Chapter 4

Motor Carrier Accident Analysis

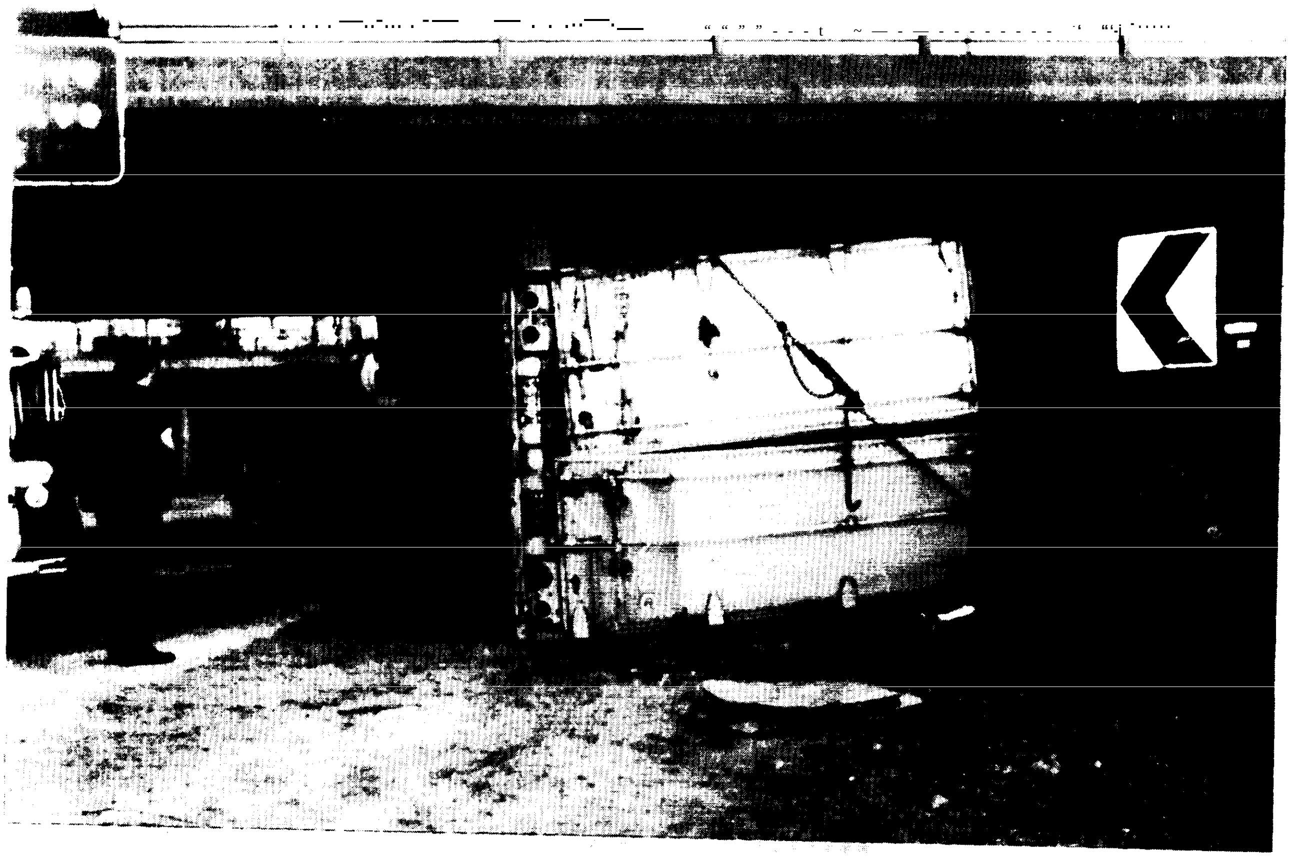

Photo credit: Ohio State Police

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Motor Carrier Accident Analysis

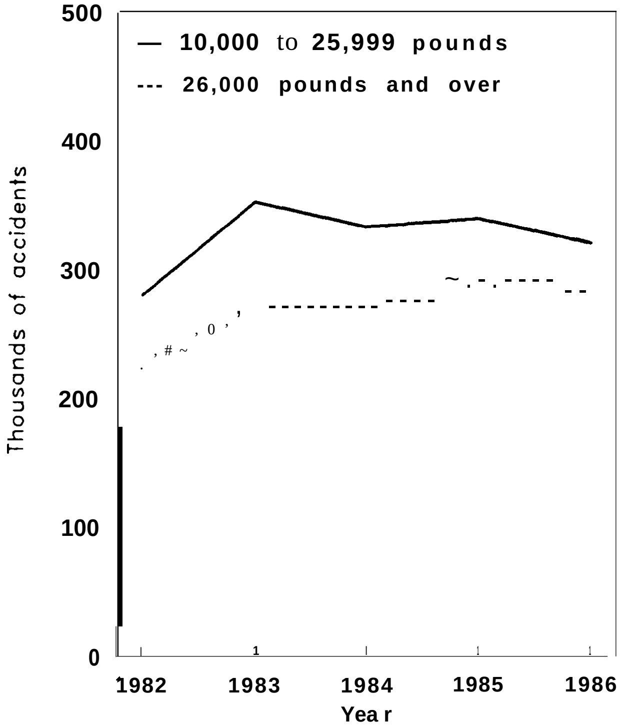
Accidents for heavy trucks (those with a gross vehicle weight rating of over 26,000 pounds) have increased over the last few years, reaching an estimated total of 278,322 accidents nationwide in 1986. (See figure 4-1.) Accidents for all trucks over 10,000 pounds increased at a slightly lower rate. Bus accidents are such a relatively small part of total accidents that accurate comparisons are difficult. Total truck-miles traveled also have risen during the 1980s, but somewhat less than the rise in heavy truck accidents.[1]

Of all heavy vehicles, tractor-trailer combinations provide the most difficult driving challenges, and the severity of the accidents in which they are involved reflects their special nature. Roughly 1 to 2 percent of these accidents result in a fatality[2]—about double the percentage for automobiles (see figure 4-2). The comparable figure for all other types of motor vehicles (except motorcycles) is well under 1 percent. In the past decade, the average annual death toll from tractor-trailer accidents has ranged between 4,000 and 5,000 fatalities (see figure 4-3), increasing slightly since 1982. About 80 percent of the fatalities in these accidents were pedestrians or occupants of other vehicles, a proportion that has increased gradually over time (see figure 4-2). When single-vehicle truck accidents are eliminated, this proportion is even greater (see table 4-1). Head-on collisions are particularly severe. They

[1] OTA estimates from the National Accident Sampling System database; also National Highway Traffic Safety Administration calculations. California officials reported a similar rise over this period. See California Highway Patrol and State of California Public Utilities Commission, *Joint Legislative Report on Truck Safety*, AB-2678, Final Report (San Francisco, CA: November 1987), p. 19.

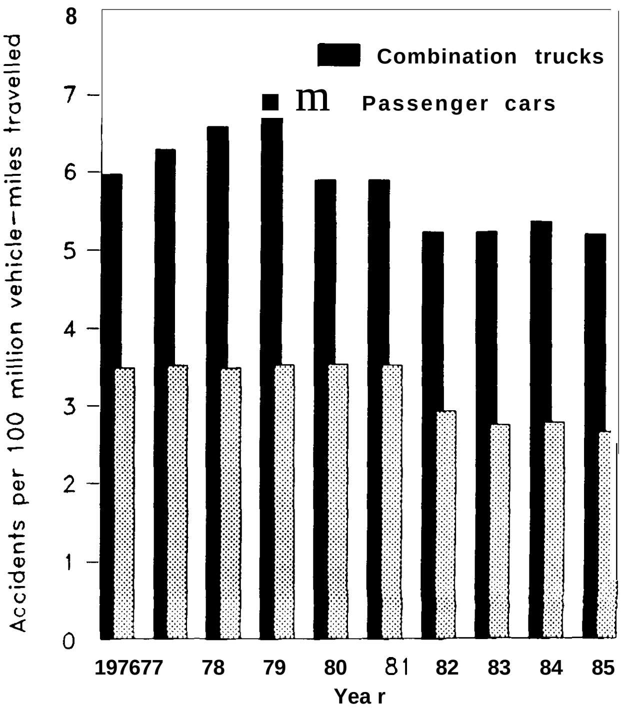
[2] Based on the National Accident Sampling System (1981-85) estimates. Multiple-vehicle accidents comprise 66 percent of all heavy truck accidents and 72 percent of all heavy truck accidents involving a fatality.

Figure 4-1.—Truck Accidents by Category of Truck



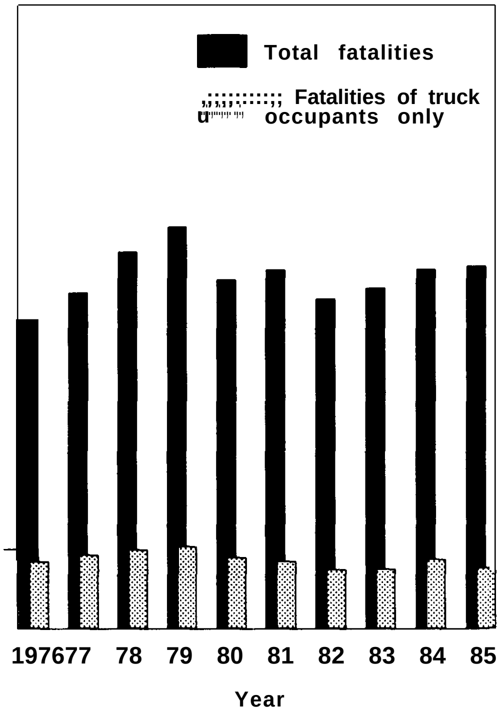
SOURCE: Office of Technology Assessment, 1988; based on National Accident Sampling System data

Figure 4-2.—Vehicles Involved in Fatal Accidents



SOURCE: Office of Technology Assessment, 1988, based on Fatal Accident Reporting System data

Figure 4-3.—Fatalities in Combination Truck Crashes



SOURCE: Office of Technology Assessment, 1988; based on Fatal Accident Reporting System data.

constitute only 3.3 percent of heavy truck accidents yet account for 29 percent of all fatal accidents involving those trucks.[3]

This chapter contains results from OTA's analysis of motor carrier accident data and a review of previous studies of three key accident causal factors: driver performance, vehicle factors, and the roadway environment. Areas needing further research are outlined, and policy options are identified that address accident causes as part of a national motor carrier safety strategy.

'Based on National Accident Sampling System (1981-85) and Federal Accident Reporting System (1983) data. For further discussion of the strengths and weaknesses of these databases, see ch. 7.

Table 4-1.—Car Occupant Deaths Compared to Truck Occupant Deaths in Fatal Crashes of Large Trucks and Cars

Year	Ratio of car occupant fatalities to truck occupant fatalities
1977	26:1
1978	28:1
1979	29:1
1980	31:1
1981	34:1
1982	28:1
1983	34:1
1964	35:1

SOURCE: Insurance Institute for Highway Safety, *Big* Trucks, 1985, p. 6.

METHODOLOGY

Thorough accident analysis requires accurately identifying the type of heavy vehicle involved, the roadway conditions, and, to the extent possible, the characteristics of the driver. However, determining all events leading to an accident is difficult because of the quality of available databases.[4] Police and insurance claim reports, the most common sources of information, are limited in detail, because the report forms ask for only certain information and investigating officers often do not adequately understand accident causation. The accident cause reported on the form is usually only the last event in a chain that includes interactions between the driver, vehicle, and highway environment as well as weather and location.

[4]One of the earliest systematic studies of the interactions in accidents examined five major factors: human, environmental, vehicular, loss-limiting, and legal and regulatory. A.D. Little, Inc., *The State of the Art of Traffic Safety* (Boston, MA: June 1966).

Exploring accident information beyond the detail in accident reports is of critical importance. When reporting accidents, police often must attribute responsibility to one of the parties, and if the accident cause is not clear, the mishap may simply be ascribed to driver error. Thus, the heavy vehicle driver may be blamed more frequently than warranted.[5] For example, in California, accident reports associate driver error with over 90 percent of truck-at-fault accidents. [6]In contrast, European data indicate multiple causes involving driver error

[5]Kenneth Perchonok, "Driver and Vehicle Characteristics as Related to the Precipitation of Accidents," U.S. Department of Transportation, National Highway Traffic Safety Administration, Report No. DOT-HS-802 355, May 1977; and P.P. Jovanis, "A Perspective on Motor Carrier Safety Issues in the 1980's," presented at the Conference on Truck Safety, Northwestern University, June 198'7.

'California Highway Patrol, op. cit., footnote 1, p. 10.

and defects in road design and the vehicle in a majority of cases.[7] OTA research indicates that while human error is the primary cause of about 65 percent of accidents, other factors also contribute to most accidents.

Combining accident and exposure data can clarify the relative importance of vehicle, driver, and environmental factors. Where appropriate, OTA used the Truck Inventory and Use Survey, the Federal Highway Administration (FHWA) monitoring program, and other survey instruments to estimate exposure. The quality and limitations of this information are discussed in chapter 7.

In those cases where exposure data are limited, OTA made inferences about the industry based solely on accident data rather than on both accident and exposure data. In each case, the sources of the information are made explicit. Improved data collection methods, such as those proposed in chapter 7, would facilitate more detailed and specific analyses.

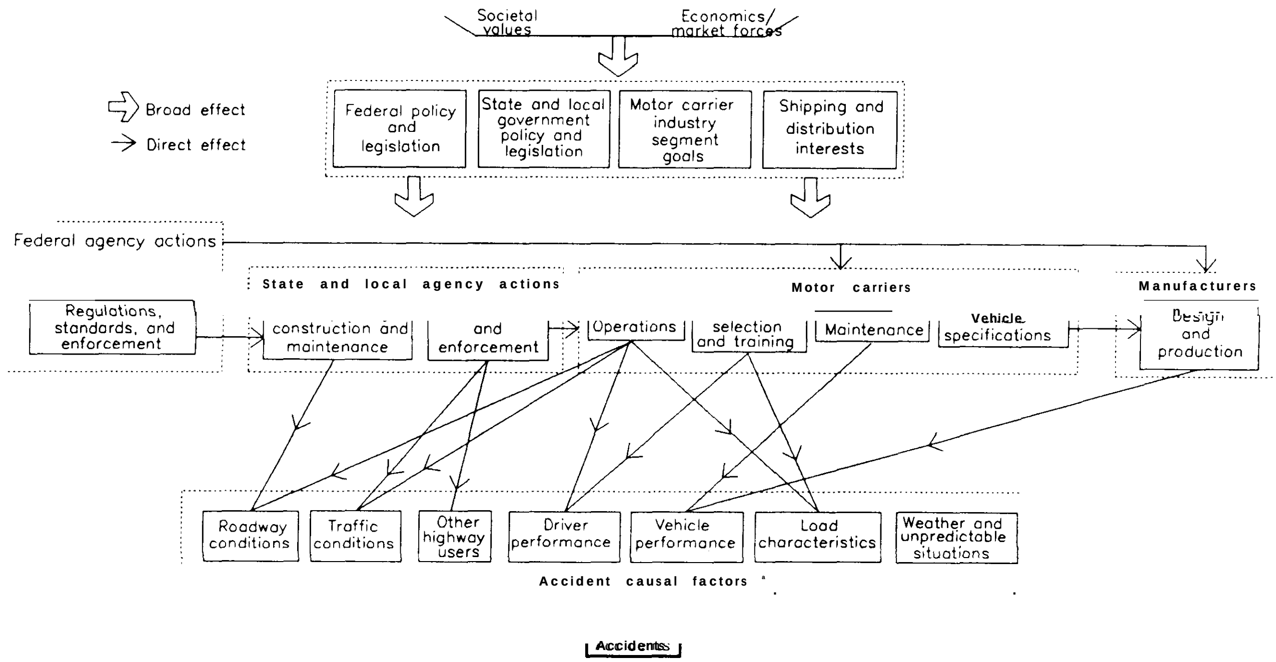
[7] J. Fructus, "Highlights on Heavy Vehicle Safety in Europe," *Symposium on the Role of Heavy Freight Vehicles in Traffic Accidents* (Ottawa, Canada: Organisation for Economic Cooperation and Development, April 1987), vol. 1, p. 1-31.

Accident Causes

Accidents usually result from a chain of events, often initiated by a single occurrence, and complicated by a number of interacting factors (see figure 4-4). The potential for an accident is partially a function of the characteristics of the driver, including experience, training, age, attitude, physical condition (fatigue, intoxication, other debilitations), and psychological state. Other factors include the condition of the vehicle, highway design, and roadway characteristics; regulatory oversight, such as licensing and traffic enforcement; and the type of management supervision exercised by the carrier.

Still other factors contribute to the disproportionate number of fatalities associated with heavy truck accidents. Because of the size and weight of these trucks relative to cars, truck occupants have more

Figure 4-4.—Motor Carrier Accident Causal and Prevention Factors



SOURCE: Office of Technology Assessment, 1988, protection in an accident than car occupants. The mismatch of size and mass between heavy trucks and cars and the special difficulties inherent in controlling a tractor-trailer on a highway designed for smaller vehicles are other major contributing factors to severe accident consequences. According to OTA's review of accident reports, the three factors most frequently associated with heavy vehicle accidents are: 1) speed too fast for conditions, 2) training of the driver, and 3) age of the vehicle.

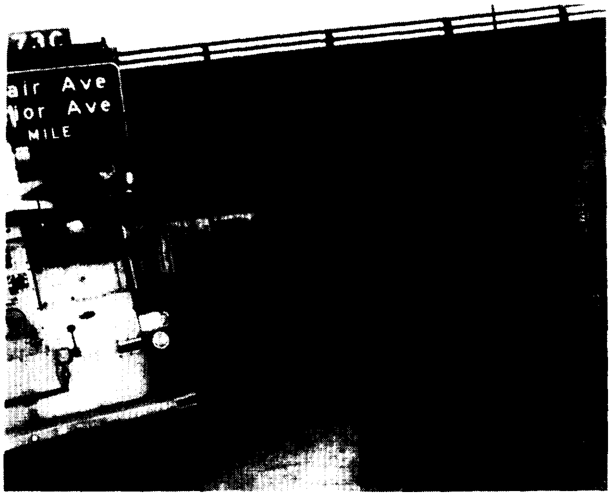
Speed Too Fast for Conditions

The phrase "speed too fast for conditions" on accident report forms masks a variety of interlocking roadway and vehicle-related factors that affect driver performance in ways the driver may not understand and probably is unable to accommodate in any case. Vehicles operating at higher speeds operate closer to the limits of friction and rollover thresholds, and drivers have very little time to carry out emergency maneuvers at high speeds. (See chapter 5 for further discussion of the driver's role in this important area.) Often a posted speed is appropriate for cars and does not adequately consider the inherent incompatibility that exists in many instances between highway design and the large trucks now common. Certain interchange ramps on major highways are examples. Variations in speed among different vehicles increase the likelihood of an accident by providing more conflict situations, such as passing maneuvers and braking.[8]

[8] D. Solomon, *Accidents on Main Rural Highways Related to Speed, Driver, and Vehicle* (Washington, DC: U.S. Department of Commerce, Bureau of Public Roads, July 1964).

Judging the speed suitable for road conditions is a complex task with a high potential for miscalculation, especially for drivers of heavy vehicles. A detailed investigation of the role of human factors in truck accidents in Finland points to failure in controlling the vehicle, in estimating the traffic situation, and in perception as the principal causes when human error is cited as the primary factor. Driver attitude and the physical or mental state of the driver emerge as key accident characteristics when human error is given as a secondary cause.[9]

[9] I.U. Stocker, "Statistical Analysis of HFV Accidents," *Symposium on the Role of Heavy Freight Vehicles in Traffic Accidents,* op. cit., footnote 7, vol. 1, p. 2-26.

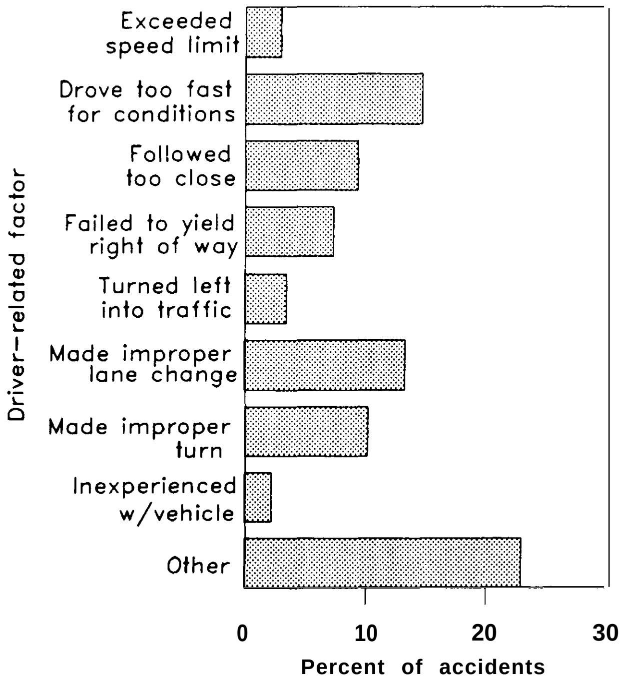


DRIVER PERFORMANCE

Speed figures prominently among driver-related factors in accidents. Where details are given on truck accident report forms (45 percent of the time in the National Accident Sampling System (NASS) from the years 1981-85), the most frequently cited include driving too fast for conditions, poor lane changes, and following too closely. (See figure 4-5.) An analysis of heavy truck at-fault collision reports in Oregon indicates that the principal causes cited are improper maneuvers, speed too fast for conditions, and driver fatigue and inattention.[10] Motor Carrier Safety Assistance Program (MCSAP) records show that several States have found excessive speed to be the most frequent human factor involved in accident causation. For example, Maryland, Massa-

[10] Oregon Public Utility Commissioner, *1984 Truck Inspections and Truck Accidents in Oregon* (Salem, OR: July 1985).

Figure 4-5.—Driver-Related Factors as Cited in Heavy Truck Accident Reports



SOURCE: Office of Technology Assessment, 1988; based on National Accident Sampling System data, 1981-85.

chusetts, Washington, and Oregon cite speeding as the most common accident causation factor.[11]

The frequencies of types of driver error for truck drivers in truck accidents in Washington State are shown in table 4-2. Areas of poor performance by the truck driver include inattention, exceeding reasonable speed, following too closely, and improper turning maneuvers.

Driver Training

Analysis of NASS data for the years 1981-85 indicates that training received by drivers of heavy vehicles involved in accidents is an important factor. Although data are limited, it appears that the majority of all heavy truck drivers have not received extensive or appropriate training.

[11]Motor Carrier Safety Assistance Program, *Annual Report* (Washington, DC: U.S. Department of Transportation, 1986).

Table 4.2.—Accident Causes Assigned in State of Washington Truck Crashes in 1984

Causal factor[a]	Number of times assigned	Percent of accidents
Driver errors:		
Inattention.	1,128	22
Failure to yield right-of-way	513	10
Exceeding reasonable speed	670	13
Alcohol	56	1
Disregard stop sign/signal	58	
Following too closely . .	277	5
Exceeding stated speed	55	1
Over center line	120	2
Improper passing	71	1
Improper turn	271	5
Apparently asleep	62	
Drugs	1	I b
Failed to signal	22	—
Disregard warning sign/signal	25	—
Improper parking location	46	—
Improper signal	10	—
No lights/failed to dim	8	—
Deficient equipment	343	7
Other violations	606	12
No violation	1,674	33
Total accidents.	5,051	

[a]The number of causal factors does not equal the number of total accidents because several causal factors are assigned in some accidents
[b]Less than 1 percent.

SOURCE: Office of Technology Assessment, 1988, based on data from the Washington Utilities and Transportation Commission, and the National Highway Traffic Safety Administration.

In an investigation of 35 accidents involving double trailers, the National Transportation Safety Board (NTSB) reported that the most common training given to drivers consisted of instructions on how to connect the combination units. No driver in the sample had received appropriate, specialized instruction on handling characteristics unique to twin-trailer operations.[12] OTA research indicates that training provided through schools and carriers varies tremendously in quality and duration. Some carriers prefer to hire drivers with over-the-road ex-

[12]National Transportation Safety Board, unpublished remarks based on research for the *NTSB Heavy Truck Study*, presented at the National Motor Carrier Safety Workshop, Washington, DC, Mar. 11, 1987.

perience, rather than hiring inexperienced drivers regardless of training. For further discussion of this important issue, see chapter 6.

Previous Driving History

Heavy vehicle drivers involved in accidents often have received citations for previous safety violations, particularly for speeding and other moving violations, and have been involved in previous accidents. Over 40 percent of truck drivers involved in accidents had at least one prior speeding conviction in the previous 3 years. OTA's comparison of NASS (1981-85) and the Federal Accident Reporting System (FARS) (1983) data revealed little difference in the previous violation and accident records of truck drivers involved in nonfatal and fatal accidents.

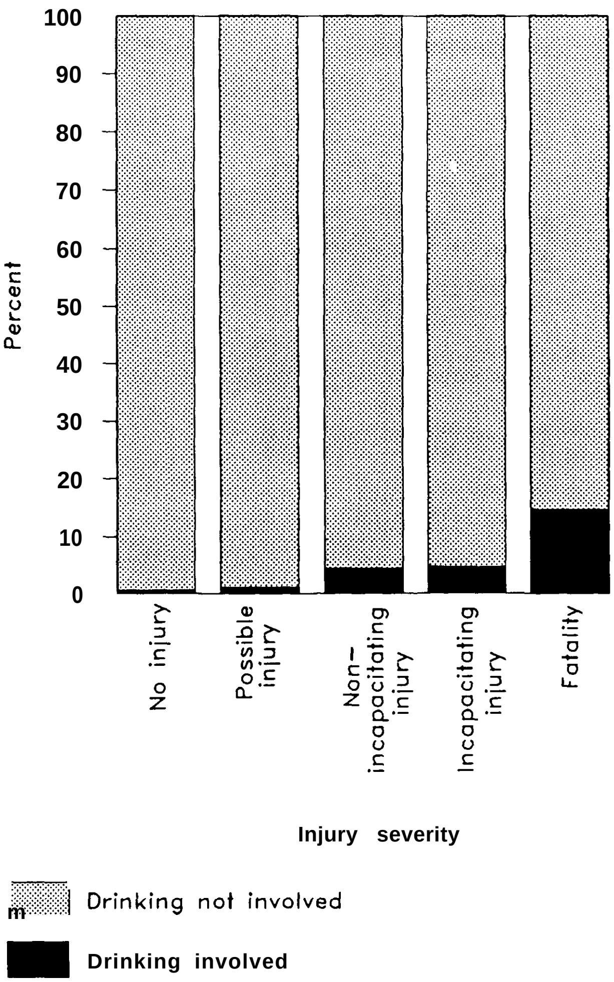
Drugs and Alcohol

Truck accident reports often show a low percentage of convictions for driving while intoxicated among truck drivers. Because of the importance of good driver performance for safety and the lack of data on drugs as contributors to accidents, NTSB is conducting a study of fatal truck accidents to determine the extent of driver impairment by alcohol and drugs. The study is expected to be completed in 1989.

Heavy vehicle drivers themselves perceive driver drug and alcohol abuse to be relatively frequent. In a 1986 survey sponsored by the Regular Common Carrier Conference of 1,319 long-haul, tractor-trailer truck drivers in Florida,[13] drivers were asked their perception of drug and alcohol use. The average respondent estimated that 36 percent of fellow drivers sometimes drive under the influence of drugs, and 18 percent of drivers sometimes drive under the influence of alcohol.

OTA analysis of NASS data indicated that alcohol involvement and accident severity are strongly related. Figure 4-6 shows the severity of injuries as a function of drinking by heavy vehicle drivers. The relationship between drinking and accident severity suggests that alcohol alone is a major factor in fatal accidents.

Figure 4-6.—injury Severity in Heavy Truck Accidents Relative to Truck Driver Drinking



SOURCE: Office of Technology Assessment, 1988; based on National Accident Sampling System data, 1981-85,

Age and Experience

Young and inexperienced truck drivers exhibit the highest risk of accidents,[14] with those under 25 years of age six times more likely than other heavy

[13] R. Beilock, 1986 *Motor Carrier Safety Survey* (Alexandria, VA: Regular Common Carrier Conference, 1987).

[14] I.J. Jones and H.S. Stein, Effects *of Driver Hours of Service on Tractor-Trailer Crash Involvement* (Washington, DC: Insurance Institute for Highway Safety, September 1987) p. 11; M.J. Sanders, Canyon Research Group, Inc., "A Nationwide Survey of Truck and Bus Drivers," unpublished manuscript, March 1977; and P. Green et al., University of Michigan, "Accidents and the Nighttime Conspicuity of Trucks," unpublished manuscript, January 1980.

truck drivers to be involved in an accident.[15] Drivers with less than 1 year of experience constitute 1 percent of the carrier work force, yet account for 3 percent of the accidents.[16]

Fatigue

Fatigue reduces a driver's sensorial and motor capacities. Research has shown that truck drivers are susceptible to both sudden fatigue, due to temporary irregularities of the sleep cycle, and accumulated fatigue, due to long working hours.

Significant increases in driver errors and decreases in alertness have been noted as early as the fourth hour of shift driving time and generally increase throughout the trip, except for a slight recovery near the end of a trip.[17] The lowest levels of alertness occur for most drivers between 2:00 a.m. and 7:00 a.m. Moreover, the adverse effects of prolonged driving are probably more pronounced for drivers aged 45 or older than for young drivers.[18] Drivers on irregular schedules experience more fatigue than drivers on regular schedules, and the effects occur earlier.[19] A recent study using a case-control design to establish comparable samples for 300 truck crashes indicated that the relative risk of crash involvement for truck drivers driving more than 8 hours is almost twice that for drivers driving fewer hours.[20] Moreover, drivers using a sleeper cab for rest periods experience greater fatigue than relay drivers.[21]

[15]K.D. Hackman et al. (eds.), *Analysis of Accident Data and Hours of Service of Interstate Commercial Motor Vehicle Drivers* (Washington, DC: U.S. Department of Transportation, Federal Highway Administration, August 1978).

[16]Jovanis, op. cit., footnote 5.

[17]William Harris et al., Human Factors Research, Inc., *A Study of the Relationships Among Fatigue, Hours of Service, and Safety of Operations of Truck and Bus Drivers* (Washington, DC: U.S. Department of Transportation, Federal Highway Administration, bureau of Motor Carrier Safety, November 1972).

[18]Ibid.

[19]Robert T. Mackie and James C. Miller, Human Factors Research, Inc., *Effects of Hours of Service, Regularity of Schedules and Cargo Loading on Truck and Bus Driver Fatigue* (Washington, DC: U.S. Department of Transportation, National Highway Traffic Safety Administration, October 1978).

[20]Jones and Stein, op. cit., footnote 14.

[21]Mackie and Miller, op. cit., footnote 19; and Robin P. Hertz, "Sleeper Berth Use as a Risk Factor for Tractor-Trailer Driver Fatality," presented to American Association for Automotive Medicine, New Orleans, LA, September 1987.

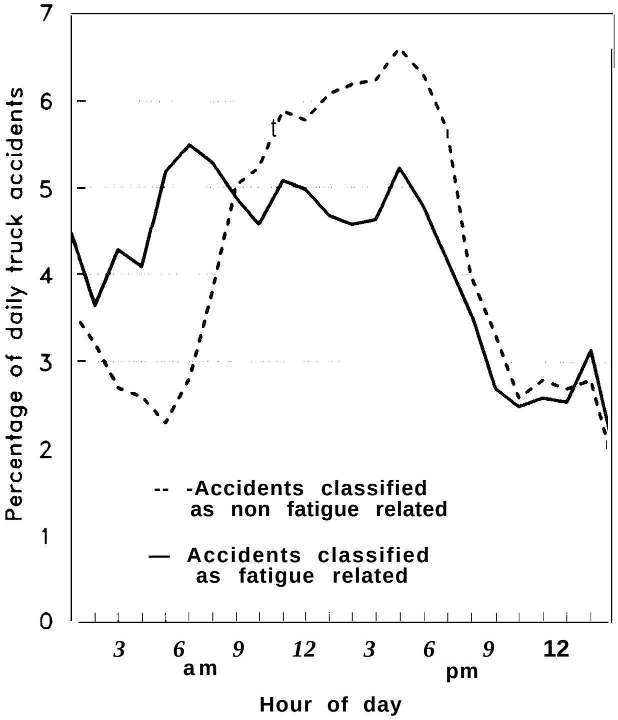
Accident data involving interstate commercial motor vehicle drivers show fatigue-classified accidents as proportionally higher during the hours between 11:00 p.m. and 8:00 a.m., suggesting an impact due to circadian rhythm (see figure 4-7).[22] NTSB also notes fatigue or hours-of-service violation as a factor in over 30 percent of its accident investigations.[23] Long hours of driver duty time, some as long as 26-31 consecutive hours prior to accidents, have been documented, often a result of carrier dispatch, delivery, or other requirements. Road and vehicle visibility are major contributing factors to accidents when a driver is fatigued, as is speed too fast for conditions.

A study of truck drivers in France found that fatigue is a major problem for drivers on the road for several days in a row. These drivers worked as fre-

[22]Hackman et al., op. cit., footnote 15.

[23]National Transportation Safety Board, op. cit., footnote 12, p. 2.

Figure 4-7.—Relationship of Driver Fatigue to Accidents, by Hour of Day



SOURCE: Office of Technology Assessment, adapted from K.D. Hackman et al, (eds.), *Analysis of Accident Data and Hours of Service of Interstate Commercial Motor Vehicle Drivers* (Washington, DC: U.S. Department of Transportation, Federal Highway Administration, August 1978),

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quently as other drivers during the day, yet remained on duty, driving and performing other tasks after normal business hours. This pattern led to both sudden fatigue and accumulated fatigue.[24] The study used a survey of truck driving patterns to measure exposure; periods of high accident risk were determined by comparing accidents with exposure. Data indicate that accident involvement rates generally increase throughout the day, reaching peaks at mealtimes, at the end of the afternoon, into the evening, and late at night. A risk peak in the first hour of any shift has been reported by other heavy truck safety research.[25]

[24] Patrick Hamelin, "Truck Driver's Involvement in Traffic Accidents as Related to Their Shiftworks and Professional Features," *Symposium on the Role of Heavy Freight Vehicles in Traffic Accidents,* op. cit., footnote 7, vol. 2, p. 3-107.

[25] Jovanis, op. cit., footnote 5, p. 8.

VEHICLE FACTORS

Vehicle design and performance affect truck safety, just as maintenance and operating practices do. Design and performance issues involve brake system capabilities, handling and stability, vehicle crashworthiness, and truck occupant protection. Maintenance practices include preventive maintenance as well as replacement of inoperable or worn parts. Vehicle operating practices include cargo loading, cargo tiedown, overall weight, and weight distribution.

The role of vehicle factors in an accident may be more subtle than that of the driver. While vehicle factors may not precipitate a crash, they can reduce the vehicle's performance capabilities below the threshold where safety can be maintained when traffic or roadway conditions require an emergency maneuver. These factors thus play a significant role in highway environments, such as heavy traffic, steep grades, curves, or narrow roadways, where peak vehicle performance is needed.

The subtleties of the role of the vehicle in accidents are emphasized in Oregon accident records for heavy trucks. Vehicle defects were cited as the accident cause in only 6.7 percent of all cases.[26] However, when truck at-fault accidents were disaggregate, over 20 percent were linked to mechanical defects, highlighting the potential for vehicle factors in preventing accidents as well as for mitigating severity.

Problems associated with vehicle equipment show up in MCSAP inspection reports. Although the number of out-of-service citations resulting from vehicle inspections varies among States, a significant number of trucks (ranging from 30 to 60 percent) are placed out of service for equipment violations immediately.[27]

[26] Oregon Public Utility Commissioner, op. cit., footnote 10.

Braking Systems

Defective brakes were the most common equipment violation cited in the MCSAP reports, followed by poor lighting and tire condition. Brake system failures were the single largest group of causes cited for large truck accidents associated with mechanical defects, constituting 31 percent of the total.[28]

The nature of brake problems has been documented in greater detail by the Oregon Public Utility Commission,[29] which found that over 60 percent of all violations related to brakes being out of adjustment; another 14 percent related to problems with the brake lining. Therefore, roughly three of every four brake-related citations identified problems that normal brake maintenance could easily detect and correct. NTSB's investigations reveal that in many cases the truck driver had responsibility for proper brake adjustment, but the carrier had not required or furnished appropriate training.[30]

[27] The process of selecting vehicles for inspection varies among States. Out-of-service citations are likely to be high (greater than 50 percent) when the selection process is nonrandom, based on inspecting vehicles that outwardly appear to have problems. Random selection yields out-of-service citation rates closer to 30 percent. Paul Melander, Tennessee Public Service Commission, personal communication, Mar. 23, 1988.

[28] Bureau of Motor Carrier Safety, 1976-1978 *Analysis of Motor Carrier Accidents Involving Vehicle Defects of Mechanical Failure* (Washington, DC: U.S. Department of Transportation, November 1979).

[29] Oregon Public Utility Commissioner, op. cit., footnote 10.

[30] National Transportation Safety Board, op. cit., footnote 12, p. 3.

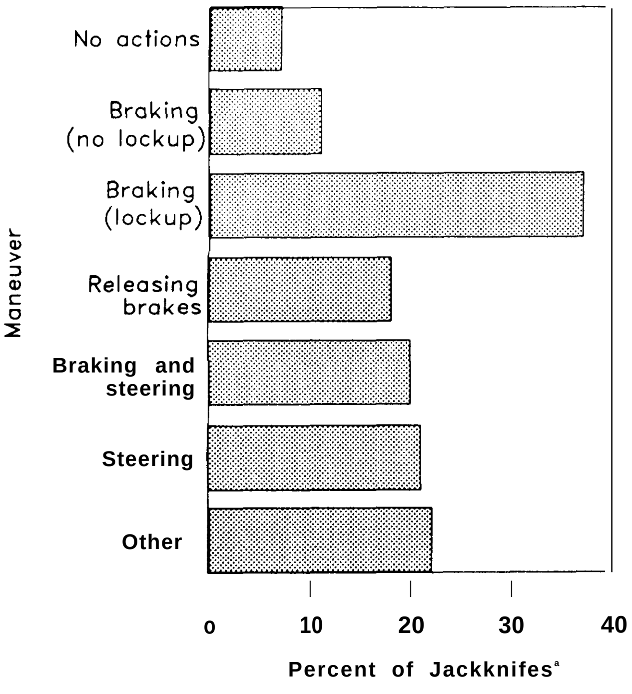
Poor brake adjustment and maintenance coupled with sudden braking or other avoidance maneuvers can increase the possibility of jackknifing,[31] a significant problem as shown in figure 4-8. Jackknifing potential is exacerbated by wet road conditions[32] and is especially prevalent among lightly loaded or empty vehicles.[33] A comparison of accident-involved articulated vehicles from the NASS (1981-85) and FARS (1983) databases does not, however, show jackknifing to be overrepresented in fatal accidents.

[31] Jackknifing is also discussed in ch. 5.

[32] H.S. Stein and I.J. Jones, *Crash involvement of Large Trucks by Configuration: A Case Control Study* (Washington, DC: Insurance Institute for Highway Safety, January 1987).

[33] C. Winkler et al., *Parametric Analysis of Heavy Duty Truck Dynamic Stability*, Report No. DOT-HS%06-411 (Washington, DC: U.S. Department of Transportation, National Highway Traffic Safety Administration, March 1983).

Figure 4-8.—Jackknifes Related to Attempted Accident Avoidance Maneuvers



[a] These numbers do not add to 100 since some jackknifes are attributed to multiple maneuvers.

SOURCE: Office of Technology Assessment, 1988; based on National Accident Sampling System data, 1981-85

Tires

Data from Oregon indicate that in 1984, 9.9 percent of truck at-fault collisions were attributed to mechanical causes, although for single-vehicle truck crashes 21 percent were attributed to mechanical causes and 24 percent of these to tires. Other data indicate tires to be the second leading cause of crashes in which mechanical defects were primary contributing factors.[34]

Tires have not been examined as extensively as other factors as a cause of accidents. Tire specialists indicate that a single tire blowout—even on the steering axle—should not result in total loss of control by the driver, unless other circumstances or equipment problems exist. Looseness in the steering system, striking a curb, or panic braking may, in combination with a blowout, cause the driver to lose control. Because specifying an accident cause is complicated, and the tire blowout is easily remembered and identified,[35] it is difficult to determine whether a blowout preceded a crash or occurred as a result of it.

Rollovers and Vehicle Handling and Stability

Rollovers often occur on curved roads, : and vehicle factors include handling characteristics and sta-

[34] Insurance Institute for Highway Safety, *Big Trucks* (Washington, DC: 1985).

[35] Christopher G. Shapeley, "A Comparison of Car and Truck Safety," presented at the American Society of Civil Engineers Symposium on Accommodation of Trucks on the Highway: Safety in Design, Nashville, TN, May 11, 1988.

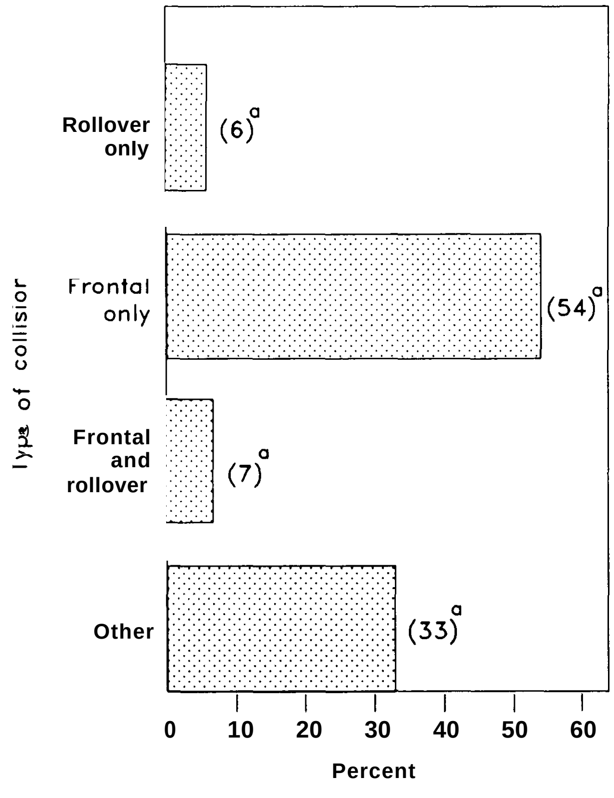
Photo credit: Michael Hines, OTA staff

Vehicle handling skills are challenged when drivers transport especially wide loads.

bility as well as load shifting, deficient brakes, and deficient tires. (For information on roadway contributory factors see chapter 5.) Driver-related factors include inattention, falling asleep, loss-of-control/skidding, speeding, and avoidance maneuvers. Operational factors, such as unbalanced cargo loads and trailer loads with high centers of gravity, also affect vehicle stability.

Poor handling and vehicle instability often lead to vehicle rollovers, which, in turn, strongly correlate with accident severity. Rollovers are more likely to be associated with accidents involving a driver fatality relative to all heavy truck accidents (see figure 4-9). OTA's NASS (1981-85) and FARS (1983) analyses also show that rollovers occur in *7.6* percent of all heavy truck accidents, but are a characteristic of 16.5 percent of truck accidents involving a fatality. Other studies substantiate the relationship between rollover and fatal accidents[36] and show that the risk of injury is higher in rollover accidents involving a single vehicle relative to multiple-vehicle accidents.[37]

Figure 4-9.—Tractors Involved in Fatal Accidents, by Type of Collision



a **Percentage of all tractor accidents.**

SOURCE: Office of Technology Assessment, 19SS; based on Motor Vehicle Manufacturers Association data, 1987.

Rollovers are a particularly acute problem for double-trailer combinations. Although the sample of doubles accidents in the NASS database is quite small, the incidence of rollovers in doubles accidents is very high. Studies show that doubles are three to four times more likely to overturn than singles in noncollision accidents[38] and that rollover occurred in close to *70* percent of twin-trailer accidents. The most common occurrence was rollover of the rear trailer.[39]

Override/Underride

When accidents occur between large trucks and cars, the mismatch between truck and car bumper heights causes trucks to override smaller vehicles or smaller vehicles to underride trucks. Override/underride accidents occur more frequently at night, when darkness reduces visibility for all drivers. Figure 4-10 shows that the override/underride prob-

[36] National Highway Traffic Safety Administration, *Truck Occupant Projection,* prepared in response to the Motor Carrier Safety Act of 1984 (Washington, DC: December 1986).

[37] Stein and Jones, op. cit., footnote 32, p. 13.

[38] Oliver Carsten, "U.S. Accident Experience of Single and Double Trailer Combinations," *Symposium on the Role of Heavy Freight Vehicles in Traffic Accidents,* op. cit., footnote 7, vol. 1, p. 2-80, table 5.

[39] National Transportation Safety Board, op. cit., footnote 12, p. 1.

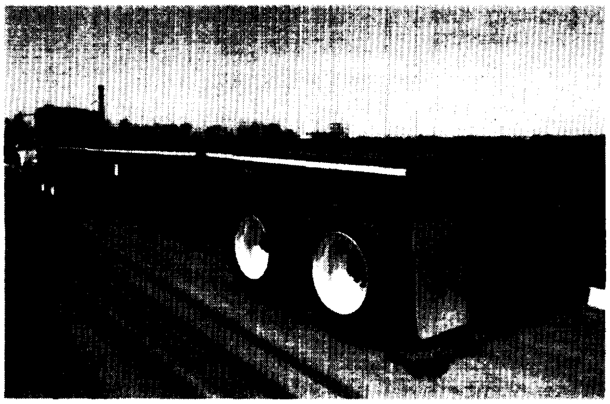
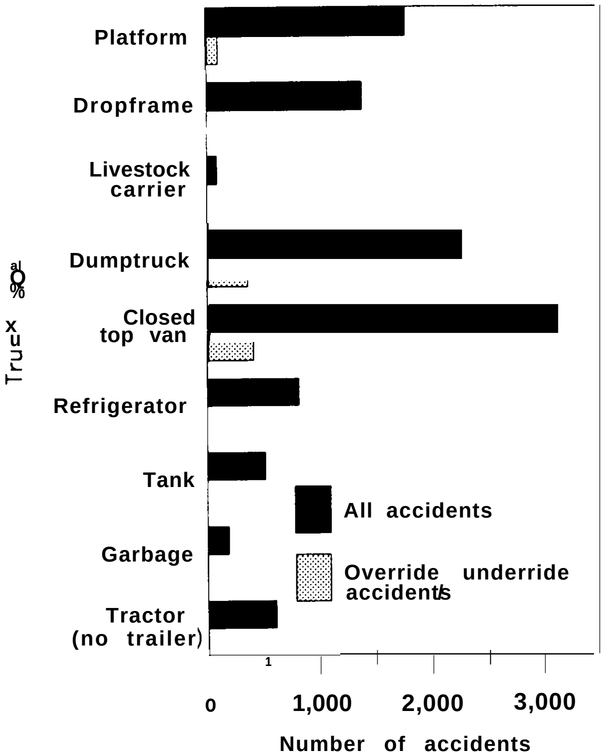


Photo credit: Land Line

Flatbed trailers are particularly difficult to see, creating the potential for severe underride accidents.

Figure 4-10.—Accidents and Override/Underride in Reduced Lighting Conditions, by Truck Type



SOURCE: Office of Technology Assessment, 1988; based on National Accident Sampling System data, 1981-85.

lem is greater for dump trucks, closed-top vans, or flatbed or platform trailers; platform trailers present the most problems.[40]

A comparison between fatal and nonfatal car-into-truck accidents shows that fatalities occur more frequently in underride accidents, including many from contact with the side of the truck. Trucks and trailers with devices to prevent underride were more likely to be involved in nonfatal accidents,[41] highlighting the value of such protection.

Truck Configuration and Utilization

Accident rates and types vary for straight and combination trucks, for single- and double-trailer operations, and for loaded and empty trucks. The operating characteristics and contributing factors—the number of powered axles, cab configuration, type of trailer, type of cargo, trip length, time of day, road type, and driver age and experience-differ for every accident. Each factor needs to be considered independently and interactively in any comprehensive analysis.[42] In fact, for single-trailer operation alone, involvement rates differed significantly by trailer type and location, as shown in table 4-3.

Table 4-4 shows fatal accident involvement percentages (truck driver and other vehicle driver) by truck body type for combination trucks. These data underscore the overinvolvement of tank trucks and the relative severity of dump truck collisions for the other vehicle driver.

The relative safety of single- and double-trailer combination trucks is highly controversial, and several studies have examined their relative risks. Each study differs in methodology and sources of data, making a comprehensive and coherent assessment difficult. For example, studies of truck accidents on turnpikes permit consistent accident and exposure information because the intercity operations of doubles are adequately represented. However, the restriction to turnpike operation eliminates consideration of the entire trip from origin to destination. National studies do not allow control for geographic location and roadway type. Thus, study results have varied due primarily to: 1) differences in exposure survey methods and uncertainties in the resulting estimates of exposure, 2) unreliable and missing ac-

[40] Motor Vehicle Manufacturer's Association, *Proceedings of the National Truck Safety Symposium* (Washington, DC: June 1987), pp. 85-86; Motor Vehicle Manufacturers Association, *Motor Truck Research* (Washington, DC: November 1985).

[41] Motor Vehicle Manufacturers Association, *Motor Truck Research*, op. cit., footnote 40, pp. 7, 9.

[42] T. Chirachavala and J. O'Day, *A Comparison of Accident Characteristics and Rates for Combination Vehicles With One or Two Trailers*, Report No. UM-HSRI-81-41 (Ann Arbor, MI: University of Michigan, August 1981).

Table 4-3.—Single-Trailer Involvement Rate (per 100 million vehicle-miles)

Trailer type	Local	Intercity
Van	168.0	75.9
Flatbed	69.9	106.8
Tank	142.2	78.1
Auto	241.6	73.6
Dump	46.1	33.1

SOURCE: T. Chirachavala and J. O'Day, *A Comparison of Accident Characteristics and Rates for Combination Vehicles With One or Two Trailers*, Report No. UM-HSRI-81-41 (Ann Arbor: University of Michigan, August 1981),

Table 4-4.—Distribution of Combination-Unit Truck Mileage and Fatal Accident Involvements by Body Type, in Texas

Body type	Percent of miles traveled	Percent of combination-unit truck driver fatalities	Percent of "other vehicle" driver fatalities occurring in collisions with combination-unit trucks
Van	45.5	28.1	24.5
Platform	22.2	25.2	27.8
Tank [a]	15.0	33.0	20.8
Dump	7.3	3.0	11.1
Pole/log	1.2	0.7	1.9
Livestock	1.3	6.7	8.0
All others	7.2	3.3	5.9
Total	100.0[b]	100.0	100.0

[a]Includes dry bulk, liquid, and gas.
[b]Sum does not equal 100 percent due to rounding.

SOURCES: Truck Inventory and Use Survey/Texas 1982 and Texas State Accident Data (1981-1983); National Highway Traffic Safety Administration

cident data, 3) differences in the definition of an accident and/or large truck, 4) differences in vehicle classification survey methods, 5) differences in driving environment, and 6) inherent stochastic variation associated with small samples.[43] Despite these variations, a summary of study results to date follows.

Using accident and exposure data during 1966-70 on the Indiana Toll Road, one study concluded that doubles had a significantly lower involvement rate than did singles.[44] However, doubles had more injuries or fatalities per accident than singles. No effort was made to separate these data by rural or urban location.

In 1977, an FHWA study analyzed the accident experience of seven large motor carriers for a 7-year period and found no significant differences between accident and severity rates of singles and doubles.[45] The carriers surveyed were among the largest common and private carriers in the country; no attempt was made to control for different operating environments.

A followup study conducted by FHWA in 1978, using data from California, found that the only significant difference in doubles and singles involvement rates on a vehicle-mile basis, was a higher fatality rate for doubles.[46] However, when a cargo-based exposure measure (ton-miles) is used, the higher tonnage capability of doubles results in a higher accident rate and injury rate for singles. Although there were problems with the accuracy of the exposure estimates in this study, the findings illustrate some of the differences in the way this topic is viewed.

The Insurance Institute for Highway Safety used a case-control study design to account for differences in operating characteristics between singles and doubles.[47] The study concluded that doubles are two to three times more likely to be involved in accidents than other large trucks on the same type of roadway. This approach preselected locations where accidents have already occurred, perhaps for reasons unrelated to vehicle configuration. The study's findings have generated substantial controversy.

Other controlled studies have been conducted for a less-than-truckload carrier by Northwestern University. % Using over 160 traffic links connecting terminal pairs served by both singles and doubles in 1983 and 1984, the studies found no statistically conclusive evidence of differences between the

[43]G.A. Sparks and J. Bielka, "Large Truck Accident Experience in Western Canada: A Case Study of Two Large Fleets," *Symposium on the Role of Heavy Freight Vehicles in Traffic Accidents*, op. cit., footnote 7.

[44]R.E. Scott and J. O'Day, *Statistical Analysis of Truck Accident Involvement*, Final Report (Ann Arbor, MI: Highway Safety Research Institute, December 1971).

[45]Federal Highway Administration, *Safety Comparison of Doubles Versus Tractor Semi-Trailer Operation* (Washington, DC: U.S. Department of Transportation, 1977).

[46]H McGee et al., *Comparison of California Accident Rates for Single and Double Tractor-Trailer Combination Trucks*, Report No. FHWA-RD-78-94 (Washington, DC: U.S. Department of Transportation, Federal Highway Administration, March 1978).

[47]Stein and Jones, op. cit., footnote 32.

[48]Jovanis, op. cit., footnote 5.

accident rates of singles and doubles. A similar study conducted for OTA corroborated these findings; moreover, after an initial driver learning period, the doubles safety record improved sufficiently to exceed that of the singles.[49]

An extensive Transportation Research Board study of the relative safety of single- versus double-trailer trucks concluded that doubles have slightly more accident involvements per mile traveled than singles operated under identical conditions at highway speeds.[50] This and other studies indicate that considerable differences exist in single- and double-trailer accident involvement rates by road type, emphasizing the importance of the operating environment as well as the configuration of the truck.[51]

Accident rates for articulated trucks exceed those for straight trucks by factors of three to four, depending on location and road conditions.[52] The consequences of articulated truck accidents are more serious as well. While single-unit trucks have nonfatal accident rates comparable to nonfatal accident rates for combination trucks (see table 4-5), their rate of involvement in fatal accidents is considerably lower.[53]

Whether the tractor is operating as a bobtail (not pulling a trailer) or attached to a semitrailer also affects accident rates. Bobtails are 14 times more likely to be involved in a fatal accident, and their injury involvement rate is 19 times greater than for the tractor-semitrailer configuration.[54] In addition, empty tractor-semitrailer trucks are more likely to be involved in crashes than fully loaded trucks.[55] This is probably due to the difficulty in maintaining control when braking empty or partially loaded tractor-trailers. (See chapter 5, figure 5-3.)

Truck Occupant Protection

Less than 1 percent of all medium and heavy truck occupants involved in accidents are killed, and only 10 percent are injured.[56] Nevertheless, truck driving is considered a relatively dangerous occupation. Table 4-6 shows fatality rates for selected occupations, indicating that truck driving and mining are the most dangerous industrial occupations.

A truck driver wearing a seat belt is much less likely to be injured or suffer severe injury in an accident, primarily because he is less likely to be thrown out of the cab by the impact. The majority of truck drivers (76 percent) involved in accidents were not wearing seat belts, as shown in figure 4-11.[57] FARS (1984) data indicate that total or partial ejection was involved in 38 percent of combination-unit truck occupant fatalities. Truck occupants were also ejected after an accident more frequently than were passenger car occupants (25 percent).[58]

Entrapment, cab crush, and contact with interior surfaces have serious consequences for truck occupants who remain in the cab during an accident. A study of truck occupants in rural accidents identified ejection and steering-assembly contact as the leading sources of injury, followed by contact with

Table 4-5.—Vehicle Involvement Rates in Fatal and Nonfatal Accidents in 1984

	Combination-unit trucks	Single-unit trucks
Vehicles in fatal accidents . . .	4,232	956
Vehicle involvements in fatal accidents (per 100 million vehicle-miles)	5.5	1.8
Vehicle involvements in nonfatal accidents (per 100 million vehicle-miles)	**279.0**	**299.0**

SOURCES: National Highway Traffic Safety Administration, Fatal Accident Reporting System, National Accident Sampling Systems, Federal Highway Administration, Highway Statistics, Truck Inventory and Use Survey

[49] P.P. Jovanis and I. Zabaneh, "Analysis of Carrier-Based Safety Data," OTA contractor report, February 1988.

[50] Transportation Research Board, *Twin Trailer Trucks,* TRB Special Report 211 (Washington, DC: National Research Council, 1986).

[51] Carsten, op. cit., footnote 38.

[52] Stein and Jones, op. cit., footnote 32, p. 9.

[53] National Highway Traffic Safety Administration, op. cit., footnote 36.

[54] K. Campbell and O. Carsten, *Fleet Accident Evaluation of FMVSS 121,* Report No. DT-HS-806-261 (Washington, DC: U.S. Department of Transportation, National Highway Traffic Safety Administration, August 1981).

[55] Stein and Jones, op. cit., footnote 32, p. 11.

[56] National Highway Traffic Safety Administration, op. cit., footnote 36.

[57] This contrasts somewhat with the safety belt use rate for truck drivers not involved in accidents. A nonobtrusive survey of safety belt use among combination-unit truck drivers revealed that over 93 percent were not using their belts. P. Allison and R. Tarkir, "Heavy Truck Occupant Restraint Use," prepared for the National Highway Traffic Safety Administration, September 1982.

[58] National Highway Traffic Safety Administration, op. cit., footnote 36, p. 14.

Table 4-6.-Occupational Fatalities in 1984

Industry group	Workers (x 10^3)	Deaths[a]	Deaths/10^8 workers
All industries	104,300	11,500	11
Trade	24,000	1,200	5
Manufacturing	19,900	1,100	6
Service	28,900	1,900	4
Government	15,900	1,400	9
Transportation and public utilities	5,500	1,500	27
Construction	5,700	2,200	39
Agriculture	3,400	1,600	46
Truck drivers	1,876[b]	1,087[c]	58
Mining, quarrying	1,000	600	60

[a]National Safety Council, *Accident Facts 1985.*
[b]U.S. Department of Labor, *Employment and Earnings, January 1985.*
[c]Federal Accident Reporting System, 1984.

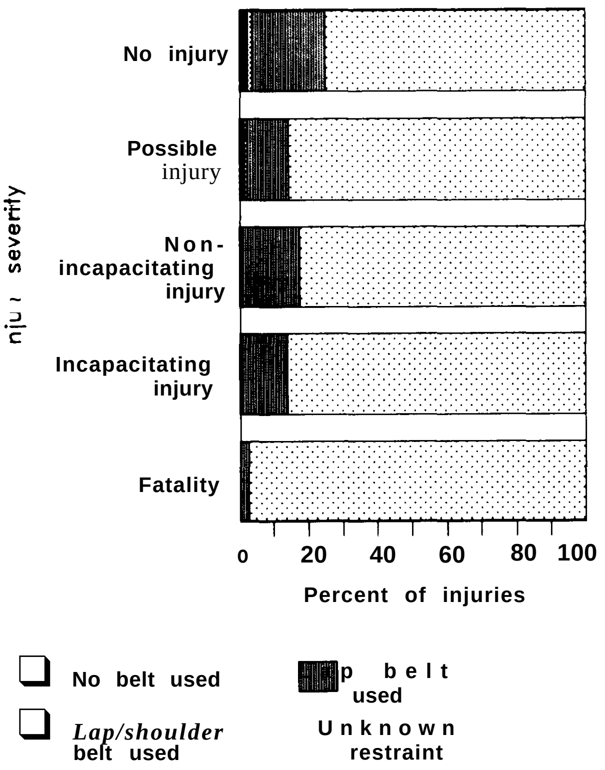
SOURCE: National Highway Traffic Safety Administration

the windshield and the door area.[59] A study of injury patterns of fatally injured truck drivers concluded that severe abdominal injuries in combination with head and/or chest injuries were more likely among combination-unit truck drivers than among drivers of other truck types.[60] The nature of these injuries suggests the steering wheel is particularly dangerous. The steering wheel was also identified as the most prominent source of injury in an analysis of 124 accidents involving Volvo trucks in Sweden.[61]

Some information is available on the relative safety of cab-over-engine units (COE) and conventional cabs. For example, the risk of injury to a COE driver is 15 percent higher, and the risk of injury to the nontruck driver slightly lower, when a COE is involved.[62] FARS data show that COEs have a greater involvement in accidents in which a fatality occurs as well as in accidents involving a truck-driver fatality.

The initial stimulus for the COE design was Federal length restrictions that are no longer in effect. Many drivers claim COEs have poorer ride quality and increased vibration that cause discomfort and fatigue.

Figure 4=11 .—Truck Driver Seat Belt Use, by Injury Severity



SOURCE: Office of Technology Assessment, 1988; based on National Accident Sampling System data, 1981-85.

[59]H. Robinson et al., Trucks *in* Rural Injury Accidents, NHTSA Report No. HS-800-232 (Washington, DC: U.S. Department of Transportation, July 1969,

[60]T. Karlson et al., "Fatally Injured Truck Drivers," *Proceedings of the 21st Conference of the American Association of Automotive Medicine* (Arlington Heights, IL: American Association of Automotive Medicine, September 1977).

[61]A. Anderson et al. "Injuries in Trucks and the Effectiveness of Seat Belts," *Proceedings of the 24th Conference of the American Association of Automotive Medicine* (Arlington Heights, IL: American Association of Automotive Medicine, October 1980).

[62]Motor Vehicle Manufacturers Association, op. cit., footnote 41, p. 11.

SAFETY OF NON REGULATED CARRIERS

A substantial safety concern has been the lack of Federal regulatory oversight of carriers operating exclusively in commercial zones and in other federally exempt categories. Analysis of NASS (1981-85) data indicates that nearly two out of every five accidents involve a heavy truck belonging to a carrier that is not Interstate Commerce Commission (ICC)-regulated. Oregon officials report that in 1984 the highest at-fault accident rate belonged to ICC-exempt, interstate carriers.[63]

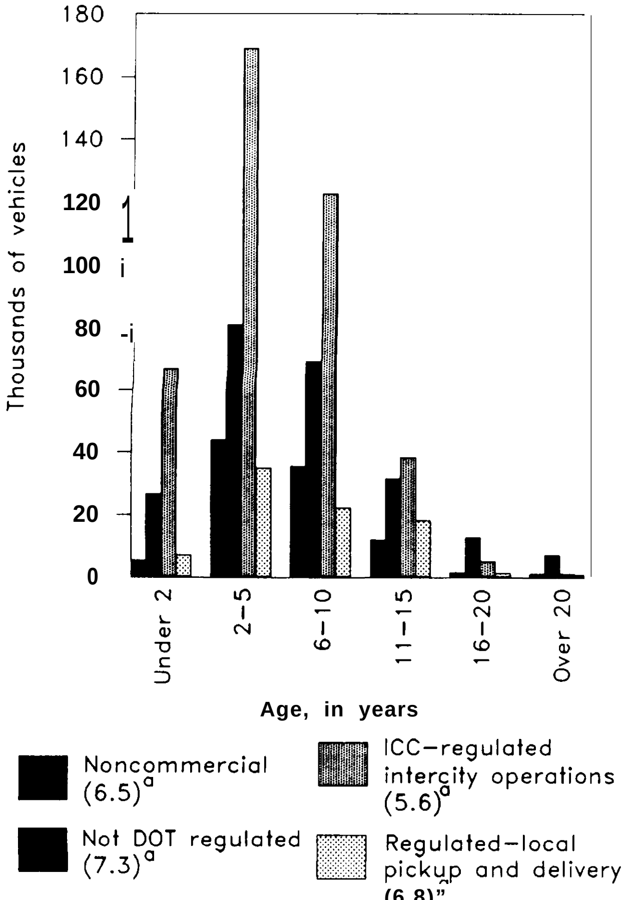
Figure 4-12 shows the age distribution of heavy trucks involved in accidents. Differences in the quality of various truck operations are also apparent when examining Federal roadside inspection data. Table 4-7 shows that ICC-exempt carriers have somewhat higher violation rates than other carriers and slightly more serious safety problems. Systematic interpretation is impossible because of numerous changes in recent years in coverage by ICC regulations and in the application of Federal safety regulations to previously exempt carriers.

Roadside inspections can serve as effective accident prevention measures. A 10-year California State study found a clear inverse relationship between the number of roadside inspections and the number of truck at-fault accidents.[64] (See figure 4-13.) Although other factors undoubtedly influenced operations over the study period, the apparent correlation between increased enforcement activities and on-the-road safety improvement is hard to ignore.

[63] Oregon Public Utility Commissioner, op. cit., footnote 10, p. 39.

[64] California Highway Patrol, *Critical Item Inspection Fact Sheet* (Sacramento, CA: 1986).

Figure 4-12.—Vehicle Age by Regulatory Status

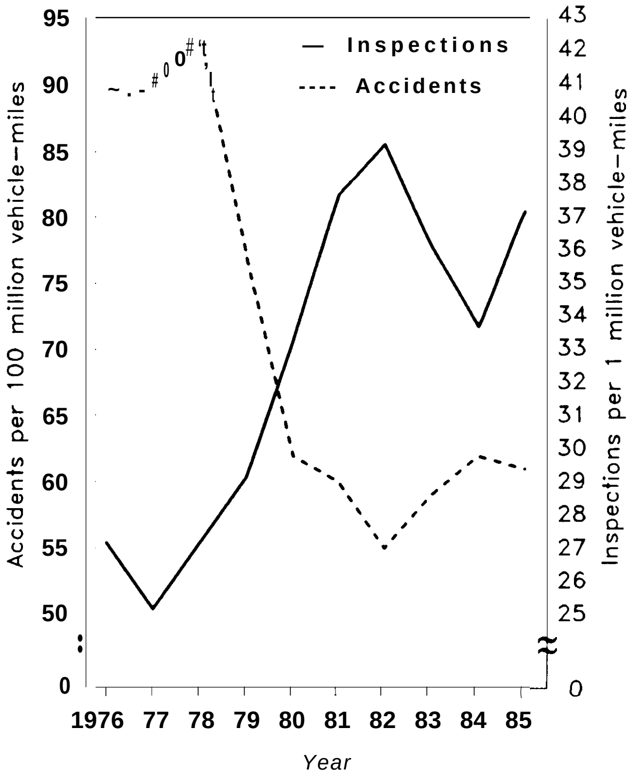


aEstimated average age, in years.

KEY DOT = Department of Transportation; ICC = Interstate Commerce Commission.

SOURCE: Office of Technology Assessment, 1988; based on National Accident Sampling System data, 1981-85

Figure 4-13.—Truck Inspection and Truck Accident Rates for California State Highways, 1976-85



SOURCE: Office of Technology Assessment, 1988; adapted from California Highway Patrol/State of California Public Utilities Commission, *Joint Legislative Report on Truck Safety* (San Francisco, CA: November 1987), p. 37

Table 4-7.—BMCS Roadside Inspection of All Carriers (in percent)

	ICC-authorized	Private	ICC-exempt other
1983			
Without violations	36	25	28
With violations	64	75	72
Out-of-service violations	28	25	32
1984			
Without violations	29	21	20
With violations	71	79	80
Out-of-service violations	31	29	36

KEY: BMCS = Bureau of Motor Carrier Safety.
ICC = Interstate Commerce Commission

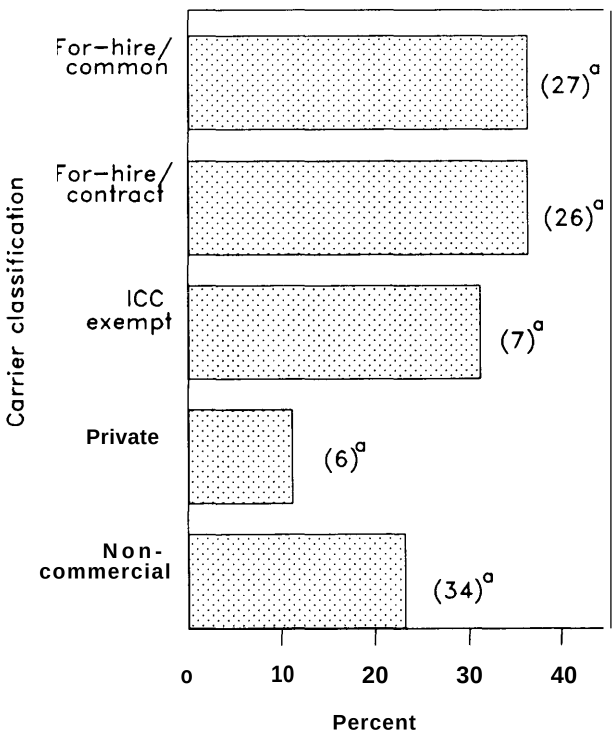
SOURCE: Bureau of Motor Carrier Safety, *BMCS Annual Roadside Inspection 1983 and 1984* (Washington, DC: September 1985).

ECONOMIC FACTORS

The U.S. trucking industry represents a diverse mix of carriers, drivers, and truck owners operating with a broad range of safety practices and levels of management control. Some limited evidence links the amount of motor carrier investment in safety-related activities to the firm's overall financial condition. One examination of for-hire, general freight carriers found that the average carrier that eventually goes bankrupt spends less on safety and maintenance, has older equipment, and depends more on owner-operators.[65] However, the basis for this finding was not a comparison of accident rates to carrier profitability, but rather a comparison of expenditures related to safety performance to a weighted combination of financial ratios. Moreover, studies of this kind are hampered by the scarcity of industry financial data maintained by ICC, particularly for new entrants. Furthermore, ICC is eliminating requirements for detailed financial reports from those carriers who must still submit records.

The question of whether driver speeding is related to the method of compensation extended to drivers has been hotly debated. Undeniably, drivers paid by the job have an economic incentive to speed to produce more revenue-generating trips within a given time period. However, numerous other factors affect a driver's desire to speed. Figure 4-14 shows the relationship between carrier classification and speeding violations among truck drivers involved in accidents. Although speeding is prevalent across all segments of the carrier industry, excessive speeding is more frequently found among ICC-exempt and for-hire carriers according to accident data. Leased drivers have the highest incidence of previous speeding violations and previous license suspensions and revocations. Furthermore, the

Figure 4.14.—Percentage of Trucks That Speed, by Carrier Classification



[a]Market share in percent.
KEY: ICC = Interstate Commerce Commission.
SOURCE: Office of Technology Assessment, 1988; based on National Accident Sampling System data, 1981-85.

[65]G. Chow, "Deregulation, Financial Condition and Safety in the General Freight Trucking Industry," presented at the Northwestern University Conference on Economic Deregulation and Safety, Evanston, IL, June 1987.

NASS (1981-85) data show that leased drivers and drivers operating for ICC-exempt carriers are disproportionately involved in drunk driving accidents. The validity of these figures is difficult to establish because of the relatively small sample size and because NASS data do not have well-defined driver or carrier classification categories.[66] Furthermore, it is difficult to delineate the class of driver on a specific trip because the same driver could be leased or not leased in different driver classifications and may drive in many different types of operations during the year.

[66] The National Accident Sampling System driver classifications are somewhat confusing, since the classification categories do not appear to be mutually exclusive (e.g., an owner-operator could be trip leased in some instances).

ENFORCEMENT

State terminal audits conducted as part of the MCSAP program raise important carrier management safety issues. In Arizona, for instance, the three most common carrier violations are: 1) failure to maintain driver qualification files, 2) hours-of-service violations, and 3) failure to maintain inspection, repair, and maintenance records. Officials familiar with Oregon's audit results concluded that carriers do not comply with the requirements because of a lack of knowledge or understanding of the regulations as applied to their operations. Moreover, even when the regulations are understood, the cost of noncompliance is so low that it is not an effective deterrent. These findings point to the need for a better education and enforcement program.

In Michigan, a direct link has been established between driver qualifications, hours of service, and vehicle operations and commercial vehicle accidents. Making compliance with driver qualification procedures a direct responsibility of carriers has proven to be an effective accident prevention tool.[67]

[67] Motor Carrier Safety Assistance Program quarterly and annual reports.

ROADWAY ENVIRONMENT

Roadway environment factors are often listed incidentally on many accident reports. Road design/geometry, weather, lighting conditions, traffic conflict opportunity, and operating speeds can all create conditions that are unforgiving of errors, making an accident more likely.

Road Type

The functional class of the roadway has a profound impact on heavy truck involvement rates for both fatal and nonfatal accidents[68] (see table 4-8). A similar relationship between rural/urban and Interstate/other roadway fatality rates appears in a corroborating study, although the magnitudes differ somewhat.[69]

Figure 4-15 depicts frequencies of heavy truck accidents and fatal heavy truck accidents by road classification. Of particular significance is the proportion of heavy truck, fatal accidents (relative to all large truck accidents) that occur on U.S. and State highways, particularly rural, non-Interstates. Some characteristics of these roads create the potential for severe accidents.

[68] U. S. Department of Transportation, Federal Highway Administration, "Monitoring Operations of Larger Dimension Vehicles Report," unpublished manuscript, Jan. 14, 1987.

[69] Carsten, op. cit., footnote 38, table 5.

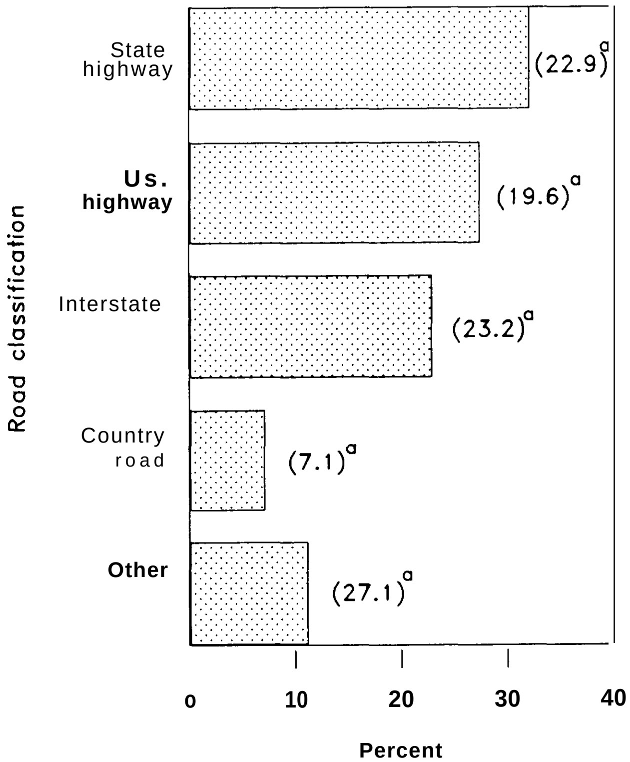
Table 4-8.—Single-Trailer Accident Involvement Rates by Highway Functional Class

	Involvement rates (per 100 mvm)	
Functional class	**Fatal**	**Nonfatal injury**
Rural Interstate	1.87	25.53
Rural-other principal artery	3.80	31.43
Rural minor arterial	6.49	41.65
Rural major collector	13.67	50.12
Urban Interstate	2.23	52.73
Urban-other principal artery	9.52	103.41
Urban local	27.79	55.59

KEY: mvm = million vehicle-miles,

SOURCE: Federal Highway Administration, "Monitoring Operations of Larger Dimension Vehicles Report, " Jan. 14, 1987.

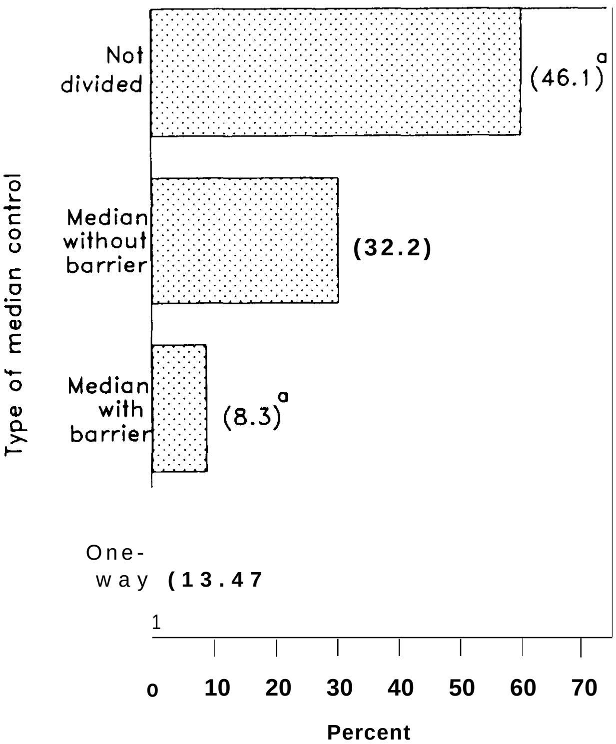
Figure 4-15.—Fatal Truck Accidents by Road Classification



aPercent of all truck accidents.

SOURCE: Office of Technology Assessment, 1988; based on National Accident Sampling System data, 1981-85 and Fatal Accident Reporting System data, 1983.

Figure 4-16.—Fatai Truck Accidents by Median Controi



aPercent of all truck accidents.

SOURCE: Office of Technology Assessment, 1988; based on National Accident Sampling System data, 1981-85 and Fatal Accident Reporting System data. 1983.

For instance, fatalities are far more likely in accidents occurring on roads that are not physically divided and thus provide greater opportunity for head-on collisions (see figure 4-16). Roads with higher posted speed limits are significantly more likely to be the site of fatal truck accidents (see figure 4-17).

Slightly less than half the heavy truck accidents (49 percent) occur at intersections, and 80 percent of heavy truck accidents occur on roadway alignments classified as "straight" according to NASS (1981-85) data. Of all heavy truck fatality accidents, only 34 percent occur at intersections and 81 percent occur on straight aligned roads. Finally, 71 percent of nonfatal heavy truck accidents occur on level ground, 28 percent occur at grade, and only 1 percent at crests or in sags. Fatal heavy truck accidents have a similar pattern, except for a slightly higher proportion of fatal accidents at hill crests.

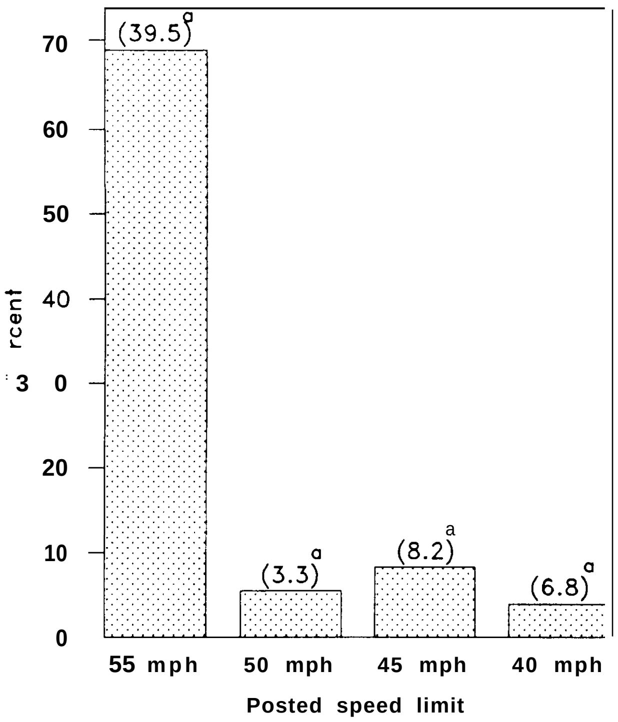
Lighting Conditions

The impact of lighting conditions on heavy truck accident rates is still imperfectly understood. Several studies find that the risk to truck safety is 1.5 to 2.0 times greater at night than in the daytime.[70] Table 4-9 indicates this is apparently true for rear-end accidents. Other studies report a higher truck accident rate in darkness during the summer, but a comparable accident rate for daylight and darkness during the winter season, or find no significant impact of lighting conditions.[71] However, there is

[70]Motor Vehicle Manufacturers Association, *Proceedings of the National Truck Safety Symposium*, op. cit., footnote 40.

[71]L. Strandberg, "On the Braking Safety of Articulated Heavy Freight Vehicles," *Symposium on the Role of Heavy Freight Vehicles in Traffic Accidents*, op. cit., footnote 7, vol. 2, p. 3-28; P.P. Jovanis and J. Delleur, "Exposure-Based Analysis of Motor Vehicle Accidents," *Transportation Research Record, No. 910* (Washington, DC: Transportation Research Board, 1983), pp. 1-7; and Stein and Jones, op. cit., footnote 32, p. 12.

Figure 4-17.— Fatal Truck Accidents by Posted Speed Limits



[a]Percent of all truck accidents. (These numbers do not add Up to 100 because not all posted speed limits are included.)

SOURCE: Office of Technology Assessment, 1988; based on National Accident Sampling System data, 1981-85 and Fatal Accident Reporting System data, 1983.

Table 4-9.—The Effect of Lighting Conditions on Rear. End Collisions

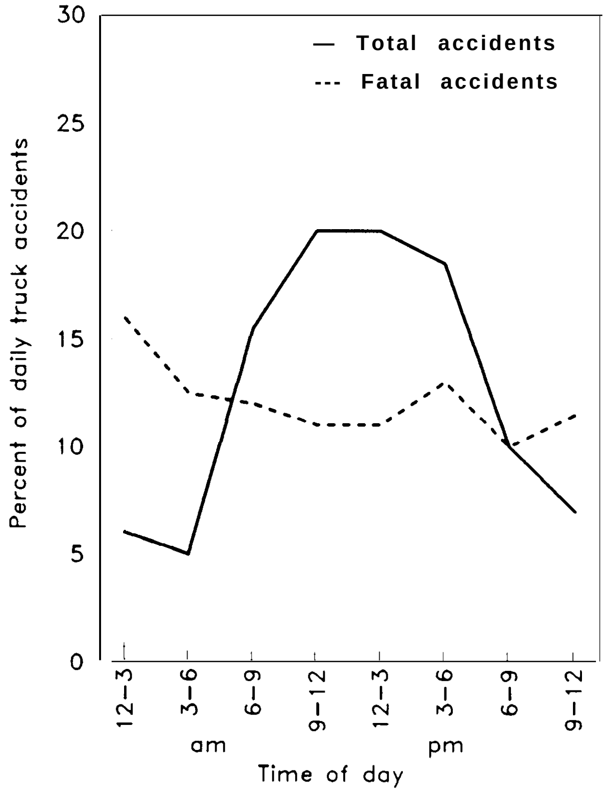
	Lighting condition	
Accident twe	Daylight	Not daylight
Rear end	27.30/o	72.70/o
Other	49.1%	50.9 "/0

SOURCE: Motor Vehicle Manufacturer's Association, *Proceedings of the National Truck Safety Symposium* (Washington, DC: June 1987), pp. 85-89.

a correlation between lighting conditions and fatalities; 50 percent of fatal accidents involving heavy trucks occur at night, in contrast to 27 percent of all heavy truck accidents (see figure 4-18). An official for the largest bus company indicated that nighttime accidents involving a bus running into a flatbed trailer truck were a major concern.[72]

[72]Robert Forman, vice president for safety, Greyhound Bus Co., personal communication, February 1988.

Figure 4-18.—Combination Truck Accidents, by Time of Day



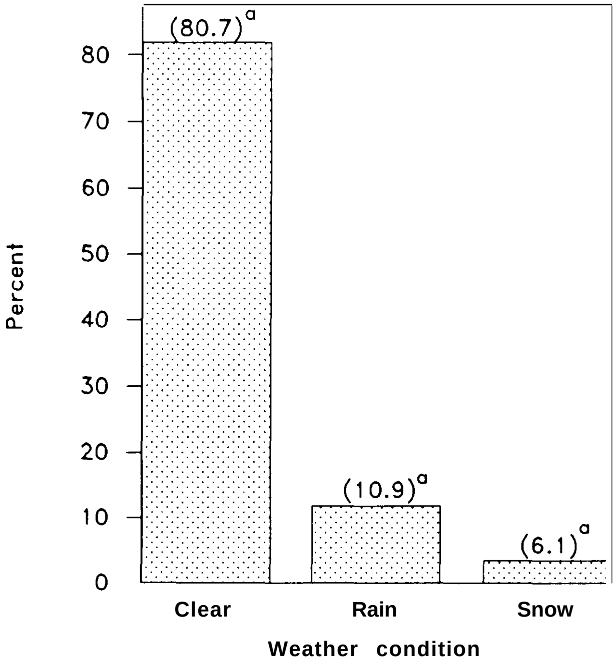
SOURCE: Office of Technology Assessment, 1988; based on National Highway Traffic Safety Administration analysis of Texas data, 1981-83.

Weather Conditions

Most heavy truck accidents (80 percent) occur in clear weather conditions (see figure 4-19). However, one study concluded that snowy weather is an important predictor of high accident rates for trucks, whereas rainy days have lower truck accident rates than do clear days.[73] Conspicuous by their absence as accident factors are splash, spray, or wind from passing trucks, likely due to difficulty in measuring this problem from accident reports. Moreover, research literature does not contain detailed discussion on this subject, although individual carriers, the American Trucking Associations, and others have recognized it as a significant problem. Additional study is needed to determine whether other characteristics, such as wet road conditions *described* in accident reports, are acting as a surrogate for splash and spray problems.

[73]Jovanis and Delleur, op. cit., footnote 71.

Figure 4-19.—Fatal Truck Accidents by Weather Condition



aPercent of all accidents. (These numbers do not add up to 100 because not all posted speed limits are included.)

SOURCE: Office of Technology Assessment, 1988; based on National Accident Sampling System data, 1981-85 and Fatal Accident Reporting System data, 1983.

Photo credit: Tse-Sung Wu, OTA staff

The need for cars and trucks to share the road can create roadway hazards.

Sharing the Road

In a majority (77 percent) of multiple-vehicle accidents involving trucks, the truck is the striking unit.[74] A subset of the accidents where the truck is the striking unit may be attributable to passenger car maneuvers into a truck's path. Annual studies carried out over the past 10 years by the California Highway Patrol of heavy truck collisions place trucks at fault 43 to 53 percent of the time.[75]

An American Automobile Association-sponsored study of multiple-vehicle accidents involving heavy trucks in Michigan notes that the nontruck driver was considered at fault in 69 percent of fatal accidents and 49 percent of serious injury accidents requiring hospitalization.[76] These results suggest that, in addition to developing policies directed at improving the skills of truck drivers, educating the driving public about truck operations and safety requirements is a priority.

[74] OTA calculations from the National Accident Sampling System (1981-85) data.

[75] National Highway Traffic Safety Administration, op. cit., footnote 36, p. 157.

[76] American Automobile Association, *Cars and Trucks: Sharing the Road Safely* (Washington, DC: December 1986).

CONCLUSIONS AND POLICY OPTIONS

Drivers, vehicles, road design characteristics, and ambient environmental conditions form a system in which motor carriers operate. Accident analysis highlights the interrelated nature of highway transportation. The accident studies referenced in this chapter underscore the complexity of this operating system and illustrate the difficulty of isolating single causal factors. Moreover, the precise role that each accident causal factor plays in heavy vehicle accidents is difficult to determine from current accident reports. **OTA finds that better understand” ing by State enforcement officers of accident causation and accident investigation methods is needed. Congress may wish to request the Department of Transportation to add accident investigation to the training provided under MCSAP.**

OTA analysis of Federal and State data shows that the three most common factors associated with heavy vehicle accidents are speed too fast for conditions, the training of the driver, and age and condition of the vehicle. The appropriate speed for conditions is a function of a variety of factors—highway and vehicle design, and environmental and human factors–that must be evaluated by the driver. Any one of them can create unsafe driving conditions. When heavy vehicles operate at speeds higher than appropriate for the road design, the vehicles are closer to their limits of braking and rollover performance capabilities. The time available to the driver to carry out emergency maneuvers is greatly reduced. Other factors, such as insufficient training, fatigue, road design inadequate for trucks, vehicle overloads, and poor visibility can all interact to limit safe speed, In view of the major role speed plays in fatal truck accidents and the many characteristics of heavy vehicles that make them more difficult and time consuming to stop safely, Congress may wish to reexamine the decision to permit truck speeds of 65 mph at the discretion **of States and to explore other methods of controlling excessive speeds for heavy vehicles.**

The heavy vehicle driver operates a complex piece of heavy equipment on roads designed for and occupied by smaller, more responsive vehicles. The driver is frequently the key factor in determining whether or not an accident occurs. However, truck drivers are often ill-prepared or inadequately trained for their jobs. Accident results indicate that better driver training could help reduce both the number and severity of accidents.

Congress may wish to consider requiring **1) that national guidelines for truck driver training be developed and validated; 2) that States must require evidence of training in a school or carrier program meeting the guidelines for the commercial vehicle driver’s license; and 3) that the special handling characteristics of different vehicle configurations be a part of the guidelines. A** key component of such a program is broad representation on the group developing the guidelines, including Federal and State regulatory and enforcement officers, scientists and researchers who study human fatigue factors, and representatives of training schools, carrier management, labor, and vehicle manufacturers.

A large number of heavy truck drivers involved in accidents have poor driving records, including speeding offenses and other unsafe maneuvers that are major causes of accidents. Young, inexperienced drivers are particularly at risk of an accident. There is a strong correlation between truck drivers under the influence of alcohol and increased accident likelihood and severity, Inspection and accident records show that carriers exempt from Federal safety regulations have more violations both for the condition of the vehicle and the qualifications of the driver.

Fatigue can play a major role in accidents, particularly early in a shift and after extended shift length. Older drivers are more affected by fatigue than younger drivers. Drivers of large trucks have shown significant increases in driving errors and decreases in driver alertness due to fatigue well within the current hours-of-service limit. Policy options addressing these driver-related factors may be found in chapter 6.

Vehicle design and operating characteristics have a significant impact on safety. Brake systems are most in need of attention, with brake maintenance a principal concern. Tire condition and performance are also key factors in safely handling a heavy truck. Override/underride accidents occur more often under conditions of reduced visibility, and trucks with underride protection are involved in fewer fatal accidents. Bobtails and combination trucks running empty pose higher accident risks, because of the complicated relationship between brake systems and truck loads. Poor handling and vehicle stability increase the likelihood of rollover, particularly for doubles operations. Policy options to address these issues directly are presented in chapter 5.

Studies of the relative safety of single and double combinations are not conclusive about differences in operating safety. **OTA finds that different safety problems are inherent in each design, and that driver training and experience with doubles and any other heavy vehicle with special handling characteristics can improve their safe operation.**

Truck occupants typically do not protect themselves by wearing seat belts. As a result, ejection and contact with the cab interior often occur, leading to serious injury or fatality. **Congress may wish to consider a requirement for heavy trucks to have substantial safety restraints and for drivers to use them.**

Furthermore, OTA concludes that stepped-up research is needed to improve cab design and safety. A public/private cooperative approach could provide a cost-effective way to integrate public health expertise and manufacturing product development.

Although roadway environment is recognized as a key part of the safety equation, U.S. and State highways are significantly overinvolved in fatal heavy truck accidents. Clear median markings and sturdy barriers are key factors in safety, and Congress may wish to encourage DOT action on developing standards for such median devices on State and rural highways heavily used by trucks.

Finally, the need for cars and trucks to share the roads safely makes education a top priority for DOT and State governments alike. The driving public must be made more fully aware of the handling characteristics of heavy trucks and the potentially life-threatening consequences of a multiple-vehicle crash.