 Population Rank	Fatal Crashes Involving Large Trucks				
	1994	1995	1996	1997	1998
1 - California	319	342	340	338	319
2 - Texas	314	316	391	384	398
3 - New York	190	142	140	141	132
4 - Florida	268	260	260	265	301
5 - Pennsylvania	190	170	169	181	162
6 - Illinois	155	153	134	155	164
7 - Ohio	180	187	181	185	175
8 - Michigan	161	148	138	124	139
9 - New Jersey	70	91	79	79	60
10 - Georgia	182	171	192	208	187
Total	2,029	1,990	2,024	2,060	2,037
Percent of US total	46.4%	47.4%	45.9%	44.6%	44.7%

Source: 1994-1998 FARS

APPENDIX VII-F. Description of *SafeStat* Factors

(For more information visit the internet at ai.volpe.dot.gov.)

Crashes: the motor carrier's crashes divided by the carrier's power units.

- Crashes are from the MCMIS Crash File, as reported by State and local police officers.
- Power units are from the MCMIS Census File information on carrier.
- Fatal crashes are weighted more than nonfatal crashes.
- Recent crashes are weighted more than older crashes.
- Counted twice.

Driver: the motor carrier's drivers placed out-of-service (OOS) divided by the number of that carrier's driver inspections.

- Data are taken from roadside driver inspections and reviews of driver records during safety compliance reviews at the carrier's principle place of business.
- Recent OOS orders are weighted more heavily than older OOS orders.
- Counted 1.5 times.

Vehicle: the motor carrier's vehicles placed OOS divided by that carrier's vehicle inspections.

- Data are taken from roadside vehicle inspections and inspections of vehicles during safety compliance reviews at the carrier's place of business.
- Recently placed OOS vehicles weighted more heavily than older OOS vehicles.
- Counted once.

Safety Management: the sum of all a carrier's closed enforcement cases times the severity weight for the closed enforcement cases. Enforcement cases are those initiated as a result of a safety compliance review conducted on a carrier.

- Counted once.