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A Special Issue

Heavy trucks are disproportionately involved in fatal crashes and are a major concern for passenger car operators on the highways because of their intimidating bulk, particularly as cars become smaller. These concerns will become further magnified in coming months as even larger and heavier trucks are permitted under new federal and state laws. So that *Status Report* readers may have a better understanding of heavy truck problems, this issue is devoted primarily to publication of "Influence of Truck Size and Weight on Highway Crashes." This article, which has been prepared as one publication in a series of IIHS *Research Notes,* has been authored by Ian Jones, Howard Stein, and Paul Zador of the Institute research staff.

Influence of Truck Size and Weight on Highway Crashes

Maximum sizes and weights of trucks allowed on public roads were for many years regulated by each state. Under state regulations, permitted truck maximums varied considerably. Maximum gross vehicle weights ranged from 73,280 pounds in Arkansas, Illinois, and Missouri to 129,000 pounds in Nevada. All but eight states restricted the width of trucks to 96 inches. Twin trailers (i.e. a tractor pulling two trailers) were permitted in most western states but not in most of the East.

Since passage of the "Surface Transportation Assistance Act of 1982" (P.L. 97-424), which increased the federal tax on fuel and earmarked the proceeds for highway purposes, the maximum allowable limits on truck sizes and weights are required to be *at least:*

- 80,000 pounds gross weight, with axle loads up to 20,000 pounds for single axles and 34,000 pounds for double axles
- 102 inches in width for all trucks
- 48 feet in length for semitrailers and trailers
- 28 feet in length for each twin trailer

No state is allowed to establish limits on overall truck length. In addition, legal gross vehicle weights must satisfy the limiting conditions in the bridge gross weight formula, which establishes maximum allowable weights for all groupings and spacings of axles. These provisions apply to all trucks operating on interstate and other "qualifying" federal-aid highways. States not complying with the new regulations by October 1983 will have their federal highway aid apportionments withheld.

The basic safety question raised by the new federal provisions for truck size and weight is whether they are likely to increase the already large numbers of deaths and injuries resulting from crashes involving large trucks. Increases could result from higher truck crash frequencies and/or greater crash severity.

Magnitude of the Truck Crash Problem

In 1978, large trucks (10,000 pounds and greater) were involved in 432,000 crashes, about six percent of the national crash total (1). In the same year, large trucks contributed to 12 percent of the national total of fatal crashes.

Trucks have a lower crash rate per mile than cars, but their fatal crash rate is significantly higher. The

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overall crash rate for large trucks in 1978 was 474 per million vehicle miles compared to 825 for cars (1). The fatal crash rate for large trucks, however, was 5.3 per hundred million vehicle miles compared to 2.8 for cars.

Combination trucks (i.e., tractor semitrailers or tractor semitrailers plus trailers) have almost twice the crash rate of straight trucks — 604 per million vehicle miles traveled compared to 351. Combination trucks also have a very high fatal crash rate, 8.6 per hundred million vehicle miles traveled. Thus, although on a per mile basis large trucks are less involved in crashes than passenger cars, large truck crashes usually are much more severe.

A principal reason for the overinvolvement of large trucks in fatal crashes is the difference in weight between trucks and other involved vehicles. In 1977, about 74 percent of fatal crashes involving large trucks also involved other vehicles, and 65 percent of these other vehicles were passenger cars (1). More than 3,000 car occupant deaths resulted from such crashes.

The proportion of all fatal crashes involving trucks has remained at 11 or 12 percent since 1977. During this period, however, the relative risk of death to occupants of passenger cars has been increasing. Table 1 shows the ratio of occupant fatalities in passenger cars to fatalities in trucks for fatal crashes involving cars and trucks. As the table indicates, the relative risk of death to passenger car occupants increased steadily between 1977 and 1980; this is most likely attributable to the increased risk of death in small cars, and these cars increased greatly in number during 1977-1980.

The crash involvement rate of trucks is higher in urban areas than rural areas (2), but the severity of the crashes is greater in rural areas because of higher travel speeds (3). Truck crash involvement rates on controlled access roads (freeways, etc.) are significantly lower than on other roads (4), although even on controlled roads truck involvement in fatal crashes is disproportionately high. Trucks account for 20 percent of vehicle mileage on freeways, but they are involved in 35 percent of the fatal crashes on such roads.

Influence of Truck Configuration On Crash Involvement Rates

Most truck safety studies have focused on the influence of truck configurations on crash involvement. The twin trailer configurations permitted by the fuel tax bill are the so-called "Western Doubles" (already permitted in western states), which consist of two 28-foot semitrailers hauled by a tractor unit. These are not to be confused with "Eastern" or "Turnpike Doubles," which are tractors pulling two 40- to 45-foot semitrailers.

The most recent Federal Highway Administration study has shown that "Western Doubles" have significantly higher crash involvement rates than single tractor trailors, regardless of the type of road on which they are traveling. Their crash rates (shown in Table 2) are based on accident and mileage data collected from selected road sections in California and Nevada where singles and doubles are operated under similar conditions.

TABLE 1

Increased Risk of Death* for Car Occupants Relative to Truck Occupants in Fatal Crashes of Large Trucks and Cars

	1977	1978	1979	1980
TRUCK TYPE				
Single-Unit	16.7	17.8	22.9	25.6
Combination	26.0	28.9	30.8	32.9
ALL LARGE TRUCKS	22.9	25.2	28.6	30.6

Source: Eicher, J.P., Robertson, H.D., and Toth, G.R., "Large Truck Accident Causation," National Highway Traffic Safety Administration Technical Report No. DOT HS-806-300, July 1982.

*E.g., in 1977 a car occupant was 22.9 times more likely than a truck occupant to be killed in a fatal large truck-car crash; in 1980, 30.6 times more likely.

TABLE 2

Truck Crash Rates Per 100 Million Miles
Singles and Doubles by Roadway Type

	RURAL		URBAN	
	Freeway	Nonfreeway	Freeway	Nonfreeway
TRUCK TYPE				
Singles	110	99	214	93
Doubles	228	468	388	428

Source: Vallette, G.R., McGee, H.W., Sanders, J.H., and Enger, D.J., "The Effect of Truck Size and Weight on Accident Experience and Traffic Operations, Volume 3: Accident Experience of Large Trucks." Federal Highway Administration Report No. FHWA/RD-80/137. Washington, D.C., July 1981, PB No. 82 139726.

Cambell and Carsten reached similar conclusions (5). Their rates — based on data from the Bureau of Motor Carrier Safety and the National Highway Traffic Safety Administration's Fatal Accident Reporting System, and exposure data over a two-year period from a random survey of truck fleets — show that doubles are overinvolved in crashes on a per mile basis (Table 3). They also show that crash involvement rates for bobtail tractors (those not pulling a semitrailer) are substantially higher than for tractors pulling either single or double trailers.

The important feature of the studies by Vallette et al. and Cambell and Carsten, from which Tables 2 and 3 are drawn, is that they compute crash rates on the basis of mileage and crash data from comparable trips. Other studies have compared the crash rates of different truck configurations, but their results have been misleading because their exposure data were not comparable for the various types of trucks they studied (6,7,8,9).

Influence of Vehicle Load on Truck Crash Involvement Rates

The study by Vallette et al. (2) is one of the few available that has considered the effects of load. It reported that empty and near-empty combination trucks have substantially higher crash involvement rates — higher by at least a factor of two — than loaded trucks. Empty doubles reportedly show a relationship between weight and crash experience that is similar to that of singles, but for all weight classes doubles have a higher crash involvement rate than singles.

It should be noted that Vallette's findings about the effects of truck weight on crash involvement depend on the correct identification of both empty truck exposure and the involvement of empty trucks in crashes. A data review indicates that these were incorrectly estimated to different extents. Using Vallette's data and making appropriate adjustments to reflect more accurately the exposure and crash involve-

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TABLE 3

Truck Crash Involvement Rates Per 100 Million Miles
(Intercity Use Only)

	FATAL (FARS 1976-78)	INJURY (BMCS 1976-78)
TRAILER TYPE		
Singles	6.5	47.9
Doubles	9.5	126.3
Bobtails	90.0	913.5

Source: Cambell, K.L., and Carsten, O., "Fleet Evaluation of FMVSS 121," UM-HSRI-81-9, Highway Safety Research Institute, Final Report National Highway Traffic Safety Administration Contract No. DOT-HS-6-01286, August 1981.

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ment of empty trucks, the Insurance Institute for Highway Safety has concluded that Vallette's findings were not justified from these data.

However, studies other than Vallette's have reported low crash involvement rates where it was known that trucks were traveling substantial portions of their journeys fully loaded. High crash involvement rates were reported where partial or empty loads were more characteristic (9,10). In addition, engineering considerations indicate that empty trucks are dynamically less stable and cannot generate braking forces as large as loaded trucks. This also suggests higher crash rates for such trucks.

Effect of Increased Gross Vehicle Weights On Truck Braking Performance

The new federal gas tax law allows gross vehicle weights of 80,000 pounds, a higher weight limit than has been allowed in some states. For fully loaded trucks, increasing the weight generally increases stopping distances, because maximum braking capability is exceeded.

Unloaded trucks usually have longer braking distances than loaded trucks. A number of studies (2,9,10) have suggested that empty combination or single unit trucks and "bobtails" have higher crash rates, because truck brake characteristics are biased toward loaded conditions. When trucks are unloaded, premature wheel lockup and consequent stability problems may occur.

Federal motor carrier safety regulations require large trucks (air brake-equipped) traveling at 20 mph to stop in 35-40 feet, and cars to stop in 20-25 feet. In 1974, the Federal Highway Administration tested this stopping capability for 1,200 trucks and 366 cars selected randomly from highway traffic (11). Eighty-seven percent of the cars tested met the 25-foot requirement, but high percentages of the trucks did not meet their stopping requirements; only 29 percent of the single unit trucks, 65 percent of the tractor trailers, and 44 percent of the tractors with twin trailers could stop within their required distances.

A large number of trucks in service thus are not meeting existing stopping distance requirements, even though such requirements are well within truck design capabilities. If future brake systems are designed to accommodate higher gross vehicle weights, without improved brake technology such as load proportioning or anti-lock systems, the already large difference in braking distance between cars and trucks is likely to increase. Additionally, the disparity between loaded and unloaded truck braking distances will increase, as will the inherent stability problems caused by this disparity.

Cargo Type and Truck Crash Involvement

The consensus of studies of trailer configuration and cargo type is that tanker trucks and flatbed trailers operated as doubles have much higher crash rates than those operated as singles — higher by a factor of four in the case of tankers, and by a factor of more than two for flatbeds (2,9). The crash rates for dump trucks also have been found to be consistently high, regardless of the trailer configuration (10). Again, these results indicate that trucks which operate exclusively either heavily loaded or empty have high crash involvement rates.

There is some discrepancy concerning rates for van trailer doubles. Their crash involvement rates have been found to be higher than singles in one study (2), but about the same in another study (9). However, van doubles included in the latter study had a high proportion of their crashes at night and on divided highways. This suggests a use pattern which would tend to reduce exposure to multiple vehicle crashes.

Influence of Truck Length and Width On Crash Involvement

For single trailer configurations, there is some evidence of decreasing crash rates with increasing trailer lengths (2). However, there are insufficient data to

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analyze crash involvement rates by individual cargo area configurations, and this may confound the results. In a comparison of 40- and 45-foot semitrailers in six states, no significant differences in crash rates were found (2).

Because trucks and trailers have almost universally been restricted to a maximum width of 96 inches, there are insufficient data to determine whether increasing overall truck widths by six inches — as provided for in the new federal gas tax bill — would affect crash rates.

Influence of Truck Dimensions on Crash Severity

Because the mass ratio between a large truck and a car weighing 3,000 pounds already is in excess of 20 to 1, there is little evidence that increasing the maximum weight of a truck to 80,000 pounds would significantly affect the already unacceptably high risk of serious or fatal injury in crashes between cars and trucks. Primary factors influencing injury in a crash include the velocity change that the car experiences, together with the protection afforded to vehicle occupants; these would not be affected appreciably by truck weight increases.

Although Herzog (12) has reported that the risk of fatality for non-truck occupants increases steadily with truck weight, the effects of road type and location were not considered. It seems probable that the apparent weight effect may have been a surrogate for increased impact speed. This view is endorsed by Hedlund (3), who has concluded that among large trucks weight is not an issue in determining fatality risk, in part because risk can be predicted from crash location (rural or urban) and road type (number of lanes), both of which are surrogates for vehicle speed.

Summary and Conclusions

Large trucks account for six percent of the nation's highway crashes and 12 percent of all fatal crashes. On a per mile basis, trucks are less frequently involved in crashes than cars, but trucks are involved in twice as many fatal crashes. The proportion of fatal crashes involving trucks has remained constant since 1977, while the relative risk of death for car occupants in crashes with large trucks has steadily increased from 23:1 to 31:1.

Combination trucks — tractor semitrailers or tractor semitrailers plus trailers — have almost twice the crash rate of straight trucks, and a fatal crash involvement rate three times that of cars. Twin trailer configurations — tractor semitrailers plus trailers — have higher crash involvement rates than tractor semitrailers. However, the exposure of different truck types varies in terms of miles traveled, kinds of highways used, and times of day operated, and the influence of these variations on crash rates has not been adequately quantified. Until detailed exposure data are collected, comparisons of truck crash experience by configuration will be limited.

In the near future, trucks of increased size and weight, as well as double configuration trucks, will be permitted by federal law on the interstate system and other "qualifying" federal-aid highways in all states. While researchers have had difficulty in precisely quantifying the influence of truck size and weight on crash involvement, there is evidence that the new legislation will almost certainly increase the magnitude of the truck crash problem.

Notes

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2. Vallette, G.R., McGee, H.W., Sanders, J.H., and Enger, D.J., "The Effect of Truck Size and Weight on Accident Experience and Traffic Operations, Volume 3: Accident Experience of Large Trucks." Federal Highway Administration Report No. FHWA/RD-80/137. Washington, D.C., July 1981, PB No. 82 139726.

3. Hedlund, J., "The Severity of Large Truck Accidents," National Highway Traffic Safety Administration Report No. DOT-HS-802-332, April 1977.

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Influence of Truck Size And Weight on Highway Crashes (Cont'd from Page 5)

7. Bureau of Motor Carrier Safety "Safety Comparison of Doubles versus Single Semitrailer Operation," Federal Highway Administration, Washington D.C. November 1977.

8. Yoo, S.C., Reiss, M., and McGee, W.H. "Comparision of California Accident Rates for Single and Double Tractor-Trailer Combination Trucks," Federal Highway Administration Report No. FHWA-RD-78-94, March 1978.

9. Chiracharaia, T. and O'Day, J., "A Comparison of Accident Characteristics and Rates for Combination Vehicles with One or Two Trailers," Highway Safety Research Institute, PB-82-209412, Federal Highway Administration, Washington, D.C., May 1982.

10. Heath, W.M., "California Tank Truck Accident Survey," California Highway Patrol, Enforcement Services Division. December 1981.

11. Winter, P.A., "1974 Brake Performance Levels for Trucks and Passenger Cars," Bureau of Motor Carrier Safety, Federal Highway Administration, Washington, D.C., 1975.

12. Herzog, T.N., "Injury Rate as a Function of Truck Weight in Car-Truck Accidents," National Highway Traffic Safety Administration Report No. DOT-HS-801-472, NHTSA Technical Note N43-31-7, June 1976.

Federal Rulemaking Languishes on Heavy Truck Safety Issues

In a technical report published last year the National Highway Traffic Safety Administration (NHTSA) pointed out that large trucks "are a serious safety problem on our nation's highways." Yet rulemaking activity to address the problem has been at a virtual standstill for many months.

In a regulatory agenda published last October, NHTSA summarized the status of heavy truck rulemaking in four areas:

- **Vehicle brake systems** — Although advance notices of proposed rulemaking have been on file for three and four years, a new brake standard for trucks has not been prepared. The old standard, FMVSS 121, is still the only operative air brake rule, but the most significant parts of it were voided by federal court action five years ago. The present status of rulemaking: "Research underway."

- **Truck rear underride protection** — Long-delayed rulemaking on this issue finally was proposed by NHTSA two years ago, to be effective Sept. 1, 1983. The present status: "Further action to be determined."

- **Commercial vehicle conspicuity** — An advance notice of rulemaking was issued nearly three years ago to amend FMVSS 108 with performance requirements for tail lighting and marking of heavy vehicles. Present status: "Further action to be determined."

- **Rearview mirror systems** — A notice of proposed rulemaking to amend FMVSS 111 to improve heavy vehicle mirror systems was proposed more than four years ago. The present status: "Further action to be determined."

As the new IIHS *Research Note* on the influence of size and weight on truck crashes (see article, Page 1) makes clear, the quality of truck braking is a vital factor contributing to the over-involvement of heavy vehicles in fatal crashes. Yet since the brake antilock and stopping distance requirements of FMVSS 121 were declared invalid in 1978, there has been little effective control of truck braking systems. The only stopping distance requirement is established for service brakes and for emergency brakes at 20 mph. The federal court order cancelled an earlier FMVSS 121 requirement for a prescribed stopping distance from 60 mph.

Indeed, the brake standard that survived the court decision failed even to require brakes on each axle. To correct this, NHTSA quickly amended FMVSS 121 to stipulate that trucks, buses, and trailers must be equipped with brakes acting on all wheels. (See *Status Report*, Vol. 14, No. 17, Nov. 28, 1979.)

Meanwhile, NHTSA issued advance notice of proposed rulemaking for a new brake standard to be designated as FMVSS 130. In February 1979 it proposed such a rule to cover basic braking problems and replace FMVSS 121 in its entirety. (See *Status Report*, Vol. 14, No. 4, March 8, 1979.) In February 1980 the agency issued a second rulemaking notice, dealing with a long-term course of action to cover evolving brake technology. (See *Status Report*, Vol. 15, No. 5, March 26, 1980.) The agency now says that research for these rules is underway.

Federal involvement in the underride protection issue dates back to the early 1950s. The Bureau of Motor Carriers (under the Interstate Commerce Commission) established a regulation in 1953 that heavy motor vehicles in interstate commerce be equipped with a rear end device to help prevent underride. The regulation was not specific as to the design and strength of the device, but provided it was to extend to within 30 inches of the ground.

When underride crashes continued to be a problem under the existing rule, NHTSA proposed a new regulation in 1969 which would have established strength tests for rear-end protection devices and provided that they have 18 inches of clearance from the ground. The agency decided in 1971 to terminate this rulemaking.

In 1976, the Insurance Institute for Highway Safety conducted a series of tests in which passenger cars were crashed into the rear of a semi-trailer. By testing a prototype underride protection device, the Institute demonstrated how the underride crash injury toll could be reduced. At the request of the Senate Consumer Subcommittee, the Institute showed films of the crash tests at a public hearing. Following the hearing the committee chairman urged the Department of Transportation to expedite an effective federal requirement for underride devices. NHTSA and the Bureau of Motor Carrier Safety (now under the Federal Highway Administration) published an advance notice of proposed rulemaking in August 1977. A notice of proposed rulemaking did not come until Dec. 30, 1980. No further action has been taken. (See *Status Report,* Vol. 16, No. 3, Feb. 25, 1981.)

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Special Issue

This special issue of** Status Report **deals exclusively with the subject of heavy truck problems. Other special issues have focused on the following subjects:

Small Car Review — Vol. 17, No. 20 (1982)
International Symposium on Drunk Driving — Vol. 17, No. 18 (1982)
Small Car Hazards — Vol. 17, No. 1 (1982)
Teens and Autos — Vol. 16, No. 14 (1981)
Drinking and Driving — Vol. 16, No. 5 (1981)
Utility Vehicle Rollovers — Vol. 15, No. 19 (1980)
Air Bags — Vol. 14, No. 13 (1979)

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