PLANNING DOCUMENT
FOR
ROLLOVER PREVENTION AND INJURY MITIGATION
DOCKET 91-68 NO. 1

Office of Vehicle Safety Standards

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INTRODUCTION

The National Highway Traffic Safety Administration (NHTSA) is considering rulemaking to decrease the number and severity of rollover crashes. The purpose of this document is to inform the public of the many issues involved in the prevention of rollover fatalities and injuries and to give a schedule for regulatory decisions affecting rollover crashes. The rulemaking programs discussed in this document would reduce injuries and fatalities by developing feasible and appropriate standards in the areas of crashworthiness and crash avoidance and would promote programs to inform the public of the hazards related to rollover crashes. The problem of vehicle rollover is multifaceted. The driver, the environment, and the vehicle design are involved. Therefore, it will not be possible to mitigate the problem with a single regulation. The Agency is using this opportunity to make it clear that its rollover program may require several rulemakings.

THE ROLLOVER CRASH PROBLEM

Rollover crashes occur for many reasons; most involve interactions of factors from the driver/vehicle/environment system. The relationship of these various factors to rollover crashes can be elicited from the analysis of data from various sources available to NHTSA. These data systems have differing levels of detail about vehicle crashes; none alone contains all the information needed to completely assess the rollover crash problem.

Various accident data studies have indicated that the vehicle is out of control before overturning in 50 to 80 percent of all rollovers. From data collected in the National Accident Sampling System General Estimates System (NASS-GES), it is estimated that there were 213,200 rollover crashes involving passenger cars, light trucks, vans, and sport utility vehicles (SUVs) in 1989. Of these, 190,600 or 89 percent were single vehicle crashes and 172,000 or 81 percent occurred off the road.

Using NASS-GES data it is estimated that 52,101 vehicle occupants were injured in rollover crashes in 1990. For the same year, the Fatal Accident Reporting System (FARS) contained 9,514 fatalities as a result of rollover crashes. There has been little variation in these numbers over the past five years.

The average number of rollover fatalities reported in FARS from 1985 through 1990, by vehicle class, is shown in Figure 1. During these years, small cars had the greatest number of rollover fatalities followed by standard-size pickup trucks. However, some types of vehicles are more common than others in the fleet. To compensate for this, the relative risk of rollover fatalities by vehicle type was assessed. The average number of fatalities in FARS from 1985 -1990 was classified by vehicle type involved and the fatality rate per million registered vehicles was calculated. These rates indicate that pick-up trucks and utility vehicles have fatality rates per million registered vehicles two to three times that of passenger cars. These data are shown in Figure 2.

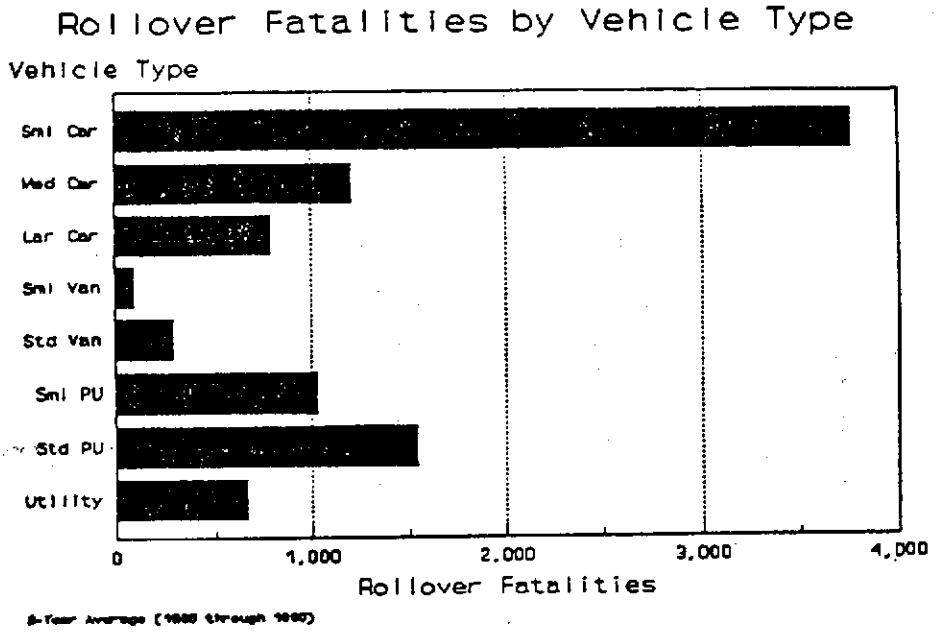

Figure 1 Rollover fatalities by vehicle type

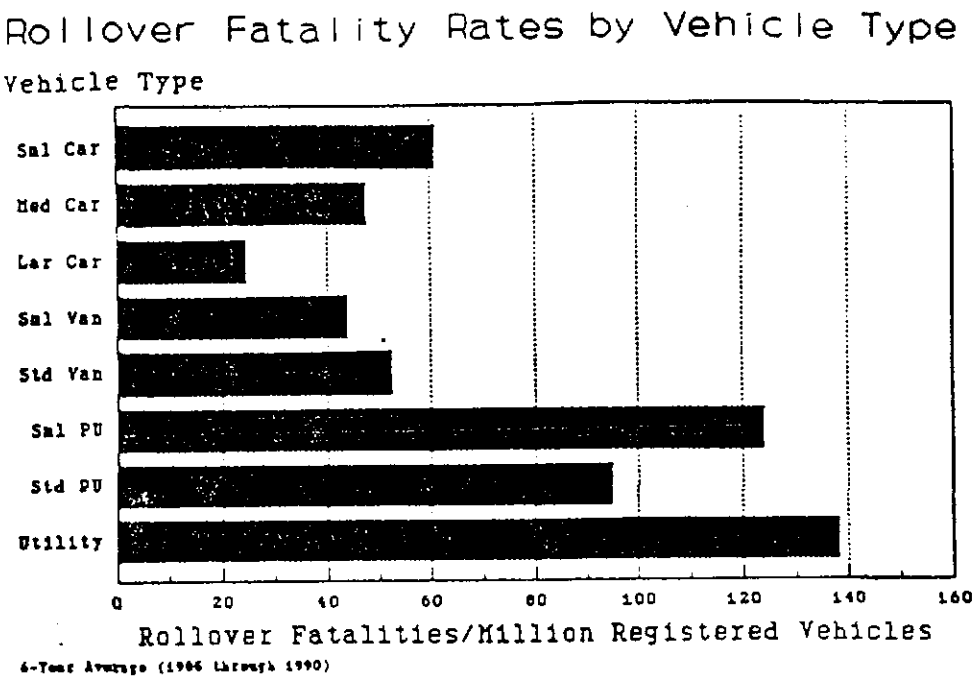

Figure 2 Rollover fatality rate by vehicle type

NHTSA turned to state accident files to obtain information on driver characteristics such as age, restraint usage, alcohol use, and information on road conditions at the accident site. Analysis of data for single vehicle crashes from four states (Michigan, Maryland, Utah, and New Mexico) for the years 1986-1988 and for 1987-1988 in Georgia revealed that rollover accidents are more common in rural areas and on slippery ("bad") road surfaces, curves, and grades than in urban areas and on good road surfaces, straight roads, and level roads. Younger drivers and drivers who had been drinking were more likely to be involved in single vehicle rollover crashes. See Figures 3 and 4.

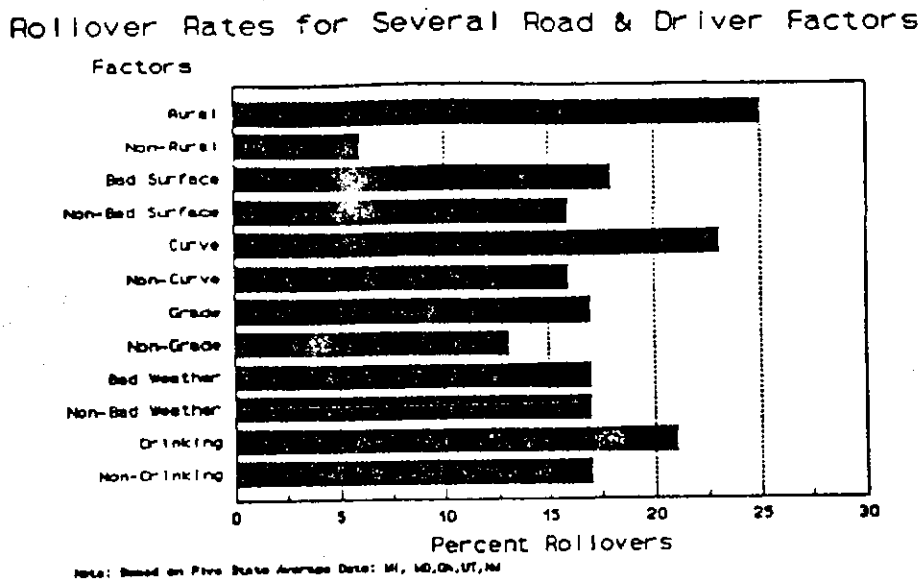

Figure 3 Rollovers per single vehicle accident for various driver factors and road conditions

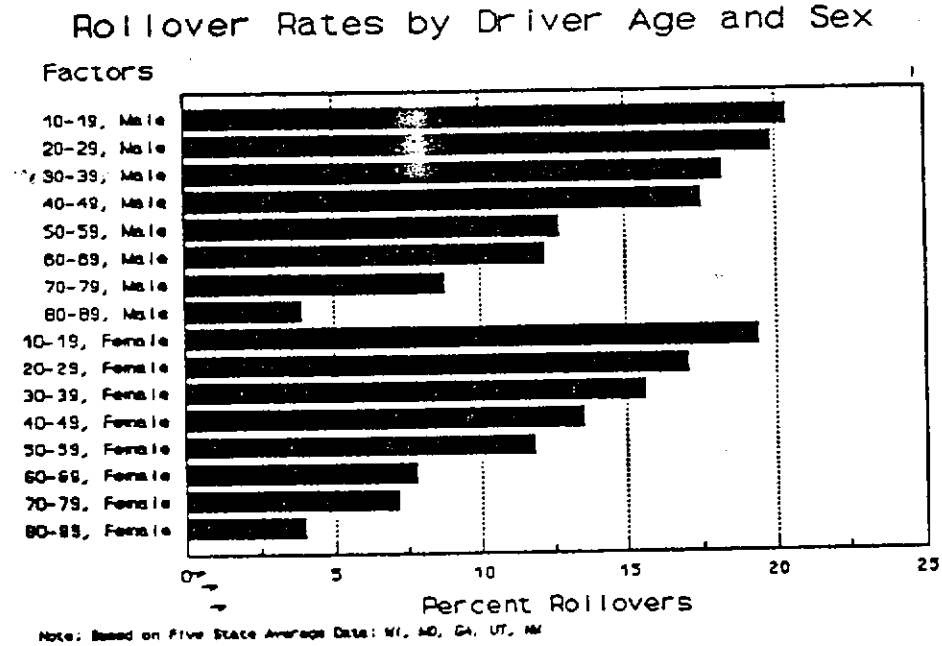

Figure 4 Rollovers per single vehicle accident by sex and age

FARS data indicate that of the 7,813 fatalities in 1990 from single vehicle non-rollover crashes, 83 percent did not use a safety belt and 19 percent were ejected from the vehicle. Among the 8,088 occupant fatalities in single vehicle *rollover* crashes, 87 percent did not use a safety belt and 63 percent were ejected from the vehicle. Hence, the risk of ejection was 3.5 times greater in a fatal single vehicle rollover crash than in other fatal single vehicle accidents. According to NASS estimates the most common ejection routes are near-side windows and doors. Side door ejections may account for approximately 18 to 20 percent of the total fatal ejections.

A study of injury data collected by NASS from 1988 to 1990 found head injuries were the most prevalent type of injury in rollover crashes. Some resulted from impact with the roof, which may have intruded into the passenger compartment during the crash; others resulted from the head hitting other interior components or the ground.

HISTORY OF ACTIVITY IN THIS AREA

In 1973, NHTSA issued an Advance Notice of Proposed Rulemaking (ANPRM), "Rollover Resistance, Docket 73-10; Notice 1," to solicit comments on the development of a test procedure, test conditions, and performance requirements to evaluate "vehicle rollover tendencies on smooth, dry pavement." After reviewing the comments to that notice and after conducting several research studies related to vehicle control and stability, the agency decided to discontinue activity in this area. One study titled "Development of Vehicle Rollover Maneuver," concluded that although a vehicle's rollover resistance is dependent on its static stability factor (i.e., the vehicle's half-track width divided by its center of gravity height) "to the first order," resistance to rollover "can, however, be degraded by other design and operational features under real life performance conditions." The agency decided until the influence of those other factors on real world accidents was better understood, agency action could not be justified.

In September 1986, NHTSA was petitioned to limit the rollover propensity of light duty vehicles, including passenger cars, light trucks, and multipurpose passenger vehicles, by defining a minimum static stability factor (SSF) of 1.2. That petition, submitted by Congressman Timothy E. Wirth, also requested a defect investigation of those existing light duty vehicles whose SSF did not meet the minimum required by the petitioned standard. The petition also asked the agency to publish SSF information for vehicles being manufactured for sale in the United States and to warn owners of vehicles that had a high propensity for rollover. The petitioner alleged that the rollover propensity of vehicles whose SSF is less than 1.2 is so great, and that the relative number of deaths and injuries is so high, that their manufacture should be prohibited. This conclusion was based on an analysis submitted with the petition. The Wirth petition was denied on December 29, 1987 (52 FR 49033), because "... basing an effort to

address the rollover problem on the stability factor alone is [a] too narrow and inappropriate approach."

In June 1988, the Consumers' Union of United States, Inc. (CU), submitted a petition for rulemaking to establish, "a minimum stability standard to protect against unreasonable risk of rollover." This petition, granted in September 1988, is the basis for current activities on this subject. Those activities include the Advance Notice of Proposed Rulemaking, January 2, 1992 (57 FR 242), issued by NHTSA to obtain information that would assist NHTSA in formulating a rulemaking decision on several rulemaking alternatives. The ANPRM fulfilled a mandate by the National Highway Traffic Safety Administration Authorization Act of 1991 that NHTSA initiate rulemaking on rollover protection by May 31, 1992. The period for public comment on the ANPRM closed April 3, 1992. Forty-two comments were received from vehicle manufacturers, safety groups, retailers of aftermarket automotive equipment, automotive consultants and a concerned citizen. This plan was developed after a thorough review of the public comments received in response to the ANPRM. The Summary of Comments is available to the public from Docket 91-68 Notice 1.

APPROACHES TO THE ROLLOVER PROBLEM

Various approaches might be considered to reduce the risk of rollover crashes and their resultant injuries and fatalities. Attempts can be made to lessen the frequency of such crashes, either by modifying vehicles to lessen the likelihood of rollover in a crash or by attempting to modify driver behavior. Attempts can also be made to lessen the risk of injury and death should such a crash occur.

Crash Avoidance Approaches

Ideally, it would be preferable to prevent the crash or prevent the rollover should a crash occur. Under these approaches, NHTSA would require changes to vehicles to lessen the likelihood of vehicle rollover. This could take the form of a requirement to meet a vehicle stability measurement or a requirement for antilock brake systems (ABS). These types of rulemaking could be applied to all vehicles in a particular class, a set of vehicles not meeting a minimum rollover resistance requirement, or all light vehicles in all classes.

NHTSA's data analysis indicated vehicle stability measurements correlated to their rollover per single vehicle accident ratio (RO/SVA). One rulemaking approach to address the rollover problem and related injuries and fatalities would be to establish a minimum rollover resistance for a vehicle, using a stability measurement, such as the tilt table ratio (TTR). Once established, no vehicle could be sold which did not meet the minimum requirement. Current make/models not meeting the new requirement would either be improved or discontinued. This would

eliminate vehicles with lower rollover resistance from the fleet. It is believed that this would lower the number of fatal and serious injuries associated with rollover crashes.

Another approach would be to institute rulemaking which would separate vehicles into classes and apply a rollover resistance requirement to each class. In this approach, a much smaller segment of vehicles within a class would be improved or removed from the fleet.

Using the available data in logistic regression analysis, very good general correlations were found between rollover stability metrics and rollovers per single vehicle accident (RO/SVA) when driver and environment factors were also included in the model. The ability of the model to predict the rollover rate of particular vehicles was somewhat lacking. Many manufacturers contend that the driver and environmental factors account for a significant portion of the likelihood of a rollover crash. However, some benefits do occur when the agency takes direct action to eliminate vehicles that have relatively very poor rollover resistance (those which have low rollover stability) and that have high rollover fatality rates as well as high RO/SVA.

In some models of light trucks and vans (LTVs), NHTSA accident data analysis indicates the addition of ABS has lowered significantly the proportion of rollovers in single vehicle crashes. In about 7,000 single vehicle crashes of four make/models, where the same vehicle existed with rear wheel only ABS and without ABS, the weighted difference in RO/SVA was about three percent lower for the ABS equipped vehicles. Analysis of ABS effect will be conducted on an extended set of all wheel ABS/non-ABS equipped pairs and results will be presented in future rulemakings concerning rollover injury mitigation.

Crashworthiness Approaches

Using a crashworthiness approach, NHTSA could require measures to lessen the likelihood of injury or death in a rollover. This could take the form of requiring padding to lessen the chance of severe head injury or better latches on doors to reduce the likelihood of ejection from the vehicle in a crash. This type of approach has an advantage over a rollover resistance requirement, that might address only the portion of the fleet which experiences a relatively high risk of rollover, in that it could be designed to affect more vehicles. For instance, requirements which mitigate the effects of rollover crashes could be applied to all light vehicles, thus the preventive measure is acting on all vehicles which roll over. Most commentors stated that all vehicles can and do roll over, suggesting that a crashworthiness rollover rulemaking applied to all vehicles would have more benefits than a stability rulemaking that only affected a subset or class of vehicles.

From 1985 to 1990 the number of rollover fatalities per million registered vehicles has fallen steadily from 168 in 1985 to 116 in 1990. Many factors other than vehicle design could contribute to this reduction. One such factor could be seat belt use. The 1990 FARS data

include 6,443 fatalities in SVA rollovers among drivers of light passenger vehicles (cars, light trucks, and multipurpose vehicles). Thirteen percent, or 851 fatalities, used the seat belts (as estimated from the cases for which the police indicated whether or not the fatally injured driver was using a safety belt). Since safety belts have been estimated as 75 percent effective in preventing rollover fatality, an estimated 2,550 lives were saved by use of safety belts, and 38 percent of those involved in potentially fatal crashes were belted. An estimated 9,000 drivers would have died in SVA light vehicle crashes in 1990 if no one had used the safety belt. If belt use were to increase to 70 percent in these crashes, safety belts would save an estimated 4,720 lives a year in these crashes, which is 2,170 more than were saved at the belt use levels existing in 1990. These numbers are rough estimates but, they demonstrate the potential significant effect that increasing safety belt use might have on reducing rollover fatalities.

The trend toward lower rollover fatality rates for utility vehicles in more recent accident years is more pronounced than in other classes of vehicles; small cars and small vans experienced a slight decrease in rollover fatality rates and other classes of vehicles had no marked change in rollover fatality rate over the same time period. This could mean that the occupants of utility vehicles (which include open and soft top utility vehicles and vehicles which did not need to meet roof crush requirements) have benefitted more from the increased use of safety belts than occupants of other types of vehicles. Other factors that might be contributing to the apparent decrease in the number of fatalities from SUV rollovers over the six-year interval are the increasing use of these vehicles in the urban environment and the aging of the driving population. Both these factors were shown to be important predictors of a rollover crash. A single vehicle crash in a rural area is four times more likely to be a rollover crash than a single vehicle crash in an urban area. Also, high publicity has been given over the last few years to the rollover problem of particular models of SUVs and this may have affected the behavior of SUV drivers in general.

Crashworthiness rulemaking could also be considered for improvement of side door latch/linkage mechanisms to prevent ejection through opened side doors and for improved glazing to prevent ejection through window areas. Occupant ejection is a major cause of injury in rollover crashes. NASS data indicate side door ejections may account for approximately 15 percent of the total fatal ejections. Two-thirds of door openings during rollover crashes are caused by latch/striker disengagement.

Based on 1988-1990 light vehicle accident data from NASS, the agency estimates 38,300 people are ejected from vehicles each year during rollover accidents. According to FARS, approximately nine percent of these ejectees are killed when they are partially or completely ejected through the windows. Approximately half of all ejections reported by NASS are out of the left and right front side windows. More specifically, 27 percent of the rollover ejections are out the driver's side window and 22 percent are out the passenger side window. One way to prevent ejection through side windows is the use of glass-plastic glazing secured to the vehicle frame. Glass-plastic glazing has been permitted in windshields since 1983. The agency is

investigating whether a two-layer penetration-resistant glazing can be manufactured which will permit the reasonable production of tempered high penetration resistant glazing for side windows. The agency has demonstrated a frame can be built around the glazing, even for a movable window, that can be attached to the plastic layer and which will hold the glazing in place during an accident (See DOT HS 807-397). The agency has amended FMVSS No.205 to remove the remaining glass-plastic regulatory barriers. This permits tempered glass-plastic glazing appropriate for side windows, known as Item 15B glazing, to be used anywhere in the vehicle exclusive of the windshield (57 FR 30161 July 8, 1992). This glazing would be manufactured from tempered glass, as is the glass currently used in the side and rear windows of automobiles, but with the addition of an inner layer of plastic.

An area where crashworthiness rulemaking is underway which will affect rollover is in padding the upper interior of vehicles. An NPRM for this action will be issued by January 31, 1993 (see 57 FR 24008, June 5, 1992). A study of 1988-1990 NASS data estimated 19 percent of restrained occupants who were not ejected in a rollover crash received fatal injuries from contacting vehicle interior components, such as roof pillars, headers and the roof itself, but not including the steering assembly. In preliminary benefit evaluations, it is estimated that 200 to 225 lives and 350 to 400 serious injuries resulting from rollover crashes could be eliminated by padding the upper interior.

FMVSS 216, "Roof Crush Resistance", has been extended to include multipurpose passenger vehicles, trucks and buses with a GVWR of 6,000 pounds or less. This standard requires compliance with a static roof crush test. Previous studies have failed to establish a causal relationship between roof crush and occupant injury seen in the accident databases. The agency is initiating research on dynamic roof crush performance.

Consumer Information/Education Approach

NHTSA could require that information be supplied to consumers, informing them of the particular dangers of driving vehicles identified as having a relatively low rollover resistance in crashes, such as utility vehicles and light trucks, explaining the dangers associated with rollover crashes in general, and/or giving additional information on the likelihood of a vehicle rolling over if involved in a crash. Several possible avenues for applying this type of requirement are described below.

1. Require manufacturers to measure the rollover resistance of each model and report the measurement at the time of sale, along with some comparative data to indicate where the vehicle ranks with its peers. Manufacturers would measure and report the stability metric to the government prior to sale. However, these data may not be available until late in the development cycle, thus making it difficult for the government to compile peer group comparisons for consumers. Manufacturers indicate that the rollover resistance measurement