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Highway Loss Data Institute

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September 1, 2023

The Honorable Ann Carlson
Acting Administrator
National Highway Traffic Safety Administration
1200 New Jersey Avenue, SE
Washington, DC 20590

The Honorable Robin Hutcheson
Administrator
Federal Motor Carrier Safety Administration
1200 New Jersey Avenue, SE
Washington, DC 20590

Notice of Proposed Rulemaking (NPRM): Heavy Vehicle Automatic Emergency Braking (AEB); AEB Test Devices. Docket No. NHTSA-2023-0023; Docket No. FMCSA-2022-0171.

Dear Acting Administrator Carlson and Administrator Hutcheson:

The Insurance Institute for Highway Safety (IIHS) welcomes the opportunity to comment on the rulemaking jointly proposed by the National Highway Traffic Safety Administration (NHTSA) and Federal Motor Carrier Safety Administration (FMCSA). IIHS strongly supports requiring AEB on all new vehicles above 10,000 pounds (as well as on light vehicles), expanding the electronic stability control (ESC) requirement, and requiring these systems to be turned on during vehicle operation. We especially support these actions because **research studies consistently find large truck AEB prevents or mitigates crashes**. For example:

- IIHS research found that AEB reduces the rate of real-world police-reportable rear-end crashes per mile traveled for large trucks by 41% and helps drivers reduce speeds by over 50% in rear-end crashes that still happen (Teoh, 2021). While limited to Class 8 trucks, this within-carrier design study involved trucks from 62 carriers traveling 2.8 billion miles that were involved in about 2,600 real-world crashes deemed at least severe enough to be reported to police.
- Another study (Kuehn et al., 2011) examined real-world crashes with in-depth investigations and estimated that 52% of rear-end crashes could have been prevented or mitigated if the striking truck had AEB.
- Woodroofe et al. (2013) forecasted the benefit of front crash prevention on large trucks at 22–24% of police-reportable crashes, using assumptions based on one real-world system's design available at that time.
- Belzowski and Herter (2015), in their survey of trucking carriers, found companies that implemented front crash prevention technologies reported a 14% reduction in crash occurrence and a 15% reduction in the average cost of those crashes.

The fact that studies using a variety of methods and data sources consistently find that large truck AEB reduces real-world crashes strengthens the evidence of its safety benefits. The Preliminary Regulatory Impact Analysis the agencies used to calculate expected benefits, which consisted of test-track braking trials involving four vehicles, estimated similar benefits ranging from 39% to 49%, depending on test condition (p. 43181 of the NPRM). Your analysis provides further evidence that this rulemaking will improve highway safety. Moreover, the estimated annual benefits presented in the NPRM are consistent with a study conducted by IIHS (Jermakian, 2012).

In light of this strong evidence for the benefits of large truck AEB, IIHS encourages NHTSA and FMCSA to finalize rulemaking expeditiously. We also offer the following two recommendations.

Formulate a plan to study and potentially require pedestrian AEB (PAEB)
IIHS agrees with the agencies that, unlike for light vehicles, there isn't yet strong evidence supporting PAEB for heavy vehicles and that sorting this out shouldn't delay the current rulemaking. However, NHTSA and FMCSA should formulate a plan to study PAEB (both on the test track and in real-world crashes) and, if it's shown to be effective, incorporate it into the AEB rules at that time. There is strong evidence of PAEB effectiveness in light vehicles (Cicchino, 2022), so making a plan to close this gap for heavy vehicles is more appropriate than dismissing PAEB outright.

Consider comments on NHTSA's NPRM for light vehicle AEB
IIHS submitted a comment (appended to this letter) to Docket No. NHTSA-2023-0021 in support of requiring AEB and PAEB on light vehicles and offered several detailed recommendations and suggestions. Some of these are relevant to the heavy vehicle AEB NPRM, especially those outlined below. It may be useful for the agencies to review others' comments on the light vehicle NPRM as well.

- Incorporate ISO 15623 Section 5.10.1 by reference, instead of the overly prescriptive mixture of SAE J2400 requirements specified in the NPRM, to regulate forward-collision-warning interface design and simplify compliance (see https://www.iso.org/obp/ui/en/#iso:std:iso:15623:ed-2:v1:en).
- Require manufacturers to record and store information about significant AEB activations, as well as about other advanced driver assistance systems (ADAS) and driving automation technologies.
- AEB and other ADAS should continuously monitor system health and notify the driver when a malfunction is detected.

In summary, IIHS applauds NHTSA and FMCSA for proposing this rule to require AEB on medium and heavy vehicles. An increasing body of research shows that this will benefit highway safety, thus furthering the missions of both agencies. Requiring AEB for light, medium, and heavy vehicles will reduce the number and severity of crashes that need to be managed by other countermeasures, which also aligns with the Safe System Approach adopted by the U.S. Department of Transportation. As technology continues to improve, especially in terms of detecting more types of road users, the benefits will grow. And the sooner this becomes finalized, the better for highway safety.

Sincerely,

Eric Teoh
Director of Statistical Services

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August 11, 2023

The Honorable Ann Carlson
Acting Administrator
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Automatic Emergency Braking Systems for Light Vehicles: Notice of Proposed Rulemaking; Docket No. NHTSA-2023-0021

Dear Acting Administrator Carlson:

The Insurance Institute for Highway Safety (IIHS) welcomes the opportunity to comment on the National Highway Traffic Safety Administration's (NHTSA's) proposed rule on automatic emergency braking (AEB) systems. IIHS wholly supports NHTSA requiring new light vehicles to have AEB systems that address rear-end crashes with other light vehicles and pedestrian AEB (PAEB) systems that address vehicle-to-pedestrian crashes during the day and night. Both technologies are preventing vehicle-to-vehicle (Cicchino, 2017) and vehicle-to-pedestrian crashes (Cicchino, 2022) reported to police and insurers (Highway Loss Data Institute [HLDI], 2023; Wakeman et al., 2019). Both technologies should be required in every new vehicle.

The NHTSA New Car Assessment Program (NCAP) and IIHS front crash prevention (FCP) rating program successfully informed consumers about AEB and accelerated its penetration into the U.S. vehicle fleet. In 2016, IIHS and NHTSA worked together to get 20 manufacturers to equip virtually all their light-duty cars and trucks with AEB by September 1, 2022. However, the conditions both programs used to evaluate AEB were only relevant to a small proportion of police-reported rear-end crashes (Kidd, 2022). This year, IIHS began evaluating AEB performance when a vehicle approaches a stationary crash partner at 50, 60, and 70 km/h. The test conditions of our updated program are relevant to nearly one third of rear-end crashes reported to police each year and will accelerate manufacturers' progress in meeting the proposed AEB requirements.

IIHS has evaluated PAEB systems in new vehicles since 2019. We began by evaluating performance during the daytime, but, recognizing that most pedestrian fatalities occur on dark roads, started evaluating PAEB performance at night last year. The requirements of our PAEB program align with many of NHTSA's proposed PAEB requirements. PAEB systems have improved dramatically since we began our testing, so manufacturers are well on their way to meeting the proposed PAEB requirements.

NHTSA's proposed rulemaking will codify and extend the AEB and PAEB performance that IIHS is evaluating in its current consumer information programs. The requirements are reasonable and attainable and should go into effect as soon as rulemaking is promulgated without phase-in periods. We see opportunities to strengthen the proposed requirements to address more rear-end crashes and crashes with vulnerable road users, but quickly moving the proposed rulemaking into law far outweighs expanding its scope and delaying implementation.

Accordingly, the NHTSA NCAP should be used to promote AEB systems that go beyond the proposed requirements and address other relevant crashes like rear-end crashes with motorcycles, turning crashes with pedestrians, and vehicle-to-bicyclist crashes, among others. IIHS will continue to evolve its consumer information programs to advance AEB, PAEB, and other active safety systems. It is essential that NHTSA and IIHS coordinate their efforts to encourage the rapid adoption of safety technologies without duplicating efforts.

Our responses to the proposed requirements and select questions posed by NHTSA follow. We appreciate the opportunity to share our information and suggestions with NHTSA and look forward to working with the agency to further improve the safety of the United States' vehicle fleet.

Sincerely,

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Senior Research Scientist

David Aylor
Vice President, Active Safety

Responses to proposed requirements and select questions posed by NHTSA in Docket No. NHTSA-2023-0021

Complete avoidance in the proposed vehicle-to-vehicle and vehicle-to-pedestrian test scenarios is achievable.

IIHS evaluations of existing AEB and PAEB systems indicate that some current systems are completely avoiding collisions in the required AEB and PAEB testing conditions. We recently evaluated the AEB performance in six model year 2021–2022 vehicles. The vehicles approached a stationary passenger-car-surrogate target in the center of the lane at 50, 60, and 70 km/h.

Five of the six vehicles completely avoided the target in all three trials at 50 and 60 km/h. Three of the six vehicles completely avoided the passenger-car target in all three trials at 70 km/h. IIHS did not evaluate these AEB systems at 80 km/h. But based on discussions with manufacturers, we know that at least one system, Subaru EyeSight, is capable of completely avoiding the passenger-car target at 80 km/h.

IIHS began evaluating PAEB performance in new vehicles during the day in 2019 and at night in 2022. Our PAEB ratings are based on a mixture of the data submitted by manufacturers for verification and the results from our internal testing. As of June 2023, we have rated 194 model year 2023 PAEB systems tested during the day. Thirty-three (17%) fully avoided the pedestrian mannequin in every test condition. Of the 114 model year 2023 PAEB systems we tested at night, 12 (11%) fully avoided the pedestrian mannequin in every test condition.

Requirements for PAEB should be immediate and not phased-in.

It typically takes 7 years for proposed rulemaking to be promulgated into law. Manufacturers have made dramatic progress in our PAEB program in a short time. We have observed complete avoidance when the vehicle is approaching a stationary adult mannequin with a 25% overlap at 60 km/h at night. Additionally, many PAEB systems do well when there is a 25% overlap between the vehicle and an adult mannequin crossing the vehicle's path, even in the dark. We anticipate that nearly every new vehicle will receive our top rating of superior in our PAEB evaluation within the next 7 years and easily meet NHTSA's PAEB requirements when the proposed rulemaking is promulgated into law. Therefore, the agency should require vehicles manufactured on or after September 1 after the publication date of the final rule to meet every PAEB requirement. The proposed multiyear phase-in period will unnecessarily delay the life-saving benefits of PAEB.

Promote AEB systems that exceed the proposed requirements through the NHTSA NCAP.

The most advanced AEB systems today are capable of meeting many of NHTSA's proposed requirements. We anticipate that systems fleet-wide will easily meet the proposed requirements by the time rulemaking is promulgated. As such, the proposed requirements set an essential floor for AEB performance, but NHTSA must be forward-looking and motivate manufacturers to address additional crash types. AEB is relevant to many more crashes than those addressed by the proposed requirements. NHTSA should use its NCAP to promote AEB systems that address crash types that are not addressed by the proposed rulemaking.

Promote AEB systems that prevent rear-end crashes with motorcycles and heavy trucks to address fatal rear-end crashes.

Speed is a significant factor in fatal rear-end crashes, but so is the body type of the struck vehicle. About 43% of fatal rear-end crashes involve a passenger vehicle striking a medium or heavy truck (32%) or a motorcycle (11%) (Kidd, 2022), even though in 2021, motorcycles only represented 3% of the registered vehicle fleet in the U.S., and combination trucks or single-unit trucks with six or more tires represented about 5% (Federal Highway Administration, 2023). Cicchino and Zuby (2019) found that, compared with rear-end crashes where a car was struck, vehicles with AEB were significantly more likely to strike a nonpassenger vehicle than similar models without AEB. NHTSA's proposed requirements only address rear-end crashes with a light vehicle. The agency should promote AEB systems that detect and automatically apply the brakes to avoid rear-end crashes with motorcycles and medium or heavy trucks in its NCAP.

NHTSA stated it is reluctant to incorporate a motorcycle target into its proposed requirements because AEB performance is dependent on the specific test scenario definition and the potential damage to vehicles under test. The agency's position conflicts with IIHS, the European New Car Assessment Programme (Euro NCAP), and ANCAP (CARHS GMBH, 2023) who have incorporated a motorcycle target into their AEB evaluation programs. IIHS recently conducted research tests to understand how current FCP systems perform when approaching a stationary motorcycle surrogate target (4activSystems 4activMC) in the center of the lane at 50, 60, and 70 km/h. All three test vehicles collided with the motorcycle surrogate target more often than a passenger-car surrogate target (DRI guided soft target). None of the vehicles avoided the motorcycle surrogate target at 70 km/h. Performance worsened when the tests were repeated with the motorcycle target offset to the left or right from the lane center. We did not observe or experience any of the concerns with the motorcycle surrogate target that NHTSA expressed in the notice of proposed rulemaking.

Vehicle testing programs rely on surrogate targets to support evaluations of AEB systems, but options are limited. A surrogate target for a medium or heavy truck does not currently exist, but a heavy truck target is being developed. Based on our recent research, current AEB systems are not expected to perform as well with medium or heavy trucks compared with passenger cars. We collaborated with Transport Canada to measure the presence and timing of forward collision warnings in five 2021–2022 model year passenger vehicles as they approached a variety of nonpassenger vehicles at 50, 60, and 70 km/h. Our testing found that FCW systems warned less often for a tractor trailer, different medium trucks, buses, motorcycle surrogate targets from 4activSystems and DRI, and an autocycle compared with a passenger car. Systems also warned less often as speed increased.

Based on our research and the involvement of motorcycles and heavy trucks in fatal rear-end crashes, our updated FCP testing program evaluates if a FCP system can detect a tractor trailer at 50, 60, and 70 km/h and avoid striking a motorcycle surrogate target in the center of the lane or offset to the left or right of the lane center at a 25% overlap with the vehicle at the same speeds. NHTSA should promote AEB systems that detect and automatically apply the brakes to avoid rear-end crashes with motorcycles and heavy trucks, once a surrogate target is available, in NCAP.

Promote AEB systems that address crashes where a vehicle turns into a pedestrian crossing an intersecting road.

We applaud the agency for requiring PAEB in every new light vehicle. Vehicle-to-pedestrian crashes are a growing safety problem. In 2021, 7,388 pedestrians were killed in motor vehicle crashes, which accounted for 17% of all crash deaths. Pedestrian deaths in 2021 were up 13% from 2020 and are up 80% since 2009.

Both IIHS's current testing programs and NHTSA's proposed requirements focus on PAEB performance when the vehicle is going straight. Recent IIHS research found that the vehicle was going straight in about 52% of police-reported pedestrian crashes and was turning in 40% (Kidd et al., 2023). Hu and Cicchino (2022) found that, relative to passenger cars, larger vehicles like minivans, large vans, SUVs, and pick-ups were significantly more likely to be involved in crashes where the vehicle turned left into a pedestrian crossing the road relative to when the vehicle was going straight. A similar trend was observed for fatal pedestrian crashes, which is concerning since large vehicles like SUVs make up an increasing proportion of the vehicle fleet and are increasingly involved in fatal pedestrian crashes (Hu & Cicchino, 2018). IIHS studies of police-reported crashes (Cicchino, 2022) and insurance loss data (Wakeman et al., 2019) have demonstrated that PAEB systems are effective for preventing pedestrian crashes overall, but also found that PAEB was not effective for preventing pedestrian crashes in certain conditions, including when the vehicle was turning.

A passenger vehicle turning into a pedestrian is the second most common precrash maneuver in pedestrian crashes and represents about 95,000 police-reported, 26,100 nonfatal injury, and 260 fatal pedestrian crashes each year (Kidd et al., 2023). As discussed above, current PAEB systems are not preventing these crashes in the U.S., but PAEB is being evaluated in this crash mode by other testing programs around the world. For example, Euro NCAP (2023) currently evaluates pedestrian AEB performance when the vehicle is turning left or right at 10–20 km/h into the path of a pedestrian moving at 5 km/h. PAEB systems that are designed to prevent vehicles from turning left or right into pedestrians should be promoted in NHTSA's NCAP program. NHTSA can adopt Euro NCAP's scenarios to rapidly incorporate this test into NCAP.

Promote AEB systems that prevent bicyclist crashes.

Bicyclist crash deaths have increased dramatically in recent years. In 2021, 961 bicyclists were killed in motor vehicle crashes, up 53% since 2009. The circumstances of police-reported bicyclist crashes resemble those of pedestrian crashes. The striking passenger vehicle was turning left or right in about 47% of police-reported bicyclist crashes during 2016–2020 and going straight in about 40% (Kidd et al., 2023). Bicyclist crashes are most common during the day, but fatal bicyclist crashes most often occur at night. The vehicle was going straight in most fatal bicyclist crashes (81%; Kidd et al., 2023), and the bicyclist is most commonly traveling in-line with the vehicle, followed by crossing the vehicle's path, and traveling against the vehicle's direction (MacAlister & Zuby, 2015).

Some existing AEB systems detect and automatically brake for bicyclists, and recent IIHS research suggests these systems are effective for preventing bicyclist crashes. Cicchino (2023) examined bicyclist crash rates for Subaru vehicles with bicyclist detection relative to those vehicles without the feature. Cicchino used a quasi-induced exposure approach that compared the ratio of bicyclist crashes to rear-end struck or side-struck crashes among Subarus with and without bicyclist AEB. The presence of bicyclist AEB was associated with a 29% reduction in crashes where the bicyclist was moving in-line with, or parallel to, the vehicle. Subaru's bicyclist AEB system was not designed to address bicyclist crashes where the bicyclist crosses the vehicle's path, and, indeed, the system did not reduce the rate of these crashes.

NHTSA's proposed rulemaking does not require AEB systems to respond to bicyclists, so NHTSA should use NCAP to promote AEB systems that prevent bicyclist crashes. NHTSA can use scenarios adopted by other testing organizations as a starting point for such an evaluation. Euro NCAP currently evaluates bicyclist AEB performance when the vehicle is traveling 25–60 km/h and encounters a bicyclist moving in a parallel direction at 15 km/h. It also evaluates AEB performance when the vehicle is turning left or right at 10–20 km/h into the path of the bicyclist moving at 15 km/h.

Incorporate ISO 15623 Section 5.10.1 by reference instead of the proposed mixture of SAE J2400 requirements and novel requirements to regulate forward collision warning interface design.

NHTSA proposes requiring vehicles to have a forward collision warning system that provides auditory and visual signals with specific characteristics. NHTSA proposes the auditory signal have a high fundamental frequency of at least 800 Hz, a duty cycle of 0.25–0.95 and a tempo in the range of 6–12 pulses per second. The proposed visual signal design requirements follow many recommendations from SAE J2400 including requiring a specific red, steady, burning crash icon that is within a 10-degree cone of the driver's line of sight (SAE International, 2003). We agree that FCWs should be multimodal and capture the driver's attention, but the proposed design requirements are unnecessarily overly prescriptive.

Our analyses of police-reported crashes and insurance loss data indicate that most FCW systems are effective for preventing rear-end crashes despite disparate designs. Cicchino (2017) examined rear-end crash involvement rates for vehicles with FCW from five automakers relative to vehicles without the system. The presence of FCW was associated with reduced rear-end crash involvement rates for each of the five automakers; three of the reductions were statistically significant. The Highway Loss Data Institute examined third-party damage (property damage liability) claim frequency for vehicles from six automakers with and without FCW. FCW systems from four of the six manufacturers were associated with a significant reduction in property damage liability claim frequency.

Existing industry practices for FCW are not only effective for preventing crashes, but are also acceptable and understandable to drivers. Our surveys of vehicle owners (e.g., Eichelberger & McCartt, 2014, 2016) and observational studies (e.g., Reagan & McCartt, 2016; Reagan et al., 2018) at dealerships have consistently found that, across various makes, owners leave FCW on, find it useful, and report that the warnings are easy to see. Only a small percentage of respondents in our surveys have indicated that they misunderstand FCW.

The existing research indicates that the specificity of NHTSA's proposed interface design requirements for FCW are unnecessary. Furthermore, the narrow design requirements may delay the rule making and unintentionally stifle the development of more innovative methods for warning drivers of potential collision threats. If NHTSA is adamant about setting interface design requirements for FCW, then it should incorporate ISO 15623 section 5.10.1 by reference (International Organization for Standardization, 2013). ISO 15623 provides guidelines for each design characteristic that NHTSA is proposing to regulate without an overly narrow scope.

If NHTSA decides to specify an audible warning, IIHS's method for assessing auditory seat belt reminders could be used to ensure auditory FCWs are easily discerned by drivers. IIHS evaluates the acoustic properties of the audible seat belt reminder in new vehicles to assess whether the reminder is easily perceived by the driver beyond ambient levels of sound in the vehicle cabin. Our procedure for measuring the acoustic properties of an auditory seat belt reminder may help NHTSA determine whether the acoustic properties of a FCW make it distinct above other warnings and sounds in the vehicle. Our seat belt reminder system test and rating protocol can be found on the *Test protocols and technical information* page of our website and is located here:

https://www.iihs.org/ratings/about-our-tests/test-protocols-and-technical-information#restraints

NHTSA should require manufacturers to record and store information about AEB events, other advanced driver assistance systems (ADAS), and driving automation technologies.

IIHS supports NHTSA's proposal to require manufacturers to record and store data from AEB events, and urges the agency to expand the requirements to include information from other advanced driver assistance features. IIHS has urged NHTSA to collect information about crash avoidance, driver assistance, and driving automation features using event data recorders (EDRs) in its comments to the docket for over a decade (IIHS, 2013, 2018, 2021). Requiring EDRs to record information about the use and function of advanced driver assistance features would support NHTSA's research and regulatory functions and serve law enforcement and insurance needs. As included in our past comments, a list of suggested variables for event-based electronic data recording in vehicles with one or more ADAS or driving automation systems is included in the Appendix.

AEB and other ADAS should continuously monitor system health and notify the driver when a malfunction is detected.

NHTSA should require manufacturers to notify the driver when AEB or other ADAS are malfunctioning or not performing as designed. Ideally, the notification also would provide directions for resolving the issue, such as cleaning the sensor or going to a service center. Drivers should not be expected to troubleshoot misbehavior or malfunctions from their ADAS, especially when the malfunction introduces new risks. Below are two examples where IIHS has encountered malfunctioning driver assistance systems that not only performed poorly but also introduced new hazards. In both cases the system did not notify the driver of a nonfunctioning or limited state.

Example 1: An IIHS employee who owned a 2013 Toyota Prius experienced inconsistent performance from the vehicle's adaptive cruise control (ACC) system after the vehicle was repaired and sensors recalibrated following a crash. The system adjusted the vehicle's speed and headway in response to taller vehicles like SUVs but not to passenger cars. The employee also reported that the FCW system frequently provided warnings when the vehicle was approaching an overpass. IIHS technicians examined the vehicle's radar and noticed that it was out of alignment. The ACC and FCW systems performed as expected once the radar unit was realigned. At no point did the vehicle indicate that the system was not functioning properly or that the sensor was misaligned.

Example 2: IIHS investigated whether replacing a vehicle's windshield affects the performance of windshield-mounted sensors and supported ADAS. We found that replacing the original windshields with aftermarket windshields had a negligible effect on FCP and lane departure warning performance in all but one vehicle: a 2016 Honda Civic. Prior to the windshield replacement, the Civic's FCP system completely avoided a stationary surrogate passenger-car when approaching it at 40 km/h. After the windshield replacement, the FCP system decelerated later and impacted the target at 18 km/h; we also found that lane departure warnings from the vehicle had shifted toward the passenger-side. We examined the sensor and found that the glued-on camera mount in the Civic was skewed by an approximate 1° roll angle relative to the vehicle centerline. The camera-mounting clip also was loose, which allowed the camera to rotate 1° relative to the vehicle's longitudinal axis. The Civic never indicated that either system was malfunctioning or performing poorly. The issues were resolved after proper recalibration.

There is no evidence that testing with an adult pedestrian mannequin leads to inequitable PAEB performance.

The current IIHS pedestrian AEB test and NHTSA's proposed PAEB test include testing with child and adult mannequins. Testing with both mannequins should ensure AEB performance for a wide range of pedestrian sizes. There is also no clear evidence that PAEB systems are tuned for and respond better to pedestrians that are similar in stature to the male pedestrian mannequin used by testing programs around the world.

IIHS analyzed information from police-reported pedestrian crashes during 2017–2022 for vehicles with PAEB and vehicles without it as a function of pedestrian age, which served as a surrogate measure for stature. As illustrated in Table 1, the proportion of pedestrians struck by vehicles with and without PAEB was similar across age groups.

Table 1

Percentage of police-reported crashes during 2017–2022 for vehicles with and without PAEB by pedestrian age

Pedestrian age (years)	PAEB-equipped vehicle (n=486)	Vehicle without PAEB (n=965)
1–7	2.7%	3.2%
8–12	5.8%	5.3%
13–17	9.5%	9.5%
18 and older	82.1%	82.0%

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Appendix

Suggested variables to include in event-based electronic data recording for vehicles equipped with one or more ADAS or driving automation systems

IIHS and HLDI recommend that the following variables be recorded by an event data recorder or autonomous vehicle data recorder when an autonomous vehicle is involved in a crash. At a minimum, each variable should be recorded every second during the period beginning 30 seconds before a crash and ending 5 seconds after, or until the vehicle comes to a stop. Some variables are currently recorded by event data recorders in conventional vehicles. It may be appropriate to record some variables more frequently.

Definitions

State: a categorical variable indicating if a vehicle system is off or on, its current setting (e.g., standby mode, low beam, high beam), or if the system is not functioning (e.g., failure mode).

Action: a categorical variable indicating when a restraint system, advanced driver assistance system, driver monitoring system, or driving automation system is warning, intervening, deploying, or responding to a safety-critical event.

Category	Variable
Time and history	Timestamp
	Ignition cycle count since being manufactured
Location and path	Latitude
	Longitude
	Elevation
	Heading
Vehicle state and kinematics	Speed
	Steering input (torque or wheel angle) (overall, amount applied by driver, amount applied by driver assistance or driving automation system)
	Brake position/input (overall, amount applied by driver, amount applied by driver assistance or driving automation system)
	Throttle position/input (overall, amount applied by driver, amount applied by driver assistance or driving automation system)
	Lateral acceleration
	Longitudinal acceleration
	Roll angle
	Transmission state (P [park]; R [reverse]; N [neutral]; D-L [forward/drive]
	Windshield wiper state
	Exterior lights state
	Engine revolutions per minute (RPM)
	Antilock brake system state and action

Category	Variable
Crash prevention, driver assistance, and restraint systems	Electronic stability control state and action
	Front crash prevention system (e.g., forward collision warning, automatic emergency braking) state and action
	Rear crash prevention system (e.g., parking sensor, rear automatic emergency braking) state and action
	Lane change crash prevention (e.g., blind spot warning, blind spot intervention) state and action
	Lane maintenance system (e.g., lane departure warning, lane departure prevention, lane centering) state and action
	Frontal airbag state and action
	Side airbag state and action
	Safety belt pretensioner state and action for each occupied seating position
	Driver fatigue monitoring system state and action
	Hands-on wheel detection state and action
	Driver monitoring system (e.g., eyes on or off road) state and action
Vehicle occupant state	Occupant presence for each seating position
	Safety belt state for each occupied seating position
	Occupant size classification for each occupied seating position
Automated driving systems (e.g., self-parking, automated highway driving, automated congestion, or traffic jam driving) *Note*. These variables are collected for each equipped Level 2–5 driving automation system, even if the system is not in use for any reason (e.g., outside the operational design domain or by driver choice)	OEM-defined SAE level of automation for each equipped system
	Vehicle within or outside the intended or specified operational design domain for each equipped system
	State of each equipped system
	Transition of control/take-over message action for each equipped system
V2V basic safety message data for each message broadcasted and received	Time
	Message count
	Temporary ID
	Position data (latitude, longitude, elevation)
	Positional accuracy (semi-major axis accuracy, semi-minor axis accuracy, semi-major axis orientation)
	Transmission state
	Speed
	Heading
	Steering wheel angle
	Acceleration (longitudinal, lateral, vertical, yaw rate)
	Brake system state

Category	Variable
	Vehicle size (width, length)
V2I safety message data for each message broadcasted and received	Signal phase and timing message data
	Signal request message data
	Signal state message data
	Map message data
	Emergency vehicle alert message data
	Intersection collision avoidance message data
	Personal safety message data (vulnerable road user data)
	Road side alert message data
	Traveler information message data