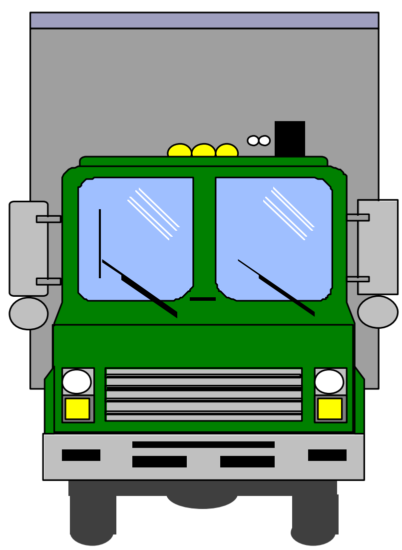
CHAPTER VIII

Safety



Introduction

Considerable debate has focused on the safety of larger and heavier trucks, and whether allowing truck sizes and weights to increase beyond what is commonly found today would degrade safety. Most studies that have attempted to answer this question have centered on two approaches—crash data analyses or comparative analyses of the safety-related engineering performance capabilities of various truck configurations. This study used both approaches. In addition, methods for relating changes in vehicle stability and control performance to changes in the expected number of truck crashes were considered.

Multiple factors that contribute to truck crashes include:

- Driver performance and behavior;
- Roadway design and condition;
- Weather and light conditions;
- Vehicle design, performance and condition;
- Motor carrier management commitment to safety and practices; and

Institutional issues such as motor carrier safety regulation and enforcement.

Within this broad context, isolating crash rates as only a function of truck size and weight (TS&W) variables is difficult. Because larger and heavier trucks are a relatively small subgroup of all trucks, differentiating their crash involvement patterns from that of other truck types becomes problematic. Available crash data bases are capable of ascertaining trends in overall truck safety and broad distinctions among vehicle types, but are less capable of clearly differentiating trends for smaller subsets of vehicles. There are, nevertheless, several key trends that are evident relative to truck safety in general and TS&W policy choices in particular. First, numerous analyses of crash data bases have noted that truck travel, as well as all vehicle travel, on lower standard roads (that is, undivided, higher speed limit roads with many intersections and entrances) significantly increases crash risks compared to travel on Interstate and other high quality roadways. The majority of fatal crashes involving trucks occur on highways with lower standards. Also, operating in higher traffic densities increases crash risk as a result of increased conflict opportunities with other vehicles. TS&W requirements affect operators' choices on which roads they will operate which types of trucks.

Second, TS&W policies influence vehicle stability and control because they directly affect key vehicle design attributes such as number of axles, track width, wheelbase, number of units in a combination, loaded weight, and overall length. Vehicle performance tests and engineering analyses have highlighted the significant differences that exist in the stability and control properties of different sizes, weights, and configurations of trucks. Some larger and heavier trucks are more prone to rolling over than other trucks; some are less capable of successfully avoiding an unforeseen obstacle when traveling at highway speeds. Some negotiate tight turns and exit ramps better than others; some can be stopped, maintaining stability, in shorter distances than others; and some climb hills and maneuver in traffic better than others. The influence of these differences increases when traffic conflict opportunities increase.

Larger and Heavier Truck Crash Patterns

Many past studies have attempted to identify the singular effect on crash propensity of size and weight differences among various truck configurations, with particular focus on double-trailer combinations or, more specifically, longer combination vehicles (LCVs). Their conclusions vary from slightly positive to slightly negative, to no difference. This disparity in findings is explained, in large part, by the different methodologies and data sets used to conduct the various studies.

Few of these past studies controlled for the confounding factors that can significantly influence overall crash rate results, principal among these being differences in operating environments. Thus, while some of these study results may appear to indicate no significant problems or concerns, the collective results cannot be used to infer what the crash experience of multitrailer combinations would be if the operational conditions under which they are now being used were to change. The results of these past studies merely reflect what has occurred under the existing restricted operating conditions.

Available data sets are capable of differentiating between the crash experiences of single-unit trucks (SUTs) and combination vehicles (principally tractor semitrailer) within the broader class of medium to heavy trucks. Further, truck crash data are available which distinguish between single-trailer and multitrailer combinations, however, this latter group includes all multitrailer combinations. Differentiation among the number or lengths of trailers in these combinations, or their operating weight, is typically not possible from reported data. This has the effect of including in the crash sample Surface Transportation Assistance Act (STAA) doubles (tractor and two 28-foot trailers weighing no more than 80,000 pounds), along with longer double-trailer and triple-trailer combinations weighing more than 80,000 pounds referred to as LCVs.

STAA doubles dominate multitrailer combination crash history since they are the most common vehicles in

Figure VIII-1. Efforts to Establish Longer Combination Vehicle Crash Rates

The Federal Highway Administration (FHWA) was not able to obtain sufficient data to estimate crash rates for longer combination vehicles (LCVs) because of the limited extent of LCV operations. One study did determine crash rates for LCVs but not by roadway and area type. However, this is not sufficient as these two parameters play a significant role in large truck crashes.

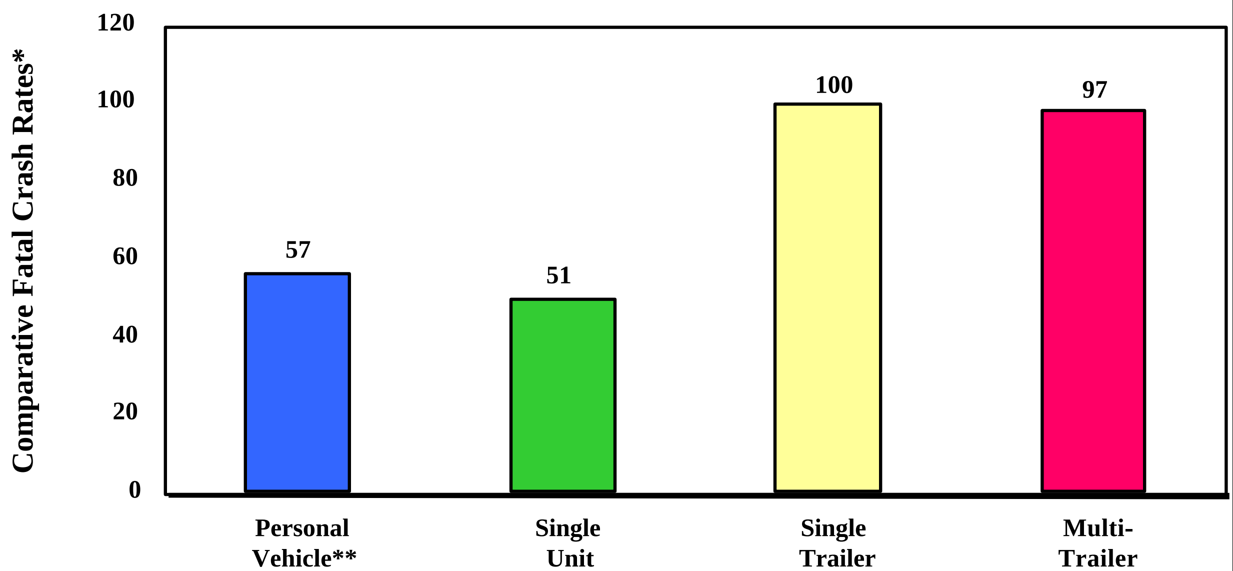
Using data from Utah, which collects the LCV crash data in the needed detail, the FHWA effort determined that: (1) over 20 years of data collection would be required in order to compute statistically reliable crash rates for long double- and triple-trailer combinations, and (2) these rates would be for Interstate highways only. If data were available from four other States in which LCVs now operate, this time could be reduced to 6 years to 8 years; but still the rate could only be applied to Interstate highways. Although not typically, LCVs do operate on non-Interstate highways to a small extent, which means that even more time would be needed to reliably estimate their crash experience on these highways.

use in this truck category. However, LCVs are configured similarly and have similar stability and control performance characteristics and, therefore, are likely to have similar crash propensities, although increasing the lengths of trailers improves some of these characteristics if weight is not increased.

Figure VIII-2 shows the 1991-1995 fatal crash involvement rates for passenger cars and for three subgroups of medium to heavy trucks: SUTs, single-trailer combinations, and multitrailer combinations. As can be seen, when aggregated data are used, multitrailer combinations exhibit a 3 percent lower overall fatal crash rate than single-trailer combinations, an apparent finding of concern for this study.
This picture changes, however, when the fatal crash rates for single-trailer and multitrailer combinations are disaggregated by roadway functional class, as shown in Figure VIII-3.
Several patterns are evident. First, the involvement rate on rural Interstate highways, is 300 percent to 400 percent lower than it is on other rural roadway types and is generally the same for all vehicle types. Of particular note is that off the Interstates, the involvement rates for combination trucks are markedly higher than for cars and SUTs and when compared on the same rural roadway types (where these vehicles accumulate the majority of their travel and, therefore, exposure to crash risk), multitrailer combinations consistently exhibit higher rates than single-trailer combinations.

These crash rate differences by roadway functional class become important when one considers the operational use patterns of single-trailer and multitrailer combinations. Figure VIII-4 shows the travel distribution patterns of

Figure VIII-2. Fatal Crash Rates by Vehicle Class

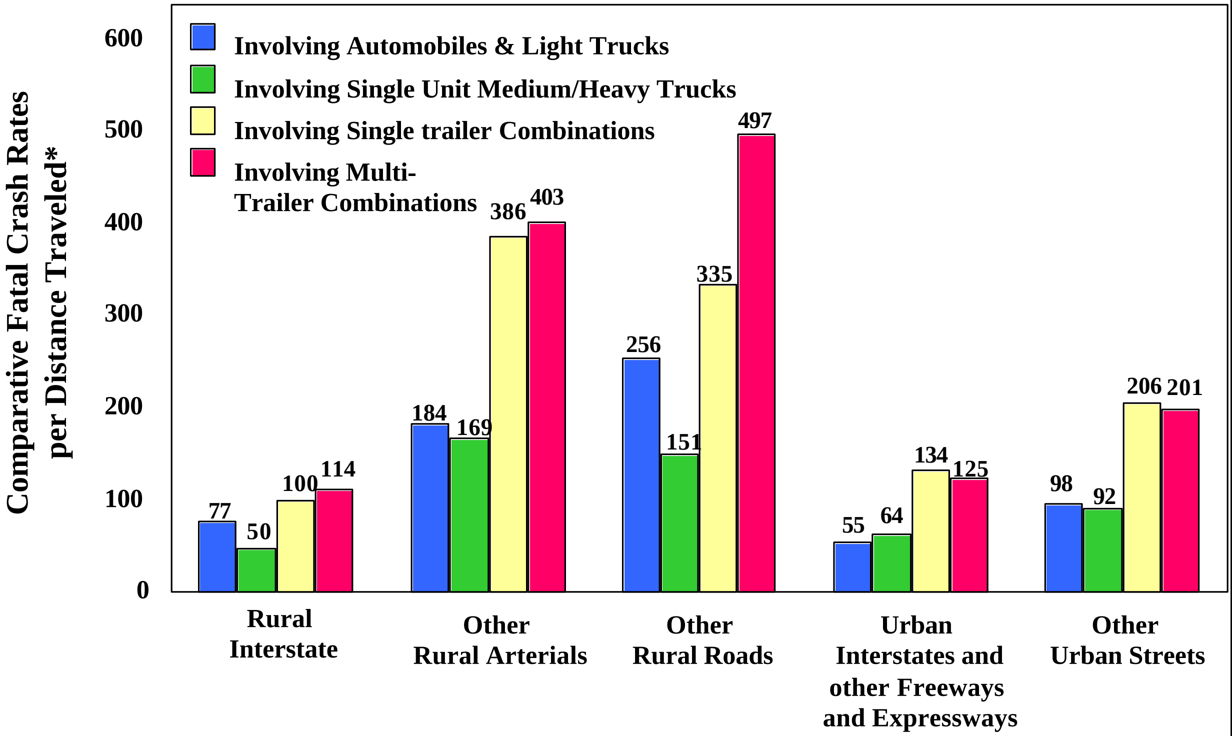


* Normalized relative to VMT for single trailer combinations which is set equal to 100.

** Includes automobiles, light trucks, and sport utility vehicles.

Source: FARS 1991-1995 (crash data), HCAS, 1997 (travel data)

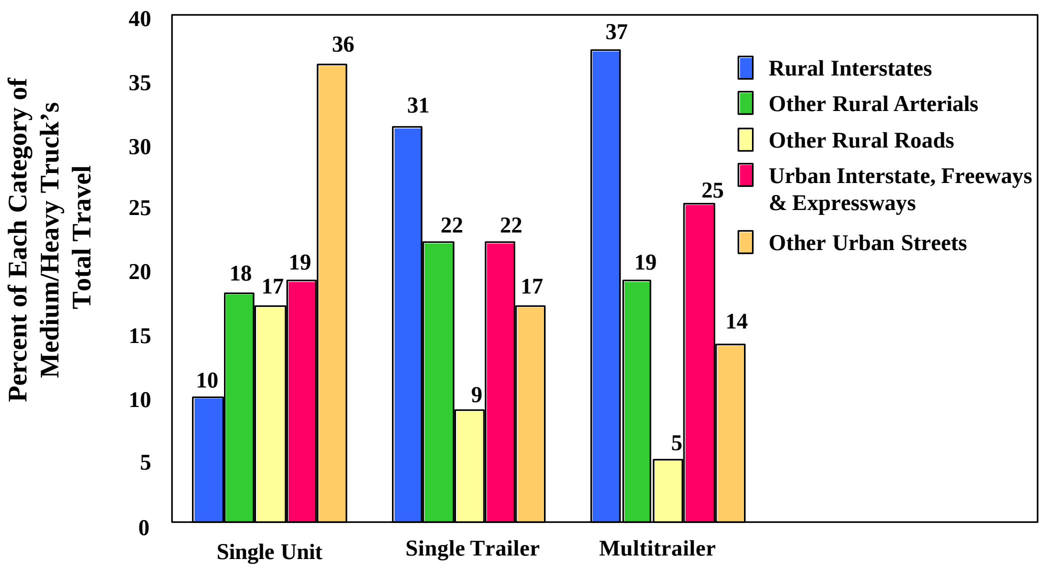
Figure VIII-3. Fatal Crash Rates on Different Highway Classes



* Normalized relative to single trailer combination units on rural interstates which is set equal to 100

Source: FARS 1991-1995 (crash data), HCAS, 1997 (travel data)

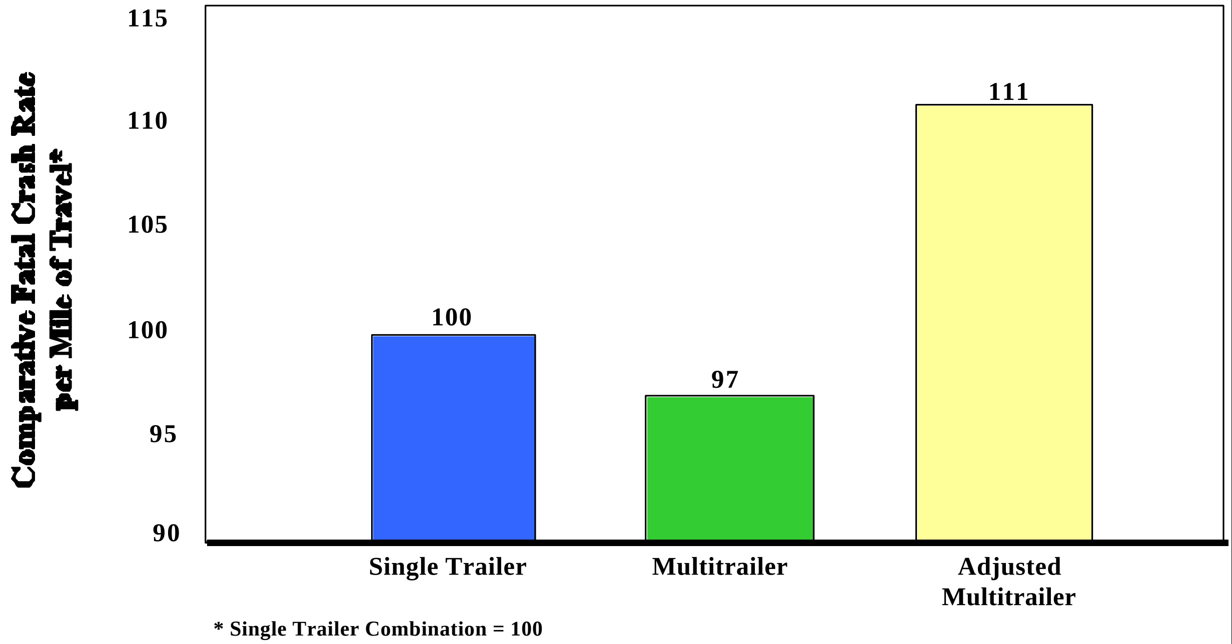
Figure VIII-4. Travel on Different Highway Classes by Single and Multitrailer Combinations.



* Based on VMT distribution estimates for 1994.

Source: Highway Cost Allocation Study, 1997

Figure VIII-5. Normalized Fatal Crash Rates



the three principal subgroups of medium to heavy trucks. As can be seen, multitrailer combinations accumulate 62 percent of their mileage on Interstate and comparable roads, compared to 53 percent for single-trailer combinations. Thus, single-trailer combination crash history is more heavily weighted and influenced by the risk exposure they experience on non-Interstate roads compared to that of multitrailer combinations.

These findings highlight a number of important issues. First, the use of aggregated rate data [that is, total number of crashes divided by total vehicle-miles-of-travel (VMT)] masks important operational differences between these two vehicle types. To adequately compare the two, it is necessary to gauge their performance in comparable operating environments. Second, any shift or increase in truck traffic, especially for multitrailer combinations, off Interstate highways would significantly increase safety risks.

One technique used to predict the future crash experience of multitrailer combinations, assuming differences in use patterns are removed from the analysis, is to apply the travel distribution pattern of single-trailer combinations to the crash rate histories of the multitrailer combinations and compute an adjusted crash rate. The result (see Figure VIII-5) indicates that, under conditions of generally unrestricted use similar to that of single-trailer combinations, multitrailer combinations—as they are currently designed and configured—could be expected to experience an 11 percent higher overall fatal crash rate than single-trailer combinations. This finding is significant in terms of the debate on “the safety of LCVs.” It is important to note that this analysis technique assumes that single-trailer and multitrailer combinations: (1) have the same design features as they do today, and (2) will operate under the same

Figure VIII-6. Trucks Involved in Fatal Crashes on Interstate Highways – 1994

roadway environment at some
point in the future, which may or may not ever occur.

This type of analysis sheds light on the significant contribution that roadway type plays in crash causation but does not make clear the strong influence that another important aspect of operating environment – namely traffic density -- has on crash likelihood. As the data portrayed in Figures VIII-6 to Figure VIII-8 indicate, 72 percent of the fatal truck crashes, which occur in this country on both Interstate and non-Interstate roads, occur in essentially the eastern half of the country. These inherent differences exclusive of any other accident contributing factors, are important in several respects. First, past assessments of LCV crash histories, have tracked their experiences where they have been allowed to operate, which is predominantly on higher quality roads in the western region of the country.

Second, if LCV use expanded into the more heavily traveled, higher risk eastern portion of the country, it is not possible to project with certainty what the crash rates for larger and heavier trucks would be. But, this analysis indicates that crash rates would be higher than past history would suggest.

Vehicle Stability and Control

In addition to using crash data, the safety performance of larger and heavier trucks may be assessed based on their comparative stability and control performance properties. Trucks have a propensity to swerve out of their travel lane or roll over out-of-the-ordinary crash avoidance, when sharp turns or out-of-the-ordinary crash avoidance, lane-change

Figure VIII-7. Trucks Involved in Fatal Crashes on Non-Interstate Highway – 1994

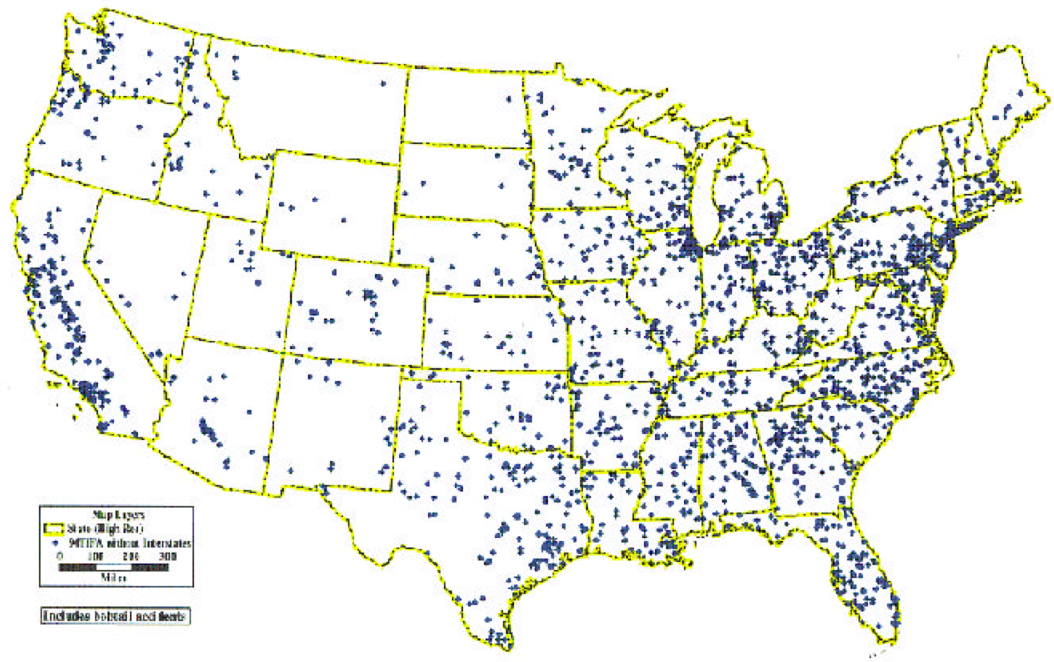
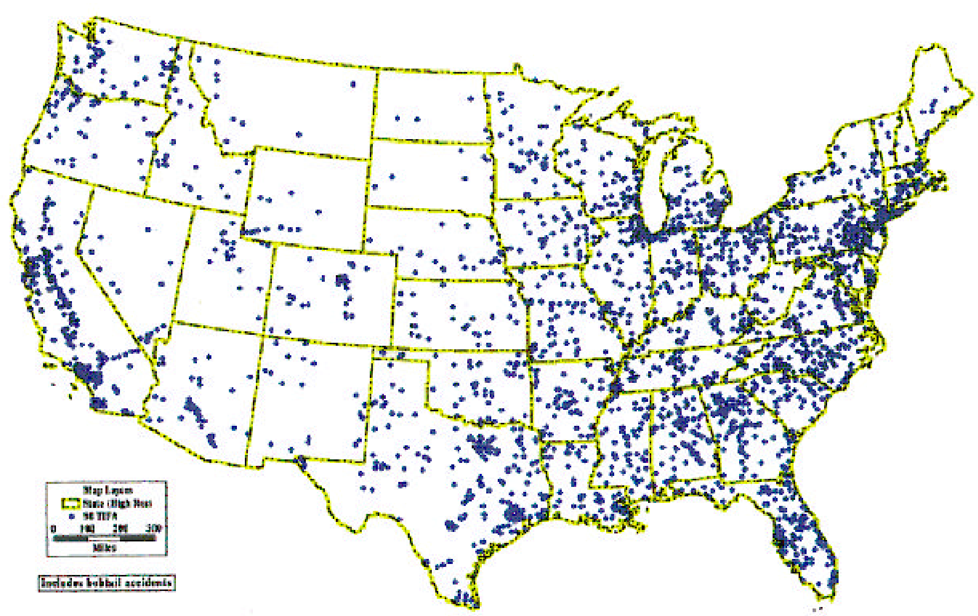


Figure VIII-8. Trucks Involved in Fatal Crashes on All Roadways – 1994



evasive maneuvers are attempted. Vehicle control issues include braking and off-tracking. Offtracking measures how well the back of a vehicle follows the front when going around a curve or making a turn.

Vehicle Stability

Rollovers account for 8 percent to 12 percent of all combination truck crashes, but are involved in approximately 60 percent of crashes fatal to heavy truck occupants. They greatly disrupt traffic when they occur in urban environments, particularly when hazardous materials are involved. There are two types of maneuvers, which if attempted at too high a speed, can cause trucks to roll over: steady-state turn induced rollover and evasive maneuver rollover.

Steady-State Turn Induced Rollover

This type of rollover typically occurs when a truck is traveling too fast and attempts a sweeping turn, usually at exit-ramps on Interstate highways or other freeways. The maneuver creates enough centrifugal force to exceed the vehicle's capability to counteract that force. All vehicles, but especially heavy trucks, are susceptible to this type of crash. The principal attributes which affect a vehicle's rollover tendencies are: the height of the center-of-gravity (c.g.) for the cargo, the track width of the vehicle, and suspension and tire properties.

The relevant measure of a vehicle's performance in this regard is its static roll stability (SRS). SRS is described in terms of the minimum amount of lateral acceleration needed to result in wheel lift-off from the ground—the point at which the vehicle then rolls over. Higher SRS scores indicate better performance in this regard. Currently designed, "typical" tractor semitrailer combinations, when fully loaded to the current 80,000 pounds gross vehicle weight (GVW) limit, generally have SRS thresholds on the order of 0.30 g’s-0.33 g's. By comparison, a car does not roll over until its lateral acceleration reaches 0.8 g’s to 1.0 g's, and even then, it must usually be "tripped" by a curb or other surface discontinuity.

Larger, heavier vehicles do not necessarily have poorer performance in terms of SRS than do smaller, lighter ones. The important variable is how the payload is distributed along the length of the vehicle. Increasing the c.g. height of a vehicle by loading more payload onto a given vehicle increases its rollover propensity. Other critical factors are the travel speed of the vehicle around a curve, and the "tightness" of the curve as measured by the curve radius.

Evasive Maneuver-Induced Rollover

This type of rollover is primarily associated with multitrailer combinations, "doubles" and "triples,” where it is the result of a “crack-the-whip” phenomenon. Single-trailer combinations do not normally experience this phenomenon, but if loaded high enough, they and other trucks can roll over as well.

Evasive-maneuver rollovers occur when vehicles are traveling at speeds generally above 50 miles-per-hour (mph), with faster speeds exacerbating the tendency and lower speeds completely eliminating it. The maneuver that triggers this response is an abrupt left then right or right then left, single-lane change maneuver as might be needed to avoid an unexpected obstacle in the truck’s path (see Figure VIII-9).

In this evasive maneuver, the lateral acceleration experienced at the tractor is amplified at each succeeding trailer in the combination, such that the rearmost trailer in the combination can experience lateral acceleration levels two to three times that of the

Figure VIII-9. Standard Evasive Maneuver

The Society of Automotive Engineers has developed a standardized test for evaluating vehicle dynamic stability performance (J2179). The test includes a rapid steering input sufficient to move the truck to one side or the other 4.8 feet within a longitudinal (in the direction of travel) distance of 200 feet while traveling at 55 miles per hour. This test is used to determine the rearward amplification and load transfer ratio for a truck configuration.

tractor. Thus, seemingly benign maneuvers successfully executed by the tractor can result in the rearmost trailer skidding sideways into adjacent lanes, or worse, rolling over.

The principal vehicle attributes which affect this tendency are: (1) the number of articulation or coupling points in the combination—doubles usually have three, whereas triples have five—with more articulation points increasing the tendency; (2) the wheelbase lengths of the trailers in the combination, with shorter trailers increasing the tendency; and (3) the SRS's of the individual trailers in the combination, with lower individual SRS's increasing the likelihood of a rollover. There are two measures which describe this performance attribute. The first is a dimensionless ratio, termed the rearward amplification (RA) factor, which is the ratio of the lateral acceleration experienced at the rearmost trailer in a combination to that of the tractor, when a lane-change evasive maneuver is executed. In this case, values of 2.0 or less for this performance measure indicate acceptable performance. Semitrailer combinations have an RA equal to 1.0, that is, there is essentially no rearward amplification. Currently designed STAA doubles (two 28-foot trailers) have RAs on the order of 1.7.

Reducing the number of articulation points in the combination from three to two improves its performance by 80 percent. Doubling the length of the trailers improves their performance 100 percent. On the other hand, eliminating articulation points and lengthening trailers degrades low-speed offtracking performance. Figure VIII-10 describes actions that can be taken to improve vehicle stability.

The second measure is also a dimensionless ratio termed load transfer ratio (LTR). It is a measure of the dynamic roll stability of a truck.

When a truck executes a lane change or other dynamic maneuver, sideward forces load one wheel on an axle more than the other. The effect of this shifting of the axle load to one side of the truck can be significant at speeds above 50 mph. Under these conditions, the LTR represents the proportion of the total axle load that is carried on one side of the truck relative to the other. A perfectly balanced vehicle has 50 percent of the load on an axle on one wheel and 50 percent on the other. At LTR's much above 0.7, most trucks or trailers are highly susceptible to rolling over, while at a value of 1.0, rollover is almost certain to

Figure VIII-10. Controlling Vehicle Instability

In the case of single-unit trucks, the tendency to transfer load from one side to the other is strongly influenced by the truck's tire and suspension properties, its physical dimensions (primarily track width and center of gravity height), frame torsional stiffness (resistance to twisting), and number of axles.

In the case of multitrailer combinations, roll coupling is a vehicle design feature which counters dynamic roll instability. It uses a coupling feature designed to take advantage of the fact that two adjacent units in a multitrailer combination roll in different directions during a dynamic lane change maneuver. By making the coupling or hitch more rigid along the roll axis, each unit in the combination "helps" the other counteract excessive roll forces.

Roll coupling is a special attribute of "B-train" and "C-dolly" connections. A "B-train" connection between two trailers in a twin configuration essentially creates a semitrailer/semitrailer combination with two articulation points instead of three. A standard “fifth-wheel” connection is used to couple the two trailers together, thereby providing significant counter-roll forces between the two trailers.

A "C-dolly" connection, which converts a semitrailer to a full trailer, also provides roll and coupling stiffness through the use of two drawbars between trailers. "A-dollies", which are used today, have one drawbar. Both B-train and C-dolly connections between two trailers effectively eliminate an articulation point and provide a large counter-roll force for each of the two trailers when they are rolling in opposite directions during an evasive lane change maneuver.

The same practical effect can be accomplished through the use of such advanced technology as electronically controlled braking systems, which employ load and speed sensitive differential braking to maintain the direction of the individual units in combination vehicles making evasive maneuvers. This greatly reduces the crack-the-whip phenomenon and dynamic roll instability inherent in multitrailer vehicles especially. These systems are currently in the demonstration research stage, but they can be expected to be operational in the near future.

occur given a steering input equal to the standard test (see Figure VIII-9). Lower values of this performance metric indicate comparatively better performance.

Vehicle Control

Braking performance is a general concern that applies to all trucks, and it is not particularly influenced by changes in truck sizes or weights. This assumes, however, that the required number of axles and brakes are added as the vehicle's weight increases and all of the vehicle's brakes are well maintained and functional. However, having more axles and brakes add to brake maintenance problems.

Counterbalancing brake

maintenance concerns is the fact that anti-lock braking systems (ABS) are being fitted to all new truck tractors and trailers. ABS will enhance vehicle stability and control during hard braking for all trucks, but it will be especially beneficial to multitrailer combinations as they have more brakes, due to more axles, to be properly applied under the control of these braking systems.

Finally, the additional measures to indicate a vehicle's ability to negotiate turns and otherwise "fit" within the dimensions of the existing highway system principally include low-speed offtracking and overall vehicle length. Excessive offtracking can disrupt traffic flow and/or damage the infrastructure. Longer length vehicles require more time to pass or to be passed by other vehicles on a two-lane road. Also, increasing vehicle weight without increasing engine power results in lower acceleration. Lower acceleration increases the potential for traffic conflicts on grades and when merging at freeway interchanges.

All these concerns can be incrementally exacerbated as trucks increase in size or weight and, therefore, also need to be addressed when considering the ability of a given segment of roadway to safely accommodate these vehicles. These properties are discussed in Chapter IX, Traffic Operations.

Comparison of Vehicle Stability and Control Performance

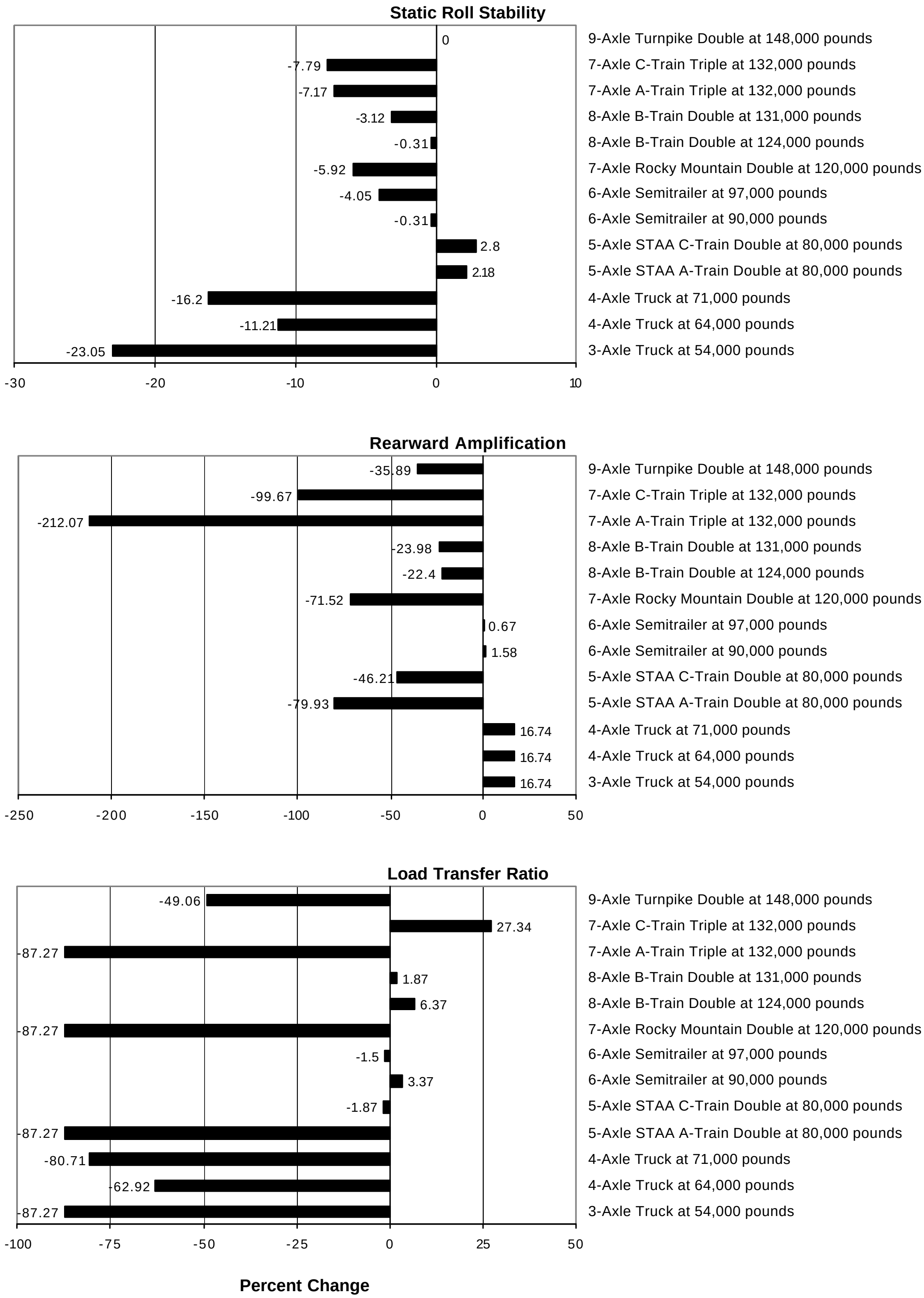
As part of this study, the performance of 14 truck configurations was analyzed, using the three vehicle stability performance measures described above. Table VIII-1 provides the vehicle weights and trailer (or cargo body) lengths, the number of axles for each truck or unit (if the vehicle is a combination), the number of articulation points in the combination, and type of hitching used in multitrailer combinations. These are the parameters that determine vehicle stability and control performance. For these analyses, worst-case loading conditions (maximum payload weight and c.g. height) and uniform loading within the available cargo body space were assumed.

Figure VIII-11 indicates how the performance of 13 study vehicles compares to that of the standard five-axle semitrailer combination loaded to 80,000 pounds. In practically all cases the performance of the larger multitrailer combinations, as well as SUTs, do not equal---in some instances by wide margins—the performance of the standard tractor semitrailer that is now in widespread use. The indicated weight for each configuration in Figure VIII-1is the sum of weights allowed on each axle group. These are the same loaded weights used to estimate scenario impacts.

It is important to note that the relative results reported in Figure VIII-11 would vary if a different base comparison vehicle were chosen. In the case of multitrailer combinations, another comparison that is often made is between the performance of different larger multitrailer combinations and a standard STAA double. When this is done, some of the multitrailer combinations (notably B-train and some C-train double combinations) perform comparatively better than STAA doubles.

Further, the results in Figure VIII-11 pertain only to presently designed and

Figure VIII-11. Comparison of Stability and Control Measures for Scenario Vehicles Relative to Five-Axle Tractor Semitrailer



configured heavier vehicles. Past studies have shown that significant performance improvements are possible through the use of different vehicle designs—such as wider vehicles and lower floor heights; new equipment such as enhanced electronic braking, tire, and suspension systems; and B-train and C-dolly trailer connections.

Table VIII-1 confirms that presently-designed multitrailer combinations experience proportionally more fatal rollover crashes than do single-trailer combinations. This statistical observation supports the use of engineering performance evaluations of these vehicle types as a means of assessing their relative crash likelihood. Although these are simulation model results, they predict vehicle stability performance with greater accuracy than crash data.

Assessment of Scenario Impacts

This section draws on information from the previous sections of this chapter to qualitatively compare the effects of the policy scenarios on highway safety. The scenarios can be qualitatively judged in terms of the relative shifts

Table VIII-1 Vehicle Descriptions and Specifications

Configuration	Loaded Weight (pounds)	Number of Axles on Power Unit, Trailer(s)	Box or Trailer Length(s) (feet)	Number of Articulation Points	Type of Trailer-to-Trailer Hitching
Five-Axle Semitrailer (Baseline Vehicle)	80,000	3,2	53	1	None
Three-Axle Single-Unit Truck	54,000	3	20	0	None
Four-Axle Single-Unit Truck	64,000	4	25	0	None
	71,000	4	25	0	None
Six-Axle Semitrailer	90,000	3,3	53	1	None
	97,000	3,3	53	1	None
Five-Axle A-Train STAA Double	80,000	2,1,2	2@28	3	A-Dolly
Five-Axle C-Train STAA Double	80,000	2,1,2	2@28	3	C-Dolly
Seven-Axle Rocky Mt. Double	120,000	3,2,2	1@53,1@28	3	A-Dolly
Eight-Axle B-Train Double	124,000	3,3,2	2@28	2	B-Train
	131,000	3,3,2	2@33	2	B-Train
Seven-Axle A-Train Triple	132,000	2,1,2,2	3@28	5	A-Dolly

Table VIII-2 Exposure Change Associated With Each Scenario

Truck Configuration	Number of Axles	Base Case Vehicle-Miles-of-Travel (VMT)	Tractor (Truck) VMT Change (percent difference from Base Case)					
			Uniformity	H.R. 551	N. Am. Trade		LCVs Nat'wide	Triples Nat'wide
					51,000 Tridem Axle	44,000 Tridem Axle		
Single Unit	3	9,707	2.5	0	-16.2	-12.1	0	0
	4	2,893	11.4	0	23.7	24.3	0	0
Semitrailer	3 and 4	14,049	0	0	0	0	0	0
	5	83,895	8.7	0.02	-70.2	-73.5	-76.6	-72
	6 and 7	6,595	-44.5	0.03	3.0	2.4	0	0
Truck Trailer	4 - 6	3,638	2.7	0	0	0	0	0
STAA Double	5 and 6	5,994	-0.1	0	0	0	-82.1	-82.1
B-Train Double	8	683	-73.9	0	6,725	7,075	204	0
Rocky Mt. Double	7	632	-54.1	0	0	0	-20.1	0

that are projected to occur from one configuration type to another and the associated tractor (truck) travel miles that would result.

As noted earlier in this section, truck crashes are not caused by any one single factor, but rather are the result of multiple factors—vehicle performance being just one. As noted earlier in this chapter increased operations of multitrailer combinations on lower standard roads would increase crash risk.

All other things being equal, increases or decreases in the exposure to crash risk proportionally increases or decreases the likelihood of a crash. Thus, changes in the number of truck trips made to haul the same amount of freight, could alter the likelihood of crashes. However, it is not possible, given data limitations, to know if this is a linear relationship.

Table VIII-2 shows estimates of the percent changes in truck VMT that single-unit and combination trucks would experience in the year 2000, under each of the above scenarios. VMT is the most frequently used measure of exposure to the risk of a crash.

Table VIII-3 qualitatively characterizes and compares the various vehicle configurations combinations in more widespread use in this country. Given lack of information on the density of the cargo being carried by trucks, one cannot reliably determine the c.g. height of loaded trucks (c.g. height is the most important determinant of vehicle stability). If this information were available, one could predict vehicle and truck fleet performance with greater certainty. However, lacking this information, the worst loading condition is assumed for comparison purposes.

Table VIII-3 Comparison of Truck Use and Stability by Configuration

Truck Configuration	Current Use	Vehicle Stability and Control Characteristics (under worst loading conditions)
Single-Unit Truck	Used extensively in all urban areas for short hauls.	At speeds above 50 mph these vehicles are very unstable when making evasive maneuvers. Of all vehicles analyzed they are the least stable.
Semitrailer	Used extensively for long and short hauls in all urban and rural areas.	Generally adding axles to these configurations (and others) improves their performance.
STAA Double	Most common multitrailer combination. Used mostly on rural freeways between less-than-truckload (LTL) freight terminals.	Due to its extra length in cargo space this vehicle is the most stable in static rollover, but it is very dynamically unstable due to its short trailers.
B-Train Double	Some use in the northern plains States and the Northwest. Mostly used in flat trailer operations and for liquid bulk hauls.	Although at the weight evaluated, this vehicle performs less well than the five-axle semitrailer, it performs much better than the Surface Transportation Assistance Act (STAA) double.
Rocky Mountain Double	Used on turnpikes in Florida, the Northeast, and Midwest and in the Northern Plains and Northwest in all types of motor carrier operations.	This vehicle performs somewhat better in rearward amplification than the STAA double but less in static rollover. It performs better than single-unit trucks.
Turnpike Double	Used on turnpikes in Florida, the Northeast, and Midwest and in the Northern Plains and Northwest in mostly truckload operations.	This vehicle is stable in both rollover and rearward amplification, but it has severe low-speed offtracking.
Triple	Used on the Indiana and Ohio Turnpikes and many western States between LTL freight terminals.	With single drawbar converter dolly (A-train), this vehicle is considerably worse than the STAA double, but with double drawbar dolly (C-train), it performs about as well in rollover, but much better in rearward amplification.