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July 18, 2023

Deputy Administrator Shulman
National Highway Traffic Safety Administration (NHTSA)

Docket Management Facility:
U.S. Department of Transportation,
1200 New Jersey Avenue SE, West Building
Ground Floor, Room W12–140
Washington, DC 20590–0001

RE: Docket No. NHTSA–2023–0012 Side Underride Guards

Dear Deputy Administrator Shulman:

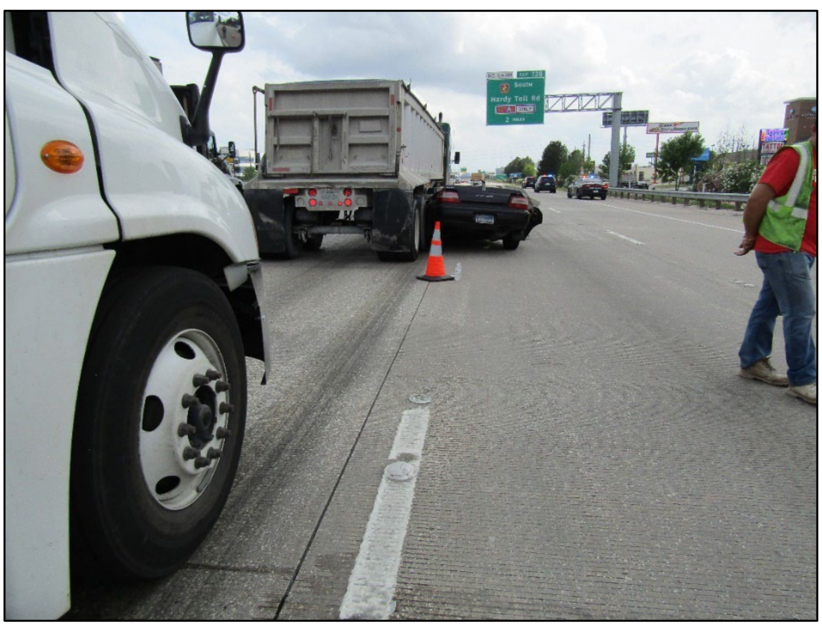
Briefly, about my background: I am an engineer that worked for a small trailer manufacturer and developed and tested a Rear Impact Guard at the time FMVSS 223 first became law. I later became employed in the field of automobile crash investigation and reconstruction. These work experiences led me to develop AngelWing, the combined aerodynamic side skirt and side guard oft referred to in the ANPRM.

The Agency has requested comment and assistance in specific areas. I do so below, following along with the Agency's requests by number:

1. **Injury Target Population**: The logic applied by NHTSA to extract the injury target population from the data is overly restrictive for at least a couple reasons. First, the included Police Crash Reports (PCRs) are limited to two-vehicle crashes. Second, inclusion in the target population requires frontal or top damage coding of the Light Passenger Vehicle (LPV) in the PCR. Attachment A includes two side underride crashes occurring in 2018 which I investigated that each capture both issues. Texas crash report, Crash ID 2018524661 reflects a three-vehicle fatal side underride crash involving two LPV's and one Combination Truck (CT). The initial collision between the two LPVs precipitated a loss of control by one of the LPVs which then moved left laterally and underneath the trailer's right side. The LPVs left side was then simultaneously crushed, trapped and dragged by the trailer wheels to final rest, subsequently catching fire and burning. In the crash report the damage to underriding LPV was coded as "LD-5" and "VB-7." According to the Texas Peace Officer's Crash Report Code Sheet "LD" is code for left door and "5" represents the severity scale (out of 7); and "VB" is the code for vehicle burned and "7" for severity. This side underride would be excluded from the target population because it's a 3-vehicle crash *and* the LPV damage is not coded as frontal or top. A photo below from the crash depicts the underride.

Police photograph from Texas Crash ID 2018524661
(See Attachment A)

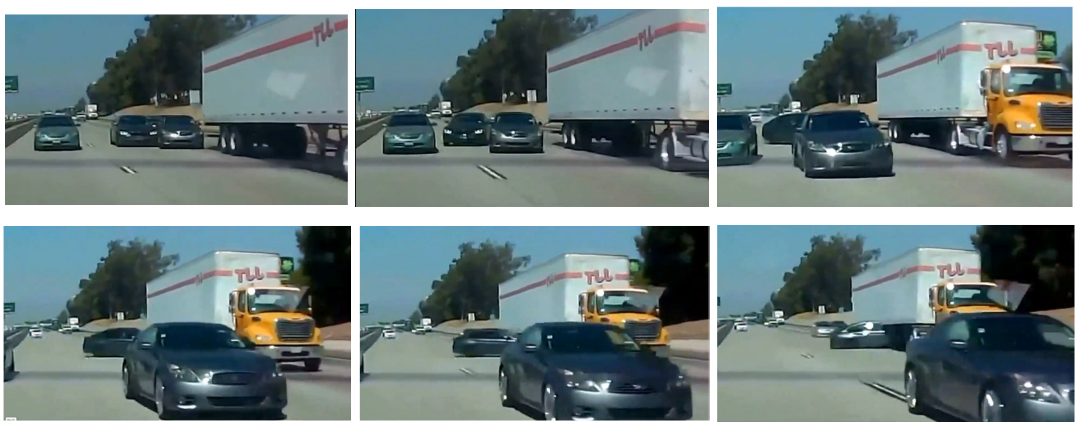
The second Texas crash report, Crash ID 2018168342 reflects another three-vehicle serious-injury side underride crash, again involving two LPVs and one CT where contact between the LPVs caused a side underride with subsequent crushing and dragging of the LPV (this time without an ensuing fire). The underriding vehicle was coded with two different vehicle damage ratings “RP” and “LP” neither reflecting any frontal or top damage which would exclude it from the target population. The driver of the underriding LPV suffered a crushed pelvis and internal organs from the semi-trailer tires.



Police Photograph from Texas Crash ID 2018168342
(See Attachment A)

I estimate over the 15 years I have been investigating side underride crashes, roughly 1/3rd are same direction collisions like the two cited above, and often there is a precipitating collision event to the underride (and often a subsequent fire due to the crushing and dragging of the LPV). Limiting the Agency's dataset to two-vehicle crashes and crashes of LPVs coded as frontal or roof damaged is highly likely to miss a significant portion of the intended target population.

The screen-captures from a side underride captured on video, below, demonstrates how these 3-plus vehicle, same-direction crashes may unfold: A reckless driver makes a lane change without adequate space, clipping another LPV which losses control and yaws into the unguarded side of a trailer (see final frame). It is unknown how this crash was coded. This crash also demonstrates how an underride collision may occur at interstate speeds, but the relative collision speeds and delta-V are much lower (elevating a side guard's potential effectiveness).



Three-vehicle same-direction side underride sequence

The use of photographs is a key component in the vast majority of scientific literature that attempts to quantify the frequency of side underride. As an accident investigator I know that the use of photographs, which are almost always available in a fatal crash, is a critical piece of information which simply cannot be ignored in accurately counting underride deaths and serious injuries.

2./3. The agency's assumed side underride guard effectiveness / estimating benefits. The Agency's assumed effectiveness in preventing fatalities and injuries is too low for two main reasons: The assumption of complete side guard failure beginning at 41 mph does not reflect the results of the IIHS testing which showed dummy injury criteria well below the serious injury thresholds (see table below). Second, not considered by the Agency is its own work which considers the mitigating effect of angled crashes on collision severity at a given speed.

Measure	Published Tolerance Threshold	Result	Time (ms)
Vector resultant acceleration (g), during frontal airbag loading	80	50	122
Vector resultant acceleration — 3 ms clip (g), during frontal airbag loading	80	49	120-123
Head Injury Criterion (HIC)	1000	297	108-144
Head Injury Criterion — 15 ms interval (HIC-15)	700	211	115-130

Dummy results from IIHS side guard test at 40 MPH

To reflect guard effectiveness more accurately, the IIHS's test results showing low injury probability at 40 MPH should be extrapolated to gradually decreasing benefits based on increased speed - not "cut off" at 41 MPH. I have crash tested a side guard at KARCO – a facility that has conducted underride testing for NHTSA – for the purpose of replicating a fatal side underride crash conditions at an **impact speed of 47.2 MPH** which created a delta-V of 44 MPH. The test resulted in no serious injury to the driver dummy. The test also demonstrates that effective side guard designs can be adapted to varied trailer configurations. That KARCO test report, along with the associated LPV's EDR is included with this correspondence as Attachment B. I also present as Attachment C, a crash report and associated EDR from an LPV into the side of a CT that was not an underride because the passenger car struck the trailer wheels. This crash is noteworthy because even with a 48 MPH delta-V and none of the occupants belted, all four passengers survived.

NHTSA's side guard effectiveness analysis should consider not only impact speed, but also the angle at which the impacts may occur. Angled impacts would create more of a "glancing blow" with a side guard. In 2018 NHTSA authored report number DOT HS 812 522, "Computer Modeling and Evaluation of Side Underride Protective Device Designs." That report, which modeled crash speeds up to 50 MPH, characterized "Impact Severity" as a function of collision angle, Θ.

$$\text{Impact Severity (I.S.)} = \tfrac{1}{2} M \left[V \sin(\theta)\right]^2$$

It follows that the Impact Severity of a crash at 90 degrees – like the IIHS tests of the AngelWing - is one-fourth as severe at angle an of 30 degrees with the trailer, and the potential side guard effectiveness for would expand accordingly. Attachment D is a 35 MPH, 45-degree angle side guard test with an instrumented dummy conducted at KARCO. In a car without airbags, none of the serious injury thresholds were exceeded.

5. **Potential effects of advanced driver assistance technologies (ADAS).** While collision mitigation technologies are unquestionably worthy of pursuit, they are not a replacement for passive technologies like guardrails (side guards included), or seatbelts, for example. To the extent that ADAS technology will help in side underride crashes - and there are questions about that- it should be viewed as a potential severity mitigant, expanding the range of crashes in which side guards are effective due to reduced collision speeds. But there are at least several instances I've investigated that the ADAS technology has failed to prevent collisions with the sides of trailers, due likely to the bottom of the trailer side residing at the horizon line and above the ADAS hazard detection zone.

6. **Cost related to weight of strengthening trailer structure**. The AngelWing was designed and developed as an add-on component and required no extra trailer reinforcement on the trailer successfully tested at IIHS. But whether or not a trailer would need reinforcement to withstand the loading from an impacting car depends on the trailer model, its construction, and its materials. Ultimately the weights of construction of a side guard will be reduced through higher strength-to-weight ratio materials. After the IIHS tested AngelWing at an 800 pounds guard weight, I successfully crash tested an AngelWing guard of reduced weight at 650 pounds employing high strength steel. More high strength steel would have been used but was not available for some of the components of certain dimensions. Higher volume production would make these components available in high-strength steel.

Side underride protection, once integrated into the load bearing and aerodynamic tasks of the trailer will doubtless result in a reduced weight associated with eliminating the side underride gap in the same way the AngelWing, for example, currently acts as a support for an aerodynamic skirt, which eliminates the weight of usual aerodynamic support bracing.

7. **NHTSA's cost estimates.** AngelWing's current cost should not be so central to NHTSA's hardware cost analysis. The AngelWing side guard has been produced only at low volumes, infinitesimal compared to the production volume of the general semi-trailer population. They have not yet been produced in assembly-line, automated fashion. Its brackets have been individually bent on press-brakes. Past discussions I've conducted with fabrication facilities indicate once volumes get over only just a thousand units, stamping brackets becomes worthwhile and their cost is roughly halved. More cost reductions through automation are there to be realized. NHTSA should consider the employment of manufacturing specialists to better estimate side guard hardware costs once scaled to semi-trailer population volumes.

One major trailer manufacturer created a side guard cost estimate for an approximately 730-pound side guard for an intermodal container chassis that was $329.82 in the year 2000. This is approximately $582.50 in 2023 dollars following the general rate of inflation, or about 80¢ per pound. The manufacturer estimate, produced in a fatal side underride lawsuit, gives an unfiltered view of the cost a trailer manufacture believes a side guard to be (see below). The manufacturer, Strick, was the 6th largest trailer maker at the time. See attachment E.

12/21/2000 SIDE GUARD ESTIMATE Stl@ 22¢/# I@ 25¢/# Tubing 28¢/# L/B@ 35/#

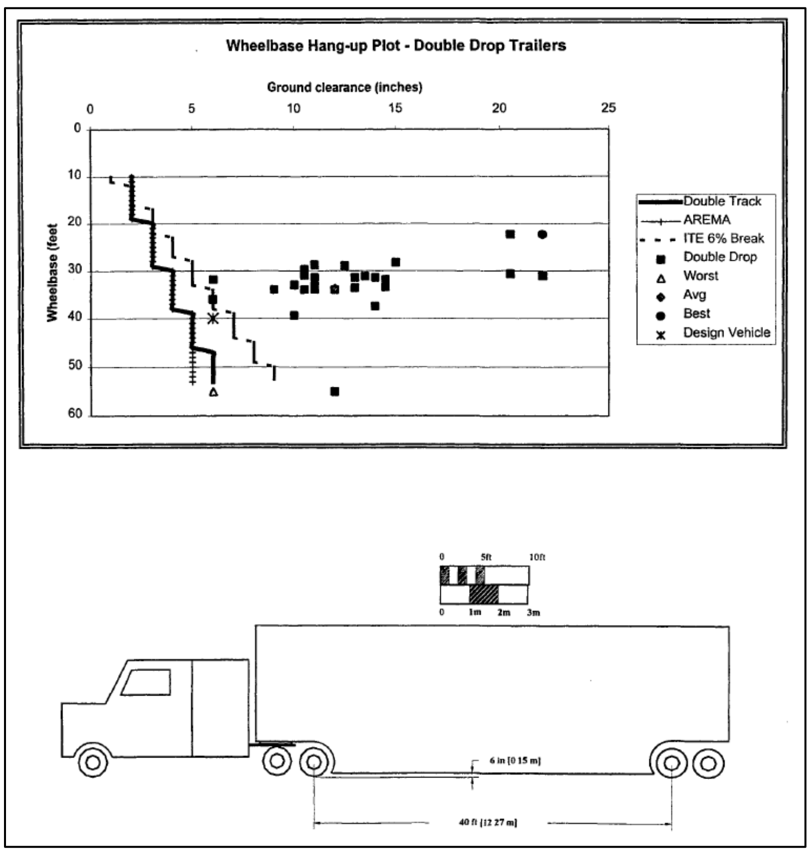
ITEM	DESCRIPTION	SIZE	WEIGHT EA	QUAN	MAT'L COST EA	LABOR & BUR EA	TOTAL
1	CROSS TIE	4" I 3.2# × 68"	18.1	5	4.53	—	22.65
2	SUPPORT	4" I × 21.7 ave	6.4	10	1.60	1.60	32.00
3	LONGITUDINAL GUARD	4×4×3/16×216" (9.42)	170	2	47.60	—	95.20
4	Xmbr	8×3½×10g	21.6	5	4.75	1.60	31.75
5	GUSSET B590007	7g×12×12 (13223)	3.65	20	.84	.64	29.60
6	CLIP	7g × 1½ × 3½	.27	20	.06	.50	11.20
7	3/8 BOLT & NUT	3/8×1		60	.05	—	3.00
8	DIAGONAL BRACE	4" I × 45" (48")	12.8	4	3.20	1.60	19.20
9	CLIP	2½×5×10g	.50	8	.11	.50	4.88
10	3/8 Bolt & nut	3/8×1		24	.05	—	1.20
	Paint						15.00
	WELD 20 GUSSETS			20		1.00	20.00
	WELD CLIPS			28		.15	4.20
	WELD CROSS TIES & LONG 7pc			5+2		.50	3.50
	INSTALL BOLTS			72		.10	7.20
	POSITION & INSTALL 4 guys 30 MIN			2hrs			70.00
						Σ	+370.58
	DEDUCT						
	Xmbr 12191	10g×8	19.0	5	4.22	.96	<25.90>
	Gusset 13223	7g×12×12	3.65	6	.84	.64	<8.88>
	WELD GUSSETS			6		1.00	<6.00>
	Xmbr WELDING SAME						
						Σ	-40.78
						TOTAL	329.82
							COST

Year 2000 manufacturer estimate for 730-pound side guard: $329.82

As a general proposition NHTSA should be especially skeptical of any side guard cost estimate that is more on a per-pound than a typical dry-freight trailer. In fact, the above estimate demonstrates it should be far less. There exists no reason a side guard, made of ordinary materials similar to that of the trailer's existing components, should cost more to construct on a large-scale basis than the trailer writ large.

8/9. The practicability and feasibility of side underride guards. Society of Automotive Engineers' Surface Vehicle Recommended Practice SAE J699A has long stated that "maximum gradient at docks should not exceed 6%." A side guard like the AngelWing tested by the IIHS does not bottom-out on the maximum 6% dock slope as set forth by SAE. Analysis shows that ground clearance is maintained even on non-compliant docks with 10% dock slopes, and even with the trailer axles set at the full rearward position. See Attachment F.

Research conducted by West Virginia University shows that for railroad grade crossings compliant with American Railway Engineering and Maintenance of Way standards (AREMA) and driveway breaks compliant with Institute of Traffic Engineers (ITE), semi-trailers only "hang up" if far closer to the ground than the side guard-fitted trailers successfully crash tested by the IIHS. See graph below and Attachment G. Compiled data on railroad grade crossing accidents shows that from 2014 to 2018 there were zero fatal grade crossing accidents coded "semi-trailer stuck on tracks" which would include the population of trailers like low-bows and beverage haulers far lower to the ground than is required by a side guard. See Attachment H for compiled data.



Graph from West Virginia University study on ground clearance and trailer wheelbase compared to Standard Railroad and Institute of Traffic Engineers driveway breaks (See Attachment H).

Ground interaction with outlier infrastructure anomalies is a negligible risk on side-guard fitted trailers. A quick internet search of "semi-trailer hits overpass" reveals instances where a typical box trailer is occasionally too tall for infrastructure. Testing of the AngelWing design by a TTMA member referenced in their comment of June 6, 2023, was on a 19.4% slope, more than three times that permissible under the SAE Recommended Practice. Repeatedly backed into loading docks, *rear* underride guards aren't at risk of falling off or compromising the trailer rear door area due to infrastructure contact. Countless under-floor appurtenances already exist on trailers - tire carriers, landing legs, loading ramps, battery boxes, fuel tanks, liftgates, side skirts, etc., – there's no reason an adequately engineered side guard cannot safely exist underneath the trailer as has been the on-the-road experience of the AngelWing.

The most obvious place to look for a reply to those voicing concerns over the practicability of side guards is the European experience with side guards for vulnerable road users. While not required the strength to prevent cars from underriding, their side guards have been mandatory for decades and share common location and geometry on the trailer with the Agency's proposal.

Thank you for the opportunity to comment on the ANPRM for side guards.

Yours very truly,

SEVEN HILLS ENGINEERING, LLC.

Perry L. Ponder, P.E.,

Attachments:

A. Side Underride PCRs Not in Target Population
B. 47.2 MPH Side Guard Test Report KARCO
C. 48 MPH LPV into Trailer Tandem Survived
D. 45 Degree Angle 35 MPH Test Report KARCO
E. Manufacturer's Side Guard Cost Estimate
F. SAE Ground Clearance Recommended Practice
G. University of West Virginia Ground Clearance Study
H. Railroad Grade Crossing Data FRA