Curve Speeds and Big Rigs

November 15, 2018

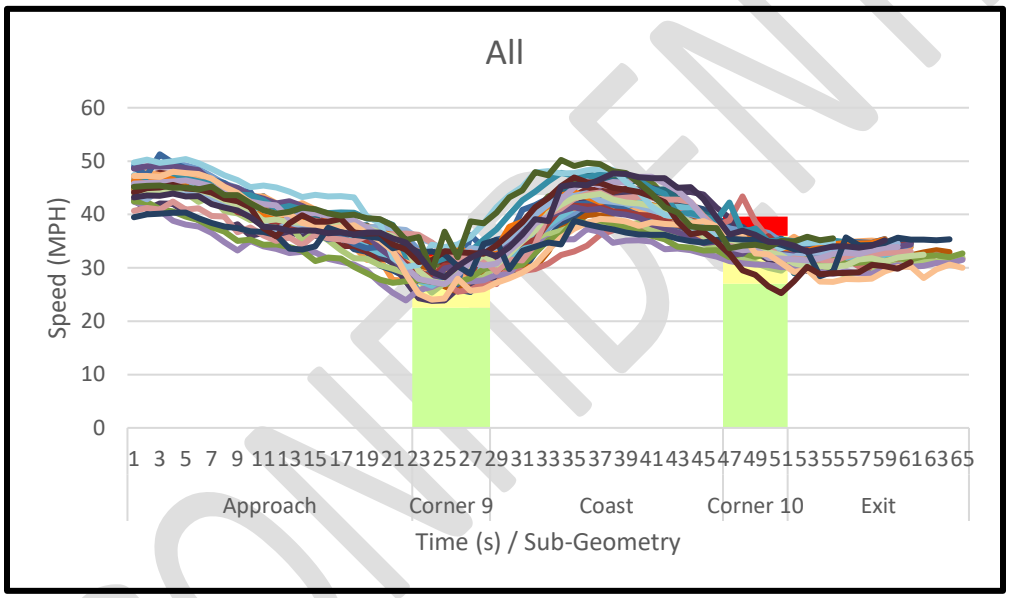
On July 7 of this year, I came upon a semi-truck that had rolled over on a curve going eastbound on AZ 97. In speaking to the ADOT official at the site, he noted that too many experienced drivers were having rollover crashes on the curves on AZ 97. “They are just going too fast around these curves,” he said. His comment prompted me to analyze the curve where the rollover occurred to estimate the threshold speed at which the trailer would rollover and pull the tractor over as well.

After measuring the height of the center of the tank and adjusting for the weight of the undercarriage, I estimated the static roll threshold for this trailer fully loaded at 0.49g. I then estimated that the compliance effects would lower the tip over threshold to 0.38g. Using the radius of the curve, I was able to estimate that the threshold speed at which a tip over would likely occur as 39 mph. Unfortunately, an actual speed was not available from the GPS tracking system and was not recovered from the ECM.

Two months later (Sept. 7), a rollover occurred on the Bagdad mine property. I was asked to provide an analysis of the crash by the mine owner. In this case, the truck was loaded with copper concentrate.

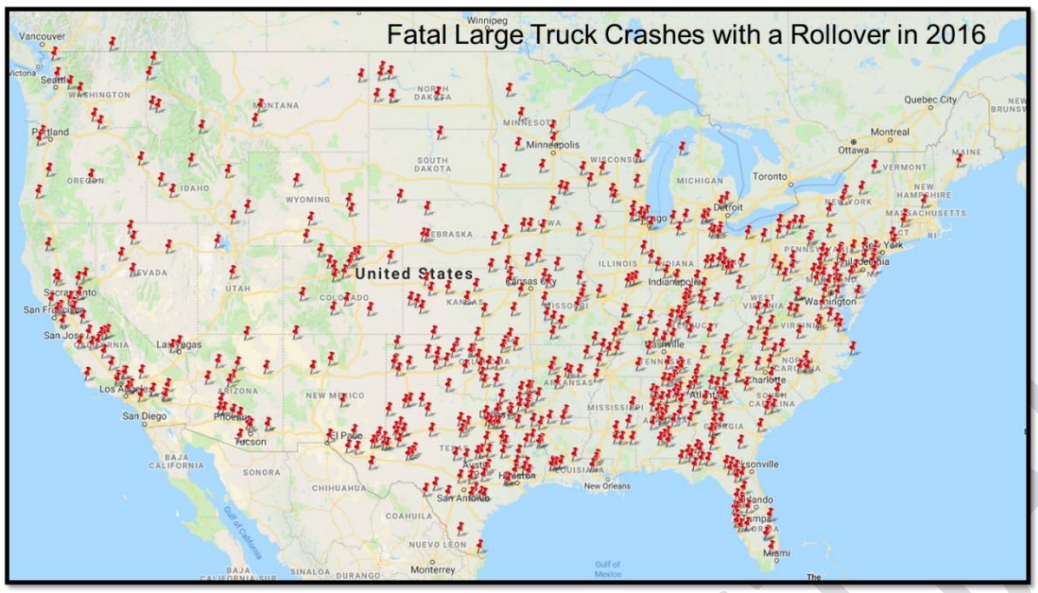
Once again, I measured the height to the center of gravity of the load and after adjusting for the weight of the undercarriage I estimated the SRT at 0.46g. I then applied an estimate for the compliance and concluded that the tip over threshold for this trailer and load would be 0.35g. Using the radius of curvature, I calculated that the tip over threshold speed would be 33 mph. In this case the owner of the truck provided a readout from the GPS tracking system and fortunately there was a recorded speed just 100 feet before the rollover location. The recorded speed was 34 mph.

During the months of September and October, we equipped 10 tractors operated by a bulk hauler with tablets that continuously logged position and speed at 1 Hz resolution. We now have thousands of records of speeds through curves along 6 routes to mines in Arizona and New Mexico including the curves on AZ 97 where so many rollovers have occurred. The two most difficult curves on AZ 97 were labeled curves 9 and 10 for this study. (The July 7 rollover was on curve 10.) The tip over threshold speeds for curves 9 and 10 were estimated at 32 mph and 39 mph respectively. Actual speeds are shown in the graphic below. Average speeds through curve 9 are about 30 mph and about 34 mph through curve 10.



Rollover crashes are not limited to mountain roads in the western US. The FARS data for 2016 show 587 large truck rollover crashes that resulted in at least one fatality. The locations of those crashes are distributed across the entire country.

The FARS data (2016) list a total for 4,213 trucks involved in fatal crashes of which 840 were single vehicle crashes and 587 included a rollover. If injury and PDO crashes were included there would be at least 6,000 large truck rollover crashes.



Why are so many professional drivers making the mistakes that lead to rollovers? Here are a few factors that contribute to this problem.

First, the driver doesn't get 'seat of the pants' feedback in the tractor because the stability of the tractor is twice the stability of the trailer. Thus, the tractor feels perfectly stable even when the trailer is approaching its limit of stability. Take a close look at videos of semi-truck rollovers on YouTube or watch the promo video on www.road-aware.com and note that all rollovers start at the rear of the trailer and progress forward.

Second, drivers that regularly use winding roads are comfortable taking curves at speeds that cause the vehicle to experience up to 0.35g. Above that it gets uncomfortable for the driver and any passengers. The problem for a semi-truck is that many trailers are at the limit of stability at 0.35g.

Third, drivers that use the same routes find that the driving gets routine so speeds creep up. However, the experience and skill of the driver do not change the radius of the curve or the physics applied to the semi-truck.

Fourth, and perhaps the most significant, is most compensation systems are 'pay by the mile' or 'pay by the trip'. Thus, the driver pay system is biased to haste rather than safety. The need to hurry is exacerbated by the EDL mandate because drivers worry that they will get caught in a traffic slowdown or a tailback from an accident and they might run out of driving hours before they get back to their terminal. Failure to complete the run for the day not only impacts their paycheck but also necessitates an overnight stay, and finishing the trip impinges on the drive time available the next day for the next trip.

Not with standing these issues **drivers must slow down** on curves, ramps and flyovers. A good rule of thumb is **to use half the posted advisory speed** for any curve or ramp. By obeying that rule rollover risk is minimized and it only adds a few minutes to your day.

Brian Bullock and Garth Lawrence, Founders