UM-HSRI-80-15

An Overview of the ON-ROAD CRASH EXPERIENCE OF UTILITY VEHICLES

(Highlights of the Technical Report)

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Prepared for
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February, 1980

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
UM-HSRI-80-15		

4. Title and Subtitle	5. Report Date
An Overview of the On-Road Crash Experience of Utility Vehicles (Highlights of the Technical Report)	February 1980
	6. Performing Organization Code UM-HSRI
7. Author(s) R. G. Snyder, T. L. McDole, W. M. Ladd, D. J. Minahan	8. Performing Organization Report No. UM-HSRI-80-15
9. Performing Organization Name and Address Highway Safety Research Institute The University of Michigan Ann Arbor, Michigan 48109	10. Work Unit No.
	11. Contract or Grant No.
	13. Type of Report and Period Covered Overview May 1978-February 1980
12. Sponsoring Agency Name and Address Insurance Institute for Highway Safety Watergate Six Hundred Washington, D.C. 20037	14. Sponsoring Agency Code IIHS

15. Supplementary Notes

16. Abstract

The purpose of this study was to investigate the on-road crash experience, safety, and stability of utility vehicles. Selected for study among the off-road, multi-purpose passenger vehicles were the JEEP, Blazer, Bronco (pre-1978) Jimmy, Ramcharger, Trail Duster, Scout, LandCruiser, and Thing.

Data studied included more than 12,000 fatal and non-fatal utility vehicle crashes in the states of Arizona, Colorado, Maryland, Michigan, New York, New Mexico, North Carolina, Texas, and Washington. Also, FARS data, R. L. Polk & Company vehicle registration data, and data from Collision Performance and Injury Report (CPIR) files were examined. Selected vehicles were subjected to physical measurement of the height of the center of gravity. Applicability of Federal Motor Vehicle Safety Standards was reviewed.

Major conclusions are that: utility vehicles experience a rollover rate 5 to 11½ times higher than passenger cars; the JEEP and pre-1978 Bronco overturn at least twice as often as Blazer; rollover and ejection in open-cab vehicles appear to be major fatal injury factors; death and injury rates are about twice as high in JEEPS as in Blazers.

The study findings raise serious questions concerning the safety and stability of these vehicles, which are exempted from or not covered by several of the Federal Motor Vehicle Safety Standards required for passenger cars. Complete technical documentation is presented in the HSRI report number UM-HSRI-80-14—*On-Road Crash Experience of Utility Vehicles* from which this overview was excerpted.

17. Key Words	18. Distribution Statement
utility vehicle; occupant injuries; occupant protection; ejection; multi-purpose; jeep-type; rollover; rollbars; crash investigation; data analysis; mass data; collision	Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	12	

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Background

The *objectives* of this study were to describe the on-road crash experience of the class of vehicles generally known as utility vehicles, and to describe the magnitude of injury and fatality problems for occupants of these vehicles.

Utility vehicles are *defined* as multi-purpose passenger vehicles designed for both on-road and off-road use.

Today's four-wheel-drive utility vehicles largely evolved from the "Jeep" of World War II. Current vehicles commonly have four-wheel drive and (in some models) open, convertible, or detachable roofs. In comparison with ordinary passenger cars, utility vehicles have a higher center of gravity, a stiffer suspension system, often a shorter wheelbase, and typically are capable of both on- and off-road operation. The specific vehicle types studied included: AMC JEEP, Kaiser and Willys Jeep, Ford Bronco (pre-1978), International Scout, and Toyota Land Cruiser—classified as the "smaller" vehicles; Chevrolet Blazer, GMC Jimmy, Plymouth Trail Duster, and Dodge Ramcharger—classified as the "larger" vehicles.

Indications of the seriousness of the utility vehicle accident *problem* have been reported by the U.S. Army. They found that 66 percent of the 1,102 M151 Jeep crashes occurring between July 1974 and July 1976 were rollovers. Unstable handling characteristics of the M151 caused the U.S. Department of Transportation in 1971 to refuse to sanction the sale of military surplus Jeeps in a driveable condition to the general public.

The military crash experience with Jeeps, coupled with a dramatic rise in utility vehicle popularity (utility vehicles are estimated to comprise one percent of all registered vehicles on the road today) has raised concerns about the crash experience and safety aspects of these vehicles used by the civilian population. This study confirms that serious problems exist relative to occupant safety and vehicle stability in the on-road driving environment.

Data Sources and Methods

Primary data sources consisted of police-reported accident data, clinical accident investigation reports, and vehicle registration data. State files containing computerized reports of crashes occurring for selected years between 1975-1978 were obtained from Arizona, Maryland, Michigan, New Mexico, New York, North Carolina, Texas, and Washington. The Fatal Accident Reporting Systems (FARS)* file for 1977, which contains virtually all U.S. fatal traffic accidents in that year, was analyzed (about 42,700 fatal accident reports).

Vehicle registration data published by the R. L. Polk and Company were obtained to estimate the number of utility vehicles registered for the years 1975, 1976, and 1977. Those data were used to determine the utility vehicle population in each study state as a percentage of all registered passenger vehicles.

Clinical data were obtained through a detailed review of police reports and photographic records of utility vehicle fatal accidents occurring in the

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* This study, *On-Road Crash Experience of Utility Vehicles* (Report No. UM-HSRI-80-14), was conducted by the Highway Safety Research Institute, and sponsored in part by The Insurance Institute for Highway Safety, Washington, D.C.

* FARS—a fatal accident data collection system maintained by the National Center for Statistics and Analysis, National Highway Traffic Safety Administration, U.S. Department of Transportation.

states of Arizona (1978), Colorado (1978), Michigan (1977), and New Mexico (1977-78). Other data sources included examination of records pertaining to product liability litigation involving utility vehicle accidents. Finally, physical measurements were conducted by HSRI on selected vehicles in order to compare the stability (rollover) thresholds of selected utility vehicles to those of passenger cars.

Analyses of State and National Accident Data Files

To establish how frequently utility vehicles were involved in accidents compared to ordinary passenger cars and to compare the incidence of death and severity of injury as a consequence of utility vehicle accident involvement, the vehicle registration and on-road accident data for five states (Maryland, Michigan, North Carolina, Texas, and Washington) were compared.

In terms of *accident involvement,* Table 1 shows that in five study states, utility vehicles were relatively less frequently involved in accidents than were passenger cars. Also shown is the ratio of utility vehicle registrations to passenger car registrations.

TABLE 1
UTILITY VEHICLE CRASHES IN RELATION TO PASSENGER CAR CRASHES: SELECTED STATES

State	Number of Utility Vehicle Crashes	Utility Vehicle Crashes as a Percent of All Passenger Car Crashes %	Utility Vehicle Registrations as a Percent of All Passenger Car Registrations %
Maryland* (1975-1977)	1,336	0.3	0.5
Michigan (1976-1977)	6,599	0.7	1.3
North Carolina* (1975-1978)	3,691	0.6	0.9
Texas (1976-1977)	6,225	0.5	0.8
Washington (1976)	1,456	0.9	1.1

* Excludes crashes with pedestrians, pedalcyclists, motorcycles, and trains in this and in subsequent tables.

These data (Table 1) show that utility vehicles in all five states are involved in proportionately fewer total crashes than their frequency in the population would suggest; i.e., utility vehicles are underrepresented in total crashes, relative to passenger cars.

However, utility vehicles are over-involved in *fatal* crashes when compared to the number of registered vehicles. A fatal crash is a crash where at least one person was killed. Rates of vehicle involvement in fatal crashes are 43.2 per 100,000 registered utility vehicles and 30.9 per 100,000 registered passenger cars.

While Table 1 compares the frequency of involvement in all types of crashes for utility vehicles and passenger cars, Table 2 shows that utility vehicles are involved in fatal crashes almost 40 percent more often than passenger cars.

TABLE 2
FATAL CRASHES AND TOTAL REGISTRATIONS: UTILITY VEHICLES AND PASSENGER CARS (ALL STATES, 1977)

Vehicle Type	Crashes %	Registrations %
Utility Vehicles	1.36	0.98
Passenger Cars	98.64	99.02
Total	100.00	100.00
Number	35,790	115,238,923

In summary, utility vehicles are less likely than passenger cars to be involved in an on-road crash of any kind, but almost 40 percent more likely to be involved in a crash that results in a fatality.

The *death rate*—the likelihood of occupant death in a crash-involved vehicle—is higher for utility vehicles than passenger cars. On a national basis for 1977, at least one occupant was killed in a utility vehicle in 31.8 fatal crashes per 100,000 registered utility vehicles. The corresponding rate for passenger cars is 18.5. Therefore, the death rate for utility vehicle crashes is 71.9 percent higher than the rate for passenger car crashes.

Comparative death rates for selected states are shown in Table 3. For each state, the total number

TABLE 3
TRAFFIC DEATH RATES (NUMBER KILLED PER THOUSAND CRASHES): SELECTED STATES

	Michigan 1976-77	Washington 1976	Texas 1976-77
	All Occupants		
Utility Vehicles	4.7	6.9	6.3
Passenger Cars	2.2	3.0	3.3
	Drivers		
Utility Vehicles	2.0	3.4	3.6
Passenger Cars	1.5	2.0	2.1
	Number of Crashes		
Utility Vehicles	6,599	1,456	3,649
Passenger Cars	498,240	153,331	663,940

of people killed per 1,000 reported crashes is about twice as high in utility vehicles as in passenger cars.

Additional study findings concerning fatal injury are: (1) in both utility vehicles and passenger cars, traffic death rates in rural crashes are considerably higher than are those for urban crashes; (2) regardless of whether a urban or rural area, the *total traffic death rates* in utility vehicles are higher than are the rates in passenger cars; (3) in urban areas, differences in *driver death rates* between utility vehicles and passenger cars are negligible; (4) death rates in single-vehicle crashes for utility vehicles and passenger cars are higher than for other types of crashes; (5) death rates in single-vehicle crashes are higher in utility vehicles than in passenger cars; and (6) utility vehicles are more likely than passenger cars to be involved in single-vehicle crashes.

The rate of serious (disabling) injury is greater in utility vehicles than in passenger cars, for both drivers and passengers, as shown in Table 4.

TABLE 4

NUMBER OF DISABLING INJURIES PER THOUSAND CRASHES: SELECTED STATES

	Michigan 1976-77	Washington 1976
	All Occupants	
Utility Vehicles	61.8	73.9
Passenger Cars	32.2	34.0
	Drivers	
Utility Vehicles	33.3	40.4
Passenger Cars	17.9	21.8

Some utility vehicle models appear to be safer than others. The data indicate that the larger utility vehicles have a lower serious injury rate, whereas the smaller vehicles are associated with the highest serious injury rates.

Utility vehicles are much more likely than passenger cars to crash in rural areas. Within rural areas, utility vehicles crash more often than passenger cars when snow or ice is on the road surface, when darkness prevails, or when there is a curve in the road.

Among crashed vehicles, utility vehicle drivers are on the average younger than passenger car drivers and more frequently male.

In *summary,* death rates and serious injury rates are substantially higher in utility vehicle crashes than in passenger car crashes. In part, these differences result from the fact that, compared to passenger cars, proportionately more utility vehicle crashes are single-vehicle and occur in rural areas.

Case Reviews of Fatal Accidents Involving Utility Vehicles

To examine accident, driver, and vehicle factors in fatal utility vehicle crashes, the utility vehicle case reports and post-crash photos were obtained from law enforcement agencies in the states of Arizona (for 1978), New Mexico (for Aug.-Dec. 1977, and all of 1978), and New York (for 1977). Factors examined included crash configuration, cab type, roll-bar presence, seat belt usage, occupant ejection, and tire type (whether original equipment, overwide, oversize, etc.). This review indicated that rollover and ejection of unrestrained occupants frequently occurred in fatal utility vehicle crashes. Typically, unrestrained occupants received critical or fatal injuries either through contact with the vehicle interior or ejection from the vehicle (often with the vehicle rolling onto them).

Vehicle Rollover

A specific study of rollover accidents was made using data from the states of Maryland, Michigan, North Carolina, Texas, and Washington, to determine if rollover collisions were a significant problem.

The ratio of utility vehicle rollovers to passenger car rollovers ranged from a low of 5.3 to 1 (North Carolina) to a high of 11.5 to 1 (Michigan), as shown in Table 5.

TABLE 5

PERCENT OF CRASHES INVOLVING ROLLOVER: UTILITY VEHICLES AND PASSENGER CARS

	Rollovers %		
	Utility Vehicles	Passenger Cars	Ratio
Maryland	9.7	1.0	9.7
Michigan	12.7	1.1	11.5
North Carolina	11.7	2.2	5.3
Texas	5.6	0.7	8.0
Washington	10.1	1.6	6.3

Rollover as a first event was reported in almost 30 percent of fatal crashes involving utility vehicles. Obviously, not all types of vehicles have the same overturn rate. Michigan data for 1976, shown in Table 6, shows the overturn rate for various types of vehicles.

Analyses of Michigan and Washington state accident data indicate that the smaller utility vehicles such as Bronco (pre-1978) and JEEP overturn more often than the larger utility vehicles such as Blazer.

TABLE 6

PERCENT OF CRASHES INVOLVING ROLLOVER, BY VEHICLE TYPE: MICHIGAN, 1976

Vehicle Type	Percent Overturn Accidents %
All Passenger Cars	1.1
Full Size	0.6
Intermediate	1.4
Compact	2.3
Sports Car	3.5
Pick-up or Panel Trucks	2.9
Straight Trucks	3.1
Utility Vehicles	12.7
All Vehicles	1.7

Rollover is substantially more prevalent in single-vehicle crashes than in other types of crashes, as is shown in Table 7.

TABLE 7

PERCENT OF VEHICLES THAT OVERTURNED IN SINGLE-VEHICLE CRASHES: SELECTED STATES

	Michigan %	Texas %	Washington %	Maryland %	North Carolina %
Utility Vehicles	39	41	36	45	37
Passenger Cars	7	6	12	10	14

Rollover rates for *all* crashes are substantially lower than the rates shown for single-vehicle crashes. This implies that rollover is coded infrequently in multiple-vehicle crashes.* Data from selected states (not reproduced here) confirm this. Compared to passenger cars, vehicle rollover is *high* in utility vehicles, especially in single-vehicle crashes and in rural areas.

Injury Mechanisms

Occupant ejection is more likely to occur in utility vehicle crashes than in passenger car crashes. For example, 15 percent of utility vehicle occupants were ejected in single-vehicle crashes in Maryland (1975-1977) compared to one percent in passenger cars. Occupant ejection is much more common in single-vehicle crashes than in multiple-vehicle crashes. Total driver ejection is much more frequent in open-topped vehicles, such as the JEEP, than in most other models of utility vehicles or passenger cars.

Little difference in seat belt usage is noticed between drivers of utility vehicles and passenger cars. In Washington, 17 percent of the utility vehicle drivers were reported to have been wearing seat belts at the time of the crash, compared with 16 percent of the passenger car drivers. Seat belt restraint systems, including some types of single-belt upper-torso systems, do not prevent occupant flailing, partial ejection, or injury to the unrestrained extremities. Injuries to upper extremities and the hand have occurred as a result of open-vehicle occupants using the roll-bar as a grip during vehicle overturn, or as a result of entrapment of the hand and forearm between the side of the open vehicle and the ground during rollover.

Rollover Stability Measurements

To establish the lateral acceleration (in g's) required to roll over five different models of utility vehicles, the vehicles were measured for wheelbase, track width, and height of center of gravity. Vehicles measured included a 1975 Chevrolet Blazer with fiberglass top, a 1979 JEEP CJ-5 with canvas top and roll-bar, a 1979 JEEP CJ-7 with canvas top and roll-bar, a 1973 Ford Bronco Ranger with a steel top, and a highly modified 1968 Ford Bronco. For purposes of comparison, the same measurements were available for several makes of passenger cars. The rollover limit of the five utility vehicles ranged from 1.01 to 1.21 g, compared to a range of 1.32 to 1.62 g for passenger cars. In general, the smaller the stability envelope of a vehicle (wheelbase times track width) the lower its rollover limit. Utility vehicles with short wheelbases and narrow tracks can be overturned solely by the side forces generated by the tires during unusual maneuvers, whereas larger utility vehicles generally overturn only if they are tripped by a road surface irregularity, curb, or other surface texture change.

Product Liability

Accident cases in litigation provided some information regarding alleged safety defects in utility vehicles. Rollover resulting in collapse of roll-bars, and steering and brake failures have been the most

* A new approach to coding rollovers was used in the 1978 FARS. Rollover, in the 1978 FARS, is coded regardless of when the event occurs during a crash. In 1977, rollover was coded only if associated with the first harmful event. Using an interim version (#86) of the 1978 FARS, 181 of 773 (23%) of the on/off road vehicles were coded as overturning in the first event. And, an additional 22 percent of the 773 vehicles overturned subsequent to the first harmful event. Thus, 45 percent of the on/off road vehicles were coded as overturning at some point during the crash. It remains to be seen if many states will adopt the 1978 FARS codes for rollover. Note that the FARS definition of an on/off road vehicle differs slightly from the definition of utility vehicle used in this study.

frequent allegation in these cases. The cases suggest significant occupant protection problems in crashes of utility vehicles, especially when rollover occurs.

Federal Standards

Many federal standards that apply to passenger cars do not apply to utility vehicles. Although a U.S. General Accounting Office report (July 1978) was critical of delays in the promulgation of standards to improve light truck (including utility vehicle) safety, nothing substantial has yet appeared. Of the 20 standards that now apply to passenger cars, only six currently apply without exception to utility vehicles. These are: FMVSS 205—Glazing Materials; FMVSS 207—Seating Systems; FMVSS 209—Seat Belt Assemblies; FMVSS 210—Seat Belt Assembly Anchorages; FMVSS 211—Wheel Nuts, Discs, Hub Caps; FMVSS 213—Child Seating Systems.

Major Conclusions:*

The major conclusions of this study of on-road utility vehicle crash involvement are:

A. *Crash Involvement*

1. Based upon 1977 data for all states, utility vehicles are *involved in fatal crashes* almost 40 percent more often than passenger cars. The proportion of 1977 total crashes in which at least one occupant was killed is 72 percent higher for utility vehicles than passenger cars (31.8 utility vehicle fatal crashes per 100,000 registered vehicles vs. 18.5 passenger car fatal crashes per 100,000 registered vehicles).
2. Utility vehicles *crash* in rural areas proportionately more often than passenger cars, accounting for about 36 percent of the difference in overall death rates between utility vehicles and passenger cars. Higher average travel speed, curves, and ice or snow on the road surface have been shown to be major factors in the rural environment that are associated with an increase in crashes among utility vehicles.
3. Utility vehicle *drivers involved in crashes* generally are younger and more often male than their counterparts in passenger cars. The importance of these factors in contributing to total crashes or fatal crashes has not yet been established.

B. *Rollover and Occupant Ejection*

1. As a group, utility vehicles are much more likely than passenger cars to overturn, especially in single-vehicle crashes and in rural areas. Utility vehicles experience *rollover* at a rate that is at least *five times* (and up to 11½ times in Michigan) higher than that experienced by passenger cars (Maryland, Michigan, North Carolina, Texas, and Washington). Among utility vehicles, some models have a higher rate of rollover than do others.
2. Based on the *height of the center of gravity*, utility vehicles as a class are more likely to overturn, and within the utility vehicle class those with a small stability envelope (JEEP, Jeep, pre-1978 Bronco, Scout, Land Cruiser) are more likely to overturn than those with a larger stability envelope (Blazer, Ramcharger, Jimmy, Trail Duster). The JEEP and the Bronco (pre-1978) overturn during a crash at least twice as often as the Blazer. Further, among those vehicles with the smaller stability envelope, the tire side forces may be sufficient to initiate the overturn, whereas utility vehicles with a larger stability envelope may require an external tripping force (curb, pothole, etc.).
3. *Driver ejection* is more often reported among JEEPS than other makes of utility vehicles or passenger cars. Driver ejection is also more often reported among open- or canvas-top utility vehicles than among rigid-top utility vehicles.
4. *Rollover* occurs in about 30 percent of U.S. fatal crashes involving utility vehicles. In comparison, rollover is reported in only six percent of U.S. fatal car crashes.
5. Until 1977, rollover was coded in the Fatal Accident Reporting System (FARS) data (when it occurred) as the first harmful event, yielding a rollover rate of 29 percent. In contrast, the 1978 FARS coded rollover as both first and subsequent harmful events. This yielded a fatal on-off-road vehicle overturn rate of 45 percent. In this study, the more conservative (first harmful event) definition was used.
6. *Rollover and ejection* of unrestrained occupants are observed to be primary factors in fatal utility vehicle crashes.
7. *Rollover protection* (roll-bars, cages, etc.) particularly in open vehicles is inadequate, as the roll protection frequently collapses or is a source of injury to the occupants.
8. *Occupant ejection* is more common in single-vehicle crashes than multiple-vehicle crashes. Fifteen percent of utility vehicle occupants were

* Reprinted from the Technical Report.

ejected in single-vehicle crashes in Maryland (1975-1977), compared with one percent in passenger cars.

9. *Ejection* from open and canvas-enclosed vehicles occurred in three-quarters (75%) of the fatal crashes but in only two-fifths (40%) of the rigid-cab vehicles in three study states (Arizona, Michigan, and Colorado) in 1978.

C. *Rate of Injury and Death*

1. Traffic *death rates and rates of disabling injury* are higher in utility vehicles than in passenger cars, whether considering all occupants or just drivers. Considering all occupants, both the death rate and rate of serious injury are about twice as high in utility vehicles. Additionally, both death and injury rates are approximately twice as high in JEEPS as in Blazers.
2. The likelihood of *serious (disabling) injury* is about twice as great in utility vehicles as in passenger cars, for all occupants and for drivers, based on Michigan and Washington data.
3. The Blazer exhibits the lowest serious injury rate when compared with Scout, Bronco, and JEEP.
4. The likelihood of *death* as a consequence of a crash (for all occupants) was found to be twice as high in utility vehicles as in passenger cars, based on Michigan, Texas, and Washington data. At least one person was killed in a utility vehicle in almost three-fourths of all fatal crashes involving a utility vehicle (the remainder killed were occupants of the other vehicles).

D. *Occupant Protection*

1. A steel *cab enclosure* reduces the chance of ejection and subsequent fatal crushing of the ejected occupant by the vehicle. In all vehicles, the use of *restraints* prevents ejection, which is a primary cause of death and injury. *Roll-bars* in open, canvas, and fiberglass-type cabs produce a measure of safety only if the occupant is not ejected. However, rollbars without sufficient upper body restraint do not offer the occupant adequate protection against flailing injury. Roll-bars themselves can produce injuries.
2. Little difference in *seat belt usage* is found between drivers of utility vehicles and passenger cars. In Washington, 17 percent of drivers of utility vehicles wore a seat belt at the time of the crash, compared with 16 percent among the passenger car drivers.

E. *Other*

1. Of the 20 *Federal Motor Vehicle Safety Standards* (Numbers 201-219), only six apply to utility vehicles in their entirety. They are: 205—Glazing Materials; 207—Seating Systems; 209—Seat Belt Assemblies; 210—Seat Belt Assembly Anchorages; 211—Wheel Nuts, Discs, Hub Caps; 213—Child Seating Systems. In two standards (201—Occupant Protection, Interior Impact; and 212—Windshield Mounting) multi-purpose vehicles are exempted from the safety requirements. In another (208—Occupant Crash Protection) there are differences in requirements between passenger cars and multi-purpose vehicles. Of particular importance, lap and shoulder belt restraint are not required (209—Seat Belt Assemblies).
2. Post-crash *fire* for utility vehicles as a result of collision is rare and was not found to be a safety problem.

Recommendations for Improving Utility Vehicle Safety

A. Federal safety standards that apply to passenger cars should be extended to utility vehicles. In particular, restraint systems should be installed in all utility vehicles, with the design of a particular system geared to the vehicle style (i.e.: full harness in open vehicles).
B. Performance standards (and perhaps design standards) should be promulgated for roll protection equipment—particularly for open vehicles.
C. Manufacturers, dealers, insurance companies, etc., should develop and distribute to prospective purchasers, drivers, educators, insureds, etc., literature describing the performance limitations (handling and stability) of these vehicles for both on-road and off-road use. Adequate consumer information can help alleviate many of the problems.
D. Additional research on the behavior of utility vehicle drivers should be conducted. We need to know to what extent the relatively high rates of utility vehicle fatal and serious-injury accidents are a reflection of how the vehicles are driven. To answer that question satisfactorily, more information is needed.
E. Additional studies need to be undertaken to examine and link the factors of vehicle design, occupant protection, driver, and environmental factors as they relate to the production of crash-induced injuries.

TABLE CROSS-REFERENCE

To assist the reader in comparing this document with the parent Technical Report, a cross reference of tables is provided.

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