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May 19, 2023

The Honorable Ann Carlson
Acting Administrator
National Highway Traffic Safety Administration
1200 New Jersey Avenue, S.E.
Washington, D.C. 20590

Side Underride Guards; Advance Notice of Proposed Rulemaking;
Docket No. NHTSA-2023-0012

Dear Acting Administrator Carlson:

The National Highway Traffic Safety Administration (NHTSA) has issued an Advance Notice of Proposed Rulemaking (ANPRM), asking for comments on its report "Side Impact Guards for Combination Truck Trailers: Cost-Benefit Analysis." In this report, NHTSA evaluated the effects of equipping new trailers and semitrailers with side underride guards. The Insurance Institute for Highway Safety (IIHS) believes NHTSA's analysis suffers from several fundamental flaws that reduce its benefit estimates for side underride guards. Specifically, we estimate the number of lives that could be saved by a side underride guard standard is up to ten times the number reported by NHTSA.

Truck underride crashes occur when another vehicle moves under the chassis of a truck or trailer during a crash. The resulting intrusion often bypasses the self-protection countermeasures in the smaller vehicle, increasing the risk of serious injury or fatality. To mitigate the risk of underride in rear-impacts of large trucks, Federal Motor Vehicle Safety Standards (FMVSS) 223 and 224 outline requirements for trailer rear underride guards. There are no existing requirements for side underride guards. NHTSA's report estimates that such a requirement would save 17 lives per year and prevent 69 serious injuries, and would not be cost effective.

Our most serious concerns with NHTSA's report fall into three categories: overly restrictive inclusion criteria used in identifying relevant fatal crashes, problems establishing whether underride occurred in specific crashes, and a misunderstanding of the relationship between crash severity and precrash travel speed. Each of these issues is addressed below, followed by an alternative approach that IIHS believes produces a more realistic estimate for the number of lives that could be saved by side underride guards.

FARS inclusion criteria

NHTSA obtained fatal crash data from the Fatality Analysis Reporting System (FARS) to use in its lives-saved estimates. NHTSA included two-vehicle crashes involving one passenger vehicle and one tractor-trailer in which the passenger vehicle's initial impact location was coded as front or roof, and the truck's initial impact location was coded as side or undercarriage. As described below, each of these criteria is overly restrictive and results in a target population of fatal crashes that is unrealistically low.

First, crashes in which a passenger vehicle underrides a large truck often involve additional vehicles, even when limiting to crashes where the truck underride is the most severe event. A previous IIHS study investigated all crashes involving at least one large truck and at least one passenger vehicle in the Large Truck Crash Causation Study (LTCCS) (Brumbelow 2012). Using photographs and coded variables, we identified 73 cases in which the most severe injury to a passenger vehicle occupant was due to side underride. One quarter of these cases (18 of 73) involved more than two vehicles.

Second, many truck side underrides involve passenger vehicles with initial impacts that are not coded as frontal, either because there was another preceding impact or because the impact with the truck was characterized as side-to-side or another configuration. Even when restricting to two-vehicle fatal crashes, 2017-2021 FARS indicates that around 14% of passenger vehicle occupant fatalities resulting from truck side crashes are coded as initial impacts to the side or rear of the passenger vehicle.

Third, NHTSA has defined truck side impacts using clock locations that do not capture the full number of relevant crashes. NHTSA included 2-4 o'clock and 8-10 o'clock crashes as truck side impacts but defined 1 and 11 o'clock as front crashes and 5 and 7 o'clock as rear crashes. As we and others have noted (Brumbelow 2012; Blower et al. 2001), these definitions are not valid for large trucks. Figure 1 shows the distribution of coded accident types for different clock locations for large trucks involved in two-vehicle crashes in 2017-2021 FARS. Accident types for both 1/11 o'clock and 5/7 o'clock impacts are much more similar to the crashes NHTSA has defined as truck side impacts than to crashes with 12 or 6 o'clock impact locations. While side underride guards would not be relevant in every crash with a 1/11 or 5/7 o'clock impact location, excluding these locations from the target population has a domino effect on the entire cost-benefit analysis and guarantees it will underestimate the true number of lives saved. Including these clock locations as truck side impacts results in a total number of passenger vehicle occupant fatalities that is 50 percent higher than when they are excluded, based on 2017-2021 FARS data.

The cumulative effect of these artificially restrictive inclusion criteria is substantial. This can be illustrated by matching fatal LTCCS cases with their corresponding FARS cases. The 2012 IIHS study of LTCCS identified 15 passenger vehicle occupant fatalities resulting from trailer side underride that could be matched with FARS. Only 5 of these would be captured by the FARS case inclusion criteria NHTSA has used for its cost-benefit analysis. In other words, two-thirds of the fatalities attributed to trailer side underride would not even show up in NHTSA's "target population" for a side underride guard rule. An appendix lists details of the 7 cases in which these 10 fatalities occurred.

The target population that could benefit from side underride guards would be even greater if NHTSA had considered fatalities to other road users involved in truck side crashes. Despite a large body of research on the effectiveness of "lateral protection devices" in mitigating pedestrian and bicyclist fatalities, including work conducted by the Department of Transportation's Volpe Center (Badgley et al. 2020), NHTSA did not attempt to estimate the potential benefits of side underride guards for vulnerable road users. From 2017-23, an average of 53 pedestrians and bicyclists were killed each year in crashes involving the side of a tractor-trailer. Likewise, NHTSA did not attempt to estimate the potential benefits of side underride guards for motorcyclists, but 52 were killed each year from 2017-23 in trailer side impacts. Again, while not all of these fatalities would be prevented by a side underride guard, the agency is overlooking roughly

100 annual fatalities by only including passenger vehicle occupants in its analysis. This is inconsistent with its final estimate that 17 lives could be saved annually by side underride guards.

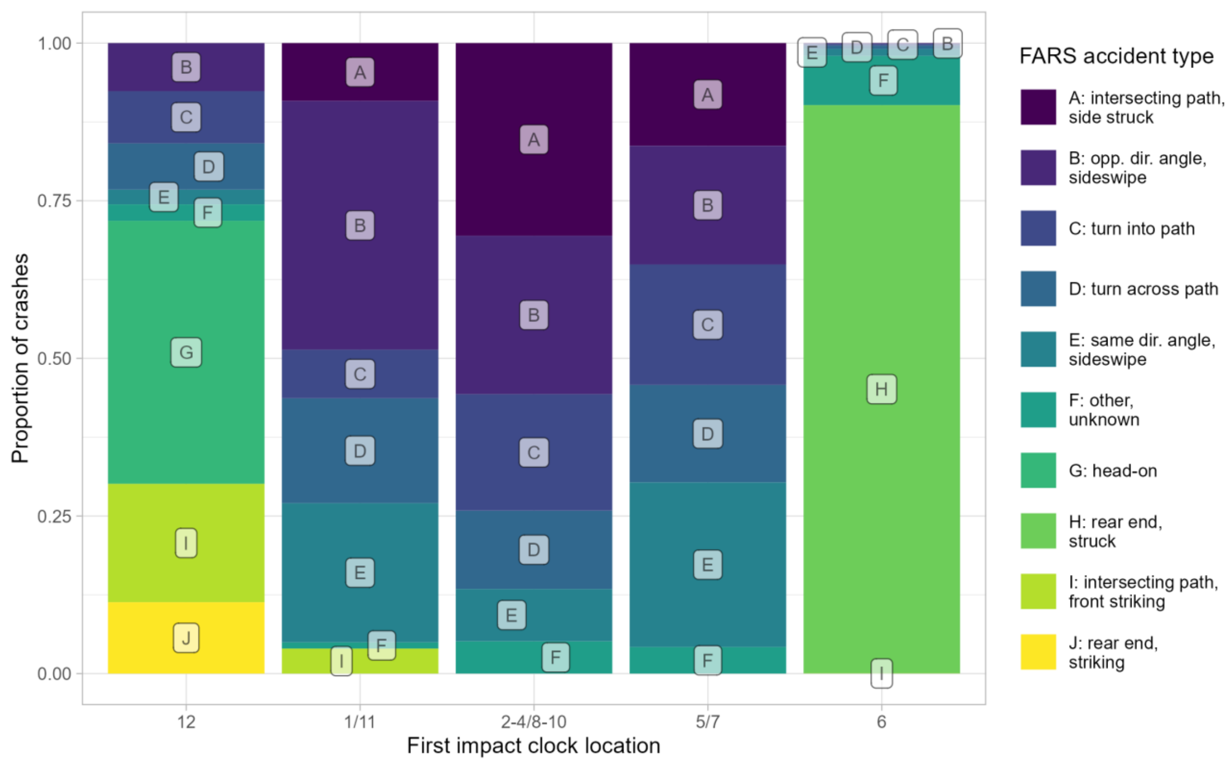

Figure 1. 2017-2021 FARS accident types by initial impact location for tractor-trailers involved in two-vehicle crashes

Establishing underride occurrence

As NHTSA noted in its report, FARS is not a reliable source of underride occurrence. Instead of relying on FARS underride codes, NHTSA conducted its own review of police crash reports (PCRs) for tractor-trailer side crashes. There are two main problems with NHTSA's approach. First, IIHS research has found that case photographs are indispensable for establishing whether underride occurred in a given crash (Braver et al. 1998; Brumbelow and Blanar 2010; Brumbelow 2012). Likewise, in a report contracted by NHTSA, the authors stated, "photographs of the trucks and the other vehicles were invaluable in determining override/underride and PCI [passenger compartment intrusion]" (Blower and Woodrooffe 2013). Despite this, NHTSA has neither used existing photographic databases nor conducted a new photographic survey of crashes. NHTSA stated that, for its PCR review, "in most cases, photographs of the incidents were not available." This means NHTSA, while acknowledging FARS undercounts underride crashes, was largely working from the same information available to the FARS coders for its own analysis.

The lack of photographic crash documentation is related to the second major problem with NHTSA's PCR analysis. Without case photos, the agency's process required them to start with an assumption either that underride did or did not occur, and then to look for positive evidence to the contrary. Previous photography-based studies repeatedly have indicated that underride occurs in the majority of trailer side impacts that produce serious or fatal injury of a passenger vehicle occupant. Braver et al. (1998) found underride occurred in 9 of 13 (69%) fatal crashes involving the side of a tractor-trailer. In our comprehensive review of LTCCS (Brumbelow 2012), underride occurred in 56 of 78 (72%) semi-trailer side crashes in which the most severe injury was attributed to the trailer impact. This included 25 of 28 (89%) cases producing a serious or fatal injury. In their analysis of a subset of LTCCS cases, Blower and Woodrooffe (2013) found that underride occurred in 42 of 59 (71%) trailer side impacts, without accounting for injury occurrence. Based on these results, it would have been most appropriate for NHTSA to assume that underride had occurred in fatal trailer side crashes unless there was PCR evidence to the contrary. Instead, its analysis was based on the opposite assumption, and the agency's final estimate that 92 of 175 (53%) fatal cases involved underride is substantially lower than previous estimates based on photographs. There is little reason to believe the true underride rate would have decreased since 2001-2003, when LTCCS crashes occurred, since there has been no crashworthiness improvement of semi-trailer side structures in that time. If anything, the improvements to passenger vehicles and the increased rate of belt use would suggest underride may be more common in crashes where passenger vehicle occupants still sustain fatal injuries today.

Crash severity

For its cost-benefit analysis, NHTSA assumed side underride guards would not prevent underride at impact speeds above 40 mi/h. NHTSA chose this cutoff speed based on one 40 mi/h IIHS test of an aftermarket side underride guard manufactured by AirFlow Deflector. In this crash test, the guard prevented underride of a midsize sedan striking perpendicularly near the center of the trailer. NHTSA's decision to assume guard failure at 41 mi/h and above does not reflect a genuine effort to establish the possible benefits of side underride guards. Rather than conduct its own higher speed testing, or even assume progressively lower benefits up to some upper speed bound, the agency again chose to assume no benefit unless proven otherwise.

Perhaps of even greater significance than the choice of a 41 mi/h failure speed for side underride guards was NHTSA's method for applying this cutoff to real-world crashes. In the same PCR review used to establish underride occurrence, NHTSA analysts assessed whether each crash occurred at a speed above or below 40 mi/h. According to the report, "impact velocity was estimated using [police reported, pre-braking] estimated speed (if available), posted speed limit, evidence of braking, and witness interviews." All of these sources must be considered questionable surrogates for impact speed, let alone for delta-V, which would be a more appropriate measure of crash severity given many trailer side crashes are not perpendicular (Figure 1). While NHTSA did not state what evidence was given the most weight, it reported that its PCR review produced essentially the same results as would be obtained using the posted speed limit. "Thus, an important share of side underride fatalities appears to involve travel speeds exceeding the maximum impact speed at which the AngelWing side guard demonstrated protection during IIHS testing. *NHTSA does not have data* on how well posted speed limits represent impact speeds within the FARS data. However, the PCR review…found that the proportion of side underride fatalities occurring at impact speeds below 40 mph is estimated to be consistent with the proportion of side underride fatalities in FARS occurring on roads with posted speed limits up to 40 mph" (emphasis added).

In fact, data are available to explore the relationship between crash delta-V, police estimated precrash travel speed, and posted speed limit in FARS. We queried the National Automotive Sampling System-Crashworthiness Data System (NASS-CDS) and the Crash Investigation Sampling System (CISS) for fatal crashes involving at least one vehicle with available Event Data Recorder (EDR) delta-V information for a front impact. We filtered EDR cases to exclude incomplete crash pulses and then matched the resulting vehicles with their record in FARS. This allows a comparison of FARS codes for speed limit and police-reported precrash travel speed with the longitudinal delta-V recorded from the EDR. EDR delta-V and FARS speed limit values for the 125 vehicles with known values of both are shown in Figure 2. Figure 3 shows the relationship between EDR delta-V and police-reported precrash travel speed for the 54 vehicles with known values. Dashed lines in both figures indicate the 40 mi/h cutoff speed used by NHTSA for side underride guard failure. It is noteworthy that investigating officers, even after visiting the crash scene, observing crashed vehicles, and interviewing witnesses, usually do not attempt to estimate the precrash travel speed “prior to any avoidance maneuvers” (NHTSA 2023), while NHTSA’s cost-benefit analysis relies on an effort to establish the more challenging quantity of speed at impact without any of the advantages available to officers on the scene.

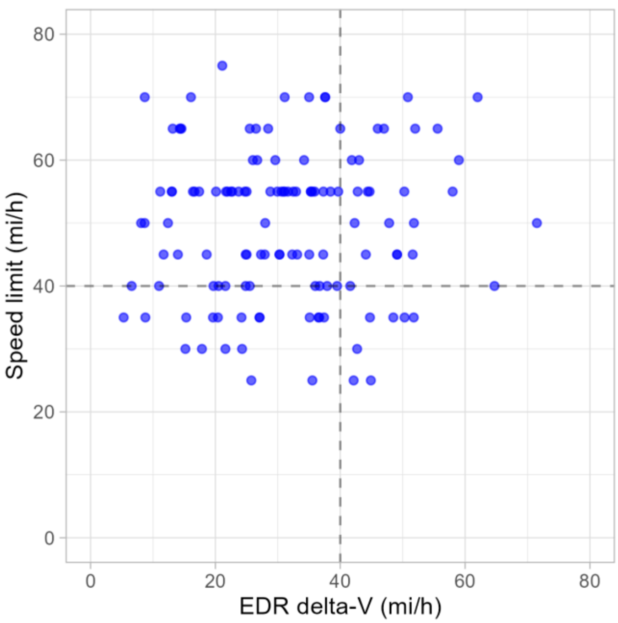

Figure 2. FARS reported speed limit vs NASS-CDS/CISS EDR delta-V for matched vehicles

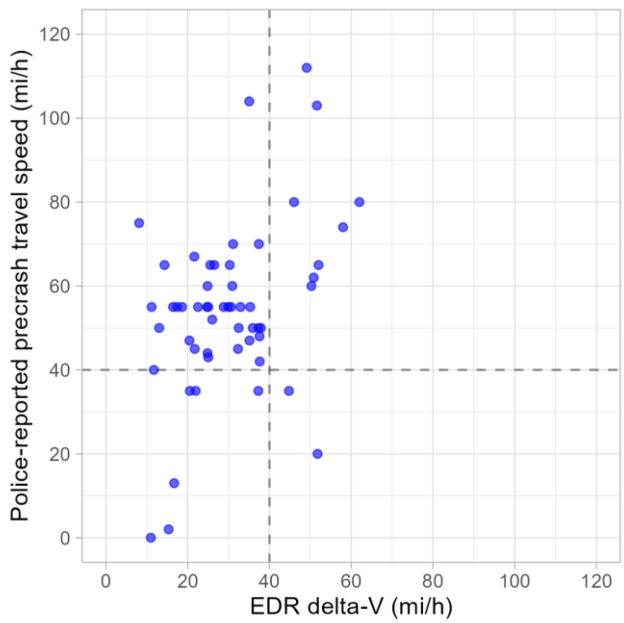

Figure 3. FARS police-reported precrash travel speed vs NASS-CDS/CISS EDR delta-V for matched vehicles

Matched EDR data demonstrate the problem with relying on posted speed limits or police-reported precrash travel speeds to estimate crash severity. Among the matched vehicles, there was no statistical correlation between speed limit and EDR delta-V (R^2 = 0.00). There was a weak correlation between police-reported precrash travel speed and EDR delta-V (R^2 = 0.16), but in 89% of cases the EDR delta-V was less than the police-reported precrash travel speed. Applying a 40 mi/h cutoff to each of these three values produces dramatically different results (Table 1). NHTSA used PCR travel speeds and speed limits to estimate 20% of side underride fatalities occurred at impact speeds below 40 mi/h. While this estimate represents a subset of fatal crash types, there is no reason to believe speed limit or PCR travel speed would be better surrogates for crash severity in trailer side impacts. In fact, NHTSA's value falls between 11% and 29%, the proportion of fatalities with PCR travel speed or speed limit at or below 40 mi/h, respectively, among the matched EDR cases. In contrast, the proportion of fatalities in crashes with EDR delta-V values below 40 mi/h was around three times NHTSA's estimate (63%). And this number may still be too low. Since many trailer side crashes are initially sideswipe or other highly angled configurations (Figure 1), the distribution of front crash EDR pulses may represent more crash energy than side underride guards typically would be exposed to.

Table 1. Vehicles and fatalities by FARS PCR precrash travel speed, FARS speed limit, and NASS-CDS/CISS EDR delta-V for matched cases

	Vehicles			Fatalities		
Severity measure	Total	≤40 mi/h	Percent ≤40 mi/h	Total	≤40 mi/h	Percent ≤40 mi/h
PCR travel speed	54	9	17%	27	3	11%
Speed limit	125	38	30%	82	24	29%
EDR delta-V	127	96	76%	82	52	63%

Alternative approach

As stated above, IIHS believes photographic documentation is essential for establishing underride occurrence and the potential for underride guards to improve crash outcomes and save lives. We strongly urge NHTSA to gather such information as the foundation of its efforts to estimate benefits of a side underride safety standard. This could be done as part of NHTSA's Special Crash Investigation program, or as a separate study such as the LTCCS. As EDR data are now much easier to obtain than in 2001-2003, a new data collection effort also would provide a much better source of crash severity information. The underride safety problem is simply too significant to rely upon the types of assumptions and estimates that form the basis of NHTSA's cost-benefit analysis.

In the absence of new photographic crash data, IIHS believes the LTCCS represents the best currently available data source for estimating the benefits of side underride guards. Trailer designs have not changed in ways that would affect the likelihood of side underride since then. While the passenger vehicle fleet has changed, IIHS data indicate 88% of 2018-22 model year vehicles still have hood heights below 110 cm, the approximate ground clearance of a typical dry van trailer. We used analyses from our 2012 study combined with FARS data to calculate the number of passenger vehicle occupant fatalities that could be mitigated by a side underride guard standard for semi-trailers. We first matched all LTCCS cases that resulted in a passenger vehicle occupant fatality with their corresponding FARS records. We then selected cases in which the FARS records included a semi-trailer with an initial impact location of 1-5 o'clock or 7-11 o'clock. Using the LTCCS analyses, we determined the proportion of all passenger vehicle occupant fatalities in these crashes that resulted from side underride of a semi-trailer. This approach obviates the need to exclude crashes involving more than two vehicles or to narrowly restrict impact locations. The results are shown in Table 2. There were 38 passenger vehicle occupant fatalities in LTCCS cases where the corresponding FARS records included a tractor-trailer with side damage. Of these, 15 fatalities (39%) resulted from underride with the side of the trailer, and in 11 (29%) the underride occurred forward of the trailer axle. A query of 2017-2021 FARS indicates there were 549 average annual passenger vehicle occupant fatalities in crashes involving the side of a tractor-trailer. (Including the 61-63 and 81-83 impact location FARS codes added in 2010.) Applying the proportions calculated from the LTCCS fatalities in Table 2 suggests that an estimated 159-217 fatalities could be addressed by a side underride guard standard, depending on whether it provided protection forward of the rear axle or along the full length of the trailer.

Table 2. Fatalities in LTCCS cases matched to FARS records

Description	Passenger vehicle occupant fatalities
Crashes involving the side of a tractor-trailer	38
Vehicles underriding side of semi-trailer	15
Vehicles underriding side of semi-trailer, forward of trailer axle	11

The LTCCS-derived estimates for relevant fatalities are roughly 9-13 times the 17.2 lives NHTSA estimated could be saved by a standard. Interestingly, the agency estimated the costs of a rule to be “6-9 times as large as the corresponding estimated safety benefits.” Establishing how many of these crashes may overwhelm side guard designs and still allow fatal underride would require higher speed crash testing of different potential designs and a better estimate of real-world crash severity in side underride crashes, including a reasonable distribution of impact angles. Even after applying a realistic upper severity limit for guard effectiveness, the available EDR data suggest a side underride guard regulation would be close to the cost effectiveness threshold established by NHTSA using passenger vehicle occupants alone. The true benefits will only be larger once the agency accounts for the number of pedestrians, bicyclists, and motorcyclists whose lives could be saved by side underride guards.

In conclusion, IIHS believes side underride guards have the potential to save many more lives than NHTSA has estimated in its cost-benefit analysis. We urge the agency to perform a more thorough analysis that does not depend on multiple assumptions that guards will provide no benefit outside a narrow range of conditions. Large truck side underride crashes result in hundreds of lost lives and debilitating injuries each year. Equipping trailers with side underride guards would immediately and significantly reduce this unacceptable toll.

Sincerely,

Matthew Brumbelow
Senior Research Engineer

References

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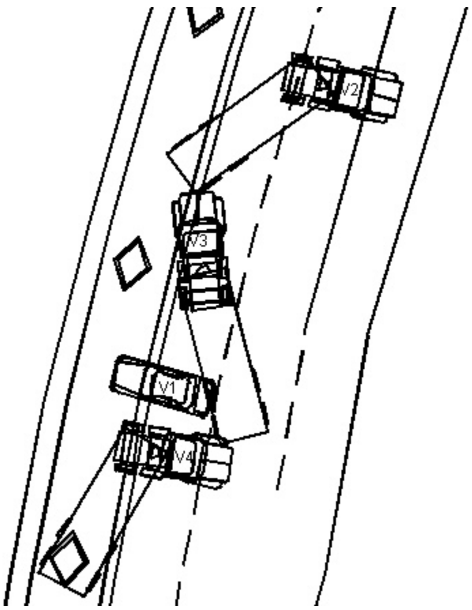
Brumbelow, M.L. 2012. Potential benefits of underride guards in large truck side crashes. *Traffic Injury Prevention*.

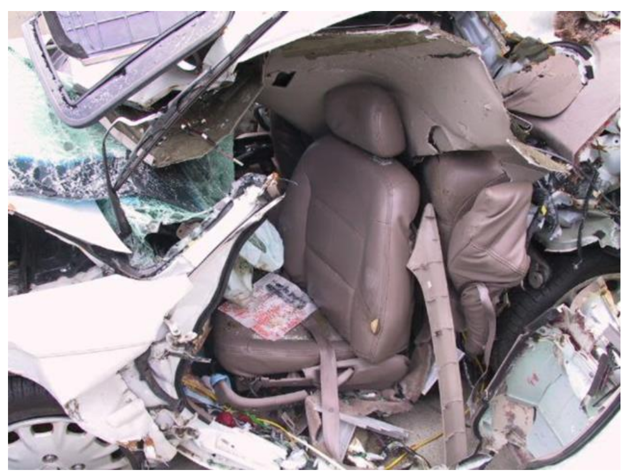
Brumbelow, M.L., Blanar, L. 2010. Evaluation of US rear underride guard regulation for large trucks using rear-world crashes. SAE Technical Paper 2010-22-0007.

NHTSA. 2023. 2021 FARS/CRSS Coding and Validation Manual. DOT HS 813 426.

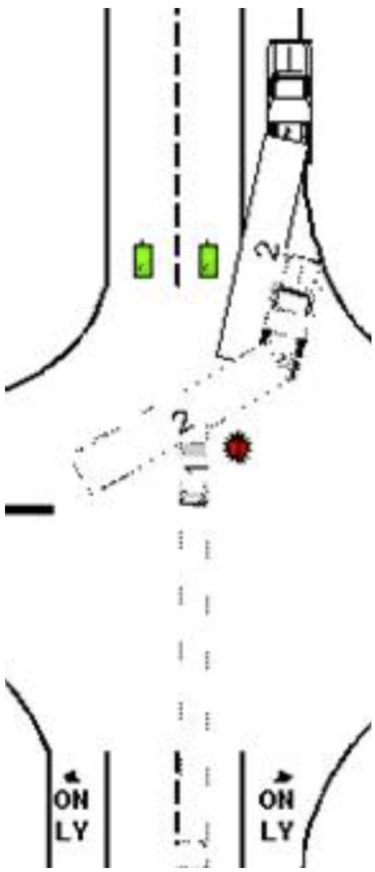
Appendix
LTCCS fatal crashes that do not meet NHTSA's FARS case inclusion criteria

LTCCS Case: 801005488
Passenger vehicle outcome: rear underrode trailer side, impacted by trailer axle; 36 year-old driver sustained fatal head and chest injuries
Reasons excluded: initial impact to rear of PV; other vehicles involved

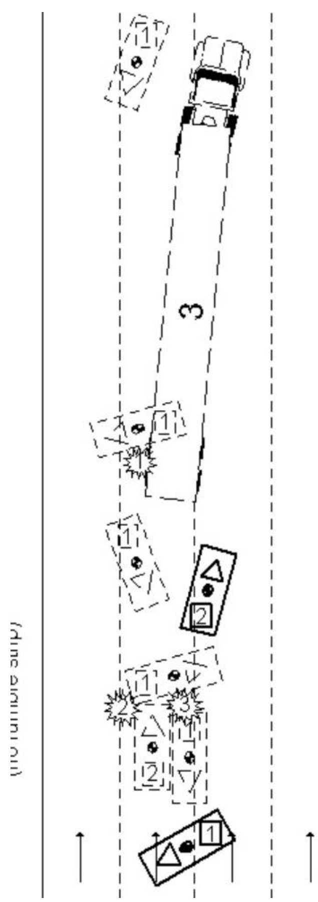


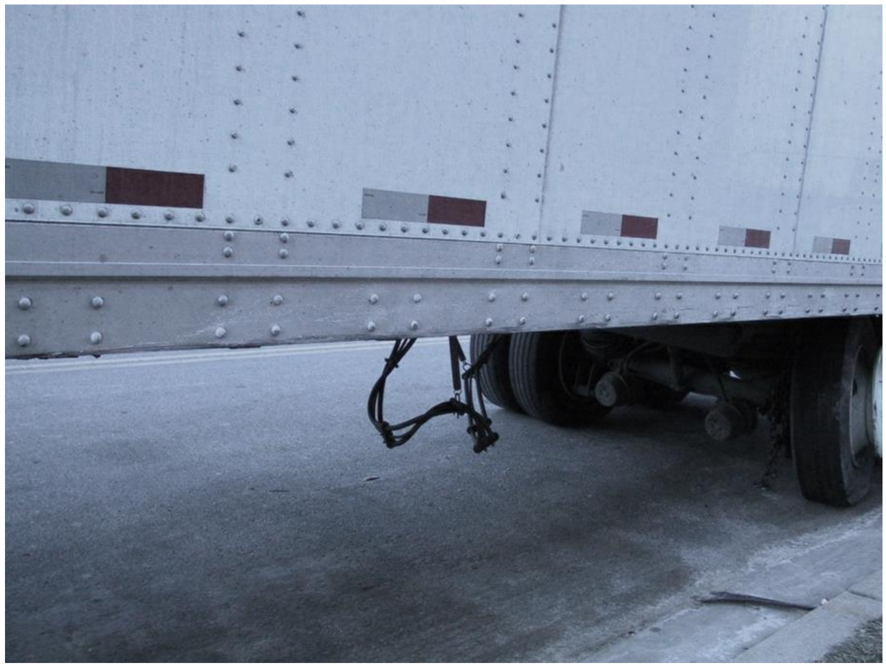


LTCCS Case: 806004734
Passenger vehicle outcome: front underrode near center of trailer; 39 year-old driver sustained fatal head injuries
Reasons excluded: FARS coded initial impact to front of truck

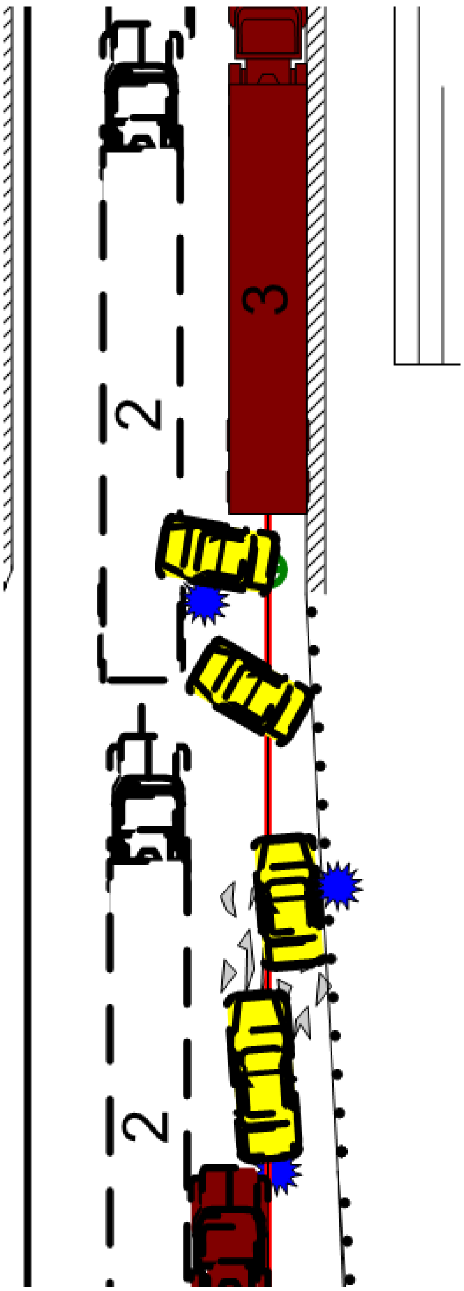


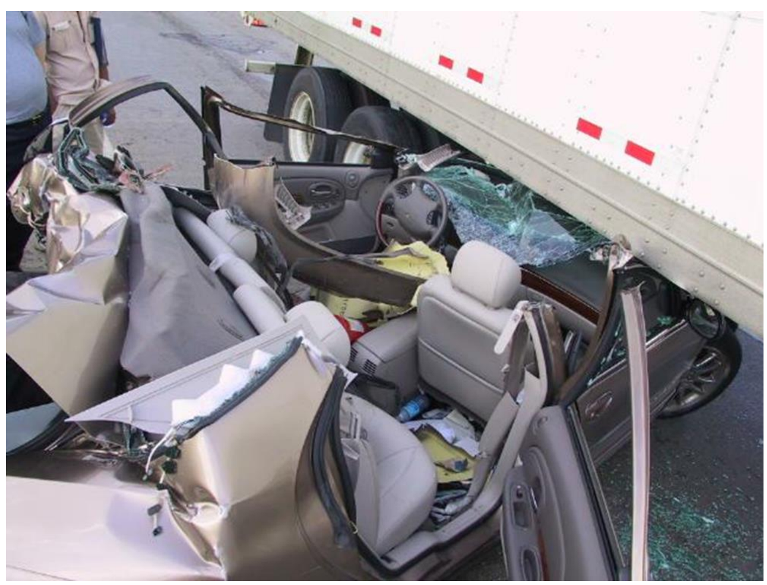
LTCCS Case: 806005874
Passenger vehicle outcome: front/side underrode trailer, impacted by trailer wheels/axle, followed by other impacts; 21 year-old driver sustained fatal spine injuries
Reasons excluded: 5 o’clock truck impact location; other vehicles involved



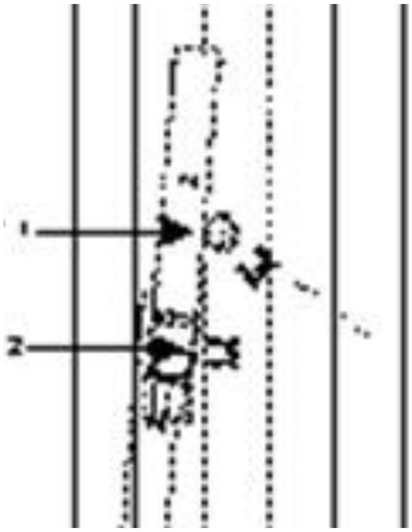


LTCCS Case: 807005329 Passenger vehicle outcome: preceding rear and side impact, front pushed under trailer side; 48 year-old driver sustained fatal head and spine injuries Reasons excluded: initial impact to rear of PV; other vehicles involved

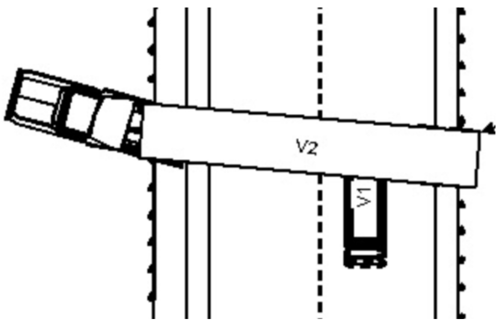




LTCCS Case: 812004812
Passenger vehicle outcome: initial underride near trailer center followed by impact with trailer wheels and axle; 42 year-old driver sustained fatal head injuries
Reasons excluded: passenger vehicle impact coded as right side



LTCCS Case: 816003626 Passenger vehicle outcome: front underride forward of trailer axle; 37 year-old driver and pregnant 36 year-old right front passenger sustained fatal head, spine, and chest injuries; 4 year-old and 2 year-old 2nd row passengers sustained minor facial abrasions Reasons excluded: 11 o'clock truck impact location from preceding event



LTCCS Case: 820005442
Passenger vehicle outcome: front underride forward of trailer axle, then impacted by wheels and dragged under trailer; 47 year-old driver, 49 year-old right front passenger, 77 year-old left rear passenger all sustained unspecified fatal injuries
Reasons excluded: 5 o’clock truck impact location