A Progress Report on Development of a Dynamic Rollover Rating Test

Dr. W. Riley Garrott
Pat Boyd
National Highway Traffic Safety Administration
May 15, 2001
Presentation Overview

• Background
• Dynamic Rollover Testing Issues
• Planned Testing
  – Testing Overview
  – Test Vehicles
  – Initial Test Maneuvers
• Preliminary Rollover Rating Ideas
• Current Status
Background
Rollover Crash Statistics

- 10,142 people were killed in light vehicle rollovers during 1999 (FARS)
  - 8,345 were killed in single-vehicle rollovers
  - 80% were not wearing a seat belt
  - 55% of occupant fatalities in light, single-vehicle crashes involved rollover
    - 46% of fatalities for passenger cars
    - 63% of fatalities for pickup trucks
    - 60% of fatalities for vans
    - 78% of fatalities for sport utility vehicles
Rollover Crash Statistics

- 27,000 serious injuries per year due to light vehicle rollovers (NASS, 1995 – 99 average)
  - 19,000 in single vehicle crashes
- 253,000 light vehicle rollovers per year (NASS, 1995 – 99 average)
  - 205,000 in single vehicle crashes
  - 178,000 occurred after vehicle had left roadway
NHTSA Action to Prevent Rollover

- NHTSA includes rollover resistance ratings as part of its New Car Assessment Program
  - Ratings based on Static Stability Factor (SSF)
    - SSF equals one-half of a vehicle’s Track Width divided by its Center of Gravity Height
  - Ratings range from one to five stars
  - Rating program official as of January 12, 2001
NHTSA Action to Prevent Rollover

- Rollover resistance ratings based on SSF are controversial
  - Some believe that the influence of vehicle factors on rollover is so slight that vehicles should not be rated for rollover resistance
  - Others believe that SSF is a useful predictor of rollover but should be supplemented by dynamic driving tests
Response to Controversy About SSF

• Congressionally-mandated National Academy of Sciences’ study to assess validity of SSF based rollover resistance ratings and to compare SSF to dynamic tests

• TREAD Act requirements for dynamic rollover resistance ratings
Requirements of TREAD Act

• SEC. 12. Rollover Tests. No later than 2 years after enactment, the Secretary shall: (1) develop a dynamic test on rollovers of light vehicles for the purposes of a consumer information program; and (2) carry out a program of conducting such tests. As the Secretary develops a rollover test, the Secretary must conduct a rulemaking to determine how best to disseminate test results to the public.
Response to TREAD Act

• Met with representatives of several organizations to gather ideas
  – Alliance of Automobile Manufacturers
  – Consumers Union
  – Daimler-Chrysler (next week)
  – Ford Motor Co.
  – Nissan Motor Co.
  – Toyota Motor Co.
  – University of Michigan Transportation Research Institute

• Received useful suggestions about dynamic testing approaches
Dynamic Rollover Testing Issues
Dynamic Rollover Testing

Issues

• Maneuver(s) to use for rollover ratings
• Ensuring that cannot get good rollover rating by degrading vehicle handling
  – By putting tires with poor traction on a vehicle, can prevent two-wheel lifts in these maneuvers
  – Safety may be degraded because cannot turn as sharply
Dynamic Rollover Testing

Issues

• Use of two-wheel lifts as safety-relevant measure
  – Minor two-wheel lifts may not be safety issue
  – Requiring major two-wheel lifts may cause test driver safety problems

• Outrigger effects
  – Must have for safety, prevention of test surface damage
  – How do they change a vehicle’s rollover propensity?
Dynamic Rollover Testing

Issues

• Tire wear
  – How much testing can be performed on a set of tires before wear effects become significant

• Tire debeading
  – What to do if tires debead while performing rollover rating testing
Dynamic Rollover Testing

Issues

• Longer-term repeatability
  – Effects of weather of results
    ✤ Summer versus winter
  – Changes to the same test surface with time
• Reproducibility
  – Effects of testing on different test surfaces
Planned Testing

Phase IV of NHTSA’s Light Vehicle Rollover Research Program
Phase IV Rollover Research

- Comprehensive test program designed to build on earlier NHTSA efforts, suggestions received from interested parties
- Attempts to take comprehensive look at identified issues
Overall Phase IV Plan

- Rating System Development Testing 1 – Spring 2001
- Hot Weather Effects Testing – Summer 2001
- Outrigger Effects Testing – Summer 2001
- Tire Wear Effects Testing – Summer 2001
- Rating System Development Testing 2 – Fall 2001
- Fully Automated Vehicle Controller Testing – Fall 2001
- Rating System Development Testing 3 – Fall 2001
- Rating System Development Testing 4 – Spring 2002
- Surface Effects Round Robin – Spring and Summer 2002
Test Vehicles

• Four Sport Utility Vehicles:
  – 2001 Chevrolet Blazer (no YSC)
  – 2001 Ford Escape (no YSC)
  – 1999 Mercedes ML-320
    ✴ YSC enabled
    ✴ YSC disabled
  – 2001 Toyota 4Runner
    ✴ YSC enabled
    ✴ YSC disabled
Test Vehicles

• Each vehicle will be tested in multiple configurations:
  – Nominal vehicle
  – Raised center of gravity height
    ‣ Weights placed on roof above c.g. so as to decrease SSF by 0.05
  – Modified handling
    ‣ Load to GVWR, load as far to rear as possible, larger or smaller tires
Test Maneuvers

• Testing broad array of maneuvers during Phase IV

• Two broad categories
  – Open-loop. Handwheel steering angle is specified function of time
    ✮ Characterization Maneuvers
    ✮ J-Turns with and w/o Pulse Braking
    ✮ Some Fishhooks
    ✮ Open-Loop Pseudo DLC
Test Maneuvers

• **Closed-loop.** Handwheel steering angle varies according to actions of vehicle
  - Driver closes feedback loop
    ✦ Double Lane Changes
  - Instrumentation closes feedback loop
    ✦ Fishhook with Roll Rate Feedback
Test Maneuvers

• Characterization Maneuvers
  – Pulse Steer – As per Phase II
  – Sinusoidal Sweep – As per Phase II
  – Slowly Increasing Steer – As per Phase II
  – Slowly Increasing Speed – Improved version of Phase II maneuver
  – Response Time Tests – 0.2 g and 0.5 g severity
    J-Turns at 50 mph. Performed with straight and curved (0.3 g) lead-in
Test Maneuvers

- **J-Turn Maneuvers**
  - J-Turn – As per Phase II
  - J-Turn with Pulse Braking – Improved Phase II maneuver
    - Improvements to Phase II maneuver discussed in earlier presentation
Test Maneuvers

• Fishhook Maneuvers
  – Fishhook 5 – Improved Phase II Fishhook 1
  – Fishhook 6 – Fishhook with roll rate feedback
    ✦ Idea discussed in previous presentation
  – Nissan Fishhook – Fishhook using Nissan technique for determining timing
Test Maneuvers

• **Double Lane Change Maneuvers**
  – Ford DLC – Perform closed loop DLC per Ford’s procedure. Use Ford’s path-correction technique to calculate limit behavior
  – VDA (Modified Moose Test) DLC
  – Consumers Union Short Course DLC
  – Open Loop Pseudo-DLC – New maneuver being developed by VRTC
Planned Phase IV Testing

• Have received many valuable suggestions about Phase IV testing
  – Comments greatly appreciated!
• Encourage additional suggestions
  – May revise Phase IV research plan in response to comments
Preliminary Rollover Rating Ideas
Rollover Resistance Score

• Star Ratings derived from a vehicle’s Rollover Resistance Score
• Rollover Resistance Score quantifies vehicles performance in tests
  – Would go from 0 to 100 (100 = best)
• Table relates Rollover Resistance Scores to Star Ratings
Rollover Resistance Score

• Composed of multiple parts:
  – Handling Score
  – Limit Maneuver Score
  – Suggestion made by speaker at National Academy of Sciences meeting:
    Include Static Stability Factor!
Current Status
Current Status

• Test vehicles purchased and instrumented
• Testing in progress
  – Vehicle characterization and limit maneuver testing underway
• Request for Comment to be published soon
  – Comments on this work are appreciated!
• NHTSA will review comments received
  – May revise Phase IV research plan in response to comments