Types and Extent of Damage to Passenger Vehicles in Low-Speed Front and Rear Crashes

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ABSTRACT

A survey of vehicles brought to five insurance drive-in claims centers in the Washington, D.C., metropolitan area was used to examine the types and amounts of vehicle damage sustained in relatively minor front and rear crashes. The sample of 509 vehicles included cars (67 percent), small and midsize sport utility vehicles (SUVs) (23 percent), and minivans (10 percent) of vehicle makes and models that had been evaluated in low-speed crash tests conducted by the Insurance Institute for Highway Safety. The mean estimated damage claim amount for cars in collisions with other cars ($820) was considerably lower than those for cars in collisions with SUVs ($1,189), minivans ($1,022), or pickups ($1,298). Of the cars involved in collisions with other vehicles, one-third sustained damage from bumper underride or override, and underride/override was associated with substantially higher mean estimated damage claim amounts. Underride/override was more common among cars sustaining front damage (39 percent) than among cars with rear damage (26 percent). Car-to-SUV crashes were particularly problematic; 67 percent of cars in these crashes sustained underride/override damage, and mean estimated claim amounts were 72 percent higher when this occurred. Underride/override occurred in about one-fifth of car-to-car crashes, usually after the bumpers initially engaged. Current low-speed vehicle crash tests do not capture the effects of underride or override, so these tests do not adequately measure the full extent of damage occurring in many real-world crashes, even for vehicles with equal bumper heights. Better low-speed crash tests to evaluate bumper performance and the implementation of meaningful federal bumper standards for SUVs, pickups, and vans, as well as cars, are needed to reduce the considerable damage costs resulting from underride and override.

INTRODUCTION

The National Highway Traffic Safety Administration estimates that 16.4 million motor vehicle crashes occurred in the United States in 2000, including both police-reported and non-police-reported crashes (Blincoe et al., 2002). The large majority (82 percent) of these crashes were relatively minor collisions, involving property damage but no personal injury, with estimated societal costs of $60 billion. The average cost for vehicles involved in property-damage-only crashes was $2,532. Insurers paid about two-thirds of the property-damage costs resulting from crashes of all levels of severity.

Based on property damage claims paid by insurers for crashes involving 1991 and later model year passenger vehicles, the Highway Loss Data Institute (HLDI) estimated that the points of impact in these crashes most often were either the front (47 percent) or rear (32 percent) of the vehicle. Among frontal crashes, 55 percent were center impacts and the remaining 45 percent were corner impacts. Among rear crashes, 69 percent were center impacts and 31 percent were corner impacts.

Property-damage-only claims often result from low-speed front or rear collisions. By absorbing or not absorbing the crash energy, front and rear vehicle bumpers play a critical role in the extent of

vehicle damage resulting from such crashes. The National Highway Traffic Safety Administration (NHTSA) established performance standards for front and rear car bumpers (49 CFR Part 581) based on a 2.5 mi/h (4 km/h) test involving the full width of the bumper and a 1.5 mi/h (2.5 km/h) test for corner impacts. The standards incorporate bumper height requirements and a "no damage" requirement for non-bumper parts; however, these tests allow unlimited damage to the bumper system itself. Although NHTSA's standards are relatively weak, some vehicles are designed and sold with stronger bumpers for competitive reasons. Still, minor collisions can cause extensive damage to bumpers and expensive sheet metal parts. NHTSA has not established performance standards for bumpers on pickups, sport utility vehicles (SUVs), or minivans, which typically are higher off the ground than car bumpers.

Since 1969 the Insurance Institute for Highway Safety (IIHS) has conducted low-speed vehicle crash tests to assess vehicle damageability — i.e., the measure of a vehicle's ability to withstand the forces of minor impacts. More stringent than NHTSA's tests, the IIHS tests include four 5 mi/h (8 km/h) impacts to evaluate bumper performance. Using a concrete barrier wall, the front-into-flat-barrier and rear-into-flat-barrier tests involve the entire surface of the front and rear bumpers, respectively. The front-into-angle-barrier test uses a similar concrete barrier, but the right front of the vehicle strikes the barrier at a 30-degree angle. In the rear-to-pole test, the center of the vehicle's rear bumper impacts a steel pole to stress the bumper bar at its weakest point. The types of vehicles tested include passenger cars (excluding convertibles and sports cars), minivans, small and midsize SUVs, and small and full-size pickups.

Crash tests of vehicle bumpers also are conducted under the auspices of the Research Council for Automobile Repairs (RCAR), an international body of national insurance research centers and repair committees. RCAR has developed low-speed tests that assess not only damageability but also repairability — i.e., how easily, quickly, and cost effectively damage can be repaired or parts replaced. These tests are intended to reflect typical low-speed impacts and produce an average level of damage that insurers are paying. Tests include a 9.3 mi/h (15 km/h) frontal offset flat barrier test and a rear offset impact with a 1,000 kg mobile barrier accelerated to 9.3 mi/h (15 km/h). Results are used in some countries to determine insurance rates for specific vehicle makes and models.

Vehicle manufacturers may make significant modifications to bumper systems to perform well in low-speed crash tests, so it is important that tests simulate real-world crashes realistically. None of the tests conducted by NHTSA, IIHS, or RCAR involve braking. Nor are they able to assess the extent of damage caused by bumper underride and override, which are common occurrences in real-world low-speed front and rear crashes. This is due to the difficulties of simulating the effects of hard braking and capturing the effects of varying bumper heights. Among vehicles of similar ride heights, underride or override may occur because hard braking tends to cause the front bumper to go down and the rear bumper to rise. Among vehicles with different ride heights, underride and override can occur even without

braking. This problem likely has worsened in recent years because of the substantial increase in the proportion of SUVs in the vehicle fleet; SUVs have higher ride heights and their bumpers are unregulated. Data on newly registered vehicles, derived from vehicle registration data from R.L. Polk & Company, indicate that SUVs, pickups, and large or cargo-size vans represented 26 percent of 1991 model year vehicles and 37 percent of 2000 model year vehicles.

There is no repository of detailed information on the types and costs of vehicle damage resulting from real-world low-speed crashes. However, insurers' drive-in claims centers provide an opportunity to gather such information on vehicles involved in relatively minor collisions. Damage to these vehicles usually is moderate because the vehicles must be driven to the claims centers. In a 1991 survey of drive-in claims centers in four major cities, IIHS examined the locations and causes of low-speed urban crashes and the types of resulting vehicle damage (Wells et al., 1991). Underride occurred in 14 percent of front/front-corner crashes involving all types of vehicles, and either underride or override occurred in 15 percent of rear/rear-corner crashes. When underride or override occurred, the resulting damage was associated with higher repair costs. Underride/override occurred in 11 percent of car-to-car crashes but approximately 21 percent of car-to-SUV/pickup/van crashes.

Data obtained from surveys of drive-in claims centers have several limitations. Not all insurers use them, the vehicles that are sampled at these centers may not be representative of all vehicles involved in minor collisions, and there is no way to determine the type or extent of any bias in the distribution of vehicles seen at claims centers. In addition, damage appraisals estimate damage based on visual inspection of the vehicle before repairs are made, so final repairs may cost more than the damage appraised by the claims center.

Despite these limitations, data from drive-in claims centers are one of the few sources of detailed information on damage resulting from relatively minor crashes. Following the same approach used by Wells et al. (1991), the purpose of the present study was to update the current knowledge about the damage sustained by bumper systems in real-world low-speed front and rear crashes. Of particular interest was determining the prevalence of bumper underride and override and the associated property damage costs, and then relating bumper underride/override to different crash modes and vehicle types. Results will assist in the development of crash tests that more realistically capture the bumper damage that occurs in real-world crashes.

METHOD

Data were collected at five drive-in claims centers in the Washington, D.C., metropolitan area between November 17, 2001 and February 1, 2002. The centers were owned and operated by two major automobile insurers: three centers by The GEICO Group and two centers by Nationwide Insurance.

Data were obtained through surveys of vehicles arriving at the centers. The study was limited to 1990 and later model year vehicles that had been involved in front or rear collisions with another vehicle or a fixed or other object. Data were collected from interviews with motorists who drove the vehicles to the claims centers, visual inspections and photographs of the vehicles, and damage estimates prepared by the centers' technicians. When multiple vehicles entered a claims center, first priority was given to vehicle makes and models that had been tested in the IIHS low-speed crash test program. Second priority was given to vehicle makes and models that had not been tested but were those IIHS routinely evaluates (e.g., passenger cars, minivans, small and midsize SUVs, pickups). If no vehicle was given priority, data were collected on other types of vehicles (e.g., sports cars, full-size vans, full-size SUVs).

The sample included claims made under collision coverage, under which drivers insure their own vehicles against losses caused by collision, and claims made under property damage liability coverage, under which drivers insure against losses to other property. Thus the sample included drivers who were presumably at fault in collisions and drivers presumably not at fault.

Driver interviews addressed the circumstances of the crash (e.g., type of other vehicle involved, roadway type). Eighty-seven percent of motorists interviewed were driving their vehicles at the time of the crash. Cost estimates of vehicle damage were taken from appraisers' estimates.

Descriptions of case vehicle damage were determined by IIHS staff, based primarily on vehicle photographs. Descriptions included the specific location of the damage and the extent of bumper involvement categorized as distributed, offset, corner, or other. Distributed damage involved more than 60 percent of the bumper, offset damage involved 20-60 percent, and corner damage involved less than 20 percent. "Other" damage included, for example, damage narrowly concentrated in the center of the bumper. For crashes involving another vehicle, photographs and damage estimates were reviewed to determine if bumper underride or override occurred. Underride was defined as the case vehicle's bumper going underneath the other vehicle's bumper. Override was defined as the case vehicle's bumper going over the other vehicle's bumper. Determination of underride/override was based on the following evidence: case bumper was pushed up or down; vertical scratches on the case bumper; scrapes or scratches on the top or underside surface of the case bumper showing evidence of the other vehicle sliding over or under the bumper; or obvious damage to the front grille, headlamps, taillamps, or undercarriage of the case vehicle. In cases of underride/override, vehicle photographs were examined for bumper damage indicating the bumpers initially engaged before underride/override occurred. Interpreting these photographs was difficult in some cases and necessarily involved judgments by the analysts. Thus for each vehicle at least two IIHS analysts were involved in assessing damage and coding related variables.

Data were collected for 752 vehicles, of which 567 (75 percent) were makes and models that had been tested in the IIHS low-speed crash test program. Forty-one vehicles involved in multiple-impact

crashes were excluded because appraisers did not disaggregate damage estimates into front and rear damage and because crash tests do not account for these types of collisions. Pickups also were excluded due to their small sample size (n = 17). Thus a total of 509 vehicles remained for analysis.

RESULTS

The 509 case vehicles included 342 cars (67 percent), 116 SUVs (23 percent), and 51 minivans (10 percent). As shown in Table 1, 61 percent of crashes involved collisions between the case vehicle and a car, and 21 percent involved collisions with an SUV (15 percent) or minivan (6 percent). Seven percent involved collisions with other vehicle types; 28 of these 37 "other" vehicles were pickups. In 10 percent of collisions, the case vehicle hit a fixed or other object (e.g., deer, pole, guardrail). Most commonly, crashes occurred on roadways at or near intersections (38 percent) or between roadway junctures (32 percent); 14 percent occurred in parking lots.

Table 1
Types of Other Vehicles and Crash Locations by Case Vehicle Type (Percent)

	Case Vehicle Type			
	Car (n=342)	SUV (n=116)	Minivan (n=51)	Total (n=509)
Other Vehicle or Object				
Car	60	66	59	61
SUV	15	11	18	15
Minivan	6	3	14	6
Pickup or other vehicle	9	6	—	7
Fixed or other object	10	13	10	10
Unknown	1	1	—	1
Crash Location				
Intersection or intersection-related	36	34	55	38
Non-junction roadway	31	37	29	32
Parking lot	15	16	6	14
Ramp-related	11	3	6	8
Other or unknown	7	9	4	7

The mean estimated damage claim amount for all crashes was $937, and the median claim was $700 (Table 2). Damage claim amounts varied by case vehicle type. For example, mean damage claims were higher for cars ($949) than for SUVs ($925) or minivans ($877). The mean damage claim for cars was considerably lower in collisions with other cars ($820) than in collisions with SUVs, minivans, pickups or other vehicle types ($1,192), or fixed or other objects ($1,037).

Mean estimated damage claim amounts for all case vehicles were examined by model year. Sixty-five percent were 1998 or later model year vehicles, and 37 percent were 2000 or later model year vehicles. Damage claim amounts varied little by model year. Meaningful analysis of estimated damage claims by model year was not possible because the model year was not known for more than half of the other vehicles.

Table 2
Estimated Damage Claim Amounts ($) by Case Vehicle Type

	All Crashes (n=509)	Case Vehicle SUV (n=116)	Case Vehicle Minivan (n=51)	Case Vehicle Car*			
				All Cars (n=342)	Car-to-Car (n=205)	Car-to-Other Vehicle (n=102)	Car-to-Other Object (n=33)
Mean	937	925	877	949	820	1,192	1,037
Median	700	636	615	766	658	1,161	861
Range	51 - 4,615	51 - 3,771	109 - 2,713	75 - 4,615	212 - 3,229	75 - 3,084	230 - 4,615
25th percentile	415	446	349	410	356	592	466
75th percentile	1,251	1,183	1,154	1,297	1,098	1,648	1,220

*Case vehicle cars exclude two collisions with "unknown" vehicle types.

Damage locations among the case vehicles were almost equally divided between the front (49 percent) and rear (51 percent). As shown in Table 3, corner damage was more common than offset or distributed damage in crashes involving front damage, but distributed damage was the most common in crashes involving rear damage. Overall, and for all three case vehicle types, mean estimated damage claim amounts were considerably higher for front damage than for rear damage. Patterns of damage location and associated mean damage claims were not consistent across vehicle types. Distributed front damage was particularly costly, resulting in a mean estimated damage claim of $1,448.

Table 3
Types of Vehicle Damage and Associated Mean Estimated Damage Claim Amounts by Case Vehicle Type

	Car		SUV		Minivan		Total	
	Percent	Mean Claim	Percent	Mean Claim	Percent	Mean Claim	Percent	Mean Claim
Front Damage	*(n=179)*		*(n=51)*		*(n=21)*		*(n=251)*	
Distributed	27	$1,448	26	$1,072	38	$1,211	26	$1,373
Offset	24	985	35	1,421	29	1,162	24	1,088
Corner	41	912	47	887	19	606	41	894
Other	7	938	14	1,798	14	388	9	1,128
Total	100	$1,078	100	$1,167	100	$965	100	$1,087
Rear Damage	*(n=163)*		*(n=65)*		*(n=30)*		*(n=258)*	
Distributed	42	$727	40	$766	33	$751	40	$729
Offset	28	901	29	764	40	1,012	30	884
Corner	29	844	29	699	20	464	28	775
Other	1	259	2	125	7	1,028	2	610
Total	100	$808	100	$736	100	$816	100	$791

Underride and Override in Case Car Crashes

Table 4 shows the extent of underride or override damage in collisions involving case cars. Underride/override was common in both front and rear crashes, and the prevalence of underride/override was highly dependent on the type of other vehicle. Some caution is warranted in interpreting the results due to small sample sizes for some vehicle types. Twenty-one percent of car- to-car crashes involved underride or override, compared with 67 percent of car-to-SUV crashes, 30 percent of car-to-minivan

Table 4
Case Car Damage with and without Bumper Underride or Override and Associated Mean Estimated Damage Claim Amounts by Location of Damage and Type of Other Vehicle

	Other Vehicle*									
	Car		SUV		Minivan		Pickup		Total*	
	Percent	Mean Claim	Percent	Mean Claim	Percent	Mean Claim	Percent	Mean Claim	Percent	Mean Claim
Front Damage	*(n=95)*		*(n=31)*		*(n=9)*		*(n=12)*		*(n=147)*	
Underride	23	$1,394	74	$1,330	44	$1,631	67	$1,514	39	$1,402
No underride	77	927	26	963	56	750	33	527	61	921
Total	100	$1,036	100	$1,235	100	$1,142	100	$1,323	100	$1,108
Rear Damage	*(n=110)*		*(n=21)*		*(n=11)*		*(n=12)*		*(n=154)*	
Underride	—	—	57	$1,469	9	$945	50	$1,581	12	$1,477
Override	19	$757	—	—	9	2,037	—	—	14	815
Neither	81	604	43	659	82	797	50	964	73	643
Total	100	$633	100	$1,122	100	$924	100	$1,272	100	$770
All Crashes	*(n=205)*		*(n=52)*		*(n=20)*		*(n=24)*		*(n=301)*	
Under/Override	21	$1,083	67	$1,378	30	$1,584	58	$1,543	33	$1,285
Neither	79	750	33	802	70	780	42	955	67	766
Total	100	$820	100	$1,189	100	$1,022	100	$1,298	100	$935

*Table excludes the following other vehicles: one bus, four trucks, and one full-size van.

crashes, and 58 percent of car-to-pickup crashes. For case car crashes, the mean estimated damage claim amount was $1,285 for collisions involving underride or override and $766 for other crash types not involving underride or override. Thus the mean estimated damage claim was 68 percent greater with underride or override. More costly damage resulted from crashes involving underride or override, regardless of the type of other vehicle. The increase in mean estimated damage claims with underride/override, compared with crashes without underride/override, ranged from $333 for car-to-car crashes to $804 for car-to-minivan crashes.

Thirty-nine percent of frontal damage to case cars involved underride. Front underride was least common in car-to-car crashes (23 percent) but most common in car-to-SUV crashes (74 percent) and car-to-pickup crashes (67 percent) (Table 4). When underride occurred, the resulting mean estimated damage claim amounts were greater regardless of the other vehicle type. Although the sample of car-to-pickup frontal crashes was small, mean estimated damage claim amounts nearly tripled when underride was involved ($1,514 vs. $527).

About one-quarter of rear damage to case cars involved underride (12 percent) or override (14 percent) (Table 4). Mean estimated damage claim amounts increased from $643 without underride or override to $815 with override (i.e., rear bumper of case car overrode front bumper of other vehicle) and to $1,477 without underride (i.e., rear bumper of case car underrode front bumper of other vehicle). Override occurred in 19 percent of car-to-car rear crashes, resulting in a moderate increase in mean estimated damage claims ($757 vs. $604), and 9 percent of car-to-minivan crashes, resulting in a dramatically higher mean estimated damage claims ($2,037 vs. $797). Underride by the rear bumper did

not occur in any of the car-to-car crashes but did occur in crashes of cars with all other vehicle types. Rear bumper underride occurred most commonly in car-to-SUV crashes (57 percent) and was associated with a doubling of mean estimated damage claims ($1,469 vs. $659).

For car-to-car crashes, mean estimated damage claim amounts associated with underride or override also were examined with reference to whether bumper damage was categorized as distributed, offset, or corner (Table 5). Sample sizes were quite small in some instances. For front damage without underride, the mean estimated claim for distributed damage ($1,121) was larger than that for either offset ($875) or corner ($892) damage. When underride did occur, mean estimated damage claims were larger for all three types of bumper involvement. For rear damage, override compared with no override resulted in larger mean estimated claims for distributed ($809 vs. $550) and corner ($790 vs. $646) damage but not for offset damage ($452 vs. $633).

Table 5
Underride or Override in Car-to-Car Crashes by Type of Location of Vehicle Damage to Case Car and Associated Mean and Median Estimated Damage Claim Amounts

	Underride			Override			Neither		
	n	Mean Claim	Median Claim	n	Mean Claim	Median Claim	n	Mean Claim	Median Claim
Front Damage									
Distributed	15	$1,462	$1,314	—	—	—	13	$1,121	$835
Offset	2	$1,336	$1,336	—	—	—	24	$875	$724
Corner	5	$1,216	$1,041	—	—	—	36	$892	$880
Rear Damage									
Distributed	—	—	—	17	$809	$551	35	$550	$352
Offset	—	—	—	3	$452	$501	29	$633	$516
Corner	—	—	—	1	$790	$790	25	$646	$538

Finally, the issue of bumper engagement was examined for car-to-car crashes involving underride or override (Table 6). Again, sample sizes were small. In almost all crashes, underride or override occurred after bumpers engaged.

Table 6
Initial Bumper Engagement in Underride or Override in Car-to-Car Crashes by Type of Location of Vehicle Damage to Case Car

	Underride			Override		
	Total	Engagement		Total	Engagement	
	N	n	%	n	n	%
Front Damage						
Distributed	15	13	87	—	—	—
Offset	2	1	50	—	—	—
Corner	5	4	80	—	—	—
Total	22	18	82		—	—
Rear Damage						
Distributed	—	—	—	17	15	88
Offset	—	—	—	3	3	100
Corner	—	—	—	1	1	100
Total	—	—	—	21	19	90

Comparison of Estimated and Final Damage Claim Amounts

As noted above, costs of actual repairs may exceed drive-in claims centers' estimates. In such cases, drivers submit supplemental claim forms to their insurers. To explore this issue, the vehicle identification numbers for 333 case vehicles (1998 model year and later) and their crash dates were matched against a special HLDI claims file to obtain final claim amounts. Records for crashes that occurred on the same date were identified for 83 vehicles. For 40 (48 percent) of these vehicles, final amounts paid by insurers matched the estimates of the claims centers. Final claim amounts were higher than estimates for 39 vehicles (47 percent), with differences ranging from $29 to $3,874 and a mean difference of $788. The remaining four vehicles (5 percent) had final claim amounts that were less than the estimates.

DISCUSSION

Data obtained from surveys of insurance drive-in claims centers provide one of the few sources of detailed information on vehicle damage resulting from relatively minor crashes. However, as noted above, these data may not be entirely representative of the population of vehicles involved in low-speed crashes. In addition to the fact that drive-in claims centers process only a portion of all vehicles involved in crashes, the claims centers in this study were located in a single urban area, and the sample of crashes may not be typical of other urban areas or of suburban or rural areas. For example, only a small percentage of study vehicles were pickups, and this percentage almost certainly would be substantially higher in some other regions of the country or in rural areas. In addition, as documented for a small segment of the study sample, final damage claim amounts paid by insurers may substantially exceed the estimated amounts from drive-in claims centers.

According to data provided by HLDI, mean estimated damage claim amounts for vehicles in this study were considerably lower than those paid by insurers for the same vehicle types (1991 and later model years) sustaining front and rear damage in crashes of all levels of severity (Table 7). Moreover, mean damage claims for cars involved in car-to-car crashes in this study also were much lower than those for front and rear car-to-car crashes of all levels of severity.

Table 7
Average Claim Amounts for Cars, Minivans, Small/Midsize SUV Final Claims, Vehicle Model Years 1991 and Later, Highway Data Loss Institute and Drive-in Claims Sample

	All Case Vehicle Types (Car, Minivan, Small/Midsize SUV)		Car-to-Car Crashes	
	Mean Claim	Median Claim	Mean Claim	Median Claim
Front Damage				
HLDI	$2,972	$2,100	$3,037	$2,327
Drive-in claims	$1,087	$918	$1,036	$917
Rear Damage				
HLDI	$1,714	$1,011	$1,656	$932
Drive-in claims	$791	$566	$633	$466

Nevertheless, the study provides compelling evidence that cars do not fare well in relatively minor front and rear collisions with SUVs and pickups. Compared with damage sustained in car-to-car crashes, car damage was far more costly in collisions with SUVs or pickups and somewhat more costly in collisions with minivans. A major factor in increased car damage in collisions with SUVs or pickups was the high prevalence of underride or override, presumably due to the discrepancy in bumper heights. Underride occurred in 67 percent of car-to-SUV crashes and was associated with a 72 percent increase in mean estimated damage claim amounts. Underride or override was not uncommon in car-to-car crashes, occurring in one in five of these crashes and resulting in much higher damage costs. Underride/override in car-to-car crashes almost always occurred after the bumpers had initially engaged. When the results of this study were compared with those from Wells et al. (1991), the prevalence of underride and override increased substantially, even in car-to-car crashes. It is possible that some of this increase may have been due to data interpretation or coding, as the present study placed a larger focus on underride/override issues.

An important step in reducing property damage costs in low-speed front and rear crashes is establishing meaningful federal bumper standards for SUVs, pickups, and minivans, as well as cars. Standards should provide a more stringent test of damageability and require uniform bumper heights on all passenger vehicles. The present study shows that discrepancies in bumper heights translate directly into higher damage costs, even in low-speed crashes. Strengthening federal bumper standards for cars and establishing standards for other types of passenger vehicles would reduce all types of front and rear damage costs, whether or not underride/override is involved.

In developing better bumper systems that meet more stringent requirements for damageability, some modifications appear straightforward. For example, extending the bumper bar could limit damage resulting from corner crashes. This study suggests that even more substantial improvements would be derived from addressing the issue of underride and override. Crash tests may be helpful in this regard but, as previously noted, current crash damageability tests do not capture the effects of underride/override, whether for vehicles of unequal bumper heights or vehicles of equal bumper heights.

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