EDR REPORTED DRIVER USAGE OF CRASH AVOIDANCE SYSTEMS FOR HONDA VEHICLES

Christopher Wiacek
Lauren Firey
Mark Mynatt
National Highway Traffic Safety Administration
USA

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ABSTRACT

Starting with the 2016 Model Year, Honda Motor Co. (Honda) began to phase-in vehicles equipped with an Event Data Recorder (EDR) that captures the status and activation of crash avoidance technologies such as forward collision warning/automatic emergency braking and lane departure warning/lane keeping assist. While not defined under the National Highway Traffic Safety Administration's (NHTSA) EDR regulation 49 CFR Part 563, Honda has elected to add these data elements. For this study, Honda EDR data were collected from the NHTSA's 2017 – 2021 Crash Investigation Sampling System (CISS) for vehicles equipped with this recording capability. The data were then assessed to identify the use and activation statuses of these crash avoidance technologies at the time of their respective crash events. If drivers choose to disable these technologies, they will not be afforded the potential collision avoidance and/or severity mitigation benefits of these systems in relevant crashes.

The 150 crash-involved Honda vehicles in this study are equipped with EDRs that captured data elements related to the function and alert status of several crash avoidance systems in the time leading up to the crash event. The results indicate that drivers of Honda vehicles equipped with crash avoidance systems are much more likely to have forward collision warning/automatic emergency braking systems "On" and the lane departure warning/lane keeping assistance systems "Off." Specifically, 99% of drivers for this study had the forward collision warning/automatic emergency braking systems "On" in the time leading up to the crash and thus could be afforded the potential benefits of these systems if they were involved in a system relevant crash situation. With respect to lane departure warning/lane keeping assistance, 49% of the drivers had these systems "Off" at the time of the crash, and therefore were not afforded the potential benefits of these systems during an appropriate situation. Differences were not identified for drivers that had the lane departure warning/lane keeping assistance "On" compared to those that had it "Off" with respect to the driver's sex, age, and race/ethnicity.

Since data on these crash avoidance technologies are collected on the vehicle's Bosch compatible EDR, information regarding the status for these systems at the time of the crash event is readily accessible. This will permit a future assessment for whether a system relevant crash event may have occurred because the system was turned "Off." Alternatively, if the system was turned "On," follow up assessment could be conducted for whether the system "Engaged" and mitigated the severity of the crash. If the system was "On" but is reported as "Not Engaged," further investigation may be warranted to understand factors that may have prevented system activation.

Vehicle level crash avoidance system data captured in the EDR is invaluable and relevant for assessing new field data collection, which will in turn contribute to assessing the real-world benefits of these crash avoidance technologies.

INTRODUCTION

Vehicles equipped with crash avoidance systems have the potential to prevent crashes or mitigate crash severity. As these technologies become more broadly available, it is important to quantify the effectiveness of these systems when evaluating real-world crashes. Existing studies conducted by the University of Michigan Transportation Research Institute (UMTRI), Impact Research, and the Insurance Institute for Highway Safety (IIHS) applied statistical methodologies to police reported crash data to estimate the effectiveness of crash avoidance systems such as forward collision warning (FCW), automatic emergency braking (AEB), lane departure warning (LDW) and lane keeping assistance (LKA). High level results from these studies are represented in Tables 1 and 2 below.

Table 1 estimates the effectiveness in reducing rear-end crashes for vehicles equipped only with FCW at 20-27% compared to vehicles equipped with both FCW and AEB at 41-50%. These results suggest that FCW in conjunction with the active AEB improves overall system effectiveness.

Table 1.
FCW and AEB rear-end crash avoidance effectiveness estimates

Study	FCW	FCW + AEB
UMTRI 2022 [1]	20%	41%
Impact Research 2021 [2]	–	43%
IIHS 2017 [3]	27%	50%

Table 2 estimates the effectiveness of LDW and LKA in reducing lane departure related crashes. The UMTRI and Impact Research studies were limited to single vehicle crashes involving road departure while the IIHS study also included head-on and side swipe crashes. Crash reduction for vehicles equipped only with LDW ranged from 8-11% while vehicles equipped with both LDW and LKA ranged from 9-17%. These findings suggest that LDW in conjunction with the active LKA improves overall system effectiveness.
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Table 2.
Lane departure (LDW/LKA) crash avoidance effectiveness

Study	LDW	LDW + LKA
UMTRI 2022 [1]	8%	17%
Impact Research 2021 [4]	–	9%
IIHS 2018 [5]	11%	–

One limitation of the three studies cited above is that they are constrained to identifying vehicles in the crash data that are *"equipped"* with the crash avoidance technologies. This means identified vehicles were confirmed to be manufactured with a specified crash avoidance technology, but there is no information available to indicate system performance or variation at the vehicle or driver levels. For example, a vehicle may be equipped with AEB, however, if the driver turns the AEB system off, they would not be afforded the benefits of AEB slowing their vehicle if the vehicle in front of theirs stopped suddenly. Furthermore, if the AEB system was engaged at the time of a crash, there is no way to determine whether the system may have performed as designed, mitigating crash severity even if the rear end collision itself was not avoided. Therefore, information about the operation and engagement of collision avoidance systems at the vehicle level is imperative to fully assess the performance of these systems and understand how/whether the systems are being used.

Honda was identified as a manufacturer who, beginning with Model Year 2016 vehicles, captured and recorded the status and activation of crash avoidance technologies such as FCW/AEB and LDW/LKA directly through the vehicle's EDR. Honda EDR data is readily accessible as it can be imaged using the Bosch Crash Data Retrieval (CDR) tool. Using NHTSA's 2017 – 2021 CISS database, data collected on vehicles equipped with this EDR recording capability can be used to identify driver usage of crash avoidance technologies at the time of the recorded crash events. This will enhance future analyses of crash data to determine whether a crash event may have occurred from an avoidance system being turned "Off" or if a system was turned "On" and was "Engaged" to mitigate the severity of the crash. If the system was "On" but is reported as "Not Engaged," further investigation may be warranted to understand factors that may have prevented system activation, such as the crash event was not a crash type that could potentially be addressed by FCW/AEB or LDW/LKA systems.

This paper provides a detailed overview of the recording capabilities of model year 2016 and newer Honda EDRs. It contains a compilation of the status of the CISS reported subject vehicle's crash avoidance technologies and driver demographic data Examples detailing how EDR vehicle data can provide insight for the performance of these systems during a crash event are also included.

Any conclusions about consumer usage of Honda's driver assistance technologies may be biased towards Honda's implementation of these technologies and may not be comparable to other vehicle manufacturers with similar systems. This study does not assess behavioral reasons why consumers have Honda's crash avoidance systems "On" or "Off." CISS and EDR data are limited to reporting vehicle and driver status at the time of the recorded crash event. They do not distinguish whether the driver of the subject Honda vehicle may have turned a crash avoidance system, such as LDW and LKA, "On" or "Off." This study also does not address how effective Honda's crash avoidance technologies are at preventing or mitigating applicable crash events.

METHODOLOGY

Honda Crash Avoidance and Driver Assistance System Terminology

Honda has described crash avoidance and driver assistance systems within their EDR using their specific marketing terms. Table 3 maps the Honda terminology listed within their owner's manual [6] to what industry accepts as more traditional nomenclature for these systems. The common terminology for these systems will be used for this paper.

Table 3.
Terminology mapping

Honda EDR Terms	Common Terms	Abbreviation	System Design/Operation
Forward Collision Warning/Collision Mitigation Braking System	Forward Collision Warning/Automatic Emergency Braking	FCW/AEB	Detects a potential collision with a vehicle ahead and provides a warning to the driver. Automatically applies the vehicle's brakes in time to avoid or mitigate an impending forward crash with another vehicle.
Lane Departure Warning/Road Departure Mitigation	Lane Departure Warning/Lane Keeping Assistance	LDW/LKA	Monitors lane markings and alerts the driver when it detects that the vehicle is drifting out of its lane. Helps prevent the vehicle from unintentionally drifting out of its lane
Lane Keeping Assist	Lane Centering Assistance	LCA	Monitors the vehicle's lane position and automatically and continuously applies steering input needed to keep the vehicle centered within its lane.
Adaptive Cruise Control	Adaptive Cruise Control	ACC	Automatically adjusts the vehicle's speed to keep a pre-set distance between it and the vehicle in front of it.

Honda Event Data Recorder

The Honda EDRs used for this study capture and report five seconds of pre-crash data at 0.5 second recording increments from the Algorithm Enable (AE) crash event. Honda generates 3 standard pre-crash output tables per event, represented by Figures 1, 2 and 3 below.

Figure 1 shows EDR output Table 1 of 3, which contains records for Vehicle Speed, Accelerator Pedal Position, Service Brake, Anti-Lock Brake System (ABS) Activity, Stability Control, Steering Input and Engine Revolutions per Minute (RPM). These elements are required and/or optional pre-crash data elements established by NHTSA regulation 49 CFR Part 563. Note that an output of "On" for Service Brake indicates the driver is physically applying the brake pedal and "On" for ABS Activity means ABS is activated during the specified pre-crash time interval. For Stability Control, "On" (time increment output value "On Non-Engaged") means the system is available for use but was not activated during pre-crash recording, "Off" (output value "Not Engaged") specifies that the system is deactivated by the driver and therefore is not available for the duration of the event, and "Engaged" (output value "On Engaged") indicates the system is available and in use during the event.

Pre-Crash Data -5 to 0 sec [2 samples/sec] (Event Record 1) - Table 1 of 3

Time Stamp (sec)	Speed, Vehicle Indicated (MPH [km/h])	Accelerator Pedal Position, % full	Service Brake (On, Off)	ABS Activity (On, Off)	Stability Control (On, Off, Engaged)	Steering Input (deg)	Engine RPM
-5.0	80 [128]	16	Off	Off	On Non-Engaged	-5	2,100
-4.5	80 [128]	8	Off	Off	On Non-Engaged	-5	2,100
-4.0	80 [128]	11	Off	Off	On Non-Engaged	-5	2,100
-3.5	80 [128]	13	Off	Off	On Non-Engaged	-5	2,100
-3.0	80 [128]	18	Off	Off	On Non-Engaged	-5	2,100
-2.5	80 [128]	18	Off	Off	On Non-Engaged	-5	2,100
-2.0	80 [128]	17	Off	Off	On Non-Engaged	-5	2,100
-1.5	80 [128]	0	Off	Off	On Non-Engaged	0	2,000
-1.0	79 [127]	0	On	Off	On Non-Engaged	0	1,800
-0.5	65 [105]	0	On	On	On Non-Engaged	0	1,600
0.0	65 [105]	0	On	On	On Non-Engaged	10	1,400

Figure 1. Exemplar Honda EDR Table 1 of 3 pre-crash output.

The output data elements for EDR Table 2 of 3, represented by Figure 2, show the status of the active and passive crash avoidance safety systems during the recorded crash event. A value of "On" for the column titled Collision Mitigation Braking System, Forward Collision Warning (On/Off) and the Road Departure Mitigation, Lane Departure Warning (On/Off) states the system is available and ready to engage if a system relevant crash event is qualified. However, a value of "Off" indicates the driver turned off the safety features, so they were not available during the recorded crash event. The columns Forward Collision Warning, Collision Mitigation Braking System, Lane Departure Warning and Road Departure Mitigation note the time when the passive systems are "Warning" or "Not warning" and active safety systems are "Engaged" or "Not engaged." By default, a value of "Off" for Collision Mitigation Braking System, Forward Collision Warning (On/Off) and Road Departure Mitigation, Lane Departure Warning (On/Off) will output values "Not warning" and "Not engaged" for their respective warning status and system engagement columns.

Pre-Crash Data -5 to 0 sec [2 samples/sec] (Event Record 1) - Table 2 of 3

Time Stamp (sec)	PCM Derived Accelerator Pedal Position, % full	Forward Collision Warning (Not Warning/ Warning)	Collision Mitigation Braking System (Not Engaged/ Engaged)	Collision Mitigation Braking System, Forward Collision Warning (On/Off)	Lane Departure Warning (Not Warning/ Warning)	Road Departure Mitigation (Not Engaged/ Engaged)	Road Departure Mitigation, Lane Departure Warning (On/Off)
-5.0	16	Not warning	Not engaged	On	Not warning	Not engaged	Off
-4.5	8	Not warning	Not engaged	On	Not warning	Not engaged	Off
-4.0	11	Not warning	Not engaged	On	Not warning	Not engaged	Off
-3.5	13	Not warning	Not engaged	On	Not warning	Not engaged	Off
-3.0	18	Not warning	Not engaged	On	Not warning	Not engaged	Off
-2.5	18	Not warning	Not engaged	On	Not warning	Not engaged	Off
-2.0	17	Not warning	Not engaged	On	Not warning	Not engaged	Off
-1.5	0	Warning	Engaged	On	Not warning	Not engaged	Off
-1.0	0	Warning	Engaged	On	Not warning	Not engaged	Off
-0.5	0	Warning	Engaged	On	Not warning	Not engaged	Off
0.0	0	Warning	Engaged	On	Not warning	Not engaged	Off

Figure 2. Exemplar Honda EDR Table 2 of 3 pre-crash output.

Honda also provides data elements for the driver assistance systems in the EDR's Table 3 of 3 outputs as shown in Figure 3. The "On/Off" columns for Adaptive Cruise Control, Lane Keeping Assist and Cruise Control indicate whether the driver had these systems "On" and available during the current drive cycle or "Off" leading up to the crash. The remaining data elements specify whether these systems were "Engaged" or "Not engaged" at any time during the pre-crash time interval, leading up to the crash event.

Pre-Crash Data -5 to 0 sec [2 samples/sec] (Event Record 1) - Table 3 of 3

Time Stamp (sec)	Adaptive Cruise Control (Not Engaged/ Engaged)	Adaptive Cruise Control (On/Off)	Lane Keeping Assist (Not Engaged/ Engaged)	Lane Keeping Assist (On/Off)	Cruise Control (Not Engaged/ Engaged)	Cruise Control (On/Off)
-5.0	Not engaged	On	Not engaged	On	Not Engaged	On
-4.5	Not engaged	On	Not engaged	On	Not Engaged	On
-4.0	Not engaged	On	Not engaged	On	Not Engaged	On
-3.5	Not engaged	On	Not engaged	On	Not Engaged	On
-3.0	Not engaged	On	Not engaged	On	Not Engaged	On
-2.5	Not engaged	On	Not engaged	On	Not Engaged	On
-2.0	Not engaged	On	Not engaged	On	Not Engaged	On
-1.5	Not engaged	On	Not engaged	On	Not Engaged	On
-1.0	Not engaged	On	Not engaged	On	Not Engaged	On
-0.5	Not engaged	On	Not engaged	On	Not Engaged	On
0.0	Not engaged	On	Not engaged	On	Not Engaged	On

Figure 3. Exemplar Honda EDR Table 3 of 3 pre-crash output.

Crash Investigation Sampling System

NHTSA has collected crash data since the early 1970s to support its mission to reduce motor vehicle crashes, injuries, and deaths on our Nation's highways. CISS [7] collects detailed crash data to help scientists and engineers analyze motor vehicle crashes and injuries. CISS collects data on a representative sample of minor, serious, and fatal crashes involving at least one passenger vehicle – cars, light trucks, sport utility vehicles, and vans – towed from the scene.

After a crash has been randomly sampled, trained Crash Technicians collect data from crash sites by documenting scene evidence such as skid marks and struck objects. They locate the vehicles involved, document the crash damage, inspect the vehicle's safety equipment such as air bags and seatbelts, identify interior components that were contacted by the occupants and image the EDR when supported. On-site inspections are followed-up with confidential interviews of the crash victims and a review of medical records for injuries sustained in the crash. CISS uses emerging technologies and methods to acquire quality data.

The data collected by the CISS field teams is used by NHTSA and others for a variety of purposes, such as:

- Identifying existing and emerging highway safety problems;
- Obtaining detailed crash performance data for passenger vehicles, including the vehicle safety systems and designs;
- Learning more about the nature of crash-related injuries and the relationship between the type and severity of a crash and the resulting injuries; and
- Assessing the effectiveness of motor vehicle standards and highway safety programs.

CISS data from case years 2017 – 2021 were examined during this study. This data set was filtered for 2016 model year or newer Honda vehicles. Since these vehicles were towed from the scene, the EDR algorithm enabled threshold should have been sufficient to capture crash and pre-crash vehicle information, including the status and activation of crash avoidance systems.

The assessed crashes were not filtered by CISS' crash type variable, meaning the scope for this study is limited to identifying whether the Honda vehicle was equipped with an EDR capable of capturing pre-crash data for crash avoidance system and, if so, reviewing the status of these systems (on/off, engaged/not engaged) at the time of the recorded event. At a high level, this Honda CISS data was then examined for whether the subject vehicle experienced a relevant crash where a crash avoidance system may have mitigated the severity of the reported crash.

There were 150 crashes involving Honda vehicles equipped with the relevant crash avoidance EDR data in CISS.

RESULTS

All Honda EDR data are compiled to assess the status of FCW/AEB and LDW/LKA at the time of each crash and determine which systems were "On" and would be available during a system relevant pre-crash event. Driver demographic information including sex, race/ethnicity, and age are also reported to provide insight into driver usage of these systems. The results for this study are limited to reporting vehicle status of the crash avoidance systems and demographics for the respective driver of the Honda for the relevant crash event. Examples for three specific CISS crashes where the crash avoidance or driver assistance systems were engaged any time during the 5 second pre-crash interval are also listed.

Crash Avoidance System Status

Table 4 presents the status of the FCW/AEB and LDW/LKA crash avoidance systems at the time of the crash for the reported CISS case. Of the 150 CISS cases reviewed, 149 drivers (99%) had FCW/AEB "On" at the time of the crash. With respect to LDW/LKA, 73 drivers (49%) had the system "On" at the time of the crash.

Table 4.
EDR status of crash avoidance systems

Crash Avoidance Systems	On	Off	Total
Forward Collision Warning/Automatic Emergency Braking (FCW/AEB)	149	1	150
Lane Departure Warning/Lane Keeping Assistance (LDW/LKA)	73	77	150

Driver Demographics

Driver demographic data for the 150 CISS cases reviewed are listed in Tables 5 and 6. The driver is reported as female in 92 cases (61%), male in 54 cases (36%), and unknown or not reported in 4 cases (3%). Regarding race/ethnicity, 70 drivers (47%) are reported as White (Not Hispanic or Latino), 20 drivers (13%) as Hispanic or Latino, 9 drivers (6%) as Black or African American, 7 drivers (5%) as Asian, 4 drivers (3%) as American Indian or Alaska Native, 2 drivers (1%) as Native Hawaiian or Other Pacific Islander, and 2 drivers (1%) as Other. The race/ethnicity was unknown for 36 drivers (24%). The average driver age is 44-years-old, with the youngest and oldest drivers reported to be 16-years-old and 91-years-old, respectively.

Table 5.
Driver demographics by sex and race/ethnicity

	Sex				
Race/ethnicity	Female	Male	Unknown	Not Reported	**Total**
White	43	27	0	0	**70**
Hispanic or Latino	10	10	0	0	**20**
Black/African American	6	3	0	0	**9**
Asian	5	2	0	0	**7**
American Indian/ Alaska Native	3	1	0	0	**4**
Native Hawaiian/Other Pacific Islander	2	0	0	0	**2**
Other	2	0	0	0	**2**
Unknown	21	11	2	2	**36**

To evaluate driver usage of the FCW/AEB and LDW/LKA systems at the time of the crash, demographic information was compiled and is reported below. As shown in Figures 4 and 5, FCW/AEB was reported as "On" in 149 of 150 cases. Only one driver, a 37-year-old white male, had the system "Off" during the crash event (CISS Case No. 1-26-2019-061-02). This data indicates widespread usage for Honda's FCW/AEB system, regardless of driver sex, race/ethnicity, and age.

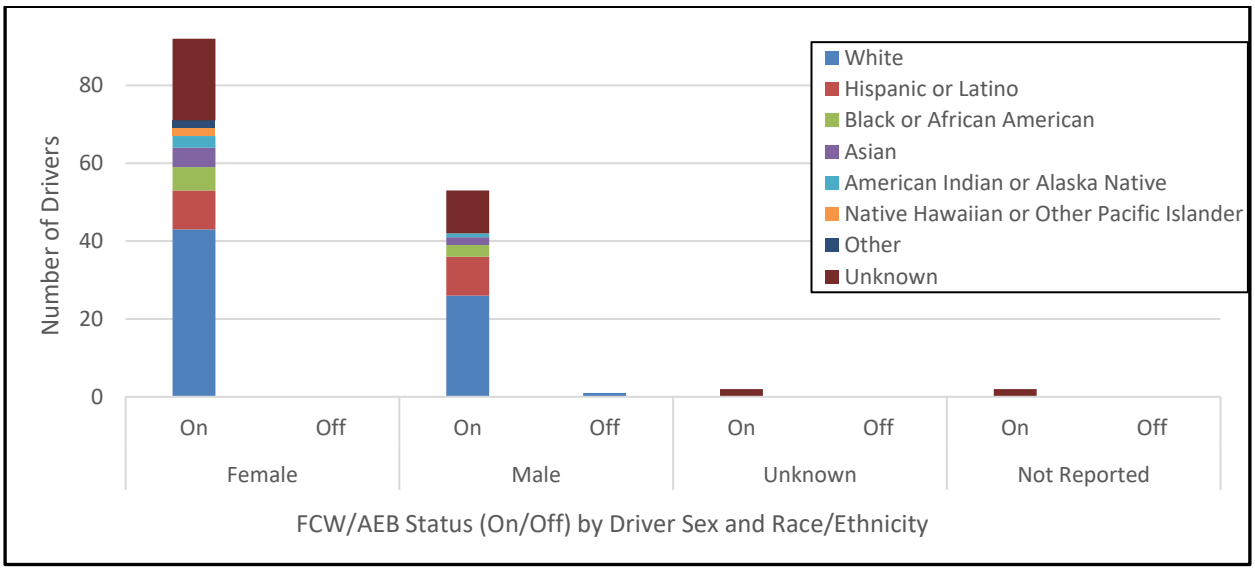

Figure 4. FCW/AEB system status by driver sex and race/ethnicity.

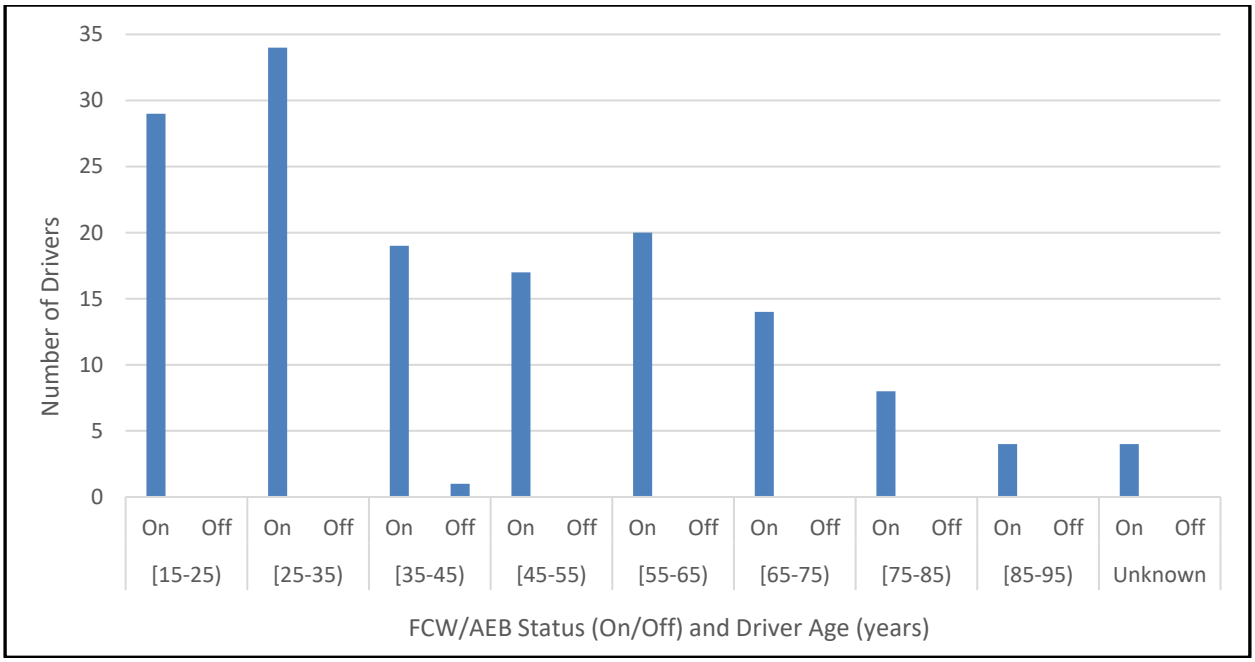

Figure 5. FCW/AEB status by driver age.

The distribution for the status of the LDW/LKA system by driver sex and race/ethnicity are shown in Figure 6 while the status by driver age is represented by Figure 7. The percent difference between drivers who had the LDW/LKA system "On" compared to those who turned it "Off" is 9% for females and 7% for males. Given the disproportionate number of drivers categorized by reported race/ethnicity, results evaluating usage of LDW/LKA by this demographic are inconclusive. The average age of drivers with LDW/LKA "On" is 42 years old and "Off" is 45 years old, which implies usage is independent of driver age. Since the percent difference between overall drivers who had LDW/LKA "On" vs. "Off" is 5%, the CISS data indicate that roughly half of Honda drivers leave the LDW/LKA system "On," regardless of sex, race/ethnicity, and age.

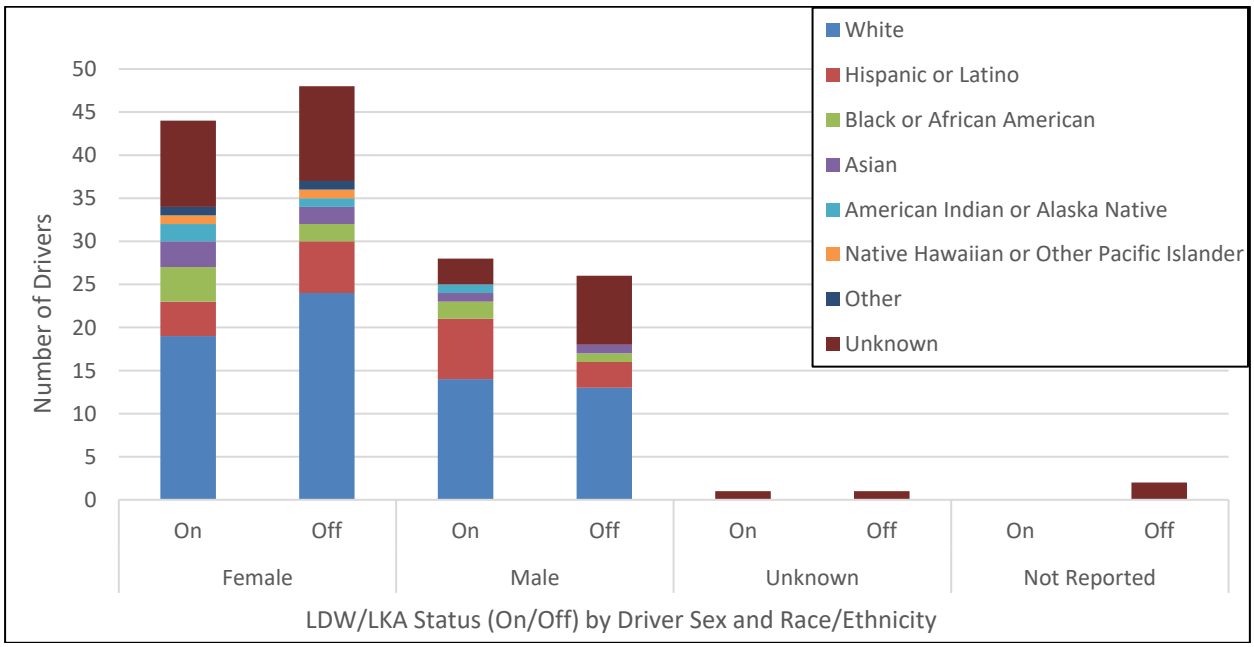

Figure 6. LDW/LKA status by driver sex and race/ethnicity.

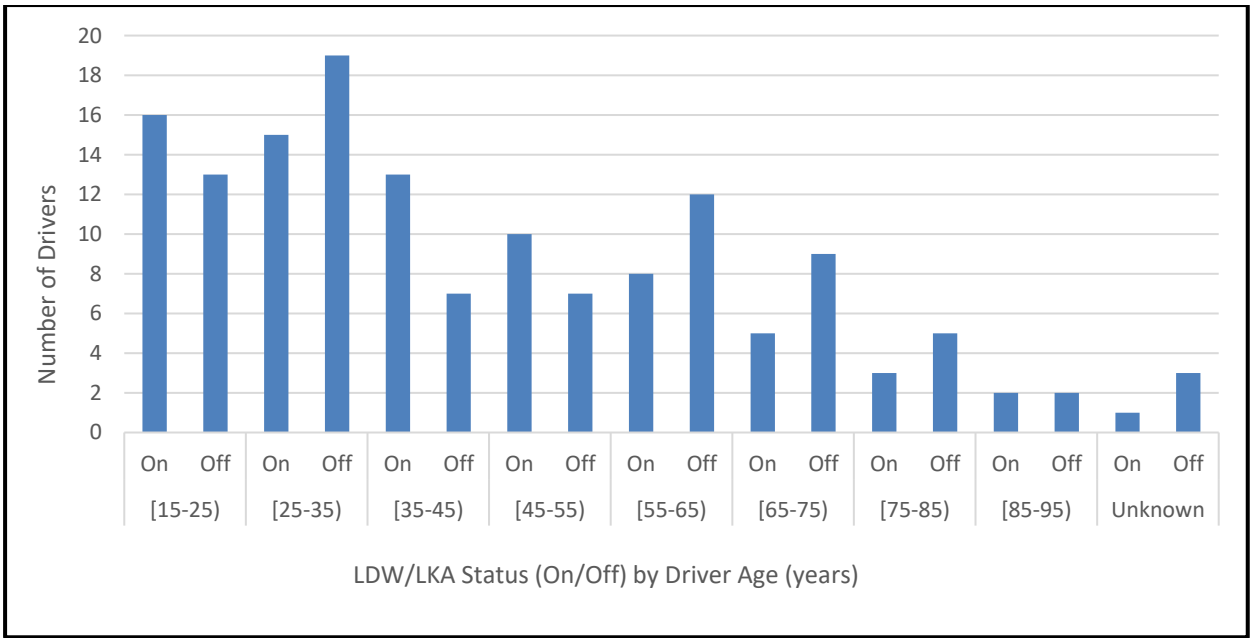

Figure 7. LDW/LKA status by driver age.

Crash Avoidance and Driver Assistance System Activated

There are 21 cases identified in the CISS data where the subject Honda's crash avoidance or driver assistance systems were reported as active during the EDR's 5 seconds of pre-crash data. Note that Honda uses the term "Engaged" to specify that the system was active (i.e., not just switched on, but actually in operation) during the pre-crash recording interval.

Table 6 lists the six cases where FCW provided a warning to the driver prior to the recorded crash event. Half of these cases simultaneously engaged AEB while the FCW system was active. Table 7 specifies the fifteen cases where a driver assistance system engaged. Of these cases, 7 engaged ACC, 5 engaged LCA, and 3 engaged both ACC and LCA prior to impact. None of the CISS cases identified activation of the LDW or LKA systems. There were no cases where an active crash avoidance system (Table 6) also had an active driver assistance system (Table 7).

Table 6.

EDR reported crash avoidance system engaged

Case No.	FCW Warning	AEB Engaged
1-26-2018-135-03	X	X
1-29-2019-079-08	X	
1-16-2020-002-02	X	X
1-21-2020-013-04	X	X
1-27-2020-063-04	X	
1-24-2021-070-03	X	

Table 7.

EDR reported driver assistance system engaged

Case No.	ACC Engaged	LCA Engaged
1-12-2021-012-01	X	X
1-17-2021-009-04	X	X
1-18-2020-088-03	X	
1-19-2020-106-03	X	
1-19-2021-106-03	X	
1-20-2021-022-03		X
1-20-2021-072-03		X
1-20-2021-142-04	X	
1-20-2021-168-04	X	
1-23-2021-142-04		X
1-24-2019-007-03	X	
1-24-2019-122-02		X
1-24-2020-181-02	X	X
1-31-2021-060-03		X
1-66-2018-064-04	X	

DISCUSSION

The EDR data suggests high usage of Honda's FCW/AEB. In all but one crash, the system was "On" and available if the vehicle encountered a system relevant crash. However, usage of LDW/LKA was not as high, given the system was turned "Off" in over 50% of the crashes. The results of this EDR study are consistent with an earlier IIHS investigation into consumer usage of passive crash avoidance systems [8]. In a survey of Honda vehicles brought into Honda dealerships for service equipped with both FCW and LDW, IIHS researchers found that for 184 vehicles, only a third of the vehicles had LDW "On," whereas all but one vehicle had FCW turned "On."

Demographic data supports driver usage of FCW/AEB, regardless of sex, race/ethnicity, or age. Driver usage of LDW/LKA is split almost equally in half between those that have the system "On" compared to those that have the system "Off." LDW/LKA system usage does not appear to have a distinct sex or age bias. There are no conclusive determinations for system usage based on race/ethnicity. Biases may exist in this dataset, given that this study is limited to the Honda vehicles themselves, the demographics for individuals that purchase and drive these vehicles, and the usage for these systems is specific to Honda's implementation.

Data from this EDR study provides additional insight to actual FCW, AEB, LDW and LKA system status availability and engagement during a collision, which was not available in prior studies that have estimated the operation of these systems thus far. Instead, prior studies relied on police reported crash data, and therefore did not benefit from detailed vehicle level reported data. This study shows over a 99% driver usage rate for FCW/AEB, meaning Honda vehicles equipped with this system should be affording maximum crash severity reduction benefits to these vehicle drivers. However, the potential benefits for LDW/LKA could be improved to optimize driver usage, as this data indicates that approximately 50% of drivers turn the system off. Additional research is warranted to further understand the disparity between drivers who have the system on and those have the system off. Moreover, additional vehicle data analyses can be conducted to provide further insight into the specific crash event which, combined with an on-site crash investigation, may begin to explain system effectiveness.

There were 21 cases (14%) identified in this study where the crash avoidance or driver assistance system was engaged within the five seconds pre-crash time interval captured in the EDR. Three example CISS cases, provided below, show how EDR vehicle data can be used to assess the performance of these technologies in system relevant crashes.

FCW/AEB - Example 1

In CISS Case No. 1-21-2020-013-04, a 2018 Honda Accord was traveling south on a median divided trafficway with positive barrier. The roadway width was reduced by cone barriers for a construction zone. The Honda was approaching a 2006 Chevrolet Medium/Heavy truck, which was also traveling south, in the same lane at a lower, steady speed. The front of the Honda contacted the back of the Chevrolet. The Honda came to rest facing a southerly direction in lane two, and the Chevrolet was driven to the shoulder. Figure 8 is a post-crash photo of the Honda showing the vehicle underrode the Chevrolet truck.

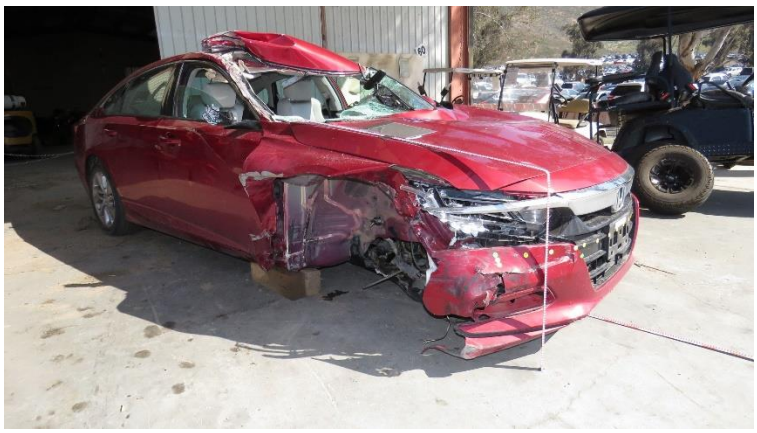

Figure 8. CISS Case No. 1-21-2020-013-04 damage.

A review of the Table 1 EDR data in Figure 9, shows the Honda was traveling at 96 mph at 5 seconds prior to the impact with the Chevrolet. Figure 10, Table 2 of 3 EDR data, reported the driver received a FCW alert at 3 seconds prior to the crash, with AEB (Honda's Crash Mitigation Braking System) engaging at 1.5 seconds prior to the crash. According to the EDR, the driver depressed the brake at 0.5 seconds, which also engaged ABS. The data indicate that the manual brake activation and the steering wheel input that occurred at 0.5 seconds prior to the crash also coincided with the suppression of both the FCW warning and AEB activation. The EDR reported vehicle speed information does not appear to coincide with the AEB and driver brake activation, although the EDR reported crash severity indicates a speed reduction. The EDR reported that the maximum longitudinal change in velocity (Delta-V) from the crash was 15 mph. Considering the 96 mph travel speed, prior to any brake activation by the AEB or driver, there was a significant speed reduction, likely resulting from AEB activation, prior to impact.

Pre-Crash Data -5 to 0 sec [2 samples/sec] (Event Record 1) - Table 1 of 3

Time Stamp (sec)	Speed, Vehicle Indicated (MPH [km/h])	Accelerator Pedal Position, % full	Service Brake (On, Off)	ABS Activity (On, Off)	Stability Control (On, Off, Engaged)	Steering Input (deg)	Engine RPM
-5.0	95 [153]	45	Off	Off	On Non-Engaged	0	3,200
-4.5	95 [153]	46	Off	Off	On Non-Engaged	-5	3,200
-4.0	96 [154]	42	Off	Off	On Non-Engaged	-5	3,200
-3.5	96 [155]	48	Off	Off	On Non-Engaged	-5	3,200
-3.0	96 [155]	48	Off	Off	On Non-Engaged	-5	3,300
-2.5	97 [156]	48	Off	Off	On Non-Engaged	-5	3,300
-2.0	98 [157]	48	Off	Off	On Non-Engaged	-5	3,300
-1.5	98 [157]	64	Off	Off	On Non-Engaged	-5	3,300
-1.0	97 [156]	0	Off	Off	On Non-Engaged	0	3,400
-0.5	84 [135]	0	On	On	On Non-Engaged	100	2,800
0.0	84 [135]	0	On	On	On Non-Engaged	85	2,600

Figure 9. CISS Case No. 1-21-2020-013-04 Table 1 EDR data.

Pre-Crash Data -5 to 0 sec [2 samples/sec] (Event Record 1) - Table 2 of 3

Time Stamp (sec)	PCM Derived Accelerator Pedal Position, % full	Forward Collision Warning (Not Warning/ Warning)	Collision Mitigation Braking System (Not Engaged/ Engaged)	Collision Mitigation Braking System, Forward Collision Warning (On/Off)	Lane Departure Warning (Not Warning/ Warning)	Road Departure Mitigation (Not Engaged/ Engaged)	Road Departure Mitigation, Lane Departure Warning (On/Off)
-5.0	45	Not warning	Not engaged	On	Not warning	Not engaged	Off
-4.5	46	Not warning	Not engaged	On	Not warning	Not engaged	Off
-4.0	42	Not warning	Not engaged	On	Not warning	Not engaged	Off
-3.5	48	Not warning	Not engaged	On	Not warning	Not engaged	Off
-3.0	48	Warning	Not engaged	On	Not warning	Not engaged	Off
-2.5	48	Warning	Not engaged	On	Not warning	Not engaged	Off
-2.0	48	Warning	Not engaged	On	Not warning	Not engaged	Off
-1.5	64	Warning	Engaged	On	Not warning	Not engaged	Off
-1.0	0	Warning	Engaged	On	Not warning	Not engaged	Off
-0.5	0	Not warning	Not engaged	On	Not warning	Not engaged	Off
0.0	0	Not warning	Not engaged	On	Not warning	Not engaged	Off

Figure 10. CISS Case No. 1-21-2020-013-04 Table 2 EDR data.

LDW/LKA - Example 2

CISS Case No. 1-19-2020-162-04 documents a single vehicle roadway departure crash of a 2019 Honda Accord equipped with LKA (Honda's Road Departure Mitigation), which the EDR reported as "On" leading up to the incident. In this case the Honda was traveling southwest on a two-lane undivided roadway, negotiating a left curve. The Honda departed the roadway (Figure 11) to the right and traveled a short distance before the front plane contacted a tree, coming to a final rest to the right of the road.

Figure 11. CISS Case No. 1-19-2020-162-04 roadway departure.

The Table 1 EDR data reported (Figure 12), shows the Honda was traveling at 34 mph, 5 seconds prior to the impact with a tree at 24 mph, resulting in a 19-mph longitudinal Delta-V crash severity. The driver applied the service brake at 4.5 second and there was a steering angle input to the left starting at 4 seconds prior to the crash. Table 2 EDR data shown in Figure 13 confirms LDW/LKA was "On," however, the LDW did not provide a warning and LKA did not engage prior to the crash. Cruise control and all other driver assistance systems were "Off" and therefore were not available leading up to the crash. The driver of the Honda was coded in CISS as attentive or not distracted.

Pre-Crash Data -5 to 0 sec [2 samples/sec] (Event Record 1) - Table 1 of 3

Time Stamp (sec)	Speed, Vehicle Indicated (MPH [km/h])	Accelerator Pedal Position, % full	Service Brake (On, Off)	ABS Activity (On, Off)	Stability Control (On, Off, Engaged)	Steering Input (deg)	Engine RPM
-5.0	34 [55]	0	Off	Off	On Non-Engaged	0	1,200
-4.5	34 [55]	0	On	Off	On Non-Engaged	0	1,200
-4.0	34 [54]	0	On	Off	On Non-Engaged	15	1,200
-3.5	32 [51]	0	On	Off	On Non-Engaged	30	1,200
-3.0	29 [47]	0	On	Off	On Non-Engaged	35	1,200
-2.5	29 [47]	0	Off	Off	On Non-Engaged	50	1,200
-2.0	27 [43]	0	Off	Off	On Non-Engaged	45	1,200
-1.5	26 [42]	0	Off	Off	On Non-Engaged	35	1,100
-1.0	25 [41]	0	Off	Off	On Non-Engaged	45	1,100
-0.5	24 [39]	0	Off	Off	On Non-Engaged	70	1,100
0.0	24 [39]	0	Off	Off	On Non-Engaged	65	1,100

Figure 12. CISS Case No. 1-19-2020-162-04 Table 1 EDR Data.

According to the Honda owner's manual [9], the LDW/LKA system becomes ready to start searching for lane markings when all the following conditions are met:
• The vehicle is traveling between about 45 and 90 mph (72 and 145 km/h).
• The vehicle is on a straight or slightly curved road.
• The turn signals are off.
• The brake pedal is not depressed.
• The wipers are not in high-speed operation.
• The vehicle is not accelerating or braking, and the steering wheel is not being turned.
• The system makes a determination that the driver is not actively accelerating, braking or steering.

There were several factors in the crash scenario that likely prevented the LDW/LKA system from engaging. Figure 11 shows there were no lane markings on the roadway, which are required for system operation. The EDR reported vehicle travel speed (24mph) was lower than the system activation travel speed (45mph) per the owner's manual. EDR data also show that the brake pedal was depressed, and steering wheel was turned before the vehicle departed the roadway. Comparing the system limitations listed in the owner's manual and the subject Honda's status for the systems listed above, the LDW/LKA system would not be expected to activate during this crash event. The LDW/LKA system appears to have operated as designed.

Pre-Crash Data -5 to 0 sec [2 samples/sec] (Event Record 1) - Table 2 of 3

Time Stamp (sec)	PCM Derived Accelerator Pedal Position, % full	Forward Collision Warning (Not Warning/ Warning)	Collision Mitigation Braking System (Not Engaged/ Engaged)	Collision Mitigation Braking System, Forward Collision Warning (On/Off)	Lane Departure Warning (Not Warning/ Warning)	Road Departure Mitigation (Not Engaged/ Engaged)	Road Departure Mitigation, Lane Departure Warning (On/Off)
-5.0	0	Not warning	Not engaged	On	Not warning	Not engaged	On
-4.5	0	Not warning	Not engaged	On	Not warning	Not engaged	On
-4.0	0	Not warning	Not engaged	On	Not warning	Not engaged	On
-3.5	0	Not warning	Not engaged	On	Not warning	Not engaged	On
-3.0	0	Not warning	Not engaged	On	Not warning	Not engaged	On
-2.5	0	Not warning	Not engaged	On	Not warning	Not engaged	On
-2.0	0	Not warning	Not engaged	On	Not warning	Not engaged	On
-1.5	0	Not warning	Not engaged	On	Not warning	Not engaged	On
-1.0	0	Not warning	Not engaged	On	Not warning	Not engaged	On
-0.5	0	Not warning	Not engaged	On	Not warning	Not engaged	On
0.0	0	Not warning	Not engaged	On	Not warning	Not engaged	On

Figure 13. CISS Case No. 1-19-2020-162-04 Table 2 EDR data.

Driver Assistance System - Example 3

CISS Case No. 1-24-2020-181-02 is an example where the EDR reported the driver assistance systems were engaged leading up to the crash. In this case, a 2014 Chevrolet Equinox was traveling eastbound on a four lane, two-way, painted median roadway. The Chevrolet was stopped on the roadway, waiting to make a left turn into a driveway. A 2020 Honda Civic was traveling eastbound on the same roadway directly behind the Chevrolet. The back plane of the Chevrolet was contacted by the front plane of Honda. Both vehicles came to final rest on the roadway near the point of impact.

In Figure 14, the Table 1 EDR data shows the vehicle was traveling at a steady speed of 67 mph pre-crash. There was no reported accelerator pedal position travel, the engine RPMs were generally steady and there was negligible steering input from the 5 seconds to 1 second pre-impact intervals. FCW/AEB was reported "ON," but did not provide a warning or activate the automatic braking prior to the rear end crash as shown in Figure 15. Figure 16 reports that the ACC and LCA (Honda's Lane Keeping Assist System) were engaged until 1 second prior to impact. EDR data shows the driver begins to steer at 1 second, depresses the service brake at 0.5 seconds which corresponds with the override of both ACC and LCA. The oblique rear-end impact resulted in a 25-mph longitudinal and 8-mph lateral Delta-V crash severity in response to the steering input beginning at 1 second prior to impact.

The driver of the Honda was coded in CISS as being distracted or inattentive.

Pre-Crash Data -5 to 0 sec [2 samples/sec] (Event Record 1) - Table 1 of 3

Time Stamp (sec)	Speed, Vehicle Indicated (MPH [km/h])	Accelerator Pedal Position, % full	Service Brake (On, Off)	ABS Activity (On, Off)	Stability Control (On, Off, Engaged)	Steering Input (deg)	Engine RPM
-5.0	67 [108]	0	Off	Off	On Non-Engaged	0	1,800
-4.5	67 [108]	0	Off	Off	On Non-Engaged	0	1,800
-4.0	67 [108]	0	Off	Off	On Non-Engaged	0	1,800
-3.5	67 [108]	0	Off	Off	On Non-Engaged	-5	1,800
-3.0	67 [108]	0	Off	Off	On Non-Engaged	-5	1,800
-2.5	67 [108]	0	Off	Off	On Non-Engaged	-5	1,700
-2.0	67 [108]	0	Off	Off	On Non-Engaged	0	1,700
-1.5	67 [108]	0	Off	Off	On Non-Engaged	0	1,800
-1.0	67 [108]	0	Off	Off	On Non-Engaged	-10	1,700
-0.5	67 [108]	0	On	On	On Engaged	-110	1,700
0.0	67 [108]	0	On	On	On Engaged	-115	1,700

Figure 14. CISS Case No. 1-24-2020-181-02 Table 1 EDR data.

Pre-Crash Data -5 to 0 sec [2 samples/sec] (Event Record 1) - Table 2 of 3

Time Stamp (sec)	PCM Derived Accelerator Pedal Position, % full	Forward Collision Warning (Not Warning/ Warning)	Collision Mitigation Braking System (Not Engaged/ Engaged)	Collision Mitigation Braking System, Forward Collision Warning (On/Off)	Lane Departure Warning (Not Warning/ Warning)	Road Departure Mitigation (Not Engaged/ Engaged)	Road Departure Mitigation, Lane Departure Warning (On/Off)
-5.0	10	Not warning	Not engaged	On	Not warning	Not engaged	Off
-4.5	10	Not warning	Not engaged	On	Not warning	Not engaged	Off
-4.0	10	Not warning	Not engaged	On	Not warning	Not engaged	Off
-3.5	10	Not warning	Not engaged	On	Not warning	Not engaged	Off
-3.0	10	Not warning	Not engaged	On	Not warning	Not engaged	Off
-2.5	10	Not warning	Not engaged	On	Not warning	Not engaged	Off
-2.0	10	Not warning	Not engaged	On	Not warning	Not engaged	Off
-1.5	10	Not warning	Not engaged	On	Not warning	Not engaged	Off
-1.0	10	Not warning	Not engaged	On	Not warning	Not engaged	Off
-0.5	0	Not warning	Not engaged	On	Not warning	Not engaged	Off
0.0	0	Not warning	Not engaged	On	Not warning	Not engaged	Off

Figure 15. CISS Case No. 1-24-2020-181-02 Table 2 EDR data.

Honda's owner's manual states [10] that the FCW/AEB system may activate when:

- The speed difference between the Honda vehicle and a vehicle or pedestrian detected in front of the Honda becomes about 3 mph (5 km/h) and over with a chance of a collision.
- The Honda's vehicle speed is about 62 mph (100 km/h) or less and the system determines there is a chance of a collision with:
    - Vehicles detected in front of the Honda that are stationary, oncoming, or traveling in the same direction.

    - A pedestrian who is detected in front of the Honda.
- The Honda's vehicle speed is above 62 mph (100 km/h), and the system determines there is a chance of a collision with a vehicle detected in front of the Honda traveling in the same direction.

Therefore, it is possible that the Honda's 67 mph travel speed exceeded the system limitation of 62mph, which prevented the system from recognizing and providing an FCW/AEB response to the stationary Chevrolet vehicle during this crash event.

Pre-Crash Data -5 to 0 sec [2 samples/sec] (Event Record 1) - Table 3 of 3

Time Stamp (sec)	Adaptive Cruise Control (Not Engaged/ Engaged)	Adaptive Cruise Control (On/Off)	Lane Keeping Assist (Not Engaged/ Engaged)	Lane Keeping Assist (On/Off)	Cruise Control (Not Engaged/ Engaged)	Cruise Control (On/Off)
-5.0	Engaged	On	Engaged	On	Engaged	On
-4.5	Engaged	On	Engaged	On	Engaged	On
-4.0	Engaged	On	Engaged	On	Engaged	On
-3.5	Engaged	On	Engaged	On	Engaged	On
-3.0	Engaged	On	Engaged	On	Engaged	On
-2.5	Engaged	On	Engaged	On	Engaged	On
-2.0	Engaged	On	Engaged	On	Engaged	On
-1.5	Engaged	On	Engaged	On	Engaged	On
-1.0	Engaged	On	Engaged	On	Engaged	On
-0.5	Not engaged	On	Not engaged	On	Not Engaged	On
0.0	Not engaged	On	Not engaged	On	Not Engaged	On

Figure 16. CISS Case No. 1-24-2020-181-02 Table 3 EDR data.

These three examples show real world crashes where Honda EDRs recorded the status of crash avoidance and driver assistance systems during crash events. This information provides insight into the performance of these technology systems during relevant crash events that could not otherwise be assessed. This vehicle level data could provide some understanding for consumer usage and acceptance of these systems. As stated earlier, using police crash reports alone to determine system effectiveness is limited. Evaluating vehicle level EDR data, in combination with a comprehensive crash investigation, will identify opportunities for the improvement and advancement of crash avoidance and driver assistance technologies.

CONCLUSION

Starting with the 2016 Model Year, Honda began to phase-in vehicles equipped with an EDR that captures the status and activation of crash avoidance technologies. To understand driver usage of these technologies, Honda EDR data were collected from the 2017 – 2021 CISS for vehicles equipped with this recording capability. Vehicle level crash avoidance system data captured in the EDR is invaluable and relevant for assessing new field data collection. This will in turn contribute to assessing the real-world benefits of these crash avoidance technologies. The 150 Honda vehicles in this study are equipped with EDRs that captured data elements related to the function and alert status of several crash avoidance systems in the time leading up to a crash event. The results indicate that Honda drivers of vehicles equipped with crash avoidance systems seem to be more likely to have FCW/AEB systems "On" and LDW/LKA systems "Off." Specifically, almost all drivers (99%) had the FCW/AEB systems "On" and thus will be afforded the potential benefits of these systems if they are involved in a relevant crash situation. With respect to LDW/LKA, about half (51%) of drivers had these systems "Off" and therefore would not be afforded the potential benefits of these systems during an appropriate situation. Driver demographic information did not identify any clear differences in usage of LDW/LKA with respect to the driver's sex, age, or race/ethnicity.

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