# What Trucking Owners and Managers should know –

**Single Vehicle Crash:**

Figure 1: July 2018 rollover on Arizona SR 97

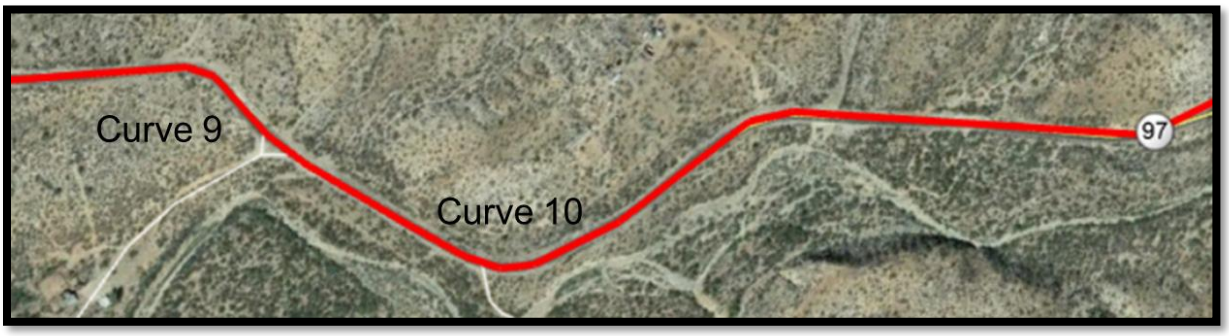
In July 2018, a semi-truck hauling an acid load rolled over on a curve going eastbound on Arizona highway SR 97. In speaking with the Arizona Department of Transport official at the site, he noted that too many experienced drivers are involved in rollover crashes on the curves on SR 97. "They are just going too fast around these curves," he lamented. This comment prompted an analysis of the curves on SR 97 with a detailed look at the curves where the rollover occurred, and to estimate the threshold speed at which a trailer would rollover and pull the tractor over as well.

Figure 2: Curves along SR 97


State Route 97 (SR 97) is a 10.91-mile-long (17.56 km) state highway in Arizona. It runs from US 93 to SR 96 southeast of the town of Bagdad. The road was built by the late 1930s and improved during the late 1940s. Established as a state route in 1962, SR 97 was paved in the early 1970s. It is a two lane highway with virtually no shoulders on either side.

There were 15 curves identified along SR 97 that could pose a problem for semi-truck drivers. Several rollover accidents including the one in July occurred on curves #9 and #10.

Figure 3: Location of curves 9 and 10 on SR 97



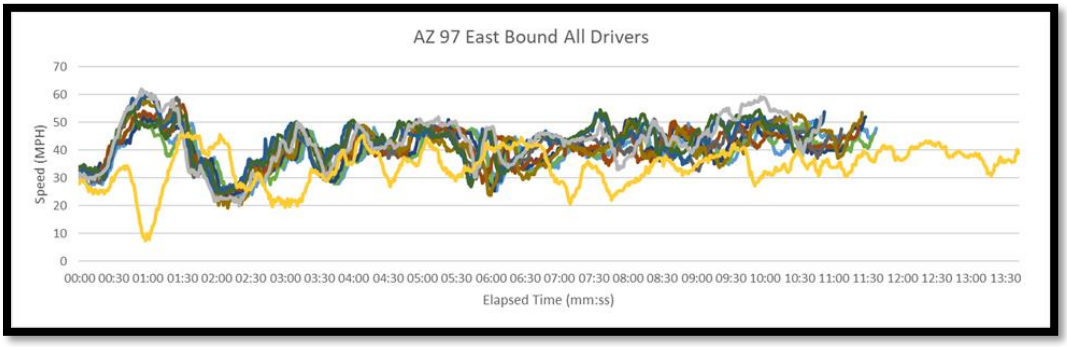

After measuring the height of the center of the tank and adjusting for the weight of the undercarriage, the static roll threshold (SRT) for this trailer fully loaded, was estimated to be 0.49g. The compliance effects, springs, tires, undercarriage etc. were estimated to be 0.11g and lowering the roll threshold to 0.38g. Using the radius of the curve, it was calculated that the threshold speed at which a tip over would likely occur was 39 mph. Unfortunately, an actual rollover speed was not available from the GPS tracking system and was not recovered from the electronic control module (ECM) in the tractor.

**Driving on the Edge:**

A study was initiated, partnering with a local carrier of bulk materials, to document driver behavior along SR 97. During the months of September and October 2018, 10 tractors were outfitted with GPS enabled tablets that continuously logged position and speed at 1 second resolution. Thousands of records of speeds through curves and down slopes along 6 pre-determined routes in Arizona and New Mexico were collected including the curves on SR 97 where many rollovers have occurred. Tip over thresholds were calculated for different trailer types hauling solid, liquid or pneumatic loads.

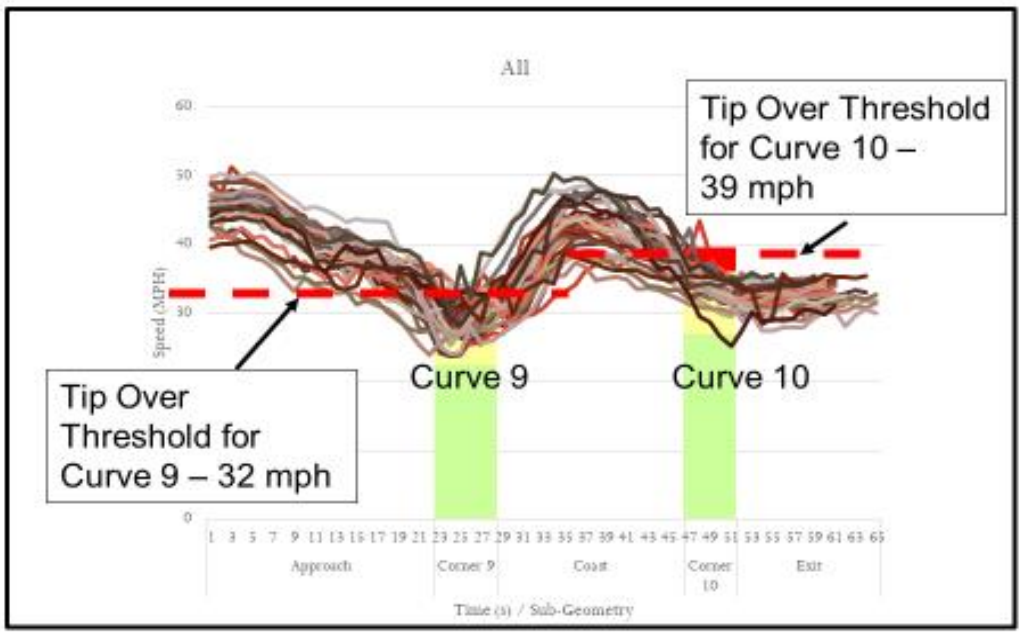
Figure 4 shows the speed tracks for multiple drivers making multiple runs down SR 97. The highway is posted at 45 mph except for the first half mile at each end which is posted at 35 mph. Advisory speeds on curves vary from 20 to 30 mph. Fully loaded (GVW about 80,000 lbs.) drivers are averaging 44 mph, reaching 50 to 60 mph in some locations. The yellow track on Figure 4 is a driver who drove at the calculated speeds recommended (not posted) for the 15 curves. Recommended speeds are based on tip over threshold calculations for each curve then reducing that speed by a 30% safety margin.

Figure 4: Drivers Eb, curves 2 to 15, on SR 97 with full load




The two most difficult curves on SR 97 were labeled curves 9 and 10 for this study and the July rollover was on curve 10. The tip over threshold speeds for curves 9 and 10 are calculated to be 32 mph and 39 mph respectively. Actual speeds driven by drivers over multiple passes are shown in Figure 5 below. Average speeds through curve 9 are about 30 mph and about 34 mph through curve 10. The top of the red bar is the calculated tip over threshold speed while the top of the green bar is a 30% safety factor line.

Figure 5: Eb speed profiles through curves 9 & 10.




Drivers are challenging the tip over threshold of these curves leaving very little margin for error. The time to drive this road safely, eliminating risk of rollover, is only 2 ½ minutes longer. The problem is that drivers don't know how close to the tip over threshold they are driving.

**Validation of Tip Over Threshold:**

During the study, there was an opportunity to validate the tip over threshold calculations. In September 2018, a rollover occurred on a curve in an active mine property. The truck was loaded with approximately 30 tons of ore concentrate. The height to the C of G of the load was measured and after adjusting for the weight of the undercarriage the SRT was estimated to be 0.46g. The compliance effects of springs, tires, undercarriage etc., that lower the tip over threshold, were estimated to be 0.11g and so lowering the rollover threshold to 0.35g. Using the radius of curvature of the curve, the tip over threshold speed at the crash site was determined to be **29 to 33 mph**. Later, the owner of the truck provided a readout from its GPS tracking system and the recorded speed, just 100 feet before the rollover, location was **34 mph**.

**The Unexpected Result:**

When we started the study, we expected that the data would show that some drivers are aggressive, some are conservation and there would be a large portion in the middle between the two extremes. Rather, we were shocked to see that **all drivers are too aggressive with their speeds**.

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

**First, - No seat of pants feedback**: 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 video at www.road-aware.com and note that all rollovers start at the rear of the trailer and progress forward while the driver is concentrating on navigating around the curve.

**Second, - Drivers comfortable to 0.35g:** 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 so while the tractor stays grounded the trailer starts to roll.

**Third**, - **Complacency:** 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. We see from the speed charts above that most drivers in the study

didn't realize they drive near the tip over threshold with very little margin for error. A small misjudgment on the speed could have serious consequences.

**Fourth**, - **Driver Pay:** Perhaps the most significant factor is driver compensation systems that 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 ELD 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 time 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.

## Conclusions:

We were surprised to see that the data show that all the drivers in the test push the limits on these curves. When the tip over threshold limit was added to the speed charts it was clear that drivers are traversing curves near the calculated tip over threshold giving themselves very little margin for error. Providing drivers with a recommended safe speed for curves based on GPS input (location and speed), vehicle dynamics specific to the tractor and trailer and road curvature will reduce the risk of rollover significantly. As well, owners and managers must take the lead through company policies, training and management follow up to get drivers to slow down on curves, ramps and flyovers. Then – truck driver at fault single vehicle rollover risk is nearly eliminated; the driver and traveling public are protected; and risk to clients and shareholders is reduced.

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