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The Dimensions of Crash Risk: Combination-Unit vs. Single-Unit Trucks vs. Other Vehicles

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This Analysis Brief is a collaborative effort involving the Office of Motor Carrier Research and Standards' Research Division and the National Highway Traffic Safety Administration's Office of Regulatory Analysis.

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Introduction

This analysis brief explores differences and similarities among the national crash experience of combination-unit trucks (CUTs), single-unit trucks (SUTs), and "all vehicles" (principally cars and light truck/vans). These CUT vs. SUT vs. all vehicle comparisons are derived from a more comprehensive analysis of the 1989–93 U.S. crash experience of different motor vehicle types (Wang, J.S., Knipling, R.R., and Blincoe, L.J. The dimensions of motor vehicle crash risk. *Journal of Transportation and Statistics.* Volume II, Number 1, April 1999).

Safety interventions to prevent motor vehicle crashes are often characterized by specificity; they are designed to prevent a specific type of crash involvement. Different vehicle types have different physical characteristics, drivers, and operational use patterns and, therefore, have different crash risks. It is helpful to separate crash statistics across multiple dimensions, including crash and vehicle type, different types of measures (monetary and nonmonetary metrics), and different frames of reference, such as annually for the nation or per vehicle mile of exposure.

Focusing on a comparison of the national crash experience of CUTs, SUTs, and "all vehicles," this brief assesses the U.S. motor vehicle crash problem from the perspective of different problem size referents for all crashes combined. The full journal article also considers a number of specific crash involvement types/roles. A valid assessment of motor vehicle crash risk and the potential impact of safety interventions requires a precise understanding of how these dimensions interact, the target crash involvement types addressed, the types of vehicles likely to be equipped or otherwise affected, the most relevant *referent* to the intervention (e.g., national annual, mileage, vehicle life), and the range of monetary crash costs to be considered (i.e., economic loss only versus measures of "human" loss including pain and suffering).

Methodology

CUT vs. SUT vs. all vehicle comparisons are made across three orthogonal dimensions:

- crash involvement type/role (e.g., single vehicle roadway departure, left-turn across-path);
- type of metric (i.e., crashes, involved vehicles, persons killed/injured, and monetary cost); and
- problem size referent (i.e., U.S. annual, per-crash, per-vehicle, per-driver, and per-mile traveled).

Unless otherwise noted, all crash data were retrieved or derived from the General Estimates System (GES) for the five-year period 1989-93 and are intended to be representative of the population of U.S. police reported (PR) crashes. Six vehicle types were addressed, including combination-unit trucks (CUTs), which include tractor- and

semitractor-trailers, and medium/heavy single-unit trucks (SUTs), also known as "straight trucks." The other vehicle types addressed were passenger cars, light trucks/vans (LT/Vs), motorcycles, and all motor vehicles combined.

Monetary Metrics

Monetary assessments of crash problem size may be based on narrow economic loss criteria or comprehensive societal value criteria (Blincoe 1996). This analysis considered both economic (E) and comprehensive (C) monetary crash problem-size metrics. Unit costs from Blincoe were adjusted to 1997 price levels using Consumer Price Index statistics.

E costs represent the value of goods and services that must be purchased as a result of motor vehicle crashes, including medical care, legal services, and vehicle repair costs. In addition, E costs include the value of workplace and household productivity lost. **C costs** incorporate not only economic losses, but a valuation of less tangible consequences such as "pain and suffering" and loss of life.

Statistics: Metric/Referent Combinations

The analysis includes various statistics such as: annual number of PR crashes, annual number of persons involved, vehicle involvement rates (per 100 million miles traveled and per 1,000 vehicles), and annual U.S. monetary cost, both E and C costs. Unless otherwise stated, all measures of the crash problem size *include all individuals and vehicles involved in the crash,* not just those in the subject vehicle (SV) type. Further, the "all vehicles" values provided are not simply the sum or weighted average of the five specific vehicle types. First, "all vehicles" includes a relatively small number of other vehicles types such as buses. More importantly, for most statistics, the crashes, vehicles, injuries, or dollars may be counted under more than one specific vehicle type column. For example, crashes involving both a CUT and a passenger car are counted in both columns.

Since the statistics provided include all involved vehicles and persons, the columns are not additive; such additions would partially double count. In **table 1**, the all vehicle type per vehicle miles traveled (VMT), per registered vehicle annually, and per vehicle over its operational life monetary values are less than any of the individual vehicle types, because the aggregation of "all vehicles" eliminates the possibility of counting "other" involved vehicles. These all vehicle type statistics (see boxed values within table 1), unlike those in other columns, do not reflect consequences to other involved vehicles and their occupants. Similarly, the table 1 values for "per driver over driving career" do not incorporate consequences to other involved vehicles and their occupants.

Findings

Vehicle-Type Comparisons

The CUT crash picture is markedly different than that of "all vehicles." Although CUTs have very low crash rates, their high mileage exposures, long operational lives, and high crash severities combine to give them very high per-vehicle crash costs (see **figure 1**). Indeed, for every crash type analyzed, CUTs have the highest per-vehicle crash costs and thus the highest potential crash-reduction benefits on a per-vehicle basis. Based on crash statistics, vehicle registrations, average years of vehicle operational life, and National Highway Traffic Safety Administration crash and injury cost figures, the study calculated the average per-vehicle-life-cycle monetary cost of CUT crashes (i.e., for *each* CUT produced). Average costs are $69,540 when only economic losses are considered, and $162,040 when values for "pain and suffering" and "loss of life" are incorporated. These costs are more than four times those of any other vehicle type, but this fact has a *positive* implication for CUT safety enhancement. That is, crash avoidance systems can be considerably more expensive and/or less effective for CUTs and still be more attractive from a safety benefits perspective than the same systems installed on other vehicle types.

SUTs have a less dramatic crash picture than do CUTs. Their crash involvement rates per mile traveled are higher than those of CUTs, but their annual mileage exposures are much less. On average, SUT crashes are somewhat less severe than CUT crashes but of course more severe than those involving only smaller vehicles. Overall, SUT crash risks per vehicle (whether per year or lifetime) are low — about 20 percent of those of CUTs and only slightly higher than "all vehicles." Thus, SUTs are generally not as attractive as CUTs as a platform for vehicle-based safety devices from a safety benefits perspective.

Figure 1.
Cost Per Vehicle Life Cycle

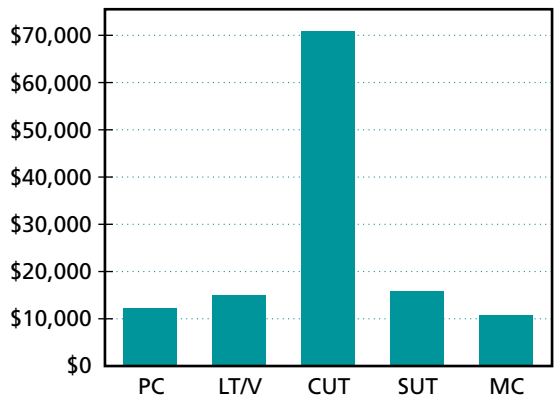

Table 1.
Statistics for All Crashes

Statistics		Crash Involving					
		All Vehicles	Passenger Cars	Light Trucks/Vans	Combination-Unit Trucks	Single-Unit Trucks	Motor-cycles
Annual # of PR Crashes		6,261,000	5,307,000	2,209,000	214,000	154,000	89,000
Annual # of Veh Involved of This Veh Type in PR Crashes*		10,964,000	7,929,000	2,485,000	221,000	157,000	90,000
Annual # of all Vehicles Involved in PR Crashes*		10,964,000	9,688,000	4,141,000	392,000	287,000	145,000
Annual U.S. # of Persons Involved in PR Crashes*		15,905,000	14,101,000	5,932,000	494,000	376,000	183,000
Not Injured (0)*		12,278,000	10,936,000	4,684,000	399,000	307,000	90,000
Minor to Moderate (MAIS 1-2)*		3,433,000	3,020,000	1,183,000	85,000	65,000	78,000
Serious to Fatal (MAIS 3-Fatal)*		194,000	146,000	65,000	9,000	5,000	15,000
Vehicle Involvement Rate in PR Crashes							
Per 100 Million VMT		500.41	556.15	415.59	225.52	289.33	927.65
Per 1,000 Registered Vehicles Annually		59.33	64.91	47.87	135.14	36.60	21.54
Expected Involvements in PR Crashes							
Over Vehicle Operational life		0.7789	0.7640	0.7684	1.9866	0.5380	0.1615
Per Driver Over Driver Career		3.7383					
Annual U.S. Monetary Cost*	(E) (C)	$164.4 B $431.9 B	$146.8 B $353.7 B	$57.7 B $147.9 B	$9.5 B $22.1 B	$5.4 B $11.6 B	$6.5 B $22.6 B
Average Monetary Cost							
Per PR Crash*	(E) (C)	$17,950 $52,610	$18,650 $50,190	$17,580 $50,750	$39,540 $89,400	$31,870 $66,370	$57,190 $206,460
Per VMT*	(E) (C)	7.50 ¢ 19.71¢	10.29 ¢ 24.81¢	9.65 ¢ 24.73¢	9.68 ¢ 22.57¢	9.99 ¢ 21.50¢	66.52¢ 233.05¢
Per Registered Vehicle Annually*	(E) (C)	$890 $2,340	$1,200 $2,900	$1,110 $2,850	$5,800 $13,520	$1,260 $2,720	$1,540 $5,410
Expected Monetary Cost							
Per Vehicle Over Operational Life*	(E) d (C) d	$9,640 $25,330	$11,780 $28,380	$14,310 $36,660	$69,540 $162,040	$15,140 $32,580	$10,230 $35,830
Per Driver Over Driving Career	(E) d (C) d	$31,070 $81,630					
Total Annual National Fatal Equivalents*		139,699	114,423	47,829	7,160	3,763	7,320
Average Fatal Equivalents Per PR Crash*		0.01702	0.01623	0.01642	0.02855	0.02120	0.06678

Legend: PR—Police Reported; B—Billion; E—Economic Cost; C—Comprehensive Cost; ¢—Cent; d—Discounted

* Inclusive; i.e. includes all crash involved vehicles and persons, except for the boxed area in "all vehicles" column. For these statistics a crash or injury may be counted in two different columns (e.g., a crash involving a passenger car and a combination-unit truck). Thus, the columns are not additive.

Researcher
This study was performed by Jing-Shiarn Wang, National Highway Traffic Safety Administration, Ronald Knipling, Federal Highway Administration, and Lawrence J. Blincoe, National Highway Traffic Safety Administration.

Distribution
This Analysis Brief is being distributed according to a standard distribution. Direct distribution is being made to the Resource Centers and Divisions.

Availability
The full journal article is available from the Bureau of Transportation Statistics, 400 7th Street, SW, Room 3430, Washington, DC 20590; Phone: (202) 366-DATA, E-mail: orders@bts.gov. The article is also available on-line at www.bts.gov/jts.

Key Words
large truck crashes, combination-unit trucks, single-unit trucks, crash types, crash costs, crash rates, cost-benefits, vehicle life cycle crash costs.

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Crash- and Vehicle-Type Interactions

Although statistics for specific crash types are not provided here, they are contained in the full journal article. These statistics show that the largest relative overinvolvement of CUTs is in lane changing/merging (LC/M) crashes. CUTs comprise only 2 percent of vehicles involved in crashes, but represent 8.5 percent of vehicles involved in LC/M crashes as the subject vehicle (the vehicle precipitating the crash). On a per vehicle life cycle basis, CUT involvements in LC/M crashes are about 12 times as costly as those of SUTs and about 14 times those of all other vehicle types combined. CUTs are also *relatively* underrepresented in certain crash types (e.g., rear-end, lead vehicle stopped and left-turn-across-path crashes), but still have the highest crash cost per vehicle over the operational life of the vehicle for every crash type studied.

The only major overrepresentation of SUTs is in backing crashes; they represent 1.4 percent of vehicles involved in all crashes, but account for 5.3 percent of SVs in backing crashes. CUTs and SUTs show a different pattern of SV involvement in rear-end crashes. CUTs have more rear-end, lead vehicle moving crashes, whereas SUTs have more rear-end, lead vehicle stopped involvements. This likely reflects the different exposure patterns of these two large truck types; CUTs accumulate most of their mileage on highways, whereas SUTs accumulate relatively more mileage on secondary/local roads.

Most Relevant Referents

The most subtle of the dimensions of motor crash risk may be problem-size referent. Safety initiatives may vary dramatically in their patterns or "spans" of application and, therefore, in the most appropriate perspective from which to assess their potential benefits. A countermeasure applied on a "per mile traveled" basis, such as roadside inspections, would likely be equally cost-beneficial for CUTs and SUTs since these vehicles have nearly equal per-mile traveled crash costs. But safety interventions applied on a per-vehicle basis (e.g., annual vehicle inspections, vehicle-installed devices) are likely to be dramatically more cost-beneficial for CUTs than for SUTs or other vehicle types. Hence a strong rationale for investing heavily in improved safety for CUTs.

Reference

Blincoe, L.J. 1996. *The Economic Cost of Motor Vehicle Crashes, 1994,* NHTSA Technical Report, Publication Number DOT HS 808 425. Washington, DC: U.S. Department of Transportation, National Highway Traffic Safety Administration. July.