Center for Transportation Analysis
Research Brief
Oak Ridge National Laboratory

Truck Rollover Characterization for Class-8 Tractor-Trailers

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OVERVIEW

The Heavy Truck Rollover Characterization Project is a USDOT-sponsored research effort conducted through its University Transportation Centers (UTCs) Program through the National Transportation Research Center, Inc. (NTRCI), located in Knoxville, Tennessee. The research is being conducted by the Oak Ridge National Laboratory (ORNL) in partnership with Michelin Americas Research and Development Corporation (Michelin), Western Michigan University, Battelle, Volvo Trucks North America, Clemson University and Dana Corporation. The long term five-phase project will: (1) contribute to the understanding of the dynamics of heavy truck rollover; (2) contribute to the development of advanced models of heavy truck vehicle dynamics that reflect project experiences, and (3) develop recommendations for improvement of the roll stability of heavy vehicles and testing such realizations in an integrated tractor-trailer concept. The five phases include: Phase 1 Tractor-Box-Trailer Characterization with Standard Dual Tires; Phase 2 Tractor-Box-Trailer Characterization with New Generation Single Wide-Based Tires (NGSWBTs) and a wider-slider trailer suspension; Phase A Tractor-Flat-Bed Trailer with standard dual tires, NGSWBTs, and Electronic Stability Control; Phase B Tractor-Tanker with technologies yet to be determined; and Phase C Development of an Integrated Tractor-Trailer Concept building on the lessons learned from the previous four phases – the SafeTruck Concept.

PHASES 1 AND 2

Phases 1 and 2 were conducted with a 1999 Peterbilt 379 class-8 tractor (see Figure 1) and a 2004 Wabash dry freight van trailer pictured in Figure 2. Both were instrumented with a number of sensors to capture the dynamics of the tractor and trailer as it engaged in various testing maneuvers that

Figure 1—Dana's Peterbilt 379 with outriggers.

Figure 2—Dana's Wabash dry-box trailer.

included: an evasive maneuver, swept sine, constant radius, and a run-off-the-road maneuver. These maneuvers were carried out utilizing both standard dual tires and NGSWBTs, and in some cases also included the use of a wider-slider suspension on the trailer. One of the main objectives of the tests that are a part of this study was to understand how different elements (e.g., dual tires and NGSWBTs, different trailer suspension types, etc.) affect the overall vehicle roll stability. Tilt-table tests were performed at the University of Michigan to characterize the static rollover propensity if the tractor trailer. For all of the tests, the vehicle was loaded with ballast for a gross vehicle weight rating of 79,000 lbs., and the speeds were gradually increased so that wheel lift-off was experienced both visually and via instrumentation. A significant amount of data was collected on all maneuvers performed (1.2 Gigabytes of data from 45 data channels sampled at 100 Hz). Analyses of the data indicated that when NGSWBTs were used on the tractor, or trailer, or both, the roll stability index (maximum angular displacement of the trailer per maximum lateral acceleration) was better than that of the tractor-trailer with standard dual tires. When a wider-slider suspension was used on the trailer, the roll stability index improved even more. For Phases 1 and 2, it was concluded that the use of NGSWBTs and wider-slider suspensions provide improved roll stability for class-8 tractor-trailers. A copy of the final Truck Rollover Report for Phases 1 and 2 efforts can be downloaded from: http://www.ntrci.org/libraries/research.html. This report included the following recommendations:

- Increase track width,
- Decrease payload Center of Gravity (CG) height,
- Decrease tire compliance to limit the lateral translation of the CG,
- Eliminate fifth wheel and spring lash, which appear as free play in the rolling motion,
- Minimize the angular or roll clearance of the roll bump stops for the tractor axles,
- Maximize the roll bump stop clearance for the trailer axles,
- Increase drive axle suspension roll stiffness,
- Reduce lateral compliance (deflection) of the suspension,
- Increase front axle suspension roll stiffness while considering ride quality trade-offs,
- Increase the stiffness of the truck frame allowing the driver to better sense roll motions,
- Raise the suspension roll axis to reduce body roll angle,
- Distribute load among suspensions in proportion to the distribution of roll stiffness,
- Reduce lateral beaming of the vehicle frame,
- Ensure cargo is placed on-center to control lateral displacement of CG, and
- Reduce torsional compliance of the vehicle frame, particularly flat-bed trailers.

<u>PHASE A (3rd Phase):</u> Building on the results of Phases 1 and 2, the research within Phase A involves test-track testing utilizing NGSWBTs and standard dual tires, ESC, a standard frame class-8 tractor (Volvo), and a flatbed trailer (Utility) (see Figure 3 and Figure 4). In addition, a standardized torsional stiffness procedure was developed for characterization of the trailers to be addressed in Phase A as well as Phase B (involving a tanker - to be conducted in the the 2008-2009 timeframe). Kinematics and Compliance (K&C) testing and torsional stiffness testing were accomplished on both the tractor and flatbed trailer in order to characterize them in the modeling work that is being conducted utilizing TruckSim and other vehicle dynamics models. Test track testing was conducted at the Transportation Research Center's (TRC's) facilities in East Liberty, OH. Completion of the testing is expected by the end of January 2008.

Figure 3—Volvo VT 830 tractor used in Phase A..

Figure 3—Volvo VT 830 tractor used in Phase A..

BEYOND PHASE A (4th and 5th Phases): Phase B (4th Phase) will repeat similar research as has been conducted in the previous three phases, but will utilize a tractor-tanker. Tentative plans include continuation of the testing with standard dual tires/NGSWBTs, and ESC, but may include advanced suspensions, and a study of the effect of varying CG height which can be easily accommodated for in tanker-based testing. Phase B will also include a run-off-the-road test regimen of particular interest to the Federal Highway Administration (FHWA) in their future highway road-edge design efforts. Phase C (5th Phase, will involve the development of a customized, integrated tractor-trailer concept (SafeTruck) that builds on the lessons learned of the previous four phases. This phase will involve a tractor Original Equipment Manufacturer (OEM), a trailer OEM, and braking, axle and suspension suppliers. Once developed, the SafeTruck concept will be tested to assess its safety margins. This research will be conducted in the 2009-2011 timeframe.

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