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

(Highlights of the Technical Report)

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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.

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ON-ROAD CRASH EXPERIENCE OF UTILITY VEHICLES*

ackground

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

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

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

Indications of the seriousness of the utility vehicle cident *problem* have been reported by the U.S. rmy. They found that 66 percent of the 1,102 151 Jeep crashes occurring between July 1974 d July 1976 were rollovers. Unstable handling aracteristics of the M151 caused the U.S. Departnt 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* eport No. UM-HSRI-80-14), was conducted by the Highway ety Research Institute, and sponsored in part by The Inance Institute for Highway Safety, Washington, D.C. The opinions, findings and conclusions expressed in this publiion are those of the authors and do not necessarily reflect the ws of the Insurance Institute for Highway Safety nor the hway Safety Research Institute.

* 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.

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.

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

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

The rate of serious (disabling) injury is greater in ility vehicles than in passenger cars, for both rivers 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	
ility Vehicles	61.8	73.9
ssenger Cars	32.2	34.0
	Drivers	
ility Vehicles	33.3	40.4
ssenger Cars	17.9	21.8

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

Utility vehicles are much more likely than passen- r cars to crash in rural areas. Within rural areas, lity vehicles crash more often than passenger rs when snow or ice is on the road surface, when rkness prevails, or when there is a curve in the ad.

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

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

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.

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 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 (#36) 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.

deral Standards

Many federal standards that apply to passenger s do not apply to utility vehicles. Although a S. General Accounting Office report (July 1978) s critical of delays in the promulgation of stan- ds to improve light truck (including utility vehicle) ety, nothing substantial has yet appeared. Of the standards that now apply to passenger cars, only currently apply without exception to utility icles. These are: FMVSS 205—Glazing Mate- s; FMVSS 207—Seating Systems; FMVSS 209 Seat Belt Assemblies; FMVSS 210—Seat Belt sembly Anchorages; FMVSS 211—Wheel Nuts, cs, Hub Caps; FMVSS 213—Child Seating tems.

jor Conclusions:*

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

Crash Involvement

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).

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.

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.

Rollover and Occupant Ejection

As a group, utility vehicles are much more

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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

passenger cars.

2. *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.

dards (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.

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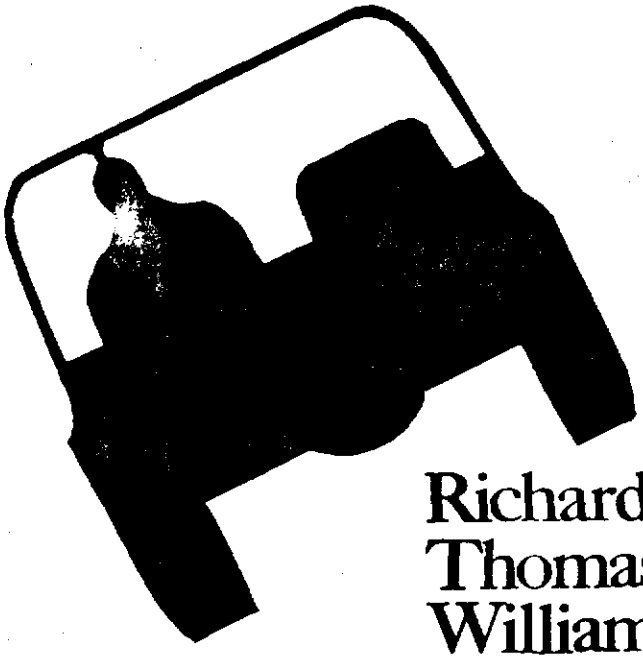

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FINAL TECHNICAL REPORT

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16. Abstract

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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 approximately twice as high in utility vehicles as in passenger cars and 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.

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EXECUTIVE SUMMARY

Use of utility vehicles designed for on/off-road use, such as the Blazer, Bronco, JEEP, Jimmy, Land Cruiser, and Scout, has increased rapidly over the past few years. The purpose of this study has been to analyze the available on-road collision experience involving this type of vehicle to determine the nature, extent, and seriousness of any problems unique to this category of vehicle, and to provide a basis for further investigation and/or safety recommendation.

The study involved large-scale accident data analysis, evaluation of in-depth reports on individual crashes, and the measurement of physical parameters on some utility vehicles. The data sources included the Fatal Accident Reporting System (FARS) of the U.S. Department of Transportation, Collision Performance and Injury Report (CPIR) file, and clinical case studies of serious traffic collisions from various locations in the U.S. Data obtained included reports on about 14,000 utility vehicle accidents occurring in the states of Michigan, New York, Texas, Washington, Arizona, Colorado, Maryland, North Carolina, and New Mexico during 1976, 1977, and 1978. From the CPIR in-depth collision files 93 utility vehicles (out of a total of 7,799 vehicles with 35,132 injuries) were analyzed. Supplemental data were added where possible to the CPIR data relative to roll-bar, cab type, restraints, and vehicle modifications (such as suspension and tires). The original written records of fatal accident reports from FARS and selected state files were also reviewed. Using these data the accident characteristics of utility vehicles were compared to those of passenger automobiles. To assist in determining the role of handling and stability, since many of these vehicles have a relatively high center of gravity and short wheelbase (as potential contribution to lateral motion instability), direct physical analyses of a Chevrolet Blazer, AMC CJ-5 and CJ-7 JEEP, Ford Bronco, and a modified Ford Bronco were conducted.

Major conclusions of the study are that:

** Utility vehicles experience rollover at a rate that is at least five times higher (and up to 11-1/2 times higher in Michigan) than that experienced by the average passenger car. The JEEP and pre-1978 Bronco overturn at least twice as often as the Blazer;

tire side forces alone in vehicles with a small stability envelope (such as the JEEP) may be sufficient to initiate overturn. Rollover and ejection from open-cab vehicles and lack of upper-torso restraints with roll bar protection appear to be major injury factors.

** Both the death rate and the rate of disabling injury (per accident) are about twice as high in utility vehicles, and both rates are approximately twice as high in JEEPS as in Blazers.

Only 6 of 20 Federal Motor Vehicle Safety Standards that apply to passenger cars also presently apply to utility vehicles without exception. Utility vehicles, for example, are exempted from the lap and shoulder belt requirements (FMVSS 209). The study findings indicate that the stability, crashworthiness, and occupant protection features of utility vehicles need to be improved.

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TABLE 2.1-1

SUMMARY OF 1,102 U. S. ARMY
JEEP CRASHES REPORTED DURING
FY1974-1976

Year	Rollover	Vehicle Ran Off Road	Fire	Fatality	Injury
1976	236	129	0	17	159
1975	211	135	0	8	173
1974	278	113	0	17	175
Totals	725	337	0	42	507

(Department of the Army, 26 October 1976)

M718A1 (0.5 accidents per million miles) are attributed to subsequent design changes (Brune, 1979, p. 16-17).

Not until 1971 did the federal government officially recognize the serious hazards to occupants of military utility vehicles in crashes. At that time an NHTSA "position paper" (Office of Defects Management, 1971) disclosed the M151 FY1967-1970 accident record of 7,460 accidents world-wide involving 138 fatalities. The Army world-wide M-151 fatality rate was 12.18 (per 100,000,000 miles driven) and the accident rate was 0.83 (per 100,000 miles driven). As a result, the NHTSA refused to sanction a Department of the Army plan to sell surplus jeeps to the general public (IIHS, 1972; Anon, 1969; Mohbat, 1969). The National Highway Traffic Safety Administration (NHTSA) was pressed by the Department of the Army and the Defense Supply Agency to allow sale of the M151 (including the older models M151A1, M151AC, and 718, and the more recent models M151A1, M825, and M718A1). An estimated 73,309 vehicles were planned to be disposed of during the next six to ten years (1971-1981 period) at the Army's estimated salvage value of $300 to $1,200 per vehicle at an average return of $750 per vehicle. Approximately $55 million was at stake.

However, it was concluded by the NHTSA Office of Defects Investigation (ODI) that the Department of Defense had already

Although similar data for the earlier M38 series vehicle were not given in the referenced study, based upon a fatality rate (in 100,000,000 miles driven) of 59 for the M38A1 in fiscal 1963 (July 1963 - 30 June 1964), the Army had projected 182 fatalities for the period FY1963 (fiscal year) through FY1967 in the European Theatre. This compares with 113 actual fatalities for the same period involving the M151 (U.S. Army Material Command, 1967).

Eight of 14 (57%) fatal U.S. Army M151 accidents occurring in Europe during fiscal year 1967 involved rollover. Two were collisions with subsequent rollover, and six (43%) involved non-collision single-vehicle rollovers; two of the latter occurred on straight sections of road and four on curves. The two non-single-vehicle collisions with rollover both occurred on straight roads (U.S. Army Material Command, 1967).

The M151 jeep was involved in 7,460 accidents world-wide in the years FY1967 through FY1970, involving 138 fatalities; 2,201 (30%) were rollover accidents (Department of the Army, 27 November 1970). During the three-year period FY1974-FY1976 the U.S. Army reported 1,102 M-151 jeep crashes, involving 42 fatalities and 507 injured occupants. Overall, 66 percent of the total FY1974-FY1976 jeep accidents involved rollovers. It is significant to note that in none of these 1,102 crashes was post-crash fire reported (Table 2.1-1).

The M151 series jeep accounted for 965 (45%) of the 2151 Department of the Army rollover crashes occurring between April 1974 and September 1978 (from U.S. Army computer data printouts cited in Brune, 1979). The basic M151 military jeep has an overturn rate of 16.1 accidents per million miles. This is reflected in the warning printed in the M151 operator's Manual stating: WARNING: Extreme care should be used when driving M151 series vehicles. They have more responsive steering and acceleration than other vehicles. Watch speed, especially on turns. A full right or left turn at speeds over 20 mph can cause any vehicle to go out of control and/or turn over (U.S. Army, 1978). It should be noted that significantly reduced overturn rates in the later M151A1, M151A1C, M718 (1.8 accidents per million miles), and in the M151A2, M825, and