NEW TRB SPECIAL REPORT

The National Highway Traffic Safety Administration's Rating System for Rollover Resistance

An Assessment

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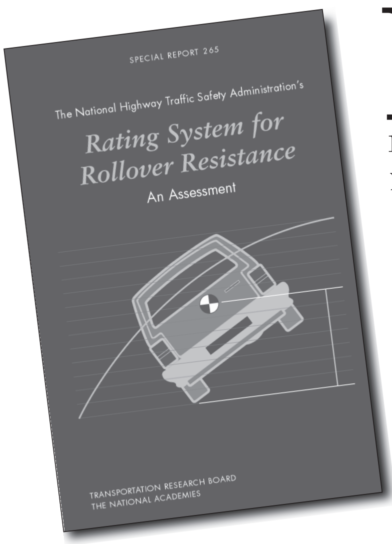

Special Report 265: The National Highway Traffic Safety Administration's Rating System for Rollover Resistance: An Assessment is available from TRB (see Publications Order Form in this issue).

Motor vehicle rollovers involving passenger cars, vans, pickup trucks, and sport utility vehicles (SUVs) result in approximately 10,000 deaths and 27,000 serious injuries each year in the United States. Rollovers occur in fewer than 1 in 10 tow-away crashes involving light vehicles[1] but account for almost one-third of light-vehicle occupant fatalities.

The risk of death or injury is particularly high in single-vehicle rollovers. Of the 8,345 people killed in single-vehicle rollovers in 1999, 80 percent were not using a seat belt, and 64 percent were ejected from the vehicle.

All automobile crashes are complex but involve three main interacting factors: the driver, the driving environment (e.g., weather and road conditions, time of day), and the vehicle. Reductions in the number of deaths and in the number and severity of injuries associated with rollover therefore would likely result from

- Changes in driver behavior—notably increased seat belt use;
- Design improvements in roadsides and roadside structures, particularly in rural areas; and
- Vehicle modifications to reduce the likelihood of rollover and to provide additional protection of occupants.

The TRB Committee for the Study of a Motor Vehicle Rollover Rating System (see box on page 32), appointed at the request of the U.S. Congress, was charged with investigating the potential role of vehicle characteristics and related consumer information in reducing the number of rollover crashes. *Special Report 265: The National Highway Traffic Safety Administration's Rating System for Rollover Resistance: An Assessment*, released in April 2002, presents the committee's findings and recommendations to the National Highway Traffic Safety Administration (NHTSA) for developing consumer information on motor vehicle rollover to (*a*) assist the public in choosing safer cars and (*b*) encourage manufacturers to investigate ways of making vehicles less susceptible to rollover.

Star Ratings

NHTSA has developed a five-star rating system to inform consumers about the rollover resistance of light vehicles. A five-star rating indicates the highest resistance to rollover, with one star the lowest. Most 2001-model SUVs received two- or three-star ratings; most passenger cars received four or five stars. The ratings—incorporated into NHTSA's New Car Assessment Program—provide an estimate of the probability of rollover in a single-vehicle crash but do not predict the likelihood of a crash or the type or severity of injuries.

NHTSA's rollover resistance rating depends on a vehicle's static stability factor (SSF)—the track width divided by twice the center-of-gravity height (see Figure 1). According to the agency's analyses of 220,000 single-vehicle crashes, taller, narrower vehicles, such as SUVs, are more likely to roll over than lower, wider vehicles, such as passenger cars, after contact with a mechanical obstacle such as a curb or other surface irregularity. NHTSA's rollover resistance rating system is based on a statistical correlation between SSF and the probability of rollover in a single-vehicle crash, as determined from crash data.

The study committee's charge was to investigate whether SSF is a "scientifically valid measurement that presents practical, useful information to the public," and to compare the SSF with "rollover metrics

[1] Passenger cars and multipurpose passenger vehicles under 10,000 pounds gross weight.

based on dynamic driving conditions that may induce rollover events" (Public Law 106–346). The committee undertook investigations in three subject areas: vehicle dynamics, crash data analysis, and consumer information.

Vehicle Dynamics

Vehicle rollover has been investigated using both static and dynamic testing. Static testing, performed in the laboratory, involves measuring vehicle parameters or testing entire vehicles and then correlating the data with rollover propensity. Dynamic testing is performed on a test track and is helpful in understanding the events preceding rollover but is expensive and requires safety precautions for the test drivers. Moreover, repeatability may be difficult to achieve.

The committee determined that SSF—which relates easily measured vehicle parameters to the level of sustained lateral acceleration that leads to rollover—is an indicator of vehicle rollover propensity and is preferable to other static measures. The concern, however, is that SSF does not address the reason a vehicle starts sliding sideways or whether a vehicle would have remained under control if equipped with a stability control system.

SSF therefore cannot yield an understanding of a rollover crash from initiation to final outcome—dynamic testing is required to understand how the handling characteristics of a vehicle affect the driver's ability to maintain control in an emergency. In particular, dynamic testing may discriminate among vehicles with similar SSF but a different likelihood of encountering out-of-control situations that result in rollover.

Because of the diversity of dynamic tests and the need to test near the limits of vehicle performance, the development of one or more dynamic rollover tests requires complex choices and extensive evaluation. A suitable dynamic test protocol should make it possible to segregate driver or vehicle systems susceptible to loss of control from those that are more robust.

Crash Data Analysis

The crash data files NHTSA used to develop the rollover resistance rating system include information on driver characteristics and road conditions. This allows the definition of different crash scenarios associated with different risks of rollover. For example, scenarios involving drivers under age 25 or drivers who have been drinking alcohol carry a relatively high risk of rollover, as do scenarios involving inclement weather or curves in the road. A critical question is the extent to which a vehicle's SSF value affects the risk of rollover for different drivers and driving environments.

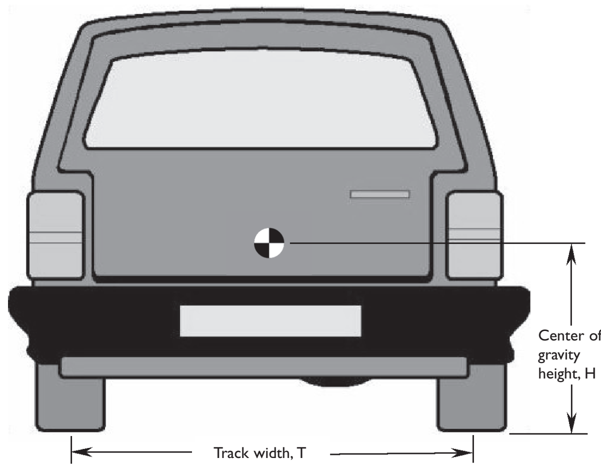

FIGURE 1 Important dimensions for static stability factor (SSF = T/2H).

Analysis of crash data reveals that, for higher-risk scenarios, SSF correlates significantly with single-vehicle rollovers, although driver behavior and the driving environment also contribute. For these scenarios, the statistical trends in crash data and the underlying physics of rollover are consistent in showing that an increase in SSF reduces the likelihood of rollover.

NHTSA derived its star ratings from an average rollover propensity curve, calculated using an exponential statistical model and regression analysis of single-vehicle crash data from six states. The five rating categories were obtained by partitioning the curve based on the probability of rollover in a single-vehicle crash.

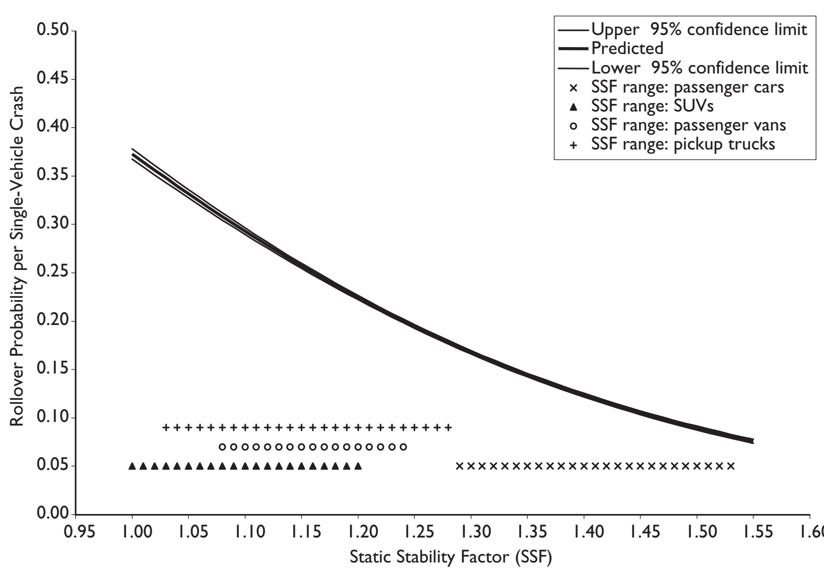

FIGURE 2 Estimated probablility of rollover and 95 percent confidence intervals based on maximum-likelihood estimation of a logit model using the data from six states combined (n = 206,822).

Committee for the Study of a Motor Vehicle Rollover Rating System

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The committee found that the relationship between rollover risk and SSF can be estimated accurately with available crash data and software using a logit statistical model, which is more appropriate than the exponential model used by NHTSA (see Figure 2). Approximating the rollover curve with five discrete levels also does not convey the full information from the available crash data. At lower SSF values, the rollover curve is relatively steep, producing a wide variation in SSF within a rating category. As a result, two SUVs may have differences in SSF and rollover propensity but the same star rating. The rating system therefore is not as helpful as it could be to a consumer.

Consumer Information

User statistics indicate that the rollover information on NHTSA's website has attracted interest. However, empirical data on consumer use of the ratings are not available. Therefore in assessing the ratings for "practical, useful information to the public," the committee focused on the process used in developing the rollover rating system.

The committee noted a gap between NHTSA's process and recommended practices for identifying and meeting consumer safety information needs. In particular, NHTSA relied on focus group studies that were limited in scope, and it did not undertake empirical studies to evaluate how consumers use the rating system in making vehicle safety judgments or purchase decisions.

Response to Congress

The committee developed two summary findings:

1. SSF captures important vehicle characteristics related to rollover propensity and is strongly correlated with the outcome of actual crashes. However, data from dynamic testing could provide important complementary information on vehicle crash-avoidance metrics.

2. NHTSA's star ratings for rollover resistance are likely to be of limited practical use to the public because of

– Shortcomings in the methodology used to produce the average rollover curve;

– The inadequacy of the five discrete rating categories in conveying vehicle differences indicated by the available crash data; and

– The limited procedures used in developing and evaluating the star rating system.

Future Approach

In accordance with the Transportation Recall Enhancement, Accountability, and Documentation Act, NHTSA is investigating several driving maneuver tests for rollover resistance. The committee recommended that NHTSA vigorously pursue this research to develop one or more dynamic tests to assess transient vehicle behavior leading to rollover. In the longer term, the agency should revise consumer information on rollover, incorporating dynamic test results to complement the information from static measures such as SSF.

The committee also recommended that NHTSA investigate alternative options for communicating information to the public on SSF and rollover. In revising the consumer information, NHTSA should

- Use a logit statistical model as a starting point for analyzing the relationship between rollover risk and SSF;
- Consider a higher-resolution representation of the relationship between rollover risk and SSF than the current five-star rating system;
- Continue to investigate presentation metrics other than stars; and
- Provide consumers with more information placing rollover risk in the context of motor vehicle safety.

Jill Wilson is Senior Program Officer, TRB Division of Studies and Information Services, and served as study director for this project.