

FRANKLIN RESEARCH CENTER
DIVISION OF ARVIN/CALSPAN

**A STUDY OF LIGHT TRUCK AND PASSENGER CAR
ROLLOVER AND EJECTION IN SINGLE-VEHICLE CRASHES**

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May 1988

Calspan Report No. 7636

Prepared for the Motor Vehicle Manufacturers Association of the United States, Inc. The Project was supported with funds under MVMA Agreement Number CAL 8717-C7167.

The opinions, findings, and conclusions expressed in this publication are those of the author and not necessarily those of the Motor Vehicle Manufacturers Association, Inc. or its member companies.

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ABSTRACT

This study follows-up previous Calspan research revealing that, while light trucks protect their occupants about as well as cars do in single-vehicle crashes, light trucks had substantially higher rollover and ejection rates than cars. The new research sought to determine (a) the roles of driver, environment, and vehicle factors in the rollovers of light trucks and (b) how occupants are ejected from light trucks. Studied were pickups, vans, and utility vehicles from model years 1979-1986, using data from the 1980-1985 files of the National Accident Sampling System (NASS). To provide additional details about roadsides, rollovers, and ejections, a special clinical file was created by coding from 487 hard-copy NASS cases. In controlling for driver and environmental factors, light truck overturn rates remained higher than car rates, with utility vehicle rates distinctly the highest. Compared to cars, light trucks exhibited more precrash lateral skidding, more on-road rollovers, and more tripping-type rollovers. Occupant ejections were the highest in utility vehicles, somewhat higher in pickups than in cars, and about the same in vans as in cars. Controlling for crash severity indicated that ejections were highly injurious to occupants. Structural failures associated with ejection were doors opening, windows and windshields breaking, and in the case of utility vehicles, roof failures. It was concluded that vehicle factors appear to play a role in

ACKNOWLEDGEMENTS

The special files created for the statistical analyses of NASS data were assembled by Mr. Charles Compton of the University of Michigan Transportation Research Institute.

Clinical analysis and coding of NASS cases to create the "clinical file" used in this study were performed by Nova Engineering of Oakton, Virginia. Mr. Francis A. DiLorenzo, P.E., was the principal analyst.

FOREWORD

The "Study of Light Truck and Passenger Car Rollover and Ejection in Single Vehicle Crashes" presents valuable insights. However, MVMA believes that readers should be aware of the limitations of the database and of the research design, so that its results are not generalized further than warranted, or intended by the researchers.

The study is based on data from the National Accident Sampling System (NASS). The number of NASS cases involving vans and utility vehicles is small and the information on each case is limited. While some information is available on the driver, the environment, and the vehicle, there is no information available on other, sometimes subtle factors, that may influence accident risk and accident type. The cases selected for inclusion in NASS are identified from listings based on police reports. Generally, all injury accidents are reported by police. Reporting of property damage accidents may vary by jurisdiction. Rollovers, with a high injury risk, are more likely to be reported.

Pickup trucks, vans, and utility vehicles are designed to be used differently than passenger cars. They are used in different applications and by different types of drivers although they are sometimes used like passenger cars. These differences in use and users are unlikely to be adequately measured by the limited information available in the NASS data base. To assess the contribution of various factors to accident causation, detailed information on these usage patterns, i.e., exposure, is needed for each vehicle type. Exposure information describes both accident and non-accident situations. Unfortunately, this information is not available. To make valid estimates of the risk of a particular type of crash, e.g., a rollover crash, both accident data and exposure information are needed. The present study is based on accident data alone.

It should be understood that this study was not intended to be a comparison of vehicle types in their relative risks of a rollover accident. To estimate relative risks, exposure data are needed. Because this was not a study of relative risks, it follows that the study does not indicate the influence of environmental and driver factors on those risks. That remains for further research.

It was a research objective to study conditional probabilities--the likelihood of vehicle rollover given that a single-vehicle crash has occurred. Consequently, the study examines various correlates of rollover percentages in single-vehicle crashes. Those percentages estimate, within the sample limitations, the conditional probabilities of rollover. The report refers to these percentages as "rates", which should not be confused with rates based on exposure data and intended to estimate risks.

The study's second conclusion that "Light trucks have a higher single-vehicle-crash overturn rate than cars; while driver and environmental factors play a role in elevating the overturn rates, vehicle factors appear to play a significant role" needs to be placed in context. As discussed above, the study did not control for the influence of driver and environmental factors on the rollover crash risk and the author acknowledges that light truck vehicle factors were not examined as it was beyond the scope of the study. The study, therefore, does not allow definitive statements to be made about the relative contribution of driver, environmental and vehicle factors to the rollover crash risk.

In summary, MVMA believes that the findings, conclusions, and recommendations of the study must be reviewed and interpreted in the context of the limitations of the NASS data, the lack of exposure data, and the limitations of the analytical methods used.

Motor Vehicle Manufacturers Association
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The Foreword was prepared by the Motor Vehicle Manufacturers Association, and it is included at the request of that organization. The opinions expressed in the Foreword do not necessarily represent the views of the author or the Franklin Research Center. Interested readers will find in Section 4.0 of the report further discussion of some of the issues raised by the Foreword.

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1.0 INTRODUCTION

In previous Calspan research, light trucks were found to protect their occupants better than cars when in two-vehicle crashes (Terhune, Ranney, Smist, and Woodill, 1984). In single-vehicle crashes, however, no clear differences between car and light truck injury rates were found (Terhune, 1986). Pickup and van occupants appeared no more at risk of injury in single-vehicle crashes than did car occupants. Results for utility vehicles were inconclusive, however, because of their small numbers in the sample. Although no overall problem of occupant protection was revealed in light truck single-vehicle crashes, high light truck rollover and ejection rates suggested particular ways in which light truck occupants may be more vulnerable to injury than car occupants. This vulnerability tended to be offset by somewhat better light truck occupant protection in nonrollover crashes.

Despite the fact that the single-vehicle injury rate of cars and light trucks differed little, the interests of light truck safety suggested that high rollover and ejection rates of light trucks merited further investigation. It is important to know whether light truck rollover rates are due mainly to the vehicles, to their drivers, or to their crash environment. It is also important to know specifically how occupants are being ejected from light trucks. Answers in each case may suggest

directions for improving light truck safety. That was the general objective of the study reported here.

1.1 Background

In Terhune's (1985) review and in subsequent research (Reinfurt, Stutts, and Hamilton, 1985; Terhune, 1986; Partyka, Sikora, Surti, and Van Dyke, 1987), rollover rates were consistently found higher in light trucks than in cars. Typically, rollover rates were highest for utility vehicles and second highest for pickups. Vans were usually found to have rollover rates between those of cars and of pickups, in studies of overall rollover rates. In the one study that examined van rollover rates in single-vehicle crashes, however, van rollover rates were second only to the utility vehicle rates (Terhune, 1986).

A fundamental question is whether the high rollover rates of light trucks are due to their intrinsic properties. Since these vehicles typically have high centers of gravity in relation to their track widths, this may make them more susceptible to overturn than cars, as some have suggested (Reinfurt et al., 1985; Robertson and Kelley, 1986). On the other hand, driver characteristics and the conditions in which the vehicles are used may elevate the light truck rates. This possibility has been raised primarily with respect to utility vehicles (Joksch, 1983). Our 1986 report examined this issue

by comparing light truck and car rollover rates while controlling for several non-vehicle factors which could possibly produce roll-rate differentials among the vehicle types; these were driver age, driver gender, and rural-urban crash location. Both State of Washington and National Accident Sampling System (NASS) data were used. Light trucks continued to exhibit higher rollover rates than cars when controlling for the possibly confounding variables, although the NASS data had insufficient sample sizes for some of the breakdowns needed. Especially important, the automated NASS file lacked detail on the environments of single-vehicle crashes, especially in regard to roadside features to which the vehicles were exposed. Hence, our study was unable to refute the idea that high light truck rollover rates may be due to crash circumstances. This remained a subject for further research.

Occupant ejection appears to be an important source of injury in rollovers. For example, 1985 NASS data revealed that 18% of occupants in light truck towaway rollover crashes were ejected, compared to only 1% of those in nonrollovers. Furthermore, 17% of the rollover ejectees were seriously injured (AIS > 3), compared with only 4% of the nonejectees (National Highway Traffic Safety Administration [NHTSA], 1987b). Thus, one may expect that high rollover rates of light trucks will elevate their ejection and injury rates. It is not surprising to learn from a NHTSA report to Congress that "The number of ejections from light trucks is three times that of

passenger cars." (NHTSA, 1987a, p.17). This tendency was also found in Calspan's study of single-vehicle crashes. However, only utility vehicles exhibited ejection rates distinctly higher than car rates, and only the Washington sample size was large enough to show this (Terhune, 1986). So on ejection also, data limitations indicated the need for further study.

As with rollovers, questions may be raised as to the interpretation of higher ejection rates of light trucks. For example, might the higher ejection rates be attributable to the more frequent light truck crashes in rural areas, where accidents are usually more severe? And if ejections occur primarily in severe crashes, would not the ejected occupants have been as seriously injured even had they remained in their vehicles? This seemed to be the implication of ejection research by Huelke, Compton, and Studer (1985). Answers to these questions will help us to understand whether ejection per se is a problem deserving special attention in light trucks. If ejection is a special light truck problem, determining how the ejections occurred should help in finding remedies. These are further matters addressed in this study.

In summary, previous research has found crash rollover and ejection rates to be substantially higher in light trucks than in cars, yet the two vehicle types differed little in overall injury rates. This paradox in itself merits further investigation and explanation. But light truck rollover and

ejection also deserve further study to see if these are special sources of injury potential in light trucks, possibly subject to countermeasures.

1.2 Objectives

As in our previous investigation (Terhune, 1986), this study examined rollover and ejection in single-vehicle crashes, a crash type important for the following reasons:

- o Past research indicated that light truck occupants are fairly well-protected in two-vehicle crashes, but a possible problem may exist in single-vehicle crashes (Terhune, 1985);
- o Rollovers are found to occur mainly in single-vehicle crashes (Huelke, Marsh, and Sherman, 1972; McGuigan and Bondy, 1980), and occupant ejections occur primarily in rollovers (Terhune, 1986);
- o This study was intended to be an in-depth follow-up of our 1986 study, in order to obtain detailed explanations and clarifications of its findings; hence it was important to examine the same types of crashes.

The specific objectives of this study were:

- (1) To determine if differences between light truck and passenger car rollover rates in single-vehicle crashes can be attributed mainly to their drivers and the circumstances in which the accidents occurred;

- (2) To determine if ejection per se is an important injury-producing event in light truck single-vehicle crashes, and if so, to determine how light truck ejections occur.

In addition to pursuing these objectives, we took advantage of an expanded NASS data set to see if our previous findings, comparing light truck and car rollover and injury rates, would be confirmed.