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Highway Investigation Report HIR-26-02

# Fatal Crashes Between Vehicles Operating in Hands-Free Partial Automation Mode and Stationary Vehicles in San Antonio, Texas, and Philadelphia, Pennsylvania

**Abstract:** This report documents the National Transportation Safety Board (NTSB) investigations into two fatal, rear-end collisions with stationary vehicles at highway speeds. In both crashes, the striking vehicle was a 2022 Ford Mustang Mach-E sport utility vehicle (SUV) operating in hands-free partial driving automation mode, which Ford refers to as BlueCruise. Partial driving automation systems are designed to provide steering and control of acceleration/deceleration, with an understanding that the driver performs the rest of the driving task and is responsible for monitoring the environment, including detecting hazards and automation failures. One of the crashes occurred in San Antonio, Texas, on February 24, 2024, and the other occurred in Philadelphia, Pennsylvania, on March 3, 2024. In the San Antonio crash, the Ford was traveling east in the center lane of Interstate 10 and collided with a stationary 1999 Honda CR-V SUV that was also in the center lane. The Honda driver died and the Ford driver sustained minor injuries. In the Philadelphia crash, the Ford was traveling north in the left lane of Interstate 95 and collided with two stationary vehicles that were also in the left lane, a 2012 Hyundai Elantra and a 2006 Toyota Prius. The impact caused both the Prius and the Elantra to strike a passing Toyota Corolla. The Prius and Elantra drivers died, the Ford driver sustained minor injuries, and the Corolla driver was uninjured. In both the San Antonio and Philadelphia crashes, neither driver-applied nor system-applied braking or steering were recorded in the moments before the crash. Safety issues identified in these investigations include:

- Alcohol-impaired driving
- Limitations and insufficient federal oversight of partial driving automation systems, including:
  - Lack of federal requirements for data recording and inadequate manufacturer awareness of crash events involving vehicles operating with partial automation
  - Driver monitoring system limitations

- Deficiencies in Ford's implementation of its partial vehicle automation system, and overall lack of federal guidelines for partial driving automation system implementation and advanced driver assistance systems integration

The NTSB issues new safety recommendations to the US Department of Transportation (USDOT), the National Highway Traffic Safety Administration (NHTSA), and the Ford Motor Company. The NTSB also reiterates a previously issued safety recommendation to NHTSA and classifies previously issued recommendations to the USDOT, NHTSA, and SAE International.

## Contents

<b>Figures .....</b>	<b>iii</b>
<b>Tables .....</b>	<b>v</b>
<b>Acronyms and Abbreviations.....</b>	<b>vi</b>
<b>Executive Summary.....</b>	<b>viii</b>
What Happened.....	viii
What We Found.....	ix
What We Recommended .....	xi
<b>1 Factual Information.....</b>	<b>1</b>
1.1 Ford Mach-E Description and Driving Technologies .....	1
1.1.1 General.....	1
1.1.2 Advanced Driver Assistance Systems.....	3
1.1.3 BlueCruise Partial Driving Automation.....	6
1.2 San Antonio, Texas, Crash .....	10
1.2.1 Crash Narrative.....	10
1.2.2 Injuries, Occupant Protection, Emergency Response, and Crash Notification .....	12
1.2.3 Roadway Information.....	13
1.2.4 Vehicle Information.....	14
1.2.5 Driver Information.....	23
1.3 Philadelphia, Pennsylvania, Crash .....	25
1.3.1 Crash Narrative.....	25
1.3.2 Injuries, Occupant Protection, Emergency Response, and Crash Notification .....	28
1.3.3 Roadway Information.....	29
1.3.4 Vehicle Information.....	32
1.3.5 Driver Information.....	42
1.4 Federal Requirements for Reporting Crashes Involving Partial Driving Automation Systems .....	44
<b>2 Analysis.....</b>	<b>47</b>
2.1 Introduction .....	47

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2.2	Crash Sequence, Driver Actions, and Performance of Forward Collision Warning and Automatic Emergency Braking.....	49
2.2.1	San Antonio, Texas, Crash .....	49
2.2.2	Philadelphia, Pennsylvania, Crash .....	54
2.2.3	Alcohol-Impaired Driving.....	60
2.2.4	Limitations of Forward Collision Warning and Automatic Emergency Braking Systems .....	62
2.3	Limitations and Insufficient Federal Oversight of Partial Driving Automation Systems .....	66
2.3.1	Lack of Federal Data-recording Requirements and Inadequate Manufacturer Awareness of NHTSA SGO-applicable Crash Events.....	68
2.3.2	Driver Monitoring System Limitations .....	76
2.3.3	Deficiencies in Ford’s L2 Implementation, and Overall Lack of Federal Guidelines for L2 Implementation and ADAS Integration .....	84
<b>3</b>	<b>Conclusions.....</b>	<b>93</b>
3.1	Findings.....	93
3.2	Probable Causes .....	96
3.2.1	San Antonio, Texas, Crash .....	96
3.2.2	Philadelphia, Pennsylvania, Crash .....	96
<b>4</b>	<b>Recommendations .....</b>	<b>97</b>
4.1	New Recommendations.....	97
4.2	Previously Issued Recommendation Reiterated in This Report .....	98
4.3	Previously Issued Recommendations Classified in This Report.....	99
	<b>Appendixes.....</b>	<b>102</b>
	Appendix A: Investigations .....	102
	Appendix B: Consolidated Recommendation Information .....	103
	Appendix C: Driver Monitoring System Examination .....	106
	<b>References.....</b>	<b>110</b>

## Figures

Figure 1. SAE International levels of driving automation. ....	2
Figure 2. Depiction of Ford Mach-E instrument panel showing engaged hands- required BlueCruise (top) and engaged hands-free BlueCruise (bottom). ....	8
Figure 3. Ford Mach-E interior DMS camera (inset) and instrument cluster. ....	9
Figure 4. Crash location on eastbound I-10. ....	11
Figure 5. East-looking view of I-10 showing the location of the crash and the rest positions of the Honda (left inset, with illuminated hazard light circled in yellow) and Ford (right inset). ....	12
Figure 6. Left: Front view of damage to the Ford with the Honda’s spare tire marking indicated by arrows. Right: View of the interior of the Ford. ....	15
Figure 7. Front-left view of an exemplar 2022 Ford Mach-E. ....	16
Figure 8. Driver gaze information in the last 5 seconds before the crash. ....	18
Figure 9. Telematic One data from the San Antonio crash, depicting driving mode transitions, hands-off driving alerts, and vehicle speed, covering a portion of the crash trip and ending approximately 5 minutes and 30 seconds before the crash. ....	20
Figure 10. Rear left view of damage to the Honda. ....	22
Figure 11. Orthomosaic image of the crash area showing the approximate positions of the involved vehicles at impact and at final rest. ....	26
Figure 12. North-looking view of I-95 showing the dark nighttime conditions, location of the crash, roadway barrier vertical blades, and rest positions of the Ford and Elantra. ....	30
Figure 13. Front-left view (left) and front view (right) of damage to the Ford. ....	33
Figure 14. Still image captured by the DMS camera. ....	34
Figure 15. Enlarged versions of the images captured by the forward-facing camera at 1-Hz intervals, from 2 seconds precrash to the point of impact. ....	37
Figure 16. Enlarged versions of the images captured by the forward-facing camera at 1-Hz intervals, from 1 second postcrash to 3 seconds postcrash. ....	38
Figure 17. Front left view (left) and rear left view (right) of damage to the Elantra. ....	40
Figure 18. Rear left view of damage to the Prius. ....	41
Figure 19. Front right view of damage to the Corolla. ....	42
Figure 20. Side-view image of the alignment of vehicle laser scans illustrating the likely maximum engagement of the Ford (right) and Honda (left) during the crash. ...	50

Figure 21. Overhead image of the alignment of vehicle laser scans illustrating the likely maximum engagement of the Ford (right) and Elantra (left) during the crash... 55

Figure 22. Graphical depiction of the crash area showing approximate vehicle positions 2.0 seconds and 1.8 seconds before the crash. .... 56

Figure 23. Forward- (left) and driver-facing (right) views of the exemplar driver in the vertical phone test position. .... 79

Figure 24. Driver-facing DMS live-image feed view of the exemplar driver in the vertical phone test condition. .... 107

Figure 25. Forward-facing view of exemplar driver in the vertical phone test condition..... 107

Figure 26. Fixation locations targeted by the exemplar driver. .... 108

## Tables

Table 1. Selected differences in activation requirements and operational parameters for hands-required and hands-free BlueCruise.....	7
Table 2. Crash-relevant parameters from the BlueCruise module with changing values during the crash sequence.....	35
Table 3. Crash-relevant parameters from the BlueCruise module that remained constant during the crash sequence.....	37
Table 4. Crash-relevant Telematic Two data from the Philadelphia crash.....	39
Table 5. Ford’s reported L2 SGO incidents to NHTSA, July 2021–December 2025. ..	46
Table 6. DMS categorization of gaze zones for exemplar driver’s fixation points. ....	109

## Acronyms and Abbreviations

<b>Abbreviation</b>	<b>Name</b>
ACC	Adaptive Cruise Control
ACM	airbag control module
ACN	automatic crash notification
ADAS	advanced driver assistance systems
AEB	automatic emergency braking
ANPRM	advance notice of proposed rulemaking
<i>CFR</i>	<i>Code of Federal Regulations</i>
DMS	driver monitoring system
EDR	event data recorder
EU	European Union
Euro NCAP	European New Car Assessment Programme
FCW	forward collision warning
FMVSS	Federal Motor Vehicle Safety Standard
g/dL	grams per deciliter
HASS COE	Highly Automated Systems Safety Center of Excellence
Hz	hertz
I-10	Interstate 10
I-95	Interstate 95
IIHS	Insurance Institute for Highway Safety
ISA	intelligent speed assistance
L2	SAE International Level 2
msec	milliseconds
NCAP	New Car Assessment Program
ng/mL	nanograms per milliliter
NHTSA	National Highway Traffic Safety Administration
NPRM	notice of proposed rulemaking
NTSB	National Transportation Safety Board
PennDOT	Pennsylvania Department of Transportation

PSP	Pennsylvania State Police
SAPD	San Antonio Police Department
SGO	Standing General Order
SUV	sport utility vehicle
TL-4	Test Level 4
TTC	time to collision
USDOT	US Department of Transportation
VOIP	Voice Over Internet Protocol

## Executive Summary

### What Happened

The National Transportation Safety Board (NTSB) investigated two fatal, rear-end collisions with stationary vehicles at highway speeds. In both crashes, the striking vehicle was a 2022 Ford Mustang Mach-E operated in partial driving automation mode. Partial driving automation systems are designed to provide steering and control of acceleration/deceleration, with an understanding that the driver performs the rest of the driving task and is responsible for monitoring the environment, including detecting hazards and automation failures.

**San Antonio, Texas.** On February 24, 2024, at 9:48 p.m. local time, a 2022 Ford Mustang Mach-E battery-electric sport utility vehicle (SUV) was traveling east in the center lane of Interstate 10 (I-10) in San Antonio, Bexar County, Texas, and approaching the Woodlake Parkway exit. At this location on I-10, the eastbound direction of travel consisted of three travel lanes with a posted speed limit of 70 mph. The Ford, traveling at a system-recorded speed of 74.7 mph, collided with the rear of a stationary 1999 Honda CR-V SUV that was also in the center lane.

Upon impact, the Honda rotated counterclockwise and then overturned onto its roof before coming to rest on the left shoulder of I-10. The Ford continued east after the collision and came to rest on the right shoulder.

The Ford driver had been operating the vehicle in hands-free partial driving automation mode, which Ford refers to as BlueCruise. Neither driver-applied nor system-applied braking or steering were recorded before impact. As a result of the crash, the Honda driver died and the Ford driver sustained minor injuries.

Moments before this collision sequence, a 2017 Chevrolet Cruze traveling east in the center lane ahead of the Ford executed a quick lane change to the right to avoid colliding with the stationary Honda.

**Philadelphia, Pennsylvania.** On March 3, 2024, at 3:16 a.m. local time, a multivehicle collision occurred in a work zone on northbound Interstate 95 (I-95) near the Betsy Ross Bridge in Philadelphia, Pennsylvania. The speed limit in the work zone was 45 mph, reduced from 55 mph. Before the crash, two vehicles, a 2012 Hyundai Elantra and a 2006 Toyota Prius, were stationary in the left travel lane, with the Elantra positioned behind (south of) the Prius. A 2018 Toyota Corolla was traveling in the center lane, approaching these stationary vehicles. At the same time, a 2022 Ford Mustang Mach-E SUV was traveling north in the left lane of I-95. Traveling at a system-recorded speed of 72.4 mph, the Ford collided with the rear of the stationary Elantra,

propelling it forward into the Prius. The impact redirected both the Prius and the Elantra forward and rightward, causing them to strike the passing Corolla.

The Ford driver had been operating the vehicle in hands-free partial driving automation mode. Neither driver-applied nor system-applied braking or steering were recorded before impact. As a result of the crash, the Prius and Elantra drivers died and the Ford driver sustained minor injuries. The Corolla driver was uninjured.

Moments before this collision sequence, a 2015 Hyundai Genesis sedan traveling north in the left lane ahead of the Ford had swerved around the stopped Elantra and Prius. Although the Genesis avoided the stopped vehicles, its driver lost control and collided with the roadside longitudinal barriers north of the crash location.

## **What We Found**

In the San Antonio, Texas, crash, we found that the Ford driver was distracted by the vehicle's infotainment system, exhibited overreliance on automation through excess dependence and failure to properly monitor the system, and failed to respond to the stationary vehicle ahead. Although the partial automation system provides steering and control of acceleration/deceleration, the driver must always be prepared to take control. We also found that the driver of the stationary vehicle was impaired by alcohol, which may have contributed to the crash.

In the Philadelphia, Pennsylvania, crash, we found that the Ford driver failed to respond to the stopped vehicles ahead due to a combination of potentially interacting factors: impairment from substance use, disengagement from the driving task (likely due to cell phone use and overreliance on the vehicle's partial automation), and speeding. If the Ford had been traveling at the posted speed limit of 45 mph instead of 72 mph, the collision avoidance systems would have been more likely to alert the driver sooner or mitigate the crash. The National Highway Traffic Safety Administration's (NHTSA) failure to meet the statutory date for requiring advanced impaired driving technology on all new passenger vehicles exposes the public to dangers posed by impaired drivers.

The circumstances of both crashes (involving a stationary lead vehicle, a striking vehicle traveling at highway speed, and nighttime conditions) were likely outside the capabilities of the Ford vehicles' collision avoidance systems available at the time of the crash. However, these scenarios are addressed in the performance parameters of a recently issued Federal Motor Vehicle Safety Standard.

The San Antonio and Philadelphia investigations revealed limitations in the Ford Motor Company's design of its telematics data collection programs (which do not transmit direct crash parameters such as airbag deployment), delays in

manufacturer awareness about crashes involving partial vehicle automation, and reporting discrepancies across manufacturers in both the number of incidents reported and the information sources for the reports. Therefore, the data that NHTSA collects about these crashes (and the factors that contribute to them) is likely not comprehensive. The circumstances of both crashes demonstrated that without federal requirements for the recording of partial automation data, critical information about these crashes remains inconsistent and inaccessible to local law enforcement, safety investigators, regulators, and automakers.

Ford's driver monitoring system (DMS) did not effectively mitigate visual distraction and driver disengagement following off-road glances, because it allowed brief driver glances to the forward roadway to reset the distraction alert timer. In the San Antonio crash, the Ford driver's repeated off-road glances and minimal on-road glances demonstrate the risks of accumulated glances away from the roadway and the need for prolonged glance pattern evaluation in DMS implementation. In the Philadelphia crash, the Ford's DMS did not distinguish between attention to the forward roadway and attention to objects positioned in the driver's forward line of sight. This limitation would have permitted the Ford driver to use her phone in a distracting manner without receiving a DMS alert.

An urgent need exists for standardized US-based DMS performance requirements, as demonstrated by:

- the DMS deficiencies observed in both crashes and in previous NTSB investigations;
- NHTSA's ongoing research in assessing DMS effectiveness in eliminating distraction; and
- the more stringent performance testing protocols already implemented by the European New Car Assessment Programme and Insurance Institute for Highway Safety.

Both crashes revealed deficiencies in the implementation of partial automation, including:

- allowing drivers to disable the automatic emergency braking system;
- not requiring the active intelligent speed assistance system to be engaged while the vehicle is in partial automation mode;
- permitting hands-free partial automation in work zones with reduced speed limits; and
- allowing the active intelligent speed assistance system to allow cruise speeds up to 20 mph above posted speed limits.

The lack of federal guidance for partial automation systems in passenger vehicles has led to safety-critical design gaps in:

- mitigating known system limitations;
- enhancing safety redundancy by ensuring concurrent engagement of safety technologies; and
- promoting driver engagement by design.

We determined that the probable cause of the San Antonio, Texas, crash was the driver's failure to respond to the stationary vehicle ahead due to distraction, likely from the in-vehicle navigation system, stemming from overreliance on the vehicle's hands-free partial automation system and disengagement from the driving task. Contributing to the crash was the inability of the Ford vehicle's partial automation system, including its automatic emergency braking system, to detect and respond to the stationary vehicle ahead. Also contributing to the crash was the location of the stationary vehicle, which may have been stopped in the center lane of the highway due to the impairment of its driver.

We determined that the probable cause of the Philadelphia, Pennsylvania, crash was the driver's failure to respond to the stationary vehicles ahead due to impairment from alcohol that may have been worsened by cannabis use, as well as distraction, likely from cell phone use, stemming from overreliance on and misuse of the vehicle's hands-free partial automation system. Contributing to the crash was the driver's operation of the vehicle about 27 mph over the speed limit in a work zone. Further contributing to the crash was the Ford Motor Company's inadequate integration of its active speed management system with its partial automation system, which permitted excessive speed, including in a work zone.

## **What We Recommended**

As a result of our investigations into these crashes involving vehicles with hands-free partial driving automation, we issued six new safety recommendations, reiterated one previously issued recommendation, and classified six previously issued recommendations. We recommended that NHTSA require manufacturers to equip new passenger vehicles with partial automation capabilities with a telematic system that notifies the manufacturer of crashes meeting NHTSA's reporting requirements.

We also recommended that NHTSA require all new passenger vehicles with partial automation capabilities to record data elements related to these systems, including system availability, engagement and activation denial, driver alerts, and system faults for the collision avoidance system, DMS, partial automation system operation, and any other systems deemed necessary.

We recommended that NHTSA require that all new passenger vehicles with partial automation capabilities be equipped with DMSs capable of minimizing driver disengagement, automation complacency, and misuse of automation. We also recommended that the Ford Motor Company revise the

DMSs in its new vehicles to detect and provide warnings about accumulated short distractions over a prolonged period of time, differentiate genuine on-road glances from attention directed to objects (such as cell phones) in the driver's forward line of sight, and issue initial and subsequent multi-modal alerts at intervals that minimize eyes-off-road duration.

We recommended that the US Department of Transportation (USDOT) issue comprehensive guidelines for vehicle manufacturers implementing partial vehicle automation systems that address known system limitations, including integration and concurrent engagement of safety technologies, promotion of driver engagement by design, reduction of the safety risks associated with automation complacency and misuse, and setting maximum operational speeds for automation systems based on overall system capabilities. We also recommended that the Ford Motor Company modify its BlueCruise system for new vehicles to require that the automatic emergency braking system is engaged and that the active intelligent speed assistance system uses speed tolerances to mitigate excessive speeding, taking into consideration the system's operational capabilities as well as traffic and highway complexity.

We reiterated Safety Recommendation H-22-22 to NHTSA to require that all new vehicles be equipped with passive vehicle-integrated alcohol impairment detection systems and/or advanced DMSs capable of preventing or limiting vehicle operation if driver impairment by alcohol is detected.

Finally, we classified six previously issued safety recommendations: one to the USDOT, four to NHTSA, and one to SAE International.

# 1 Factual Information

This report documents the National Transportation Safety Board (NTSB) investigations into two fatal, rear-end collisions with stationary vehicles at highway speeds. In both crashes, the striking vehicle was a 2022 Ford Mustang Mach-E sport utility vehicle (SUV) equipped with a Co-Pilot360 Active 2.0 system and operating in hands-free partial driving automation mode, which Ford refers to as BlueCruise.<sup>1</sup> One of these crashes occurred in San Antonio, Texas, on February 24, 2024, and the other occurred in Philadelphia, Pennsylvania, on March 3, 2024. The factual section of this report first describes the relevant driving technologies that were equipped on the Ford Mach-E vehicles involved in both crashes (section 1.1). Next, the factual section discusses the sequences of events, highway factors, recorded data associated with the partial driving automation and supporting systems, and human performance factors related to the San Antonio crash (section 1.2) and the Philadelphia crash (section 1.3). Finally, the factual section discusses the federal reporting requirements for crashes involving partial driving automation systems (section 1.4).

## 1.1 Ford Mach-E Description and Driving Technologies

### 1.1.1 General

In both crashes, the Ford vehicle involved in the crash was a 2022 Mustang Mach-E, battery-electric, rear-wheel-drive SUV with a 91-kilowatt-hour extended lithium-ion battery. The vehicles were equipped with Ford's optional Co-Pilot360 Active 2.0 system, a suite of advanced driver assistance systems (ADAS) including BlueCruise partial automation capabilities. This report uses SAE International Level 2 (L2) as an alternative term when referring to partial automation systems, consistent with SAE International taxonomy and definitions for terms related to driving automation systems.<sup>2</sup> Figure 1 shows an overview of the SAE International levels of driving automation.

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<sup>1</sup> *Co-Pilot360 Active 2.0* refers to a suite of driver assistance systems. These systems are discussed in detail in section 1.1.

<sup>2</sup> (a) According to SAE International, a partial driving automation (L2) system provides lateral (steering) and longitudinal (acceleration/deceleration) control, while the driver is responsible for monitoring the environment, including detecting hazards and automation failures. For more information, see the SAE International [J3016\\_202104](#) standard. (b) The National Highway Traffic Safety Administration has adopted the SAE International taxonomy for vehicle automation systems in all of its publications and regulatory actions.



## SAE J3016™ LEVELS OF DRIVING AUTOMATION™

Learn more here: [sae.org/standards/content/j3016\\_202104](http://sae.org/standards/content/j3016_202104)

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	SAE LEVEL 0™	SAE LEVEL 1™	SAE LEVEL 2™	SAE LEVEL 3™	SAE LEVEL 4™	SAE LEVEL 5™
What does the human in the driver's seat have to do?	You <b>are driving</b> whenever these driver support features are engaged – even if your feet are off the pedals and you are not steering			You <b>are not driving</b> when these automated driving features are engaged – even if you are seated in “the driver’s seat”		
	You <b>must constantly supervise</b> these support features; you must steer, brake or accelerate as needed to maintain safety			When the feature requests, you <b>must drive</b>	These automated driving features will not require you to take over driving	

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	These are driver support features			These are automated driving features		
What do these features do?	These features are limited to providing warnings and momentary assistance	These features provide steering <b>OR</b> brake/acceleration support to the driver	These features provide steering <b>AND</b> brake/acceleration support to the driver	These features can drive the vehicle under limited conditions and will not operate unless all required conditions are met	This feature can drive the vehicle under all conditions	
Example Features	<ul style="list-style-type: none"> <li>• automatic emergency braking</li> <li>• blind spot warning</li> <li>• lane departure warning</li> </ul>	<ul style="list-style-type: none"> <li>• lane centering <b>OR</b></li> <li>• adaptive cruise control</li> </ul>	<ul style="list-style-type: none"> <li>• lane centering <b>AND</b></li> <li>• adaptive cruise control at the same time</li> </ul>	<ul style="list-style-type: none"> <li>• traffic jam chauffeur</li> </ul>	<ul style="list-style-type: none"> <li>• local driverless taxi</li> <li>• pedals/steering wheel may or may not be installed</li> </ul>	<ul style="list-style-type: none"> <li>• same as level 4, but feature can drive everywhere in all conditions</li> </ul>

**Figure 1.** SAE International levels of driving automation. (Source: [SAE International](http://SAE International))

The Ford Mach-E vehicles were operating BlueCruise version 1.0 with hardware version ML3T-14H107-FCC and software/firmware version ML3T-14H102-ABS. According to Ford, this was the factory-installed version of the software. These were also the most recent hardware and software versions at the time of the two crashes.

### 1.1.1.1 Sensors and Data Recording

The Ford Mach-E vehicles were equipped with a suite of systems that monitor the environment, vehicle, and driver, and interpret the acquired data. These included:

- radar system with one mid-range and four short-range units;<sup>3</sup>
- forward-facing camera system mounted in the upper center of the windshield, designed to detect lane lines and objects;

<sup>3</sup> Three radars were positioned behind the front bumper. Those three radars included the mid-range radar in the center and two angled short-range radars in the corners. The remaining two short-range radars were installed in the corners behind the rear bumper.

- driver monitoring camera system mounted on top of the steering column, designed to monitor driver eye gaze and head position during BlueCruise engagement;
- mapping system, including global positioning system and high-fidelity mapped roadway information provided by a third party, displayed on the vehicle's infotainment console;<sup>4</sup> and
- steering wheel torque sensor.

The vehicles were also equipped with modules capable of recording some crash-relevant information and limited ADAS and BlueCruise data, plus telematic capabilities for wireless data transmission to the Ford Motor Company.<sup>5</sup>

### **1.1.1.2 ADAS and BlueCruise Features**

As part of the Co-Pilot360 Active 2.0 system, the Ford Mach-Es were equipped with numerous ADAS, including:<sup>6</sup>

- forward collision avoidance and mitigation systems, including forward collision warning (FCW) and automatic emergency braking (AEB);
- adaptive cruise control (ACC) and Intelligent ACC;
- lane keeping assistance systems, including lane keeping and lane centering;
- BlueCruise, including a hands-required mode and hands-free mode; and
- driver monitoring system (DMS).

## **1.1.2 Advanced Driver Assistance Systems**

### **1.1.2.1 Forward Collision Avoidance and Mitigation Systems**

The Ford Mach-E's FCW and AEB systems assist drivers in detecting and avoiding forward hazards, including vehicles, pedestrians, and bicyclists. The FCW is designed to provide bi-modal alerts—visual displays in the instrument panel and

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<sup>4</sup> The mapping data provided by the third party included broad elements such as roadway identification and large structure mapping (such as overpasses) as well as smaller and more detailed elements (such as roadway geometry and traffic signs).

<sup>5</sup> Transmission of data as part of Ford's various data collection programs, as discussed in later sections, was conducted through the vehicle's own Wi-Fi/cellular connection. Telematic data transmission required the vehicle owner's consent.

<sup>6</sup> For a comprehensive description of BlueCruise and other ADAS, see the Vehicle Automation Factual Report in the public dockets for the [San Antonio](#) and [Philadelphia](#) crash investigations.

auditory chimes—when forward hazards are detected. The FCW system is always operational and cannot be deactivated by the driver.

The AEB is designed to apply brakes when the driver does not respond adequately to a forward hazard or to provide supplemental braking force when driver braking is determined to be insufficient. Although AEB is operational by default, drivers can disable it after vehicle startup; however, this setting automatically resets to being operational at the next ignition cycle. Disabling AEB after vehicle startup does not affect the availability and engagement of BlueCruise. AEB activates based on the fusion of data from camera and radar sensor systems, whereas FCW can activate even with radar-only detection of moving objects.<sup>7</sup>

According to the Ford Mach-E vehicle owner's manual, FCW and AEB systems operate at speeds above 3 mph, with different maximum speed thresholds. Forward vehicle detection operates up to the Ford Mach-E's maximum speed (for both moving and stationary vehicles), and pedestrian and bicyclist detection works up to 50 mph.

The vehicle owner's manual outlines system limitations and conditions that may degrade performance, including warnings about the limited detection capability of "...vehicles at night without tail lights..." The owner's manual does not specifically address limitations in the ability to respond to stationary vehicles. Ford informed the NTSB that although these systems can detect stationary vehicles, their performance may degrade under certain conditions, and activation of FCW and AEB is dependent on the systems' level of certainty that the detected object is indeed a hazard. To activate, AEB requires a high level of confidence from the radar-camera fusion sensor suite. Ford representatives stated that, given the limitations of the industry's sensing technologies combined with other factors such as high vehicle travel speed, the presence of a stationary vehicle, nearby vehicle maneuvers, and environmental factors such as nighttime conditions—most of which were present in the San Antonio and Philadelphia crashes—Ford would not expect the current generation of radar-camera fusion AEB systems to have sufficient confidence to identify and activate in response to a stationary collision target.<sup>8</sup>

### **1.1.2.2 Adaptive Cruise Control and Intelligent Adaptive Cruise Control**

ACC is an on-demand system that helps maintain a driver-set cruise speed and following distance behind a lead vehicle by automatically adjusting speed (by

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<sup>7</sup> *Fusion* refers to combining data from multiple sensors to generate a more comprehensive interpretation of the surroundings.

<sup>8</sup> Ford's representatives provided this input during NTSB meetings with Ford staff regarding FCW and AEB response to stationary targets in conditions similar to the San Antonio and Philadelphia crashes.

braking or reducing throttle) when approaching slower vehicles and accelerating to the set cruise speed when the path ahead is clear.

At speeds above 65 mph, ACC is designed not to respond (decelerate) to detected stationary vehicles, which are defined as those that have never been interpreted as moving by the vehicle sensors. According to Ford, this operational design choice was made due to concerns about false alarms (when other objects such as signs, overpasses, or bridge abutments are misidentified as stationary vehicles) and the impact of sudden phantom deceleration (braking without cause) on surrounding traffic.<sup>9</sup> At higher speeds and longer distances, sensor limitations become more prominent, and the risk of false detections and incorrect target selections increases.<sup>10</sup> This restriction does not apply at speeds below 65 mph. However, regardless of travel speeds, ACC's deceleration in response to detected stationary vehicles remains dependent on the sensors' determination that the detected object is indeed a hazard.<sup>11</sup>

The vehicle owner's manual includes warnings about ACC limitations, such as that "the system is not a crash warning or avoidance system," but it does not specifically state that ACC will not decelerate in response to detected stationary vehicles at speeds above 65 mph.

Ford's Intelligent ACC is a form of active intelligent speed assistance (ISA) and combines standard ACC functionality with the vehicle's capability to determine posted speed limits through mapping system data and speed limit signs detected by the forward camera system.<sup>12</sup> When discrepancies occur between camera and mapping data, Ford's Intelligent ACC system gives precedence to the camera system's speed limit determination.

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<sup>9</sup> False alarms, or the activation of an alert or safety system when no actual hazard exists, are a concern for any collision avoidance system. This issue is discussed in greater detail in section 2.2.4.1 of this report.

<sup>10</sup> Ford representatives stated: "...at long ranges, which equates to higher speeds, there is a greater probability of an incorrect target selection. Ford algorithms are developed to balance the risk of false detections and subsequent unnecessary braking events. Ford believes its consideration of false detection risks is consistent with the industry."

<sup>11</sup> The ACC may also not decelerate in response to a detected stationary vehicle during the vehicle's execution of a high-complexity maneuver (such as during a sudden lane change). The exact response threshold depends on a function of distance to a detected hazard, yaw rate, and speed.

<sup>12</sup> *Passive ISA* issues alerts to the driver—visual, auditory, haptic, or a combination of these modalities—when it detects that the vehicle is exceeding the roadway speed limit. *Active ISA*, by contrast, provides back pressure on the accelerator pedal when the speed limit is exceeded, making it more difficult to accelerate further, or electronically limits the vehicle's speed, thereby preventing drivers from exceeding the speed limit entirely.

Intelligent ACC is an on-demand system that can be activated even if AEB is disabled and can operate independently or in combination with other ADAS, including BlueCruise. The system includes a tolerance setting that allows drivers to set cruise speeds up to 20 mph above or below the system-detected posted speed limit. By design, none of the vehicle's data-recording sources capture the operational status of Intelligent ACC, and none record the system-detected speed limit (whether based on the high-fidelity mapping data or the forward camera).

### **1.1.3 BlueCruise Partial Driving Automation**

#### **1.1.3.1 General Description**

BlueCruise combines ACC (standard or Intelligent) with lane centering systems and requires constant driver supervision, which is enforced by driver monitoring mechanisms. This combination creates a partial automation or L2 system that, according to SAE International definitions, provides both lateral (steering) and longitudinal (acceleration/deceleration) control. The driver remains responsible for the rest of the driving task, including constant supervision of the environment, detecting and responding to objects and events, and taking over when the automation fails.

When BlueCruise is engaged, the system is designed to:

- detect obstacles on the travel path;
- keep the vehicle centered in its travel lane;
- maintain a driver-set cruise speed (which may vary with Intelligent ACC engagement);
- adjust speed to maintain predetermined following distance behind a slower-moving lead vehicle;
- apply brakes when detecting certain obstacles ahead, including slower-moving or stopped vehicles (with limitations pertaining to stationary vehicles); and
- monitor the driver's engagement with the driving task through different mechanisms—the DMS and steering wheel torque—depending on the engaged BlueCruise mode, and alert the driver when disengagement is detected.

BlueCruise offers two distinct operating modes, each with separate activation protocols and operational requirements: hands-required and hands-free. To activate, both of these operating modes require that visible markings are present on both sides of the vehicle's travel lane, that the vehicle is centered in the travel lane, that the driver's gaze is directed toward the forward roadway (as determined by the DMS),

and that the driver is applying torque to the steering wheel.<sup>13</sup> Table 1 shows the main differences in activation requirements and operational parameters between the hands-required and hands-free BlueCruise modes, and figure 2 shows the distinct icons for the two modes that are displayed to the driver on the Ford Mach-E's instrument panel. Intelligent ACC and AEB do not need to be engaged for BlueCruise to operate; while BlueCruise is engaged, each of these systems may be either enabled or disabled.

**Table 1.** Selected differences in activation requirements and operational parameters for hands-required and hands-free BlueCruise.

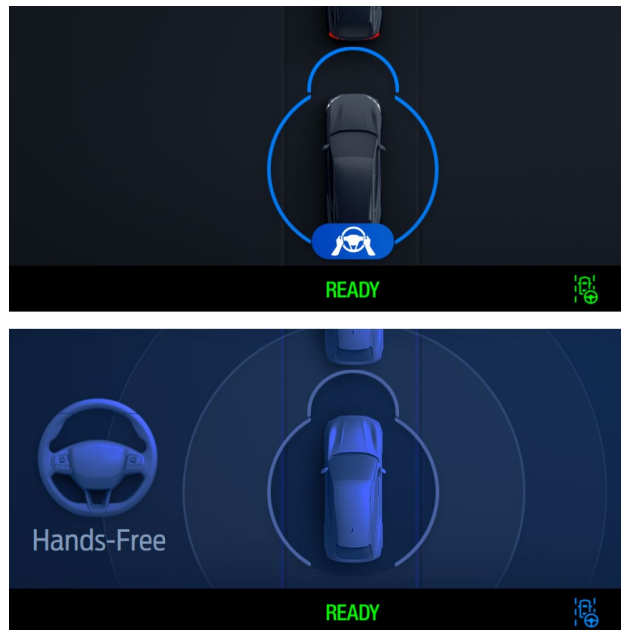
Parameter	Hands-Required	Hands-Free
Roadway type	No roadway restrictions	Blue Zone roadway
Driver engagement monitoring mechanisms	Steering wheel torque <sup>a</sup> Driver gaze	Driver gaze
Maximum cruise speed	113 mph	80 mph <sup>b</sup>

<sup>a</sup> When no steering wheel torque is detected, the system initiates a series of escalating alerts to the driver. The first warning appears as a visual alert after 15 seconds of not detecting steering wheel input.

<sup>b</sup> When drivers manually accelerate above 80 mph while in hands-free BlueCruise mode, the system automatically switches to hands-required BlueCruise mode.

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<sup>13</sup> Visible lane markings on both sides of the travel lane, a centered position within the travel lane, and the driver's gaze directed to the forward roadway are also requirements for continuous BlueCruise engagement. For hands-free mode, steering wheel torque is required only for initial activation of BlueCruise, although the system permits driver steering input and remains active as long as the vehicle stays within the travel lane.



**Figure 2.** Depiction of Ford Mach-E instrument panel showing engaged hands-required BlueCruise (top) and engaged hands-free BlueCruise (bottom). (Source: Ford Motor Company)

Blue Zone roads are certain limited-access highways (those with dedicated entrance and exit ramps) where hands-free BlueCruise may be engaged. Blue Zone roads include high-fidelity mapping and meet other criteria for maximum and minimum lane width and minimum road curve radius. Both BlueCruise modes also have minimum lane width and roadway curvature requirements.

BlueCruise functionality in work zones depends on the same factors as non-work zones. Work zones alone do not disengage or restrict hands-free BlueCruise, but lane closures or lane narrowing typically will. Reduced speed limits in work zones (such as from 55 mph to 45 mph) without lane restrictions do not affect system operation unless Intelligent ACC is also engaged.

The Ford Mach-E vehicle owner's manual outlines system limitations and includes warnings to drivers about their responsibilities, such as, "You are responsible for keeping your eyes on the road at all times. The system is designed to be an aid and does not relieve you of your responsibility to drive with due care and attention."

Access to hands-free BlueCruise requires a subscription to Ford's BlueCruise service. Without an active subscription, drivers can still activate ACC and lane centering systems (which provide hands-required partial automation capability).

### 1.1.3.2 Driver Monitoring System

During BlueCruise operation (either in the hands-free or hands-required mode), the DMS monitors driver gaze and head position to determine gaze direction and provides alert sequences when driver distraction is detected (see figure 3).<sup>14</sup> The system defines distraction as looking away from the forward roadway continuously for more than 5 seconds.



**Figure 3.** Ford Mach-E interior DMS camera (inset) and instrument cluster.

Ford has established several “zones of interest” to identify areas where drivers may direct their gaze, both inside and outside the vehicle.<sup>15</sup> After 5 seconds of off-road gaze where the driver is not looking toward the forward roadway, the system determines that a driver is distracted and provides an initial alert to direct the driver’s attention back to the forward roadway.

<sup>14</sup> DMSs on Ford Mach-E vehicles are designed only to detect distraction. They are not designed to detect drowsiness or impairment. According to Ford, a separate ADAS feature, Driver Alert System, is designed to detect drowsiness and lack of alertness through variability in steering. As such, it can only be used during manual steering of the vehicle. The vehicle owner’s manual contains several warnings recommending “against the use of any hand-held device while driving.”

<sup>15</sup> Some of the zones of interest are as follows: the front windshield (both left and right, indicating that a driver is looking at the forward roadway), infotainment console (high center stack and low center stack), instrument cluster, left front window, right front window, and footwells. Only the front windshield is considered to be an *attentive* zone.

The modality of the initial alert depends on where the driver is looking when the distraction threshold is reached; if the driver is looking at the instrument cluster, the DMS provides a visual alert in the instrument cluster. If the driver's gaze is directed to any other off-road zone, the system provides a bi-modal alert combining a visual warning in the instrument cluster with an auditory chime. If the initial alert is visual-only (displayed in the instrument cluster) and the driver fails to return their gaze to the forward roadway, after 3 seconds the system presents a bi-modal alert. If the driver continues to not return their gaze to the forward roadway, the DMS issues increasingly urgent alerts. These alerts include a continuous auditory alert and a haptic (touch-based) alert, which supplements the visual and auditory alerts to create a tri-modal warning. If the driver still does not return their gaze to the forward roadway, the system initiates braking to either 10 km/h (6.2 mph) or a complete stop.<sup>16</sup> The DMS's 5-second gaze monitoring timer resets whenever the system detects a driver's forward roadway gaze, even for a single observation of at least 0.2 seconds.

## **1.2 San Antonio, Texas, Crash**

### **1.2.1 Crash Narrative**

On February 24, 2024, at 9:48 p.m. central standard time, a 2022 Ford Mustang Mach-E battery-electric SUV was traveling east in the center lane of Interstate 10 (I-10) in San Antonio, Bexar County, Texas, and approaching the Woodlake Parkway exit. The Ford collided with the rear of a stationary 1999 Honda CR-V SUV that was also in the center lane (see figure 4).<sup>17</sup>

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<sup>16</sup> The system brakes to 10 km/h (6.2 mph) if no lead vehicle is present and the vehicle's travel lane lines are visible, or to a complete stop if the lane lines are not visible.

<sup>17</sup> (a) In this report, all times pertaining to the San Antonio crash investigation are central standard time. (b) Visit [ntsb.gov](https://www.nts.gov) to find additional information in the [public docket](#) for this NTSB investigation (case no. HWY24FH006). Use the [CAROL Query](#) to search safety recommendations and investigations.



**Figure 4.** Crash location on eastbound I-10. (Source: Google Earth; annotated by NTSB)

Data from the Ford's airbag control module (ACM) showed the vehicle traveling at 74.7 mph at impact. Other data-recording systems indicated that the driver had engaged the vehicle's BlueCruise partial automation system and had maintained an almost constant speed in the moments leading up to the collision. Neither driver-applied nor system-applied braking or steering were recorded in the moments before the crash. Roadway evidence at the location of the crash showed two short, parallel tire friction marks centered within the travel lane. These marks exhibited characteristics consistent with tire deformation due to heavy downward force during impact.

Upon impact, the Honda rotated counterclockwise and then overturned onto its roof before coming to rest on the left shoulder of I-10, about 143 feet from the crash location and at an approximately 90° orientation to the travel lane (see figure 5). The Ford continued east after the collision and came to rest on the right shoulder, approximately 167 feet from the crash location. At final rest, the Ford partially occupied the right lane and had rotated approximately 20° clockwise relative to the travel lane. Two parallel tire friction marks extended to the Ford's position of rest, while a trail of small debris and roadway surface scars extended to the Honda's position of rest. The roadway surface scars were consistent with the overturned Honda sliding across the roadway surface.



**Figure 5.** East-looking view of I-10 showing the location of the crash and the rest positions of the Honda (left inset, with illuminated hazard light circled in yellow) and Ford (right inset). (Source: San Antonio Police Department; annotated by NTSB)

### 1.2.2 Injuries, Occupant Protection, Emergency Response, and Crash Notification

As a result of the crash, the Honda driver died and the Ford driver sustained minor injuries. The San Antonio Police Department (SAPD) crash report indicated that the Honda driver was wearing his lap/shoulder belt at the time of the collision. The driver's seat belt pretensioners and airbags did not deploy during the crash, which is consistent with their design not to activate in rear-end collisions.<sup>18</sup> Based on the SAPD crash report for the Ford—which indicated deployed pretensioners and airbags, and abrasion marks on the seat belt webbing—as well as the Ford's ACM data, the Ford driver was also restrained by a lap/shoulder belt when the crash occurred.

The SAPD dispatcher received a 911 call at 9:49 p.m., approximately 1 minute after the crash occurred. SAPD patrol units were immediately dispatched, with the first unit arriving at the scene at 9:55 p.m. San Antonio Fire Department personnel arrived approximately 2 minutes later, followed by emergency medical services about

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<sup>18</sup> In rear-end collisions, the struck vehicle's frontal airbags typically do not deploy because the impact forces come from behind, not from the front where frontal airbags are designed to respond.

5 minutes after the initial SAPD response. After receiving initial emergency care on scene, the Honda driver was transported to a hospital in critical condition at 10:27 p.m. The Ford driver was not transported to a hospital.

The Ford Motor Company learned of the San Antonio crash on March 8, 2024 (about 2 weeks after it occurred), from a post by the crash-involved driver on an online forum that Ford staff monitors.<sup>19</sup> On March 9, Ford obtained a crash report from the SAPD and submitted an incident report to the National Highway Traffic Safety Administration (NHTSA), as required by Standing General Order (SGO) 2021-01. For detailed discussions of SGO 2021-01, see sections 1.4 and 2.3.1.

The crash-involved Ford Mach-E was equipped with an automatic crash notification (ACN) system, which Ford refers to as 911 Assist. When enabled, this system automatically places an emergency call to area dispatchers and operators, alerting them of the crash and providing basic vehicle identifying information as well as the vehicle's location. The factory default setting is that 911 Assist is turned off; drivers must enable the feature through the infotainment console and pair it with a cell phone, which the system then uses in the event of a crash. Although the investigation was unable to determine whether the Ford's 911 Assist was enabled, examination of the 911 calls received by the SAPD showed that none were made by the vehicle's 911 Assist/ACN system.<sup>20</sup>

### **1.2.3 Roadway Information**

The crash occurred on eastbound I-10 between the North Foster Road overpass and the Woodlake Parkway exit (Exit 584). At this location, I-10 was a six-lane divided highway with three travel lanes in each direction separated by a 42-inch-tall Test Level 4 (TL-4) concrete median barrier.<sup>21</sup> Each of the three eastbound through-lanes was 12 feet wide. The exit ramp for Exit 584 began to separate from the through-lanes approximately 360 feet west of the crash location.

The eastbound roadway featured a 12-foot-wide left shoulder and a 10-foot-wide right shoulder. Single-slope concrete traffic guardrails bordered the outside

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<sup>19</sup> The post appeared on [www.macheforum.com](http://www.macheforum.com).

<sup>20</sup> The NTSB was unable to access any data from the module that controls the Ford Mach-E's infotainment console. The Ford Motor Company stated that at time of the attempted download, these data were not accessible with commercially available hardware. As a result, information related to the vehicle's ACN system (911 Assist), as well as its battery charge status, was not available.

<sup>21</sup> A TL-4 barrier is typically installed for general use on high-speed freeways with a mix of passenger vehicles and truck traffic. The crash test for TL-4 barriers is intended to provide resistance in most real-world crashes where typical impact scenarios do not exceed the practical worst-case scenarios of a 15° impact angle at 50 mph with a 19,700-pound single-unit truck.

edge of the right shoulder.<sup>22</sup> The crash occurred on a straight section of roadway with a 2.2% upward grade that began about 1,300 feet before the impact location and continued about 1,200 feet past the impact location.

The posted speed limit on I-10 in the area of the crash was 70 mph. The crash occurred in nighttime conditions, the weather was clear, and the roadway surface was dry. The eastbound lanes in the crash area were illuminated by roadway lighting, including dual-sided light poles mounted atop the center median barrier at approximately 270-foot intervals and single-mast poles along the right shoulder for the exit ramp.

According to a Texas Department of Transportation traffic study conducted in 2023, the annual average daily traffic volume for eastbound I-10 near the crash site was 52,188 vehicles, of which passenger vehicles (cars and pickup trucks) accounted for approximately 82% and commercial vehicles (single trucks, combination vehicles, and buses) accounted for approximately 18%. An examination of the 5-year crash history (2019–2024) for this section of I-10 between the North Foster Road overpass and the crash location—a distance of about 1,300 feet—revealed 68 crashes, including two fatal collisions (with one of these being the subject crash of this report).<sup>23</sup>

The area of I-10 where the crash occurred was designated by Ford as a Blue Zone roadway.<sup>24</sup> At the time of the crash, the Ford Mach-E's roadway mapping data were the most recent data that were available.

## **1.2.4 Vehicle Information**

### **1.2.4.1 Ford Mach-E**

#### **1.2.4.1.1 General**

The Ford involved in this crash was a 2022 Mustang Mach-E, Premium trim, battery-electric, rear-wheel-drive SUV with a 91-kilowatt-hour extended lithium-ion battery. The vehicle had an active BlueCruise subscription.<sup>25</sup> There were no

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<sup>22</sup> A single-slope concrete traffic rail is a concrete barrier designed to separate traffic lanes, particularly on bridges and roadways.

<sup>23</sup> Based on information provided by the Texas Department of Transportation, the other fatal crash involved a vehicle striking a pedestrian on the left shoulder of eastbound I-10.

<sup>24</sup> For further discussion of Blue Zone roadways, refer to section 1.1.3.1.

<sup>25</sup> The vehicle was purchased new by the owner (the crash-involved Ford driver) and came with a free 3-year subscription to BlueCruise. At the time of the crash, the vehicle's odometer read 11,970 miles.

unrepaired safety recalls or active defect investigations for this vehicle.<sup>26</sup> Refer to section 1.1 for a detailed description of the driving technologies, including ADAS and BlueCruise partial driving automation, that were equipped on the Ford Mach-E vehicle involved in the San Antonio crash.

#### 1.2.4.1.2 Damage

Damage to the Ford was primarily limited to its front end. The front of the hood was pushed backward, causing it to buckle upward to a nearly vertical position. An impression of the Honda's rear-mounted spare tire was visible on the Ford's hood (see figure 6, left image). The Ford did not experience a postcrash fire.

The Ford's occupant compartment survival space remained well preserved with minimal intrusion (see figure 6, right image). Investigators found no evidence of occupant contact with hard vehicle surfaces such as the internal panels, pillars, windshield, dashboard, or steering wheel.<sup>27</sup> Figure 7 shows an undamaged 2022 Ford Mach-E for comparison.



**Figure 6.** Left: Front view of damage to the Ford with the Honda's spare tire marking indicated by arrows. Right: View of the interior of the Ford.

<sup>26</sup> See [Check for Recalls: Vehicle, Car Seat, Tire, Equipment | NHTSA](#).

<sup>27</sup> The only evidence of occupant contact was with the steering wheel airbag.



**Figure 7.** Front-left view of an exemplar 2022 Ford Mach-E. (Source: [edmunds.com](https://www.edmunds.com))

SAPD body camera video footage showed that when officers arrived at the crash scene, the Ford's hazard lights were activated (refer to figure 5).

#### 1.2.4.1.3 Electronic Data

**Airbag Control Module.** The SAPD removed and retrieved the data from the Ford's ACM. The ACM data included 5 seconds of precrash data.<sup>28</sup> According to these data, the crash occurred in the 26th minute of the vehicle's current ignition cycle, and the driver was wearing a seat belt at this time. The ACM longitudinal crash data indicated a maximum longitudinal delta-V of -34.2 mph, 210 milliseconds (msec) after the trigger (crash), which corresponds with a reduction in vehicle speed accompanying an impact into the rear of a stationary vehicle.<sup>29</sup>

The ACM data showed minor changes in speed within the 5-second precrash period, including a vehicle speed of 74.7 mph at the time of the crash. The data also showed no braking or accelerator application and no evasive steering maneuver

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<sup>28</sup> ACM data recording is triggered when the system detects an established threshold rate of change in acceleration (longitudinal or lateral). These "wake-up thresholds" initiate the recording of various vehicle parameters and prepare the vehicle's restraint system for possible activation. The ACM records some parameters, such as stability metrics (including lateral and longitudinal acceleration and steering wheel angle) at 10-hertz intervals, and others (including speed, accelerator pedal percentage, and service brake status) at 5-hertz intervals.

<sup>29</sup> (a) In the context of a crash, *delta-V* refers to the change in vehicle speed before and after impact. (b) The *trigger* refers to the moment that the module's threshold for recording a crash event was reached. For clarity, when discussing data modules or recorders, this report uses the term *crash* or *impact* as a timing reference point, equating the time that a recording was triggered and the time that a crash occurred.

before the crash, and that the collision mitigation system (specifically, AEB) was enabled, but its activation was not requested by the vehicle.<sup>30</sup>

**Driver Monitoring System Module.**<sup>31</sup> The DMS module is an in-vehicle data processing and recording component of the DMS system. It determines the driver's gaze by processing imagery from the driver-facing camera and provides the previously described sequence of distraction alerts if the gaze does not return to the forward roadway. Data are recorded only during BlueCruise engagement (hands-free or hands-required) and only when triggered by ACM activation, sudden deceleration by the driver, or AEB engagement.

The NTSB removed the DMS module from the vehicle. Using a non-commercially available tool and working with the DMS vendor, Ford retrieved and decrypted the data and provided these data to the NTSB. The DMS module data showed 5 seconds of precrash and 1 second of postcrash data at 5-hertz (Hz) intervals, as designed. The recorded parameters included information about driver gaze direction (eyes on or off the road as well as specific predefined gaze zones), driver-facing camera system validation, and various vehicle dynamic metrics (such as steering wheel angle and accelerator and brake pedal status).<sup>32</sup>

In the 5 seconds before the crash, the Ford driver was alternating glances between the infotainment console (where navigation information would have been presented) and the front windshield, with considerably longer glance durations (between 1 and 1.6 seconds) to the infotainment console.<sup>33</sup> During these 5 seconds, the driver's forward glances (to the front windshield) were limited to three glances totaling a maximum of 0.4 seconds, including the last glance of 0.2 seconds before impact (see figure 8). The DMS module also recorded that AEB activation was not requested by the vehicle during this time.

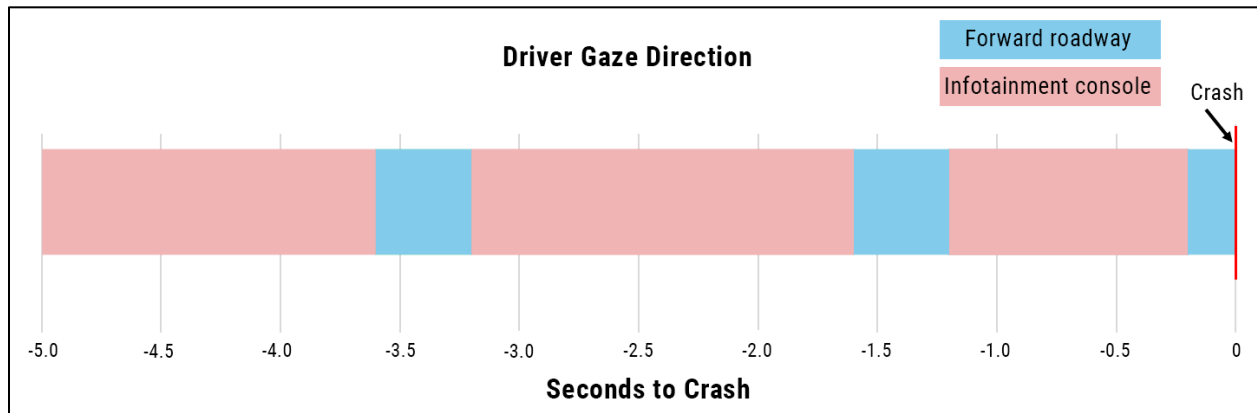
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<sup>30</sup> These AEB-related data elements indicated that the driver did not disable the system and that AEB engagement was not requested by the vehicle because the system did not detect a forward hazard. Reporting of these separate elements is particularly useful when determining whether non-activation resulted from the system being disabled by the driver or from no hazard being detected. The minor steering angle changes are attributed to the system maintaining the lane position.

<sup>31</sup> Ford refers to this module as the camera module rear. The factual reports and attachments in the public dockets for the [San Antonio](#) and [Philadelphia](#) crash investigations use Ford's terminology.

<sup>32</sup> Data showed that the accelerator and brake pedals were not depressed in the 5 seconds before the crash, and the minor steering wheel angle changes (consistent with the system maintaining lane position) indicated a lack of any evasive maneuver by the system or the driver.

<sup>33</sup> During an interview with the SAPD, the Ford driver reported following navigation directions to a charging station during the trip in which the crash occurred. For more information, see section 1.2.5.1.



**Figure 8.** Driver gaze information in the last 5 seconds before the crash.

Further, the DMS module recorded variables that assess driver distraction based on gaze patterns over time, along with the system's confidence in these assessments (on a 5-point scale, representing low to high confidence). These variables indicated to the system that the driver was *attentive* and not distracted during the 5-second precrash period, with the system's confidence in this determination ranging between *medium* and *high*. The system did not provide any alerts to the driver during this 5-second period.

The DMS module also captured a single image of the driver 2 seconds before impact, as designed.<sup>34</sup> The image showed the driver sitting upright and facing forward with his head resting (or nearly resting) on the headrest and slightly rotated to the right. The driver's left eye appeared closed and his right eye partially open. He was wearing glasses. The driver's hands were not visible in the image, nor were any objects or other obstructions.

**BlueCruise Module.**<sup>35</sup> The BlueCruise module is an in-vehicle module that processes and records various ADAS-related parameters and captures forward-facing camera images when triggered by specific conditions (for example, ACM activation or AEB engagement). The NTSB removed this module from the vehicle with the assistance of Ford technicians. At the request of the NTSB, Ford retrieved and decrypted the data from the module. Analysis of the retrieved data revealed that the BlueCruise module did not record any information related to the crash. Therefore, some critical precrash information was not available, including detection of a forward vehicle by different sensor systems along with their confidence levels, determination of the forward vehicle's movement (as moving or stationary), FCW or AEB activation,

<sup>34</sup> The image was recorded as a PNG file with 1280-by-963-pixel resolution at 24 bits per pixel.

<sup>35</sup> Ford refers to this module as the image processing module A. The factual reports and attachments in the public dockets for the [San Antonio](#) and [Philadelphia](#) crash investigations use Ford's terminology.

images from the forward-facing camera for 2 seconds precrash and 3 seconds postcrash, and other information typically also captured by other modules.

Ford suggested that the recording failure might have resulted from a sudden loss of electrical power needed for data storage. Unlike ACM recording, which is mandated by federal regulation 49 *Code of Federal Regulations (CFR)* Part 563, "Event Data Recorders," the recording of ADAS-related data is neither required nor federally regulated for voluntary implementation.

**Telematic Data Programs.** *Telematics* refers to data that are recorded and transmitted wirelessly to the automaker as opposed to being stored in a component or module of the vehicle. Ford's telematics data collection consisted of several programs, each with different goals. When triggered by certain conditions meeting criteria designated by Ford, these programs recorded information at varied intervals for the automaker's internal evaluation of the BlueCruise system.<sup>36</sup> Initial activation of BlueCruise requires driver consent to share data with Ford and participate in its telematics data programs, but vehicle owners can later opt out of data sharing without losing access to BlueCruise functionality.

The Telematic One program records a broad set of parameters from program-eligible vehicles as continuous data (at 1-Hz intervals) when a vehicle is traveling on Blue Zone roads. The program periodically transmits these data over cellular or Wi-Fi networks to Ford servers, depending on wireless signal strength. The recorded parameters include vehicle dynamics such as speed, yaw rate, and acceleration. The Telematic One program also records parameters related to ADAS functionality and supporting metrics such as BlueCruise status, hands-off-wheel or eyes-off-road alerts, location, detected roadway hardware, roadway markings, and lane width.

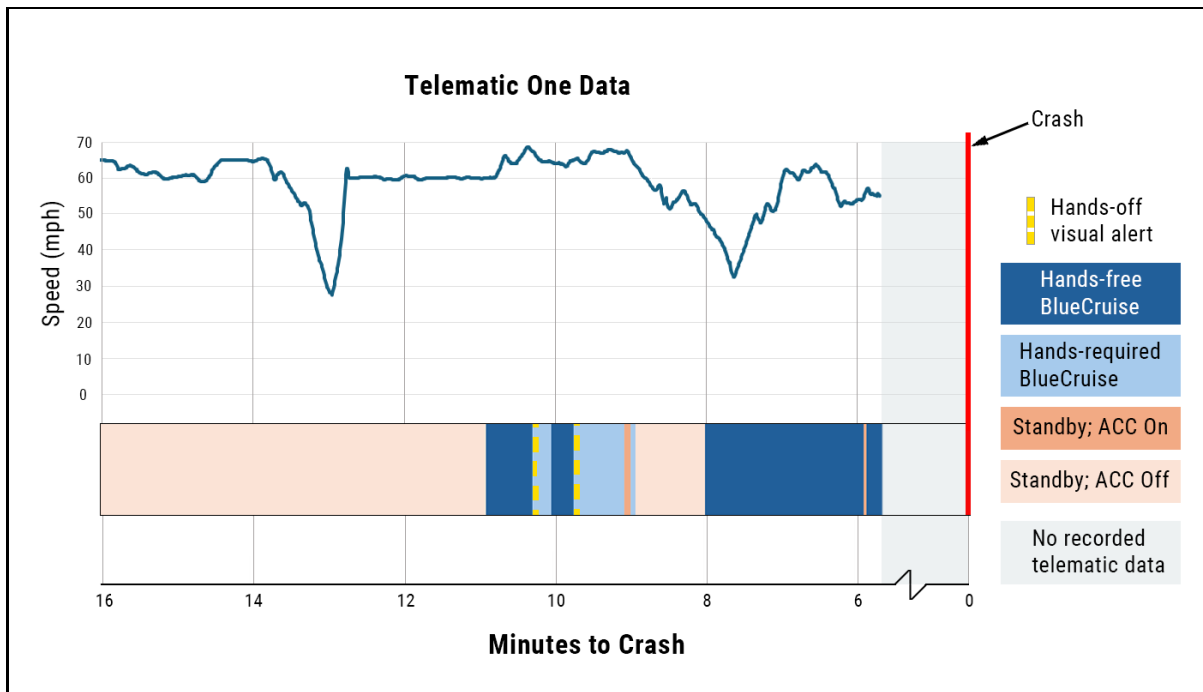
The crash-involved Ford Mach-E was part of the Telematic One data collection program, and the recorded dataset captured a portion of the crash trip but not the crash itself. The recorded data spanned about 10 minutes, ending approximately 5 minutes and 30 seconds before the crash. The data showed multiple transitions between different driving modes (manual, ACC, and BlueCruise). The data also showed some variability in the Ford's speed during this interval. A vehicle operating in L2 mode may show a wide range of speeds, with lower speeds indicating slower-moving and likely denser traffic.

During this time, two visual alerts were presented in the instrument cluster for the driver to keep hands on the steering wheel (see figure 9). Both alerts occurred as BlueCruise transitioned from hands-free to hands-required mode; in both instances, the system detected driver-applied steering wheel torque within 2 seconds of the

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<sup>36</sup> Ford aggregates and deidentifies data for system-level testing and evaluation, although individual vehicles can be linked to specific telematic datasets for investigative purposes.

alert. Telematic One data indicated that the last recorded trip before the crash trip ended about 8:00 p.m. on February 23, the night before the crash.



**Figure 9.** Telematic One data from the San Antonio crash, depicting driving mode transitions, hands-off driving alerts, and vehicle speed, covering a portion of the crash trip and ending approximately 5 minutes and 30 seconds before the crash.

The Telematic Two program records limited data regarding DMS activity during hands-free and hands-required BlueCruise operation.<sup>37</sup> When DMS-related variables change state (for example, when the DMS issues an alert for a driver to return their gaze to the forward roadway), the program transmits a limited set of variables. The recorded information includes date and time (hour/minute/second), vehicle speed, odometer value, and parameters related to driver eye gaze (on-road or off-road) and distraction alert status.

The crash-involved Ford was part of the Telematic Two data collection program, and the recorded dataset captured the crash trip. The initial recording began approximately 25 minutes before the crash, and the last recorded data sample occurred 6 seconds before the crash.<sup>38</sup>

<sup>37</sup> For this program, Ford collects data from a limited number of randomly selected vehicles equipped with DMSs.

<sup>38</sup> This report aligned the Telematic Two data timestamp with the recorded timestamp in the DMS module.

The data showed multiple transitions between different driving modes as well as two bi-modal alerts to the driver to return his gaze to the forward roadway, presented at 29 seconds and 8 seconds before the crash.<sup>39</sup> Both alerts were the first bi-modal alert in the warning progression sequence during hands-free operation.<sup>40</sup> However, Telematic Two data do not distinguish between different timings of the first bi-modal alert, whether it was triggered after 5 or 8 seconds of driver off-road gaze.<sup>41</sup>

#### **1.2.4.2 Honda**

The Honda involved in this crash was a 1999 CR-V SUV. The vehicle's structure sustained extensive deformation that extended to the rear of the second-row doors (see figure 10). The bottom of the rear hatchback surface and rear-mounted spare tire were angled downward approximately 45° relative to the ground. The right rear tire was oriented 90° horizontally and nearly parallel to the ground. The tops of both the left and right A-pillars were displaced downward and inboard. The front roof header showed marked downward displacement on the right side at approximately the front seat centerline. Examination of the vehicle's undercarriage revealed that the drive shaft had separated from the front axle at the differential, and a deep gouge and crack were present on the front end of the fuel tank. There was one unrepaired safety recall for this vehicle but no active defect investigations.<sup>42</sup>

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<sup>39</sup> (a) Telematic Two data do not record the specific zone where a driver's gaze is directed. Instead, it only records whether the driver is looking at the forward roadway (on-road) or not (off-road). (b) The recorded data do not distinguish between system- and driver-initiated mode changes.

<sup>40</sup> To resolve these alerts, the DMS would need to detect that the driver's gaze had returned to the forward roadway.

<sup>41</sup> The initial alert always occurs after 5 seconds of continuous off-road gaze. The timing and type of the first bi-modal alert depends on where the driver is looking. If the driver's gaze is off-road and away from the instrument panel, the system issues the bi-modal alert as the initial alert. If the driver's gaze is on the instrument panel, the system first issues a visual-only alert, followed by a bi-modal alert 3 seconds later if the driver does not return their gaze to the forward roadway.

<sup>42</sup> For more information, see [Check for Recalls: Vehicle, Car Seat, Tire, Equipment | NHTSA](#). The unrepaired safety recall was issued on January 17, 2020, for the vehicle's non-azide, or alternative chemical, driver airbag inflators.



**Figure 10.** Rear left view of damage to the Honda.

The rear impact and subsequent rollover resulted in severe intrusion into the occupant space. The rear occupant compartment seatbacks were pushed forward to the front quarter of the rear doors. The driver's seatback was reclined approximately 50° from vertical with leftward angular displacement. The roof's peak downward deflection occurred near the right front passenger seat's centerline and extended rearward past the middle of the headrest. The roof above the driver's seat was significantly dented inward and showed evidence of contact with the driver.

SAPD body camera video footage documented that when officers arrived at the crash scene, the Honda's tail- and headlights were illuminated, and the left upper bulb of the taillight assembly (hazard light) was flashing. The instrument panel displayed activated hazard lights. The NTSB removed both the left and right taillight assemblies for advanced laboratory examination. This examination revealed evidence of filament stretching in the left middle bulb (the indicator for the brake and parking light). *Filament stretching* is a deformation associated with hot shock and occurs when an incandescent bulb filament is energized (the bulb is illuminated) and at an elevated temperature when subjected to sudden mechanical loading, such as during a vehicle crash. This indicated that either the brake light or the parking light was energized at the time of the crash.<sup>43</sup>

The NTSB could not download the ACM data due to the age of the vehicle. Working with Honda, the NTSB attempted to retrieve historical fault code information but was unable to do so because the vehicle's transmission shift position was stuck in the driving gear (rather than neutral or park).<sup>44</sup> Although the Honda technician was

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<sup>43</sup> The left middle bulb had two filaments, one of which showed evidence of stretching. However, the investigation could not determine whether that filament functioned as a brake light or parking light indicator.

<sup>44</sup> *Fault codes* (also called diagnostic trouble codes) are standardized alphanumeric codes generated by a vehicle's on-board diagnostics system to identify and diagnose specific malfunctions in components or systems like the engine, transmission, or emissions.

able to view existing diagnostic trouble codes, the only code present was for the supplemental restraint (airbag) system.

## **1.2.5 Driver Information**

### **1.2.5.1 Ford Driver**

The Ford driver was a 44-year-old male residing in Houston, Texas, with a Texas Class C and M (non-commercial vehicle and motorcycle) driver's license issued in August 2021. His license carried a corrective lens restriction. A review of his Texas driving record revealed no prior crashes or moving violations.

Cell phone records obtained for the driver showed limited activity, with the driver sending no text messages and making no phone calls during the 3 hours before the crash. The SAPD postcrash body camera footage showed the driver with a second cell phone that was determined to be associated with a Voice Over Internet Protocol (VOIP) number. However, the NTSB was unable to obtain phone records from the VOIP provider.<sup>45</sup>

A review of the driver's pharmacy records revealed no significant findings. The SAPD crash report indicated that the Ford driver was evaluated on scene for possible intoxication and that no signs were found.<sup>46</sup> SAPD officers also interviewed the driver at the scene.<sup>47</sup> During this interview, the driver stated that he had been visiting a friend in San Antonio and was returning to Houston, having left his friend's residence approximately 30 minutes before the crash. He explained that he was following navigation directions to a charging station and reported that the BlueCruise system was engaged at the time of the collision. Regarding the crash itself, the driver stated that he believed a vehicle was stopped in the center lane and that he did not see it, remarking, "I saw a black thing, and that's about all."

Approximately 2 weeks after the crash, Ford representatives spoke with the driver and shared their conversation notes with the NTSB. According to these notes, the driver did not recall seeing taillights on the stopped vehicle or receiving any alerts from his vehicle's systems. He stated that he did not use his phone but

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<sup>45</sup> The NTSB had several email exchanges and sent multiple subpoena requests, but as of the date of this report, Google, the owner of the VOIP number, has not provided any data.

<sup>46</sup> The SAPD body camera footage indicated that the officer performed a horizontal gaze nystagmus test (an indicator of impairment due to central nervous depressant substances, including alcohol). Per SAPD policy, a report and a checklist for a field sobriety test is generated only when the driver is arrested.

<sup>47</sup> (a) The interview was captured on the officer's body camera video. (b) Texas does not automatically require toxicological testing in fatal crashes (see Texas Transportation Code [section 724](#)).

acknowledged that he might have glanced at the center console (infotainment) screen where navigation directions to a charging station were being displayed. The notes also indicated that the driver stated that “he was definitely paying attention to the road...” The NTSB’s subsequent requests to interview the driver were declined through his attorney.

### **1.2.5.2 Honda Driver**

The Honda driver was a 56-year-old male who held a Texas Class C and M driver’s license last issued in August 2019. His license had no restrictions, and examination of his Texas driving record showed no crashes or moving violations.

The NTSB did not obtain phone records for the Honda driver, as no phone was recovered from the vehicle and the investigation could not determine whether he possessed one.<sup>48</sup> Although we spoke with a relative of the driver, the NTSB was unable to locate anyone with knowledge of his activities in the days preceding the crash.

The Honda driver’s medical records indicated that he had a history of high blood pressure, which was being managed with medication. Postmortem toxicology testing identified ethanol at 0.326 grams per deciliter (g/dL) in femoral blood and 0.357 g/dL in vitreous fluid.<sup>49</sup> *Ethanol* is the intoxicating alcohol in beer, wine, and liquor. Texas’s legal standard for presuming that a driver is impaired by alcohol is 0.08 g/dL.<sup>50</sup> The autopsy determined that the cause of death was head and brain injuries. The autopsy also identified moderate coronary artery disease and an enlarged appearance of the heart.

### **1.2.5.3 Witness**

The NTSB interviewed a witness to the crash who was traveling east on I-10 in a 2017 Chevrolet Cruze ahead of the Ford. The witness reported that she was in the center lane preparing to exit at the next exit ramp when she narrowly avoided colliding with a stationary vehicle (the Honda). She described making a faster-than-

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<sup>48</sup> No phone was recovered from the vehicle, and NTSB investigators could not locate a working cell phone number associated with the driver.

<sup>49</sup> Vitreous fluid tends to have slightly higher water content than blood, which can result in vitreous fluid ethanol levels exceeding blood ethanol levels after alcohol consumption (see Kugelberg and Jones 2007).

<sup>50</sup> (a) See [Texas Penal Code § Title 10 Chapter 49](#) for more information on Texas’s intoxication laws. (b) This report refers to legal *standards* rather than legal *limits* because impairment can begin at blood alcohol content levels well below a state’s standard for presuming impairment without the need for any additional evidence.

usual lane change to the right but emphasized that she did not “jerk” the vehicle during this maneuver.<sup>51</sup>

The witness stated that while looking in her center rearview mirror after changing lanes, she saw a vehicle striking the stationary one that she had just evaded. She provided varying estimates of the timeframe between her lane change and the collision, ranging from 5 to 15 seconds.<sup>52</sup> The witness estimated her travel speed to be 65-70 mph and noted that she was manually controlling her speed because her vehicle lacked cruise control capabilities.

The witness stated that she did not recall seeing any illuminated hazard, tail, brake, or license plate lights on the Honda. She described traffic conditions on eastbound I-10 as sparse at that time. When questioned by investigators, she could not recall either passing or seeing the Ford before the crash occurred. The witness made a 911 call after observing the crash.

## **1.3 Philadelphia, Pennsylvania, Crash**

### **1.3.1 Crash Narrative**

On March 3, 2024, at 3:16 a.m. eastern standard time, a multivehicle collision occurred in a work zone on northbound Interstate 95 (I-95) near the Betsy Ross Bridge in Philadelphia, Pennsylvania.<sup>53</sup> Before the crash, two vehicles, a 2012 Hyundai Elantra and a 2006 Toyota Prius, were stationary in the left travel lane, with the Elantra positioned behind the Prius. Simultaneously, a 2018 Toyota Corolla was traveling in the center lane, approaching these stationary vehicles. The speed limit in the work zone was 45 mph, reduced from 55 mph.

At the same time, a 2022 Ford Mustang Mach-E SUV, operated by a 23-year-old driver, was traveling north in the left lane of I-95. Traveling at an ACM-recorded speed of 72.4 mph, the Ford collided with the rear of the stationary Elantra, propelling it forward into the Prius. The impact redirected both the Prius and the Elantra forward and rightward, causing them to strike the passing Corolla.

The recorded data showed that the Ford driver had activated the vehicle’s hands-free BlueCruise partial automation system and was maintaining a nearly constant speed immediately before the collision. Neither the Ford’s ACM nor any

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<sup>51</sup> None of the Ford’s systems recorded the presence of the Chevrolet Cruze.

<sup>52</sup> The witness gave differing estimates of the time at different points during the interview.

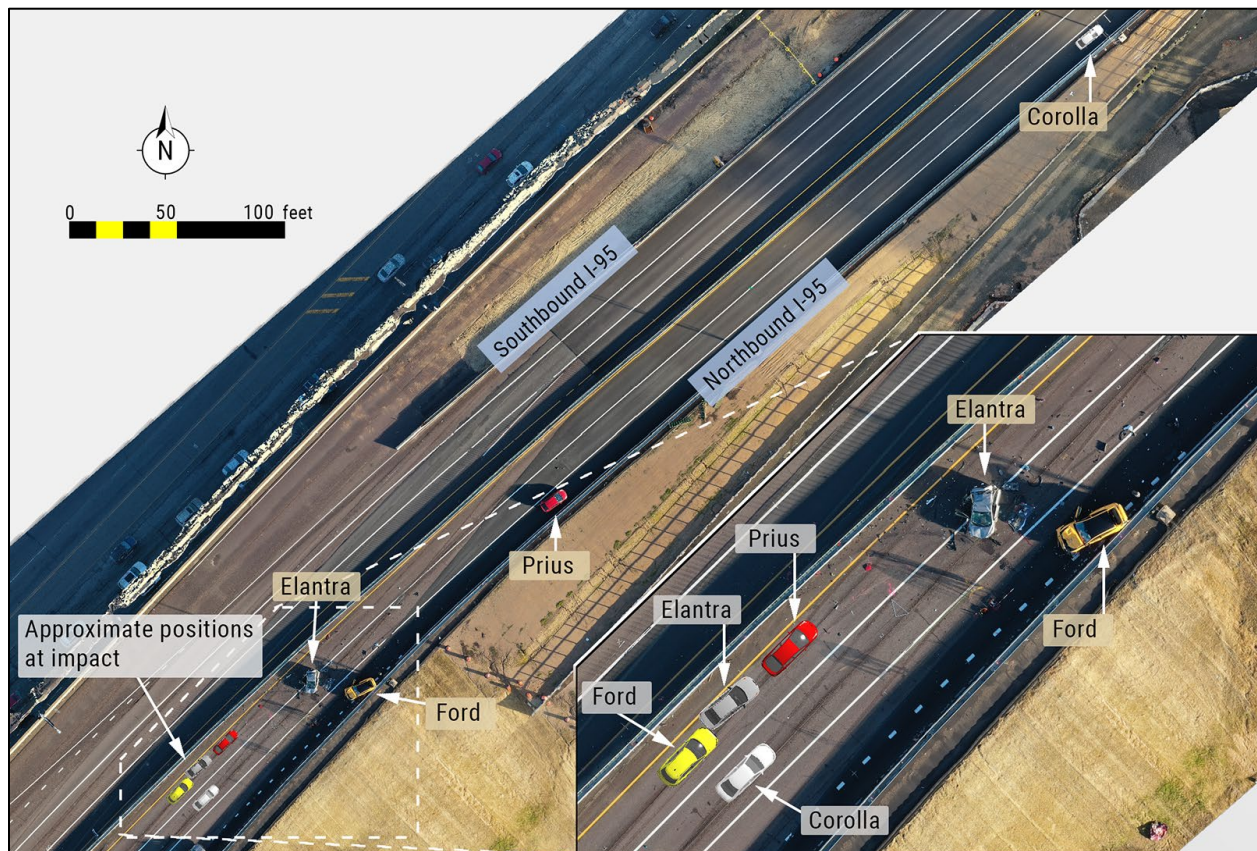
<sup>53</sup> (a) In this report, all times pertaining to the Philadelphia crash investigation are eastern standard time. (b) Visit [nts.gov](https://www.nts.gov) to find additional information in the [public docket](#) for this NTSB investigation (case no. HWY24FH008). Use the [CAROL Query](#) to search safety recommendations and investigations.

other data-recording modules registered any driver- or system-initiated braking or evasive steering before impact.

The Pennsylvania State Police (PSP) crash report indicated no traffic congestion or vehicle queue in the area. The crash report also indicated that the Prius was disabled, and the Elantra driver had parked behind the Prius to provide assistance.

The forward-facing camera imagery recorded by the Ford's BlueCruise module showed the Elantra stopped in the left travel lane with a slight rightward angle and its left rear tire positioned close to the left shoulder line. Investigators were unable to determine the exact position of the Prius, including its precise orientation and distance from the Elantra.

The postcrash evidence path included intermittent tire friction marks, scattered vehicle components, and fluid deposits extending toward the final positions of all involved vehicles (see figure 11). No precrash tire marks typically associated with emergency braking or evasive steering maneuvers were observed.



**Figure 11.** Orthomosaic image of the crash area showing the approximate positions of the involved vehicles at impact and at final rest. (Source: PSP; annotated by NTSB)

The investigation determined the approximate vehicle orientations at impact based on analysis of physical evidence, recorded images, and likely postcrash movement trajectories. The Corolla's exact position during the sequence remains uncertain due to unknown vehicle speed at the time of involvement.

After the initial collision, the Ford rotated counterclockwise nearly 180° from its initial direction of travel, coming to rest facing southwestward in the right travel lane approximately 94 feet from the area of initial impact. The Elantra came to rest approximately 76 feet north of the impact area and 24 feet west of the Ford's position. Scene documentation showed the Elantra straddling the left and center lanes after having rotated counterclockwise just over 180° from its original orientation. The Prius came to rest facing northward in the right travel lane about 223 feet north of the impact area, positioned at a slight rightward angle and centered within the lane. The Corolla driver maintained control of the vehicle and brought it to a controlled stop about 352 feet north of the Prius' final position.

**Preceding Crash.** The primary crash sequence was preceded by another incident involving a vehicle attempting to avoid the stationary Elantra and Prius. Shortly before the primary crash sequence began, a 2015 Hyundai Genesis traveling north in the left lane ahead of the Ford executed an evasive maneuver to avoid the stopped Elantra and Prius. Although the Genesis successfully evaded the stationary vehicles, its driver subsequently lost directional control, resulting in a collision with the roadside longitudinal barriers.<sup>54</sup> In the postcrash interview with the PSP, the Genesis driver stated that she was driving in the left lane when she saw a crash ahead and lost control of her vehicle after swerving to avoid striking the vehicle in front of her. (Note that in her interview statement, the driver mentioned a crash when referring to the stationary Elantra and Prius. The PSP accident report describes this event as a vehicle breakdown.)

Distinctive tire friction marks consistent with the Genesis' loss of control were visible in the center travel lane just north of the final rest positions of the Elantra and Ford. These marks exhibited a characteristic arc pattern from the center lane toward the left lane and median barrier, displaying indicators of vehicle rotation as they continued northward. The friction marks led directly to evidence of impact with the right-side barrier, followed by signs of sudden path deflection and continued vehicle rotation. The tire mark evidence terminated at the Genesis' final rest position, approximately 598 feet north of the Prius' final position. At rest, the Genesis was oriented perpendicular to the travel lanes, facing westward with its rear section against the right barrier. The Genesis' path of travel through the scene crossed the at-rest locations of at least some of the vehicles involved in the later primary crash.

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<sup>54</sup> The PSP documented this incident as a separate, single-vehicle crash.

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### 1.3.2 Injuries, Occupant Protection, Emergency Response, and Crash Notification

As a result of the crash, the Prius and Elantra drivers died. Examination of PSP crash documentation and images captured by the Ford's forward-facing camera confirmed that the Prius driver was standing outside his vehicle near the left side of the Elantra at the time of impact. According to PSP evidence, the collision propelled the Prius driver over the median barrier onto the southbound travel lanes, where he was subsequently struck by one or more southbound vehicles.

The Elantra driver was found in the northbound center lane, approximately 5-6 feet from his vehicle's final rest position. Physical evidence suggested that he was carried along the vehicle's postcrash trajectory. Vehicle and roadway evidence indicated that he was in the process of exiting his vehicle when the impact occurred.

The Ford driver sustained minor injuries, and the Corolla driver was uninjured. None of the vehicles experienced a postcrash fire. ACM data showed that the Ford driver was restrained with a lap/shoulder belt. The PSP crash report indicated that the Corolla driver was restrained with a lap/shoulder belt. According to the PSP crash report documenting the preceding collision, the Genesis driver was uninjured and was wearing a lap/shoulder belt during the incident.

An emergency response was initiated at 3:21 a.m.<sup>55</sup> The first police units arrived on scene 9 minutes later, followed by emergency medical services and fire personnel from the Philadelphia Fire Department. Additional response came from the Pennsylvania Department of Transportation (PennDOT) and Philadelphia Police Department personnel, who assisted with the complete closure of I-95.<sup>56</sup>

Ford learned of this crash on April 4, 2024 (about 1 month after it occurred) from NTSB investigators who contacted Ford to obtain initial details about the crash.<sup>57</sup> Ford then submitted an incident report to NHTSA, as required by SGO 2021-01. For detailed discussions of SGO 2021-01, see sections 1.4 and 2.3.1.

According to documentation that Ford provided to the NTSB (collected as part of a telematic data program related to this system), the vehicle's ACN (911 Assist) system initiated an emergency call approximately 2 seconds after the crash

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<sup>55</sup> The PSP crash report indicated the time of the crash as 3:20 a.m. The time of the crash in this NTSB report, 3:16 a.m., is based on the recorded data from the Ford Mach-E.

<sup>56</sup> The highway remained closed for approximately 7 hours, reopening to traffic at 10:39 a.m.

<sup>57</sup> A PSP officer contacted an NTSB investigator on April 2, 2024, inquiring if we had experience with Ford BlueCruise for a crash that the PSP was investigating, which prompted the NTSB to contact Ford.

occurred.<sup>58</sup> This call process was completed after several connection attempts, about 7 minutes after initiation. The transmission included information about restraint system deployment status and basic vehicle dynamics but did not include data related to ADAS feature status.<sup>59</sup> However, the NTSB could not confirm that Philadelphia emergency services received this call.<sup>60</sup> Ford stated that the 911 Assist call may have been routed to an adjacent emergency center due to the crash location's proximity to the state border.<sup>61</sup>

### 1.3.3 Roadway Information

The initial impact occurred in the left lane of northbound I-95, approximately 0.75 miles north of the Betsy Ross Bridge toll road (New Jersey Route 90). At this location, I-95 had three travel lanes in each direction and was within a long-term work zone due to a multi-year reconstruction project that included lane realignment, reduced lane width, and at the time of the crash, a lower posted speed limit of 45 mph instead of 55 mph.<sup>62</sup> No construction personnel were present when the crash occurred.

The northbound through-lanes at the crash location were 11 feet wide, reduced from the standard 12 feet.<sup>63</sup> An acceleration lane from the Betsy Ross interchange merged with the right travel lane at this location, terminating approximately 118 feet north of the crash location. Through-lanes were delineated by solid white 6-inch-wide pavement striping, and short broken white striping separated the acceleration lane from the right travel lane. The left shoulder was 4.5 feet wide and was marked by solid yellow 4-inch-wide pavement striping. There was no right

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<sup>58</sup> This telematics program, which is distinct from Telematic One and Telematic Two, collects information solely based on ACN (911 Assist) activations.

<sup>59</sup> According to Ford, the 911 operator would have heard the following prompt after answering this call from the 911 Assist system: "Attention, a Ford Mustang Mach-E has been in a frontal crash at a speed of 64 mph, and airbags have deployed. Press 1 to get the GPS location of the vehicle; press 0 to open the line to talk to the occupant(s)." The reported speed of 64 mph may have been captured by the Ford shortly after the crash occurred.

<sup>60</sup> The PSP reported having no awareness of a 911 call received from the vehicle's emergency assist system.

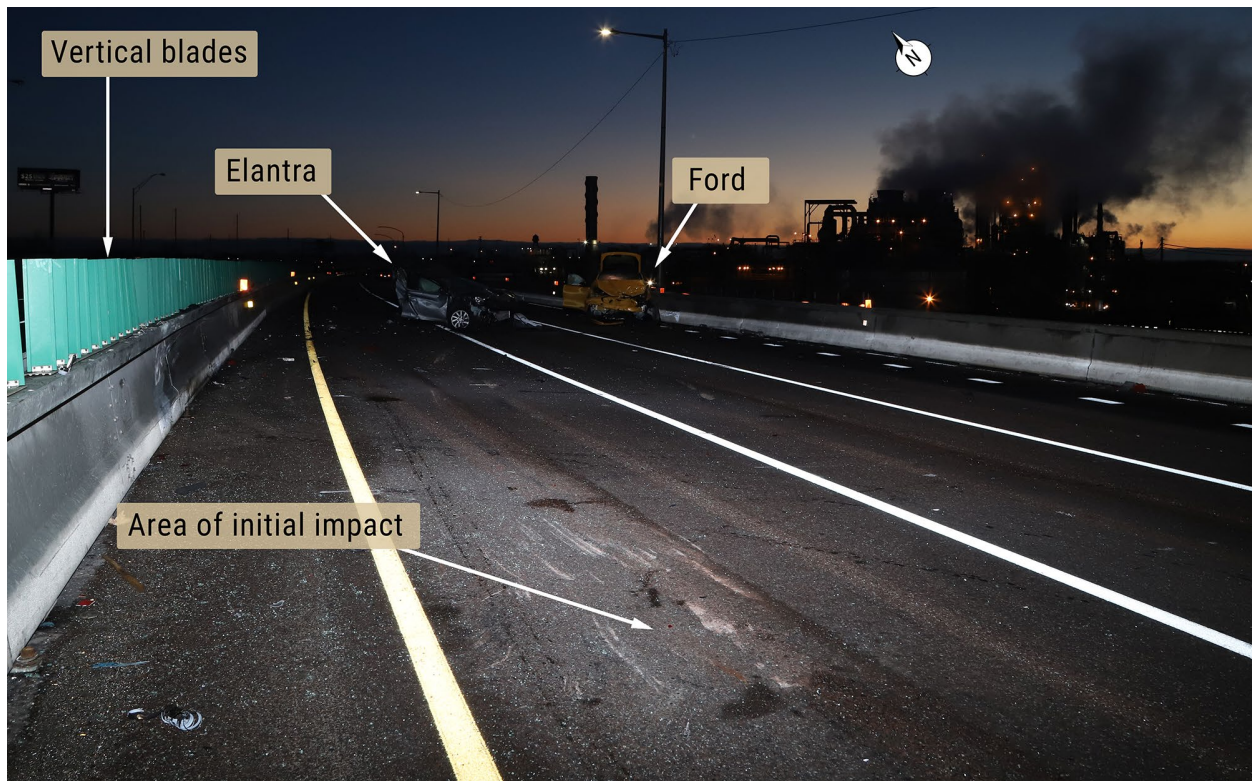
<sup>61</sup> Ford representatives stated "...because the highway is located directly across from New Jersey, it's possible that the call was routed to another Public Safety Answering Point center..." The NTSB did not review the 911 records from the adjacent centers in New Jersey.

<sup>62</sup> According to the *Manual on Uniform Traffic Control Devices for Streets and Highways*, long-term refers to work that occupies a location for more than 3 days (FHWA 2023, p. 841, section 6N.01, "Work Duration").

<sup>63</sup> Although they were reduced from the standard 12 feet, the 11-foot-wide through-lanes were still within lane width requirements for Blue Zone roads.

shoulder. No shoulder rumble strips were present on either side. PSP scene photographs showed that the pavement markings exhibited clearly visible retroreflective properties.

The roadway surface was dry at the time of the crash. The crash occurred during nighttime. Luminaire fixtures installed along the right roadway edge with mast arms extending over the rightmost travel lane provided roadway illumination along northbound I-95. The crash occurred between two light fixtures, one located 114 feet north and another 170 feet south of the crash location. As shown in figure 12, PSP photographic documentation confirmed minimal direct illumination at the crash location. The separation between the northbound and southbound traffic was provided by a temporary, portable, 36-inch-high steel barrier system, atop which were 18-24-inch-high vertical blades to reduce glare from oncoming vehicles.<sup>64</sup> According to PennDOT documentation, the barrier adjacent to the right lane was a temporary concrete barrier system.



**Figure 12.** North-looking view of I-95 showing the dark nighttime conditions, location of the crash, roadway barrier vertical blades, and rest positions of the Ford and Elantra. (Source: PSP)

<sup>64</sup> According to manufacturer specifications, the BarrierGuard 800 portable steel barrier system is designed to meet either TL-3 or TL-4 crash performance standards, depending on its specific installation configuration.

For this construction phase, PennDOT implemented a lateral shift of the travel lanes from left to right. The area where the crash occurred was approximately 1,885 feet into a realigned 2,464-foot-long rightward curve.<sup>65</sup> This curve transitioned into a temporary tangent section beginning approximately 232 feet north of the crash site.<sup>66</sup> The crash occurred on a 500-foot-long vertical curve that had 1% approach and departure vertical slopes.<sup>67</sup>

Multiple advance warning and regulatory signs were installed along northbound I-95 approaching the crash location within the work zone, alerting drivers to work zone conditions. This signage included:

- a speed reduction warning sign positioned 6,317 feet before the crash location;
- four separate 45-mph regulatory speed limit signs with work zone notification plaques mounted above, placed along both the left and right roadsides at distances ranging from 5,217 feet to 917 feet before the crash location; and
- lane narrowing warning signs at two locations, the nearest being 1,217 feet before the crash location.<sup>68</sup>

Traffic volume data collected by PennDOT in 2023 indicated an annual average daily traffic volume of 163,000 vehicles along this section of I-95, 5% of which were trucks.

The area of I-95 where the crash occurred was a Blue Zone-designated roadway. At the time of the Philadelphia crash, the Ford's map data were the most recent mapping data available for Ford. Ford reported that at the time of the crash, the high-fidelity mapping data on the Ford included a 55-mph speed limit for this section of I-95; it did not reflect the reduced work zone speed limit.

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<sup>65</sup> Before construction activities began, this highway section featured a rightward curve with a radius of 5,729 feet.

<sup>66</sup> Before construction activities began, the northern end of the 5,729-foot-radius curve transitioned into a rightward compound (spiral) curve with an approximate radius of 4,411 feet.

<sup>67</sup> A *vertical curve* or *vertical crest curve* is a parabolic, longitudinal curve used in highway engineering to provide a smooth transition between two *slopes* to prevent abrupt changes in elevation. Vertical curves help to ensure adequate sight distance, driver comfort, and proper drainage.

<sup>68</sup> (a) The regulatory speed limit signs featured two size configurations (48 by 60 inches and 30 by 36 inches) and were placed on either the right side of the roadway only (at one location) or on both the left and right sides. These speed limit signs were placed at four locations in advance of the crash location: 5,217 feet, 1,717 feet, 1,067 feet, and 917 feet. (b) Warning signs alerting drivers to narrowing lanes were positioned at two locations in advance of the crash location: 1,867 feet and 1,217 feet.

## **1.3.4 Vehicle Information**

### **1.3.4.1 Ford Mach-E**

#### **1.3.4.1.1 General**

The vehicle involved in this crash was a 2022 Ford Mustang Mach-E in the California Route 1 trim configuration—a battery-electric, all-wheel-drive SUV equipped with a 91-kilowatt-hour extended-range lithium-ion battery. Ford representatives confirmed that this was the factory-installed software version and that the vehicle had an active BlueCruise subscription.<sup>69</sup> A search of the vehicle recall database revealed no unrepaired safety recalls or open defect investigations for this vehicle.<sup>70</sup> Refer to section 1.1 for a detailed description of the driving technologies, including ADAS and BlueCruise partial driving automation, that were equipped on the Ford Mach-E vehicle involved in the Philadelphia crash.

#### **1.3.4.1.2 Damage**

The Ford sustained crash-related damage mostly to its front end, extending across approximately three-quarters of the vehicle width about 45 inches inboard from the driver's side (see figure 13). The hood sustained substantial displacement and vertical deformation, and the left front fender exhibited significant contact damage. The vehicle did not have a measurable reduction in wheelbase or compromise to the occupant compartment. The Ford did not experience a postcrash fire.

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<sup>69</sup> The vehicle was purchased new by the owner and came with a free 3-year subscription to BlueCruise. According to the PSP crash report, the vehicle title owner shared the same last name and home address as the crash-involved driver.

<sup>70</sup> See [Check for Recalls: Vehicle, Car Seat, Tire, Equipment | NHTSA](#).



**Figure 13.** Front-left view (left) and front view (right) of damage to the Ford.

#### 1.3.4.1.3 Electronic Data

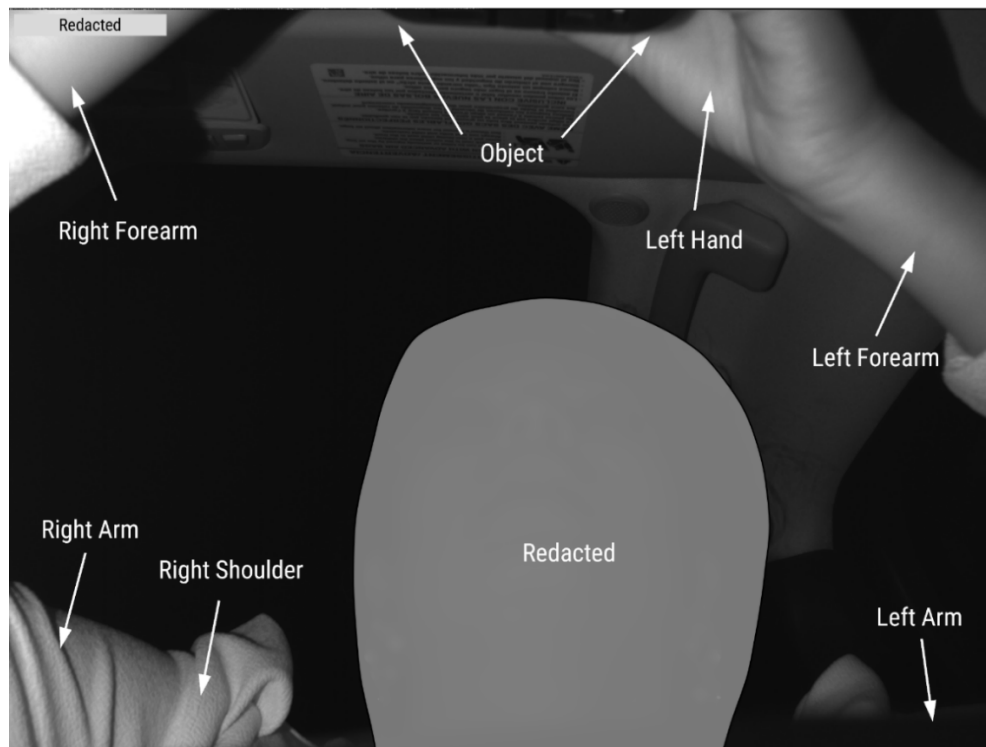
**Airbag Control Module.** The PSP removed the Ford's ACM and retrieved the data from the module. The ACM data showed that the module recorded the crash and captured 5 seconds of precrash data. According to these data, the crash occurred in the 16th minute of the vehicle's current ignition cycle, and the driver was wearing a seat belt. The ACM longitudinal crash data indicated a maximum longitudinal delta-V of -39.8 mph, 280 msec after the crash.

The ACM data showed that the Ford was traveling at a mostly consistent speed within the 5-second precrash period (between 70.9 and 72.4 mph), including a vehicle speed of 72.4 mph at the time of impact. The data also showed no braking, accelerator application, or evasive steering before the crash, and that the collision mitigation system (AEB) was enabled but not requested by the vehicle.

**DMS Module.** The NTSB requested the assistance of Ford technicians to retrieve data from the DMS module upon removal. Using the same methodology as in the San Antonio crash investigation, Ford technicians retrieved and decrypted the data from the module. The DMS module data captured 5 seconds of precrash and 1 second of postcrash data at 5-Hz intervals, as designed. Based on the data, the DMS had determined that the driver's gaze was directed at the forward roadway for the full duration of the 5 seconds before the crash.

The DMS module also recorded that AEB activation was not requested by the vehicle and that cruise control was active. The data element that recorded the driver's overall disengagement indicated that the driver was *attentive* during the 5-second precrash period, with the system assigning a *high* confidence level to this determination. The DMS module also captured a single image of the driver 2 seconds before the crash, as designed (see figure 14).

The captured image showed the driver sitting upright and facing forward with both eyes open. The headrest was not visible. The driver's left hand and right forearm/wrist appeared at the top of the image, positioned at approximately the 11 and 1 o'clock regions of the image. The driver's left hand was shown holding a barely visible dark object that was straight on the bottom with curved edges leading up to the left hand, with the thumb wrapped around it on the side facing the driver. The right wrist appeared near the object on the right side, while the right hand was outside the frame and not visible. For reference, the steering wheel was just outside and surrounding the image frame.



**Figure 14.** Still image captured by the DMS camera (annotated and redacted by NTSB).

**BlueCruise module.** The NTSB requested the assistance of Ford technicians to retrieve and decrypt the recorded data from the BlueCruise module upon removal. The BlueCruise module download confirmed that the module recorded the crash. As designed, the BlueCruise module captured 2 seconds of precrash and 3.8 seconds of postcrash data at 5-Hz intervals.<sup>71</sup> The recorded parameters captured system status for BlueCruise, FCW, and AEB (including availability and engagement), camera and radar-camera fusion signals, vehicle dynamics metrics, and driver gaze direction data

<sup>71</sup> The last 2.8 seconds of the postcrash data were invalid. Except for the vehicle speed, other variables reported in table 2 retained the same values between 0.2 seconds and 1.0 seconds postcrash.

(see tables 2 and 3).<sup>72</sup> The parameters also captured the longitudinal and lateral distance to a lead vehicle and the calculated time to collision (TTC).

**Table 2.** Crash-relevant parameters from the BlueCruise module with changing values during the crash sequence.

Time to collision (TTC) (seconds)	Vehicle speed (mph)	Camera-radar fusion detection: (1) longitudinal distance to lead vehicle (LV) [meters (feet) / TTC]; (2) lateral distance to LV; (3) type of detected vehicle and detection confidence level (0-5) <sup>a</sup>	Driver override of AEB (by steering or accelerator pedal)	FCW status
-2.0	71.1	(1) 71m (233 ft) / 7.3s (2) -4.65m (-15 ft) (3) Moving / Confidence = 0	No override	None
-1.8	71.0	(1) 71m (233 ft) / 7.2s (2) -5.05m (-16 ft) (3) Moving / Confidence = 0	No override	None
-1.6	70.9	(1) No vehicle <sup>b</sup> (2) No vehicle (3) Moving / Confidence = 0	No override	None
-1.4	70.8	(1) No vehicle (2) No vehicle (3) Moving / Confidence = 0	No override	None
-1.2	70.7	(1) No vehicle (2) No vehicle (3) Moving / Confidence = 0	No override	None
-1.0	70.9	(1) No vehicle (2) No vehicle (3) Moving / Confidence = 0	No override	None
-0.8	71.2	(1) No vehicle (2) No vehicle (3) Moving / Confidence = 0	No override	None
-0.6	71.5	(1) No vehicle (2) No vehicle (3) Moving / Confidence = 0	No override	None
-0.4	71.7	(1) 15m (49 ft) / 0.4s (2) 0.45m (1.5 ft)	No override	None

<sup>72</sup> For additional information, see the Vehicle Automation Attachment - IPMA Data in the public docket for the [Philadelphia](#) investigation.

Time to collision (TTC) (seconds)	Vehicle speed (mph)	Camera-radar fusion detection: (1) longitudinal distance to lead vehicle (LV) [meters (feet) / TTC]; (2) lateral distance to LV; (3) type of detected vehicle and detection confidence level (0-5) <sup>a</sup>	Driver override of AEB (by steering or accelerator pedal)	FCW status	
		(3) Stationary / Confidence = 0			
<b>-0.2</b>	72.0	(1) 8m (26 ft) / 0.2s (2) 0.75m (2.4 ft) (3) Stationary / Confidence = 0	No override	None	
<b>0</b>	72.3	(1) 0 (2) 0.95m (3.1 ft) (3) Stationary / Confidence = 0	No override	Yes <sup>c</sup>	
<b>0.2</b>	68.5	No vehicle	Moving / Confid. = 0	Override	Yes

<sup>a</sup> (1) Fusion-based detection confidence level ranges from 0 to 5, with level 5 (highest confidence) required for AEB engagement. FCW activation does not have an associated confidence threshold. (2) Lateral distance is measured from the center of the Ford's rear bumper to the detected forward vehicle's center, where negative values indicate rightward offset of the detected vehicle and positive values indicate leftward offset (the lead vehicle is to the left of the Ford). (3) TTC (time to collision) refers to the time remaining before impact with a detected hazard, calculated based on the relative direction and speed of both the vehicle and the hazard.

<sup>b</sup> If no vehicles (or other designated objects) are detected within 150 meters (492 feet), the "No vehicle" value is reported and "Moving" is set as a default vehicle type value.

<sup>c</sup> An FCW alert was requested between 200 msec before impact and the time of impact. Because the module does not record the time of execution of the requested command, it is unknown whether the FCW alert was actually presented to the driver. The driver had selected the normal alert timing setting for the FCW system.

**Table 3.** Crash-relevant parameters from the BlueCruise module that remained constant during the crash sequence.

Parameter	Value
BlueCruise mode	Hands-free in precrash period; "Off" in postcrash period
Threat detection by forward camera <sup>a</sup>	Not detected
AEB (Turned on; Disabled by brake module; Deceleration request; Activation) <sup>b</sup>	Yes; Not disabled; No request; Not applied
ACC (Status; Driver override by acceleration; Brake application)	Active; No override (a single "Override" value at 0.2 seconds postcrash); Not applied
DMS-categorized driver gaze zone	Front windshield
BlueCruise warning status (Eyes / hands off, resume control)	No warnings

<sup>a</sup> The forward-facing camera system did not detect a hazard and as such did not request AEB activation. Other variables that monitor forward camera operational factors (such as a blockage or environmental object) reported nominal values.

<sup>b</sup> The variable infers whether the driver had disabled AEB. "Not disabled" indicates that AEB was not disabled by the driver.

As designed, the BlueCruise module recorded six images captured by the Ford's forward-facing camera at 1-Hz intervals, from 2 seconds before to 3 seconds after the crash. The images were saved at a 120-by-160-pixel resolution. Figure 15 shows enlarged versions of the first three images in this sequence (from 2 seconds precrash to the moment of the crash), and figure 16 shows the last three images (from 1 to 3 seconds postcrash).



**Figure 15.** Enlarged versions of the images captured by the forward-facing camera at 1-Hz intervals, from 2 seconds precrash to the point of impact.



**Figure 16.** Enlarged versions of the images captured by the forward-facing camera at 1-Hz intervals, from 1 second postcrash to 3 seconds postcrash.

The first captured image (2 seconds before the crash) showed vehicle lights or reflectors and roadway lighting in the distance. The second image (1 second before the crash) showed a vehicle approximately 100 feet away (based on vehicle speed and impact time) in the left travel lane, with its left side aligned with the left edge of the travel lane.<sup>73</sup> The vehicle's center brake light was not illuminated.<sup>74</sup> Although the side tail/brake lights appeared illuminated in the image, this illumination could not be distinguished from reflection from the Ford's headlights. The image also showed the apparent shape of a person (pedestrian) on the vehicle's left side. The third image showed the same vehicle just before impact. The vehicle's center brake light was still not illuminated. The left tail/brake light appeared either not illuminated, reflecting minimal light, or obscured from view. The right tail/brake light was illuminated or reflecting light. The vehicle appeared offset to the left in the frame. The three postcrash images showed various parts of a damaged vehicle.

**Telematic Data Programs.** The Ford was part of the Telematic One data collection program, which is designed to record information including vehicle speed, acceleration, ADAS functionality, and BlueCruise status. However, the Telematic One program did not capture the Philadelphia crash or any part of the crash trip. The last precrash data point was recorded at 10:05 p.m. on March 2, the night before the crash.

The Ford was also part of the Telematic Two data collection program, which is designed to record DMS-related information such as driver eye gaze and distraction alert status as well as the date, time, and vehicle speed when a DMS alert occurs. The Telematic Two dataset captured at least a portion of the crash trip. The first recorded

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<sup>73</sup> At a speed of 72 mph, a vehicle travels 105.6 feet in 1 second.

<sup>74</sup> Center brake light or center high-mounted stop lamps are required by federal regulation (see [Federal Motor Vehicle Safety Standard 108](#)). This brake light illuminates when the brake pedal is depressed.

data point was approximately 16 minutes before the crash, and the last recorded data point was approximately 23 seconds before the crash.<sup>75</sup>

The data showed multiple transitions between different driving modes as well as one bi-modal alert to the driver to return her gaze to the forward roadway, presented 26 seconds before the crash (see table 4). This was the first bi-modal alert in the warning progression sequence. Because Telematic Two data do not differentiate between different timings of the first bi-modal alert, it could not be determined whether it was triggered after 5 or 8 seconds of the driver's off-road gaze.

**Table 4.** Crash-relevant Telematic Two data from the Philadelphia crash.

Time to crash (minutes, seconds) <sup>a</sup>	Vehicle Speed (mph)	Eyes On/ Off Road	Warning	BlueCruise State
-15m, 52s	0	Initial data point	Initial data point	Initial data point
-1m, 53s	77.3	Eyes off-road	None	Standby <sup>b</sup>
-1m, 47s	77.2	Eyes off-road	None	Off
-1m, 46s	77.4	Eyes off-road	None	Standby
-1m, 43s	77.7	Eyes on-road	None	Hands-required
-1m, 26s	78.1	Eyes on-road	None	Hands-free
-26s	71.1	Not determined	Alert	Hands-free
-23s	71.1	Eyes on-road	None	Hands-free

<sup>a</sup> This time is based on the recorded timestamp from the Telematic Two data and the DMS module-recorded time of crash of 3:16:11 a.m.

<sup>b</sup> *Standby* indicates that BlueCruise (either hands-required or hands-free) is available to be activated.

### 1.3.4.2 Hyundai Elantra

The first vehicle struck by the Ford was a 2012 Hyundai Elantra GLS, a four-door compact sedan. The Elantra sustained substantial rear contact damage extending across the full width of the vehicle (see figure 17). The damage was more severe on the right rear side, with structural intrusion into the passenger compartment as far as the front seat. The right rear wheel and suspension components were significantly displaced and deformed. Contact damage was also visible across the full width of the vehicle's front. The hood showed deformation, gouging, and material transfer consistent with the color of the Prius. The driver's-side door showed damage patterns consistent with having been open at the time of the collision, including the inner shell of the door being fractured and displaced and

<sup>75</sup> This report aligned the Telematic Two data timestamp with the recorded timestamp in the DMS module.

biological material on the back side of the door panel and along the left edge of the instrument panel.



**Figure 17.** Front left view (left) and rear left view (right) of damage to the Elantra.

The Elantra was equipped with an ACM capable of recording parameters related to restraint system activation, vehicle speed, and brake and accelerator application. PSP investigators retrieved the data from the Elantra's ACM.

The complete record included 5 seconds of precrash data at 2-Hz intervals. The precrash data confirmed that the vehicle was stationary, showing 0-mph velocity and a constant engine speed of 600 revolutions per minute, consistent with an idling engine. The steering angle indicated leftward turning of the front wheels (250°), and the throttle position was at 0%. The recording indicated that the driver's lap/shoulder belt was latched.<sup>76</sup>

The postcrash data showed a peak forward longitudinal velocity change of 36 mph at 125 msec after the crash, consistent with a rear impact. The driver's frontal airbag deployed at 160 msec postcrash. The ACM data also recorded a sudden change in longitudinal acceleration between 130 and 170 msec postcrash, from +11.5 g to -7 g, corresponding with the deployment of the driver's-side frontal airbag.

### 1.3.4.3 Toyota Prius

The second stationary vehicle, positioned in front of the Elantra, was a 2006 Toyota Prius, a four-door hybrid compact hatchback (see figure 18). The Prius

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<sup>76</sup> The PSP postcrash photographs showed that the driver's seat belt latch was secured in the buckle with the webbing appearing taught across the seat pan and seat back, which is consistent with the belt having been latched when the pretensioners deployed but not overlaying a seat occupant.

sustained rear contact damage extending across its entire width. The trunk pan showed more pronounced forward displacement toward the passenger side. Additional damage appeared at the lower portion of the right front fender, which exhibited substantial linear scraping and paint removal.



**Figure 18.** Rear left view of damage to the Prius.

PSP investigators retrieved the data from the Prius ACM and discovered that although the recording module contained data for three separate events, none were related to the crash. Although the module was designed to detect and record rear impacts, the vehicle's ignition system would have needed to be powered on at the time of impact for the recording to be generated.

#### **1.3.4.4 Toyota Corolla**

The fourth vehicle involved in this crash was a 2018 Toyota Corolla, a four-door sedan. The Corolla sustained minor localized contact damage to the left front fender, primarily concentrated below the headlamp level and extending slightly inward toward the center of the vehicle (see figure 19). Due to the Corolla being a bystander vehicle, the NTSB did not attempt to obtain data from the vehicle's ACM.



**Figure 19.** Front right view of damage to the Corolla.

### **1.3.5 Driver Information**

#### **1.3.5.1 Ford Driver**

The Ford was operated by a 23-year-old female who held a Pennsylvania Class C driver's license valid until October 22, 2025. A review of her Pennsylvania driving record revealed no moving violations prior to the crash. The Ford was registered to an individual with the same surname as the driver. The extent of the driver's previous experience with the vehicle could not be determined.

PSP investigators conducted an on-scene interview with the driver. She reported departing from North Philadelphia and entering I-95 North at Girard Avenue, approximately 3.4 miles south of the crash location. According to the PSP crash report, the driver stated that she was unaware of what had occurred or the severity of the incident. She indicated that her vehicle was in "auto drive" mode and estimated that her speed was no more than 64 mph.

The PSP crash report stated that the driver acknowledged consuming alcoholic beverages. Officers noted signs consistent with alcohol consumption during their interaction with her. Specifically, the investigating trooper documented "the odor of an alcoholic beverage emanating from her breath" and observed that her "eyes were glossy and bloodshot."

After the crash, emergency medical services transported the driver to a nearby hospital for treatment of suspected minor injuries. According to the PSP crash report, while at the hospital, the Ford driver refused a law enforcement blood draw.

Hospital records referenced in the PSP report indicated that an ethanol test performed on a serum specimen collected from the driver at 6:47 a.m.,

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approximately 3 hours and 30 minutes after the crash, yielded a result of 0.126 g/dL.<sup>77</sup>

At the request of the PSP, an external laboratory performed additional toxicological testing on a blood specimen obtained via warrant, though the collection time was not documented in available reports. According to the toxicology report, this testing detected ethanol at 0.078 g/dL, delta-9-tetrahydrocannabinol (delta-9-THC) at 7 nanograms per milliliter (ng/mL), and carboxy-delta-9-THC at 24 ng/mL. Delta-9-THC is the primary psychoactive chemical in cannabis, including marijuana, hashish, and other cannabis products such as extracts and edibles. Carboxy-delta-9-THC is a metabolite of delta-9-THC.

Pennsylvania law establishes specific prohibitions for impaired driving. The state's standard for presuming that a driver is impaired is a blood alcohol concentration of 0.08 g/dL or higher when measured within 2 hours after driving.<sup>78</sup> Cannabis is classified as a Schedule I controlled substance under Pennsylvania law, and the state prohibits driving with any detectable amount of a Schedule I controlled substance (including cannabis) or its metabolites in the blood.<sup>79</sup> Pennsylvania does allow registered patients with qualifying medical conditions to obtain medical cannabis from approved dispensaries.<sup>80</sup>

The NTSB obtained the driver's cell phone records covering the 72 hours before the crash. The records revealed one outgoing call lasting 5 seconds at 3:07 a.m., approximately 9 minutes before the crash. Additionally, the driver's phone received five incoming calls, each lasting 2–5 seconds, during the hour before the crash (between 2:24 a.m. and 3:07 a.m.). Before this activity, the most recent phone usage occurred around 10:00 p.m. on March 2, the night before the crash.<sup>81</sup>

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<sup>77</sup> The emergency department care timeline documented the collection time of the specimen and the numeric result. The PSP General Investigation Report stated that a serum specimen was used (as is common for hospital ethanol testing). Because hospital ethanol testing is used to guide patient care, it typically does not include secondary testing to confirm a reported result for legal purposes.

<sup>78</sup> See [75 Pa. C.S.A. § 3802](#).

<sup>79</sup> (a) Cannabis (referred to by Pennsylvania law as "marijuana") is classified as a Schedule I controlled substance under Pennsylvania law [28 Pa. 25.72](#). (b) [75 Pa. C.S.A. § 3802](#) is Pennsylvania's statute related to driving under the influence of alcohol or controlled substance. Also, according to [47 Pa.B. 4045](#), the lowest reportable results admissible in a prosecution are 0.5 ng/mL for Delta-9-THC and 1 ng/mL for carboxy-delta-9-THC.

<sup>80</sup> (a) For more information, see [Pennsylvania Medical Marijuana Program](#). (b) The NTSB was not able to determine whether the driver was certified and registered to obtain medical marijuana in Pennsylvania.

<sup>81</sup> The NTSB was not able to obtain the driver's phone, and the PSP was not able to download the phone's data.

### 1.3.5.2 Toyota Corolla Driver

PSP investigators interviewed the Toyota Corolla driver at the crash scene. He reported traveling north in the center lane when he observed a sedan stopped in the left lane with activated hazard lights. As he was passing the stationary vehicle, he heard a loud noise and then the stopped vehicle was suddenly pushed toward his vehicle, striking the left front portion of his Corolla.

### 1.3.5.3 Witness

PSP investigators interviewed a witness who had been traveling on northbound I-95. The witness stated that she entered the highway at Girard Avenue (about 3.4 miles in advance of the crash location), and as she merged, a yellow vehicle—which she later identified as the Ford—passed her on the right at an estimated speed of 80 mph. Shortly afterward, she noticed traffic slowing due to a crash ahead. Upon approaching the scene, she recognized that the same yellow vehicle that had passed her was involved in the collision. The witness called 911 and remained at the scene.

## 1.4 Federal Requirements for Reporting Crashes Involving Partial Driving Automation Systems

In July 2021, NHTSA issued SGO 2021-01, requiring manufacturers and designated operators to report to NHTSA crashes and certain events involving their vehicles equipped with automated driving systems or with SAE Level 2 ADAS.<sup>82</sup> NHTSA's stated purpose for the SGO is to monitor manufacturer and operator compliance with obligations to produce vehicles free from safety defects and to collect crash data for identifying potential safety concerns related to automated driving technologies. The L2 SGO mandates that manufacturers and operators report a crash if an L2 system was in use within 30 seconds of an incident involving (1) a fatality, (2) a vulnerable road user, (3) a vehicle towaway, (4) airbag deployment, and/or (5) transportation of an individual to a hospital.<sup>83</sup> NHTSA makes most of the reported incident information publicly available on its website.

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<sup>82</sup> SGO 2021-01 also includes a separate requirement for reporting crashes and incidents involving driving systems with higher levels of automation, SAE Levels 3-5. For more information, see [Standing General Order on Crash Reporting](#).

<sup>83</sup> At the time of the San Antonio and Philadelphia crashes, the L2 SGO required manufacturers and operators to report incidents involving vulnerable road users, fatalities, or transportation of an individual to a hospital within 1 day of learning about such an incident. Incidents involving vehicle towaway or airbag deployment but without any of the other three criteria were required to be reported by the fifth day after learning about the incident. On June 16, 2025, NHTSA updated the SGO to require all incidents meeting any of the five criteria to be reported by the 5th day after learning about the incident. For more information, see the [third amendment](#) of SGO 2021-01.

Ford provided the NTSB with documentation describing the company's crash identification mechanisms and NHTSA notification process, including: (1) American Road Services Company (Ford's insurance service program), (2) NHTSA customer complaints database, (3) vehicle telematic data, (4) staff monitoring of media outlets, and (5) other methods, such as social media.<sup>84</sup> Ford follows up on potentially relevant incidents to determine compliance with SGO reporting requirements.<sup>85</sup>

According to NHTSA's SGO 2021-01 database, Ford submitted 35 reports meeting the L2 requirements between July 2021 and December 2025. Table 5 shows the information sources for the crashes that occurred between July 2021 and May 2024 (the time period covering the establishment of the SGO through the reporting of the San Antonio and Philadelphia crashes) as well as those that occurred between June 2024 and December 2025 (the time period since the two crashes occurred and were reported).<sup>86</sup> Of these 35 incidents, three included fatal crashes: two involving 2022 Ford Mach-E vehicles (discussed in this report) and one involving a 2021 Ford F-150 pickup truck.

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<sup>84</sup> Most of these incidents (at least 92%) are reported through the American Road Services Company (before their initial relevance to the SGO reporting requirements is determined).

<sup>85</sup> Most of the incidents received through the sources discussed above were considered by Ford to be not relevant to the SGO reporting requirements, meaning that the BlueCruise system was not in use before or during the event. About 8-14% of the initially received incidents are considered potentially relevant to the SGO reporting requirements, necessitating further investigation by Ford.

<sup>86</sup> This information was combined from NHTSA's L2 [incident report data prior to June 16, 2025](#), and from the agency's [current incident report database](#).

**Table 5.** Ford's reported L2 SGO incidents to NHTSA, July 2021–December 2025.

Information Source	July 2021 - May 2024	June 2024 - December 2025
<b>Driver or their representative</b>	7	9
<b>NHTSA's vehicle owner's questionnaire <sup>a</sup></b>	1	1
<b>Telematic</b>	1	1 <sup>d</sup>
<b>NTSB inquiry</b>	1	
<b>Ford's social media search</b>	1	
<b>Another automated driving system developer</b>		1
<b>Ford's test operation <sup>b</sup></b>		1
<b>Unknown source <sup>c</sup></b>	6	5
<b>Total</b>	17	18

<sup>a</sup> NHTSA's vehicle owner's questionnaire serves as a reporting mechanism for vehicle owners to report safety issues with their vehicles.

<sup>b</sup> Ford was testing a vehicle made by another automaker, but because the vehicle was owned by Ford, the company reported the incident to the SGO.

<sup>c</sup> The SGO incident database lacks sufficient information to determine how Ford learned about the remaining 11 reported incidents.

<sup>d</sup> Although telematics was marked as the source of the incident knowledge, the description states that the driver reported the crash to Ford.

## 2 Analysis

### 2.1 Introduction

This report documents two fatal, rear-end collisions with stationary vehicles at highway speeds that occurred in San Antonio, Texas, and Philadelphia, Pennsylvania. In each case, the striking vehicle was a Ford Mach-E operating in hands-free partial driving automation mode.

In the San Antonio, Texas, crash on February 24, 2024, a 2022 Ford Mach-E collided with the rear of a stationary Honda CR-V in the center lane of eastbound I-10. One person died and one person sustained minor injuries. In the Philadelphia, Pennsylvania, crash on March 3, 2024, a 2022 Ford Mach-E collided with the rear of a stationary Hyundai Elantra in the left lane of northbound I-95, triggering a sequence of crashes involving two other vehicles. Two people died and one person sustained minor injuries.

Although not required by federal regulation, the Ford vehicles in both crashes were equipped with a suite of advanced driver assistance systems (ADAS) including Adaptive Cruise Control (ACC), lane centering, forward collision warning (FCW), and automatic emergency braking (AEB). In these crashes, neither the Ford drivers nor the vehicle's partial automation system and supporting ADAS responded to prevent or mitigate the crashes with the stationary vehicle ahead. At the time of manufacture, there were no minimum vehicle safety standards for these ADAS features.

The analysis first examines factors that can be excluded as causal or contributory to the two crashes and then discusses each crash sequence, including the actions of the involved drivers and the limitations of the FCW and AEB systems (section 2.2). The analysis also discusses the following safety issues:

- Alcohol-impaired driving (section 2.2.3)
- Limitations and insufficient federal oversight of partial driving automation systems (section 2.3), including:
  - Lack of federal requirements for data recording and inadequate manufacturer awareness of NHTSA SGO-applicable crash events (section 2.3.1)
  - Driver Monitoring System (DMS) limitations (section 2.3.2)
  - Deficiencies in Ford's implementation of its partial vehicle automation system, and overall lack of federal guidelines for SAE International Level 2 (L2) implementation and ADAS integration (section 2.3.3)

Based on our investigation of the San Antonio crash, the NTSB established that the following factors did not cause or contribute to the crash:

- *Licensing:* Both the Honda and Ford drivers had a valid driver's license.
- *Ford driver experience with vehicle:* Although NTSB investigators did not interview the Ford driver, available evidence indicated that he was familiar with the vehicle and the BlueCruise system. This assessment was based on the fact that he purchased the vehicle new, had accumulated more than 11,000 miles, and demonstrated knowledge of the system during his communication with Ford representatives after the crash.
- *Intoxication of the Ford driver:* Evaluation conducted by the SAPD immediately after the crash showed no indications of intoxication.
- *Mechanical condition of the Ford:* Postcrash examination of the vehicle revealed no preexisting mechanical defects.
- *Highway factors:* The section of I-10 where the crash occurred met current roadway design standards and featured appropriate regulatory and warning signage and roadway lighting.
- *Weather:* The weather was clear and dry and did not have an adverse effect on driving conditions or the performance of the Ford's L2 system.

Therefore, the NTSB concludes that none of the following were factors in the San Antonio crash: (1) the licensing of either driver; (2) the Ford driver's experience with his vehicle; (3) intoxication of the Ford driver; (4) the mechanical condition of the Ford; (5) highway factors; or (6) weather.

Based on our investigation of the Philadelphia crash, the NTSB established that the following factors did not cause or contribute to the crash:

- *Licensing:* The Ford driver had a valid license.
- *Mechanical condition of the Ford:* Postcrash examination of the vehicle revealed no preexisting mechanical defects.
- *Highway factors:* Although the crash occurred in a work zone, there were no lane restrictions, appropriate signage was present, and the speed limit had been reduced to 45 mph.
- *Weather:* The weather was clear and dry and did not have an adverse effect on driving conditions or the performance of the Ford's L2 system.

Therefore, the NTSB concludes that none of the following were factors in the Philadelphia crash: (1) the licensing of the Ford driver; (2) the mechanical condition of the Ford; (3) highway factors; or (4) weather.

The investigation found that the emergency responders in both the San Antonio and the Philadelphia crashes were promptly dispatched, with initial units arriving at each scene within 11 and 9 minutes, respectively. The NTSB concludes that

the emergency responses to both the San Antonio and Philadelphia crashes were timely and adequate.

## **2.2 Crash Sequence, Driver Actions, and Performance of Forward Collision Warning and Automatic Emergency Braking**

### **2.2.1 San Antonio, Texas, Crash**

#### **2.2.1.1 Reconstruction of Crash Sequence**

Data from the Ford Mach-E involved in the San Antonio crash indicated that the vehicle maintained a steady speed of approximately 75 mph before the crash. All in-vehicle recording systems—the airbag control module (ACM) and DMS module—showed no system or driver-applied evasive steering torque, confirming that the vehicle remained in its lane during the 5 seconds before the crash. These recording modules also consistently showed that neither the driver nor any ADAS functions initiated or requested braking or steering before striking the stationary Honda.

At the time of the crash, the Ford driver was en route to Houston, Texas. Telematic data indicated that he had begun traveling approximately 30 minutes before the crash occurred. The investigation found no evidence suggesting driver fatigue. The examination of the phone records for one of the Ford driver's phones showed minimal cell phone use during the preceding 3 days; however, the NTSB was unable to obtain phone records for the driver's secondary phone associated with a VOIP phone number.

In postcrash interviews with the SAPD and Ford representatives, the Ford driver reported frequently glancing at the infotainment console for directions to a charging station before the crash. He told the SAPD that while he believed a vehicle—the Honda—was stopped in the travel lane, he did not see it clearly.

The NTSB could not determine why the Honda was stopped in the center lane of I-10. Postcrash examination of the Honda revealed a crack in the gas tank—likely as a consequence of the crash—but it remains unknown whether the vehicle had lost power, run out of fuel, or had stopped for another reason. The damage patterns observed on both vehicles indicated an underride impact, as shown in figure 20.



**Figure 20.** Side-view image of the alignment of vehicle laser scans illustrating the likely maximum engagement of the Ford (right) and Honda (left) during the crash.

The driver of a witness vehicle traveling at a self-estimated 65–70 mph described suddenly encountering the stopped vehicle—the Honda—and executing a quick lane change to the right. The witness did not recall seeing the Ford or any other vehicle around the time that she narrowly avoided striking the stopped Honda. Based on the witness’s reported passage of time between her lane change and witnessing the crash in her rearview mirror (which she estimated to be between 5 and 15 seconds), the available line of sight back to the crash location, and the Ford driver not reporting seeing other vehicles, the Ford was not directly behind the witness vehicle. Although the witness vehicle driver’s time estimate between changing lanes and witnessing the crash spanned a broad range, it is notable that eastbound I-10 continued as a straight section with a slight upward slope for 1,200 feet past the crash location, providing the witness with a clear line of sight to the crash location in her rearview mirror for at least 11 seconds. Traveling at a speed of 70 mph, the witness vehicle would have traveled 1,200 feet in 11.7 seconds. As such, this incident does not represent a “cut-out” crash scenario, characterized by a sudden revelation of a previously obscured stopped vehicle.

### **2.2.1.2 Honda Driver**

The Honda driver’s toxicology results indicated that his blood alcohol level was likely above 0.3 g/dL at the time of the crash, nearly four times Texas’s legal standard of 0.08 g/dL for presuming that a driver is intoxicated. Such a markedly elevated blood alcohol level can cause unconsciousness in occasional alcohol drinkers without developed tolerance. The Honda driver’s history of alcohol use and tolerance are unknown, and whether he was completely incapacitated at the time of the crash could not be determined. The Honda driver’s cardiovascular disease also conveyed risk of an incapacitating medical event, although there was no specific evidence that such an event occurred. The Honda driver was fatally injured in the crash.

The NTSB concludes that in the San Antonio crash, the reasons for the Honda being stopped in the center lane could not be determined, but the Honda driver's alcohol impairment could have contributed.

### **2.2.1.3 Hazard Detection and Ford Driver Actions**

A driver's ability to detect roadway hazards depends on various perceptual and cognitive cues, especially during nighttime driving. Key perceptual cues include hazard visibility (the saliency or conspicuity of the hazard), looming effects (apparent expansion of an object in the visual field), and environmental features that affect time and distance judgments. The primary cognitive cues pertain to driver expectations.

At the crash site, roadside lighting provided adequate illumination across all travel lanes. The roadway geometry afforded a clear line of sight toward the stopped Honda for the preceding 1,300 feet.<sup>87</sup> Although the roadside lighting illuminated the Honda, the determination of its movement was dependent on the available perceptual cues and driver attention.

Although neither the witness nor the Ford driver recalled observing flashing hazard lights on the Honda, postcrash evidence—SAPD body camera footage and NTSB examination of bulb filaments—indicated that at least some of the Honda's hazard, tail, and brake lights were likely illuminated at the time of impact.

Perceptual looming—the visual expansion of an image on the retina causing a physiological response to perceive an object as approaching rather than stationary or receding—plays a crucial role in hazard detection (DeLucia and Tharanathan 2009; Kennedy, Jentsch, and Smither 2001). Given the sparse traffic conditions and overall roadway lighting, looming would have served as the primary perceptual cue that the Honda was stationary.

The effectiveness of perceptual cues is also dependent on driver expectations, which in turn influence driver attention. During rush-hour conditions, drivers typically anticipate congestion, sudden traffic queues, and stopped vehicles. However, the sparse traffic conditions on eastbound I-10 at the time of the crash, 9:48 p.m., would have created expectations of unimpeded travel rather than encountering stopped vehicles.

A sudden lane change by a vehicle ahead—such as the witness's maneuver to avoid the Honda—can provide a salient cue of a potential hazard. However, considering that the Ford was reportedly 5 or more seconds behind the witness's

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<sup>87</sup> Traveling at a speed of 74.7 mph (as captured by the ACM in the last 5 seconds before the crash), it would have taken the Ford about 12 seconds to travel the line-of-sight distance of 1,300 feet to the Honda.

vehicle, the quick lane change as a hazard cue could have been missed and would have depended on where the Ford driver directed his attention at that time. DMS data from the Ford, discussed below, provided insight into its driver's gaze patterns and lack of attention to the forward roadway before the crash.

**Ford Driver Gaze Pattern and Hazard Detection.** The Ford's telematic data showed that in the 30 seconds before the crash, while operating in hands-free BlueCruise mode, the DMS provided two bi-modal (visual and auditory) alerts warning the driver about looking away from the forward roadway, the first at 29 seconds and the second at 8 seconds before impact. Each alert indicated that the DMS had detected the driver continuously looking away from the forward roadway for at least 5 and possibly 8 seconds. The witness vehicle's avoidance maneuver ahead of the Ford may have occurred during the period immediately before the second DMS alert (8 seconds before the crash) identifying the driver as being distracted.

The Ford's DMS module recorded only 5 seconds of precrash information but still provided important details about the driver's eye glances. These data revealed that the driver was alternating glances between the infotainment console and the front windshield, with significantly longer fixations directed at the console. During the 5-second interval before the crash, the Ford driver spent approximately 1 second of cumulative time looking at the forward roadway. His final glance toward the road ahead—lasting 0.2 seconds—was insufficient for detecting the hazard and initiating an avoidance maneuver.

Although the investigation could not determine whether this glance pattern extended farther back in time, the driver's statements to both the SAPD and Ford representatives regarding his focus on the infotainment console for navigation information to a charging station, combined with telematic data, suggested that this distracted glance behavior had persisted for a longer period.

Research demonstrates that under certain conditions, humans can detect sudden, obvious hazards (such as lane incursions) from brief exposure to driving scene footage (up to 450 msec). However, these rapid perceptual abilities tend to manifest in conditions of hazard expectation, specifically when 50% of scenes contain hazards (Wolfe and others 2019).<sup>88</sup> Conversely, when hazard prevalence is low (1% of scenes), brief viewing periods result in participants failing to detect sudden, obvious hazards in 57% of trials (Kosovicheva, Wolfe, and Wolfe 2022). These laboratory

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<sup>88</sup> This study included both younger and older participants, and its design varied the video footage presentation duration to maintain 80% accuracy in hazard detection. The older group required longer video presentations (about 450 msec) to maintain 80% hazard detection accuracy compared to the younger group (about 250 msec).

findings show the limits of our perceptual ability and how expectations influence performance.

A 2006 simulator study by Horrey and Wickens (2007) investigated how in-vehicle glance duration (away from the forward roadway) affects drivers' capacity to detect and respond to forward hazard incursions during manual vehicle operation. Their experimental design incorporated infrequent hazards that initiated—with an approximately 2.5-second time to collision (TTC)—only after drivers returned their gaze to the forward roadway. Results demonstrated that longer in-vehicle glances corresponded to increased hazard response times. Specifically, in-vehicle glances exceeding 1.6 seconds resulted in average hazard response times of 2 seconds with more frequent collisions, while shorter glances of less than 1.1 seconds produced average response times of 1.5 seconds with no collisions.

**Summary.** The San Antonio crash scenario presented two challenging situations: sparse traffic that reduced driver expectations of encountering stopped vehicles, and the difficulty of quickly identifying and reacting when a vehicle ahead is stationary rather than moving. However, several factors were present that would have enabled an attentive driver to overcome these challenges. The adequate line-of-sight distance, sufficient roadway illumination, likely illumination of the Honda's parking or brake lights, and possible activation of the Honda's hazard lights should have provided the Ford driver with adequate opportunity to observe the Honda, determine its stationary status, and at least initiate an evasive action, which the driver of the witness vehicle traveling ahead of the Ford was able to do.

The Ford driver's self-reported focus on navigational directions, documented glances to the infotainment console, failure to perceive the Honda earlier, and complete absence of avoidance maneuvers all indicate significant disengagement from the driving task. The manner of driver disengagement—returning his gaze to the forward roadway for a period of only up to 0.4 seconds, the earlier distraction alerts for continuous off-road gazes of at least 5 seconds, and the evidence that the driver understood the BlueCruise system's functionality and limitations—all indicate that his disengagement resulted from overreliance on and complacency with the vehicle's automation.<sup>89</sup>

The NTSB concludes that the Ford driver in the San Antonio crash did not respond to the stationary vehicle ahead, despite having adequate opportunity to identify the hazard and initiate an evasive maneuver, due to distraction from use of

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<sup>89</sup> Automation overreliance occurs when a vehicle operator or driver uses an automated system without properly monitoring it and/or in situations for which it is not designed. Overreliance is sometimes also characterized as automation misuse or automation bias, depending on the situation (Parasuraman and Riley 1997).

the vehicle's infotainment system and overreliance on the vehicle's partial automation.

## **2.2.2 Philadelphia, Pennsylvania, Crash**

### **2.2.2.1 Reconstruction of Crash Sequence**

The Philadelphia crash occurred in an active work zone on a rightward curve of I-95. Despite construction having reduced the original curve radius and narrowed both travel lanes and shoulders, lane markings remained clearly visible, with the posted speed limit reduced from 55 mph to 45 mph throughout the work zone.<sup>90</sup>

Data from the Ford Mach-E indicated that the vehicle maintained a steady speed of approximately 71-72 mph before the crash. All in-vehicle recording systems—the ACM, DMS module, and BlueCruise module—showed no system or driver-applied evasive steering torque, confirming that the vehicle remained in its lane during the 5 seconds before the crash. These recording modules also consistently showed that neither the driver nor any ADAS functions initiated or requested braking or steering before striking the stationary Elantra.

The Elantra's ACM data confirmed that it was stationary for at least 5 seconds before the crash. Its driver-side frontal airbag deployed after the vehicle was propelled into the Prius stopped ahead of it. The data also showed a rapid change in longitudinal acceleration from -11.5 g to -7 g within a 40-msec window ending at 170 msec postcrash. This timing, along with the fact that frontal airbags typically do not deploy in rear-end collisions, indicated that although the ACM recording was triggered by the impact from the Ford, the airbag deployment resulted from the Elantra's secondary frontal collision with the Prius.

Data from the Prius ACM contained no record of the crash. To initiate a recording, the Prius ACM would have required both sufficient impact force to meet wake-up thresholds—which were present in this crash—and an active ignition. Therefore, the Prius was likely turned off when struck. Although the NTSB investigation did not evaluate why the Elantra and Prius were stopped in the left lane of I-95, the PSP crash report indicated that the Prius was disabled and the Elantra driver had stopped to provide assistance.

Images captured by the Ford's forward-facing camera showed the Elantra positioned with its left rear tire near the left highway shoulder line. At least some of its rear lights appeared to be illuminated, but the NTSB was unable to verify their status due to the low resolution of the forward-facing camera images and the presence of

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<sup>90</sup> The changes in lane width of roadway curvature were within the requirements for Blue Zone roadways.

reflectors. Analysis of roadway evidence and vehicle damage patterns confirmed that the Ford struck the Elantra with a rightward offset at a slight angle (see figure 21).



**Figure 21.** Overhead image of the alignment of vehicle laser scans illustrating the likely maximum engagement of the Ford (right) and Elantra (left) during the crash.

Based on the roadway geometry, including curve radius and vertical crest curve characteristics, the unobstructed driver sight line to the Elantra's location in the northbound direction would have extended at least 524 feet. At the Ford's recorded speed of 71 mph, this sight line distance would have made the stopped Elantra visible to the Ford driver for approximately 5 seconds before impact, absent any obstructing traffic or environmental factors. Had the vehicle been traveling at the posted work zone speed limit of 45 mph, this clear line of sight would have extended to 7.9 seconds.<sup>91</sup>

The NTSB analyzed the Ford's recorded ADAS data to better understand the precrash dynamics. Although Ford had no federal requirement to record this information, the 2 seconds of precrash data recorded by the BlueCruise module included detection of vehicles ahead, their longitudinal and lateral positions relative to the Ford, and the calculated TTC. These variables provided critical insights into the precrash traffic environment.

The BlueCruise module data showed that the radar-camera fusion system detected a lead vehicle at two different intervals:

- *At 2.0 and 1.8 seconds before impact:* Detection of a moving vehicle
- *Between 0.4 seconds and time of impact:* Detection of a stationary vehicle

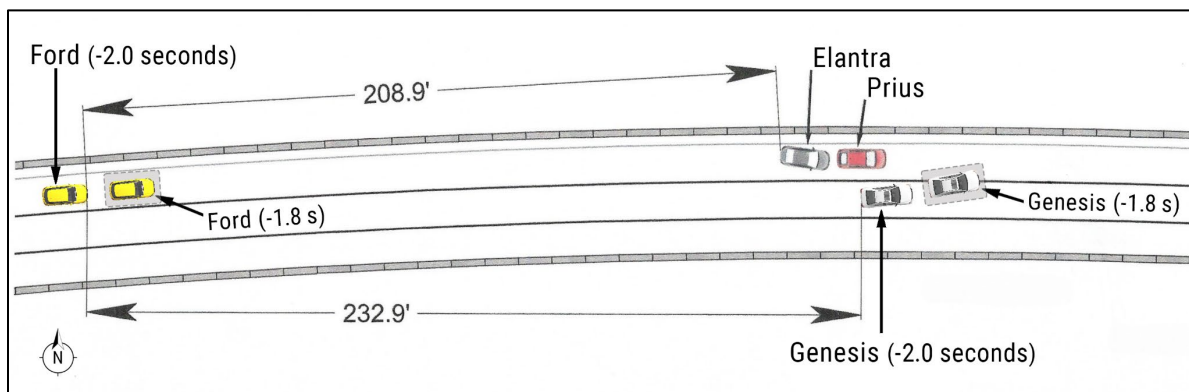
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<sup>91</sup> Section 2.3.3.1 discusses the Ford sensors' capabilities related to detection of speed limit signs.

To determine the identity of the detected moving vehicle at 2.0 seconds before the crash—with the recorded 15.3 feet of right lateral offset and 232.9 feet of longitudinal offset—the NTSB examined the preceding single-vehicle crash involving the Genesis. The PSP crash report indicated that the Genesis driver had been traveling in the left lane when she encountered stopped vehicles, swerved to avoid a collision, lost control, and struck both the left and right roadside barriers. Physical evidence, particularly the tire friction marks, confirmed that the Genesis was ahead of the Ford and moved through the area directly behind the stopped Prius and Elantra before the Ford crash occurred. (Refer to table 2 for additional information about crash parameters including lateral and longitudinal distances.)

The recorded parameters of the detected stationary vehicle 0.4 seconds before the crash—with left lateral offset of 1.5 feet and longitudinal offset of 49.2 feet—matched the expected characteristics of the stopped Elantra, which was offset in the lane to the left. At a speed of 71 mph at that time, the Ford would have traveled 41.7 feet in 0.4 seconds.

Based on the Ford's recorded speed, it would have been 208.9 feet from the Elantra 2.0 seconds before the crash. However, at this time, data showed detection of a moving vehicle 232.9 feet ahead and 15.3 feet to the right of the Ford. These coordinates place the detected vehicle—likely the Genesis—in the center lane, just beyond the position of the stopped Elantra (see figure 22). However, the stationary vehicle was not yet detected at this time.



**Figure 22.** Graphical depiction of the crash area showing approximate vehicle positions 2.0 seconds and 1.8 seconds before the crash.

Although the Ford Mach-E's suite of ADAS technologies tracks multiple objects in the environment, the BlueCruise module records information only about the lead vehicle—the vehicle traveling ahead in the same travel lane. The two BlueCruise-recorded data points at 2.0 and 1.8 seconds before impact likely represented the

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final tracking of the Genesis as it moved out of the Ford's travel path.<sup>92</sup> This interpretation aligns with evidence of the Genesis swerving around the stopped Elantra and Prius ahead of the Ford.

However, beyond the PSP crash report on the Genesis incident—which did not indicate driver distraction or impairment—limited information was available about the Genesis driver's attentiveness or vehicle speed as she encountered the stopped vehicles and initiated a rapid avoidance maneuver that resulted in loss of vehicle control.<sup>93</sup> The roadway evidence, combined with the Genesis driver's statement and the Ford's BlueCruise module data, indicated that another vehicle—the Genesis—rapidly changed lanes in front of the Ford, significantly reducing the amount of time that the Ford driver had a clear line of sight to the stopped Elantra. However, because the BlueCruise module recorded only 2 seconds of precrash data, the NTSB could not determine when the Genesis changed lanes or whether that action created a "cut-out" scenario for the Ford driver.<sup>94</sup>

Earlier analysis of the San Antonio crash in this report examined driver expectations. Similarly, drivers on I-95 would not have expected to encounter stopped vehicles in a travel lane around 3:00 a.m. However, the illuminated rear lights on the Elantra, along with the reduced highway speed limit of 45 mph, should have aided in drivers' hazard detection by providing perceptual cues and extending time for hazard recognition. The evasive actions of the Genesis driver ahead of the Ford served as a significant cue of a potential hazard, and the illuminated rear lights on the Elantra provided visual cues. Although the stopped Elantra was only briefly in the Ford driver's line of sight, an attentive driver traveling at the posted speed limit would likely have had sufficient time to detect the hazard and at least initiate an avoidance maneuver.

### **2.2.2.2 Ford Driver Actions**

The NTSB was not able to interview the Ford driver, and the investigation did not obtain any information to determine her overall familiarity with the BlueCruise

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<sup>92</sup> Although the longitudinal and lateral separation placed the Genesis—the detected moving vehicle—in the center lane, the TTC still reported a value (a collision path), which may be due to the road curvature or the method of TTC calculation.

<sup>93</sup> Based on the recorded TTC in the BlueCruise module data, the detected moving vehicle—the Genesis—would have been traveling at 48–49 mph 2 seconds before the Ford crash. However, its speed before swerving around the stopped Elantra is unknown. The work zone speed limit was 45 mph.

<sup>94</sup> Euro NCAP's Safe Driving Vehicle Assistance Protocol ([version 1.1](#), October 2025) describes evaluation of the performance of ACC alone and AEB during ACC engagement. The protocol includes cut-out scenarios in which a previously obstructed moving lead vehicle is revealed at 2- and 3-second TTCs.

system. However, other evidence provided information about her state and activities leading to the crash and the reasons for her lack of response to the stopped vehicles.

The driver reported to the PSP that she had consumed alcohol, and PSP officers interacting with her after the crash observed signs consistent with alcohol consumption. Hospital testing of a serum specimen collected from the driver approximately 3 hours and 30 minutes after the crash detected ethanol at 0.126 g/dL. Although this was a clinical and not forensic test, it likely was representative of the driver's serum ethanol level at the time of the specimen collection.

The hospital serum ethanol level was used to estimate the driver's blood alcohol content at the time of the crash. Based on an estimate of blood ethanol obtained by dividing the serum ethanol result by 1.2 and extrapolating backward to the time of the crash using an assumed ethanol elimination rate of 0.01–0.025 g/dL per hour, the NTSB estimated her blood alcohol content at the time of the crash to be 0.14–0.19 g/dL (Jones and Tilson 2023; Jones 2010).<sup>95</sup> Pennsylvania's legal blood alcohol content standard for presuming that a driver is impaired is 0.08 g/dL.

Additional toxicological testing performed by an external laboratory at the request of the PSP detected ethanol at 0.078 g/dL and delta-9-THC at 7 ng/mL in a blood specimen from the driver. These results had limited interpretive utility because they lacked a documented specimen collection time.

Although a delta-9-THC level of 7 ng/mL may indicate cannabis use within several hours of specimen collection for an occasional user, for a frequent user, the same level might persist significantly longer after last use, well beyond the typical window of acute psychoactive effects (Peng and others 2020, Karschner and others 2009, Odell and others 2015). Nevertheless, any psychoactive effects of cannabis present would have potentially worsened the driver's impairment beyond the effects of alcohol alone (Couper and others 2024).

The DMS module data showed that the Ford driver was looking ahead (specifically, her gaze was detected to be directed to the front windshield) for the 5 seconds before the crash. However, the driver-facing image captured 2 seconds before the crash showed the driver resting her arms on the steering wheel, sitting upright and facing forward with both eyes open while also revealing the driver's left hand holding a partially visible rectangular object resembling a cell phone, with her thumb wrapped around it (refer to figure 14). Phone records showed that the Ford driver made one outgoing call (lasting 5 seconds) about 9 minutes before the crash

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<sup>95</sup> This estimation assumes that any consumed ethanol had already been absorbed from the digestive tract into circulation by the time of the crash. This often is a reasonable assumption in cases involving social drinking before driving but is less certain in the presence of delta-9-THC, which may delay ethanol absorption.

and was not using her phone to talk or text when the crash occurred.<sup>96</sup> However, the NTSB did not have access to the driver's phone to examine her potential interactions that would not appear on the phone records, such as third-party communication applications or interaction with other non-communication and/or social media applications.

Although the Ford driver's eyes were facing forward for at least 5 seconds before the crash, her lack of response to the hazard ahead indicated significant disengagement from the driving task, likely due to use of her cell phone. Section 2.3.2 discusses the extent to which her disengagement was enabled by the DMS's limitations in detecting the use of a phone positioned between the steering wheel and the forward roadway. Although the NTSB did not interview the driver to determine her level of familiarity with BlueCruise, the manner in which she likely used her phone to avoid receiving distraction alerts, combined with an earlier distraction alert for a continuous off-road gaze of at least 5 seconds, indicates that her disengagement was at least partially due to overreliance on and complacency with the vehicle's automation.

Finally, in the 5 seconds before the crash, the Ford (as operated by the BlueCruise system) had maintained a steady speed of 71-72 mph, well above the posted speed limit of 45 mph. Traveling the posted speed limit would have provided the Ford driver with nearly 8 seconds of clear line of sight to the stopped Elantra, which would have been sufficient for an attentive driver to detect the hazard and initiate an evasive maneuver.

The NTSB concludes that the Ford driver in the Philadelphia crash did not respond to the stopped vehicles ahead, despite having adequate opportunity to identify the hazard and initiate an evasive maneuver, due to a combination of potentially interacting factors, including:

- impairment from substance use;
- disengagement from the driving task, likely due to cell phone use and overreliance on the vehicle's partial automation; and
- speeding, which reduced the duration of clear line of sight to the stopped Elantra.

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<sup>96</sup> Although the Ford driver reported to the PSP that she had entered I-95 North approximately 4 miles from the crash location, the investigation could not conclusively determine whether she was operating the Ford during the phone call made 9 minutes before the crash because the NTSB was unable to interview the driver, and Telematic One data did not capture the crash trip. Telematic Two data, which showed an initial data sample about 16 minutes before the crash, indicated that the call occurred during the same ignition cycle as the crash, although whether the vehicle was parked or being driven manually at that time is unknown.

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### 2.2.3 Alcohol-Impaired Driving

As evident in these investigations, the dangers of impaired driving persist when a vehicle is operating in partial automation mode. In the San Antonio crash, driver impairment may have contributed to the development of an unexpected hazard (a stationary vehicle) presented to a vehicle operating with partial automation. In the Philadelphia crash, impairment was a factor in the driver's lack of response to a hazard ahead (in this case, two stationary vehicles). ADAS technologies, including partial driving automation systems, may assist drivers but should not be relied on to compensate for the attentional deficiencies of fatigued, distracted, or impaired driving. Drivers who are impaired—whether from alcohol, cannabis, or other drugs—represent a danger on roadways regardless of whether they are operating a vehicle manually or in partial driving automation mode.

Driver impairment is a frequent cause of fatal crashes. Based on NHTSA's Fatality Analysis Reporting System data for 2020–2023, approximately 30–32% of traffic fatalities occurred in crashes involving alcohol impairment (NHTSA 2025, NHTSA 2023, Stewart 2022). In 2023, the number of fatalities in traffic crashes involving at least one alcohol-impaired driver was 12,429.

Since 1968, the NTSB has issued about 150 safety recommendations addressing impaired driving. In 2013, we published the safety report *Reaching Zero: Actions to Eliminate Alcohol-Impaired Driving*, which provided a comprehensive examination of elements necessary to achieve meaningful reductions in impairment-related crashes (NTSB 2013). In that report, we issued numerous recommendations for stronger laws, improved enforcement strategies, and development and deployment of in-vehicle impairment detection technologies.<sup>97</sup>

More recently, the NTSB investigated a January 2020 crash in Avenal, California, in which an alcohol-impaired SUV driver, operating at speeds above 90 mph, lost control of the vehicle, crossed the highway centerline, and collided head-on with a pickup truck (NTSB 2022). As a result of that crash, the pickup truck caught fire and its 8 occupants (the driver and 7 child passengers) died; the SUV driver also died.

In the investigative report for the Avenal crash, we emphasized that impaired drivers often cannot make sound decisions about their ability to drive safely, necessitating vehicle-integrated, automated interventions. The report also provided

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<sup>97</sup> One of the recommendations pertaining to stronger laws was issued to all 50 states, the Commonwealth of Puerto Rico, and the District of Columbia to establish a per se blood alcohol concentration limit of 0.05 (Safety Recommendation [H-13-05](#)).

an overview of impairment detection technologies. The NTSB issued the following safety recommendation to NHTSA:

Require that all new vehicles be equipped with passive vehicle-integrated alcohol impairment detection systems, advanced driver monitoring systems, or a combination thereof; the systems must be capable of preventing or limiting vehicle operation if driver impairment by alcohol is detected. ([H-22-22](#))

In November 2021, the Infrastructure Investment and Jobs Act was enacted and required the US Department of Transportation (USDOT) to issue a final rule within 3 years (no later than November 2024) requiring that all new passenger vehicles be equipped with advanced impaired driving technology.<sup>98</sup>

In its February 2023 correspondence with the NTSB, NHTSA stated that it was developing an advance notice of proposed rulemaking (ANPRM) under the Infrastructure Investment and Jobs Act requirements. However, because the agency had not shared a timeline for developing this rulemaking, Safety Recommendation H-22-22 was classified Open–Unacceptable Response in November 2023.

In January 2024, NHTSA issued an ANPRM titled “Advanced Impaired Driving Prevention Technology.”<sup>99</sup> In the ANPRM, NHTSA sought comments on how the agency could propose minimum performance requirements and set compliance test procedures. NHTSA received more than 18,000 comments. In our response to the notice, the NTSB emphasized NHTSA’s lack of a realistic timeline for mandating impaired driving prevention technologies and urged the agency to deploy available technologies immediately—including incorporating them into the New Car Assessment Program (NCAP)—rather than pursuing possibly unachievable standards.<sup>100</sup> Specifically, the NTSB encouraged NHTSA to determine how vehicle-integrated alcohol impairment detection systems including touch and breath sensors could be deployed in the short term to prevent or mitigate alcohol-impaired driving. We also asked NHTSA to determine how DMSs as well as lane keeping, AEB, and ACC could help prevent or mitigate crash risk if impairment is detected. In the current Unified Agenda of regulatory and deregulatory actions regarding this regulatory activity, NHTSA projected completing analysis of the ANPRM comments by

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<sup>98</sup> See the [Infrastructure Investment and Jobs Act](#), section 24220, for additional details. The act (Public Law No. 117-58) was enacted on November 15, 2021.

<sup>99</sup> See [89 Federal Register 830](#) (January 5, 2024).

<sup>100</sup> For the NTSB response, see docket [NHTSA-2022-0079](#).

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November 2026 but did not include a projected timeline to issue a notice of proposed rulemaking (NPRM) and final rule.<sup>101</sup>

Nearly 4 full years have passed since Congress finalized the legislation requiring the USDOT to issue a ruling within 3 years mandating that all new passenger vehicles be equipped with advanced impaired driving technology. Other recent crashes investigated by the NTSB have included drivers who were impaired by substances other than alcohol (NTSB 2024, 2023a, and 2023b), further exemplifying the urgency of acting on Safety Recommendation H-22-22.

The NTSB concludes that NHTSA's failure to meet the statutory date for completing a final rule requiring advanced impaired driving technology on all new passenger vehicles continues to expose the public to dangers posed by impaired drivers.

Therefore, the NTSB reiterates Safety Recommendation H-22-22 to NHTSA.

## **2.2.4 Limitations of Forward Collision Warning and Automatic Emergency Braking Systems**

### **2.2.4.1 Functionality in the Two Crashes and Performance Expectations**

The Ford Mach-E vehicles in both the San Antonio and Philadelphia crashes were equipped with a suite of ADAS including FCW and AEB. Despite these features being available, AEB did not engage in either crash. The FCW system began to engage only in the Philadelphia crash, requesting an alert 0.2 seconds before impact with the stationary Elantra, although it is not known if an alert was presented to the driver. These ADAS features were not mandated by the Federal Motor Vehicle Safety Standards (FMVSS) at the time of the vehicle's manufacturing.

The Ford in the Philadelphia crash recorded more data than the Ford in the San Antonio crash, and these data provided additional information that may explain the overall system functionality in the last few seconds before the crash. According to the Ford's BlueCruise module data, the forward camera system did not detect a threat and therefore did not request AEB activation. The radar-camera fusion system did detect a vehicle at two different times within the 2-second period before the crash, including the stationary Elantra at 0.4 seconds before impact. However, due to low confidence that the stationary vehicle represented a threat, the fusion system did not request AEB activation. Considering that the camera system did not detect a threat, the most likely explanation is that detection of the Elantra at 0.4 seconds before impact was based on the positive radar signal. Because concerns about false

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<sup>101</sup> For more information, see the [Spring 2025 Unified Agenda \(RIN: 2127-AM50\)](#).

alarms are greater for AEB than for FCW due to the activation of emergency braking with AEB, the system may not have considered this radar-only signal to be sufficient to request AEB engagement.<sup>102</sup>

Further, although the system did request FCW activation just before the crash (between 0 and 0.2 seconds before impact), whether the FCW alert was actually presented to the driver is unknown, as the system does not record the execution of a requested command.<sup>103</sup> Even if presented, the warning would have been too late for the driver to initiate an avoidance maneuver.

The Ford vehicle owner's manual states that the FCW and AEB systems can detect stationary vehicles and are designed to operate at speeds above 3 mph up to the vehicle's maximum speed, with a 50-mph limit for detection of pedestrians and bicyclists. However, the manual cautions that AEB performance can degrade due to numerous factors, including nighttime conditions.

Considering the somewhat conflicting information in the vehicle owner's manual—AEB being operational up to the maximum vehicle speed but with reduced performance in low-visibility conditions—it is unclear whether the AEB and FCW systems should have been expected to activate in time to help the Ford drivers avoid or reduce the severity of the San Antonio and Philadelphia crashes. Further contributing to this uncertainty is Ford's statement about not expecting current-generation radar-camera fusion systems to detect a stationary vehicle as a hazard in nighttime conditions and at highway speeds.

#### **2.2.4.2 Performance Testing Protocols**

Because the FCW and AEB systems on the crash-involved 2022 Ford Mach-E vehicles were not federally mandated to meet any performance requirements, the NTSB investigations did not examine the ability of current-generation radar-camera fusion systems to detect a stationary vehicle as a hazard in nighttime conditions and at highway speeds. Instead, we examined the expected system performance based on testing protocols used by leading automotive safety organizations when these vehicles were manufactured.

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<sup>102</sup> The main advantage of radar is detecting the velocity of a moving object, while one of its primary limitations is interference from other sources (for example, an overpass or bridge abutment), resulting in false detection of static objects. Due to this limitation, manufacturers may delay or even deny AEB engagement for stationary vehicles based solely on radar data.

<sup>103</sup> The FCW activation indicated that the system required a lower level of certainty to trigger an FCW than to activate AEB. However, even with this lower threshold, the system identified the threat too late to be effective.

For about a decade, NCAP, the Insurance Institute for Highway Safety (IIHS), and the European New Car Assessment Programme (Euro NCAP) have been assessing the performance of FCW and AEB systems using various testing protocols. All were and continue to be based on three typical rear-end crash scenarios, including encountering a stopped vehicle in the same travel lane. The other two test scenarios are encountering a slower-moving lead vehicle and following a vehicle that decelerates after a period of time.

NCAP's testing protocol for the stopped lead vehicle condition limited maximum vehicle speed to 45 mph for FCW and 25 mph for AEB, while IIHS testing protocols were limited to 25 mph for AEB systems.<sup>104</sup> Euro NCAP's testing protocols for the stopped lead vehicle scenario included test speeds up to 80 kph (49.7 mph).<sup>105</sup> Although the FCW and AEB systems installed on the 2022 Ford Mach-E performed well in tests by these three organizations, the maximum speed parameters in the test protocols were well below the speeds of the Ford Mach-E vehicles involved in the San Antonio and Philadelphia crashes. As discussed in section 2.2.2.1, the 2024 Euro NCAP testing protocols for evaluating ACC and AEB/FCW during ACC engagement include cut-out scenarios, although the test vehicle speed is limited to a maximum of 90 kph (56 mph), and the scenarios involve a revealed vehicle that is moving rather than stationary. Euro NCAP has not conducted these tests on any Ford Mach-E vehicles.

The parameters of the San Antonio and Philadelphia crashes were beyond those of the current testing protocols, particularly because both crashes involved encountering a stationary vehicle while traveling at highway speed. Therefore, the FCW and AEB systems' failure to respond effectively in these crashes is not unexpected.

Based on available testing protocol scenarios, the NTSB concludes that if the Ford in the Philadelphia crash had been traveling at the posted speed limit of 45 mph instead of 72 mph, the FCW and AEB systems would have been more likely to alert the driver sooner or mitigate the crash, based on the Ford Mach-E performance in the existing testing protocols.

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<sup>104</sup> (a) See NHTSA's testing protocols for [AEB](#) and for [FCW](#) evaluation, NHTSA's NCAP [website](#) for the 2022 Ford Mach-E all-wheel drive safety rating, and NHTSA's 2022 light vehicle [AEB research summary](#), which includes 2022 Ford Mach-E test performance. (b) See the IIHS [ratings for the 2022 Ford Mach-E](#) test performance. In April 2025, the IIHS published [Front Crash Prevention 2.0](#) test protocols that increased the test velocity to 43 mph.

<sup>105</sup> (a) See Euro NCAP's current and previous [AEB assessment protocols](#). (b) See Euro NCAP's [2021 Ford Mach-E safety rating](#).

### 2.2.4.3 2024 NHTSA Final Rule on FMVSS 127

In May 2024, NHTSA issued a final rule creating FMVSS 127, which requires AEB, including pedestrian AEB, on all new light vehicles.<sup>106</sup> The compliance date for the rule, for most vehicles, is September 1, 2029.<sup>107</sup> The final rule includes performance requirements for FCW and AEB systems in passenger vehicles. These performance requirements and accompanying test protocols are based on the three rear-end crash scenarios discussed in section 2.2.4.2.

FMVSS 127 requires AEB systems to completely avoid collisions with lead vehicles (including stationary ones) at speeds up to 62 mph and to activate at speeds up to 90.1 mph. For speeds between 62 mph and 90.1 mph, the only requirement is that AEB must activate, with no specified reduction in impact speed.<sup>108</sup>

These performance requirements also apply during nighttime conditions when using low-beam headlights. The mandate includes requirements for pedestrian detection, specifying that pedestrian AEB systems must activate and prevent collisions with pedestrians at speeds up to 45.4 mph.

Although FMVSS 127 does not apply to the crash-involved 2022 Ford Mach-E vehicles, which were manufactured before the effective date of the standard, the NTSB examined whether its requirements would cover the parameters of the San Antonio and Philadelphia crashes.

**San Antonio Crash.** The Ford in the San Antonio crash, traveling at approximately 74 mph, encountered a stationary Honda that likely had illuminated taillights and flashing hazard lights. Under the new FMVSS, the Ford's AEB system would not need to completely avoid striking the Honda but would be required to engage before impact. Because the rule does not specify how much impact velocity must be reduced at speeds above 62 mph, the potential benefits of AEB engagement remain speculative.

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<sup>106</sup> See [89 Federal Register 39686](#) (May 9, 2024).

<sup>107</sup> In November 2024, NHTSA [amended the rule](#) in response to a petition for reconsideration. In the amended final rule, the agency denied the petition while making minor language and technical changes, stating that the "final rule clarifies requirements applicable to FCW visual signals and audio signals, corrects an error in the test scenario for obstructed pedestrian crossing the road, and removes superfluous language from the performance test requirement for lead vehicle AEB."

<sup>108</sup> The NTSB had previously recommended in Safety Recommendation [H-15-4](#) that NHTSA use test parameters that reflect real-world crash scenarios. In its [2023 NPRM](#) that preceded the [final rule](#), NHTSA stated that its 2020 research on lead vehicle AEB performance showed practicability of higher-speed testing. The NTSB expressed support for this testing in our [response](#) to the NPRM.

For example, assuming a braking deceleration of 1 g (typically achievable on vehicles similar to the Ford Mach-E on dry, level surfaces), a vehicle traveling 62 mph would need to initiate braking at least 146 feet before the stationary vehicle to avoid striking it, thus meeting the mandate.<sup>109</sup> For a vehicle traveling 74 mph, if its AEB activated at the same distance of 146 feet and with the same braking force, the impact speed would be reduced to about 39 mph, substantially reducing the likelihood of fatalities. A study that examined crash data from NHTSA's national automotive sampling system found that the probability of serious or fatal injuries in rear-end collisions is approximately 76% with an impact speed of 74 mph; at 39 mph, this risk drops to less than 1% (Doecke and others 2020).

**Philadelphia Crash.** The Ford in the Philadelphia crash, traveling about 72 mph, encountered two stopped vehicles and a driver outside one of the vehicles. Under the new FMVSS, the AEB system on the Ford would not need to completely avoid striking the vehicles but would be required to engage before impact. Had the Ford been traveling at the posted speed limit of 45 mph, the AEB system would have been required to completely avoid striking the Elantra, thus preventing the two fatalities. The role of speed in the Philadelphia crash is further examined in section 2.3.3.1, which discusses the safe implementation of partial automation systems.

The NTSB concludes that the circumstances of the San Antonio and Philadelphia crashes—stationary lead vehicle, striking vehicle traveling at highway speed, and nighttime conditions—were likely outside the capabilities of the Ford vehicles' collision avoidance systems (FCW and AEB) available at the time of the crash but are addressed in the performance parameters of the recently issued FMVSS 127.

## **2.3 Limitations and Insufficient Federal Oversight of Partial Driving Automation Systems**

In both the San Antonio and Philadelphia crashes, Ford vehicles operating in hands-free partial automation mode did not detect and respond to stationary vehicles ahead. The drivers also failed to respond, though due to different causes of distraction and disengagement from the driving task. Both incidents revealed deficiencies in data recording and highlighted inherent limitations of partial driving automation, both in general and in Ford's implementation of its BlueCruise system. These incidents also exemplified the potential for catastrophic outcomes resulting from the insufficient federal oversight of partial driving automation systems.

By nature of their classification set by SAE International and adopted by NHTSA, partial automation systems have limited perceptual and functional

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<sup>109</sup> The calculation of distance is based on the initial vehicle speed of 62 mph, its braking force of 1g, and a brake ramp-up time (to achieve the maximum braking force) of 0.2 seconds.

capabilities. The standard describes L2 as being “capable of only limited OEDR [object and event detection and response], meaning that there are some events that it is not capable of recognizing or responding to.”<sup>110</sup> As such, the driver remains responsible when using partial automation, but the driver’s primary role shifts to being an automation monitor who must always be prepared to take control when the system fails to detect and respond to a hazard. The difficulty of this task has been exemplified in the NTSB’s previous investigations of L2 crashes, which showed drivers being susceptible to automation overreliance and complacency, leading to disengagement from their primary role of monitoring automation and the driving environment.<sup>111</sup>

Research has shown the safety benefits of FCW and AEB systems in reducing crashes and mitigating their severity (PARTS 2022, Cicchino 2017, NTSB 2015). However, the safety benefits of L2 systems are more questionable. Specifically, it is uncertain whether additional safety benefits are gained (beyond those achieved through FCW and AEB) when automated lane keeping is incorporated within the limited functionality of L2 systems (Mueller, Reagan, and Cicchino 2021). Any additional potential safety benefits of L2 systems must be weighed against the increased safety risks associated with driver distraction and disengagement during L2 operation (Seppelt and Victor 2016). Increased involvement in non-driving activities is associated with increased crash risk (Klauer and others 2010; Liang, Lee, and Yekhshatyan 2012). Further, drivers may modulate their behavior and disengage from the driving task in situations they view as less risky (Lin and others 2018). The San Antonio and Philadelphia crashes demonstrate that even short periods of distraction and disengagement during L2 operation can result in fatal outcomes, underscoring the critical importance of robust partial automation system design and driver monitoring.

Recently, the IIHS published a report comparing the crash rates of vehicles from two manufacturers with L2 capabilities to the same or similar vehicles with only crash avoidance ADAS such as FCW, AEB, and lane departure warning systems (Cicchino 2024).<sup>112</sup> When controlling for other factors (such as vehicle headlight ratings and visibility conditions), the IIHS found that the presence of L2 systems did not result in lower crash rates, concluding that L2 systems function primarily as convenience features rather than safety enhancements.

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<sup>110</sup> For more information, see again the SAE International [J3016 202104](#) standard.

<sup>111</sup> See our investigations of crashes in Culver City, California (NTSB 2019); Delray Beach, Florida (NTSB 2020a); and Mountain View, California (NTSB, 2020b).

<sup>112</sup> The IIHS study examined the crash rate of model-year 2017–2019 Nissan Rogue and model-year 2013–2017 BMW vehicles.

Considering the increasing evidence that L2 systems provide convenience but do not necessarily enhance safety, there is a critical need for continued safety assessment of these systems, particularly given the known risk of driver disengagement when operating in partial automation mode. Since the NTSB's investigation of the first fatal partial automation crash in Williston, Florida, in 2016, we have been concerned with the safe implementation of this technology (NTSB 2017). Following that investigation, several additional crashes involving vehicles operating in partial automation mode have occurred, and the NTSB has issued numerous recommendations—several of which are discussed in later sections of this report—related to data recording, driver monitoring, and system performance. The following sections explore a multi-pronged approach for enhancing the safety of partial driving automation systems.

### **2.3.1 Lack of Federal Data-recording Requirements and Inadequate Manufacturer Awareness of NHTSA SGO-applicable Crash Events**

#### **2.3.1.1 Background and Deficiencies in San Antonio and Philadelphia Crashes**

The issues revealed in the San Antonio and Philadelphia crashes exposed broader deficiencies related to the safety assessment of partial automation systems, particularly regarding automakers' and, subsequently, safety regulators' crash awareness and crash reporting limitations (discussed in section 2.3.1.2) as well as data-recording and accessibility limitations (discussed in section 2.3.1.3).

The Ford Motor Company learned of the San Antonio crash nearly 2 weeks after it occurred through a post on an online forum monitored by Ford staff. Ford became aware of the Philadelphia crash about a month after it occurred when NTSB investigators sought initial crash details from the automaker. Upon learning about these crashes, Ford informed NHTSA, as required by SGO 2021-01, which established a federal requirement for documenting and reporting crashes involving vehicles equipped with partial automation (L2) systems.

The Ford vehicles involved in the two crashes were equipped with multiple in-vehicle recording modules and telematic data transmission capabilities, which captured some elements of the crashes and provided an understanding of their circumstances. However, both crashes also revealed data-recording limitations, including absent or inconsistent data capture. More importantly, Ford's recording of data related to L2 system operation or other ADAS functions was voluntary, as no federal requirements exist for recording ADAS features or partial automation system operation. The federal regulation that sets the standards for event data recorders (EDR) in light vehicles (if equipped; 49 *CFR* Part 563) does not include requirements

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for recording crash mitigation systems or other ADAS features, including those pertaining to automation.<sup>113</sup>

### 2.3.1.2 Crash Notification and Reporting of L2 Incidents to NHTSA

**Limitations of the L2 SGO.** SGO 2021-01 requires reporting a crash if the L2 system was in use within 30 seconds of an incident involving (1) a fatality, (2) a vulnerable road user, (3) a vehicle towaway, (4) airbag deployment, and/or (5) transportation of an individual to a hospital. NHTSA's stated purpose for the SGO is to evaluate whether manufacturers and operators are "meeting their statutory obligations to ensure that their vehicles and equipment are free of defects that pose unreasonable risks to motor vehicle safety."<sup>114</sup> The SGO incident database also provides limited data to the public about each reported incident. About 1 year before NHTSA established the SGO, the NTSB investigated a 2018 crash involving an L2 system in Mountain View, California, and issued Safety Recommendation [H-20-2](#) for NHTSA to evaluate the crash-involved automaker's L2 system and ensure that any identified safety defects are corrected (NTSB 2020a).<sup>115</sup>

NHTSA's SGO for L2 systems demonstrates the agency's recognition of potential safety issues and provides a mechanism for safety assessment through incident data. Through numerous investigations, the NTSB has expressed concerns about the safety of L2 system implementation and has therefore expressed support for the SGO as one mechanism for monitoring L2 system safety.<sup>116</sup> However, NHTSA cannot be fully effective in monitoring the safety of L2 system implementation in passenger fleets if its L2 SGO incident database is incomplete or inconsistent, and automakers cannot provide comprehensive information about their L2 crash incidents to NHTSA if they do not have a means of ensuring that they are aware of all crashes that occur involving their vehicles operating in partial automation mode.

For example, around the time of the San Antonio and Philadelphia crashes, Ford had submitted 17 incidents to NHTSA as required by the L2 SGO.<sup>117</sup> The

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<sup>113</sup> (a) An EDR is a "device or function in a vehicle that records the vehicle's dynamic time-series data during the time period just prior to a crash event (e.g., vehicle speed vs. time) or during a crash event (e.g., delta-V vs. time), intended for retrieval after the crash event." (b) This requirement applies to all passenger vehicles manufactured after September 1, 2012, that are equipped with an EDR. For more information, see [49 CFR Part 563](#), which came into effect in September 2014. (c) Vehicles are not required to be equipped with EDRs, but according to [NHTSA estimates](#), 99.5% of model-year 2021 passenger vehicles are equipped with EDR capability.

<sup>114</sup> See NHTSA's [website](#) for additional information on the SGO.

<sup>115</sup> Safety Recommendation H-20-2 is classified Open–Acceptable Response.

<sup>116</sup> The NTSB discussed the SGO requirements in our [response](#) to NHTSA's notice of proposed rulemaking "[Event Data Recorders](#)," published on June 22, 2022.

<sup>117</sup> Based on NHTSA's [incident report data](#) through May 2024.

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database indicated that telematics was the source of awareness for only one incident, which involved the automaker's testing of a developmental automation system.<sup>118</sup> Since that time, Ford has reported 18 other incidents to the L2 SGO database; telematics was potentially the initial source for only one of those reports.

More broadly, the NTSB's review of the L2 SGO incident database revealed significant reporting disparities among vehicle manufacturers. Since the start of the L2 SGO reporting requirements in July 2021 through December 2025, the reported number of incidents varied dramatically among automakers. Nine automakers reported fewer than 10 incidents, eight reported between 10 and 31 incidents, one reported 60 incidents, and one reported 99 incidents.<sup>119</sup> In contrast, Tesla reported 2,439 incidents, accounting for about 85% of all reported incidents. NHTSA's database indicated that telematics was the source for approximately 74% of all reported incidents, with Tesla's telematics accounting for 95% of those reports.<sup>120</sup>

Understanding the market penetration of L2 systems is useful for interpreting these reporting disparities. A market penetration study conducted by NHTSA and its industry partners through the Partnership for Analytics Research in Traffic Safety found that among 2023 model-year vehicles from automakers representing 80% of the US passenger vehicle fleet, 54% were equipped with lane centering capabilities and 68% were equipped with ACC, indicating that more than half of the new vehicles from these major automakers are equipped with L2 capability.<sup>121</sup> (Tesla was not included in the study.) Although differences in L2 system sensor capabilities and overall system performance may contribute to varying incident rates, the magnitude of disparity in incident reporting between Tesla and other automakers suggests another causal factor. For example, 83% of incidents reported by Tesla listed telematics as the source of the crash awareness. By contrast, Ford's telematic data collection programs were not intended to detect incidents meeting the L2 SGO

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<sup>118</sup> This incident occurred in September 2023 and involved a Ford F-150 pickup truck.

<sup>119</sup> (a) As of December 2025, graphical data on the [SGO website](#) reflected that Ford had reported 31 total incidents. However, NHTSA's archived data showed that Ford submitted 35 total incidents (as shown in table 5 of this report). The discrepancy is likely due to the agency's determination that some of the incidents were not required to be reported (for example, if it was determined that the Ford vehicle in a submitted incident was not operating in partial automation mode). (b) These numbers exclude the reported incidents by automated driving systems developers that are conducting testing.

<sup>120</sup> Some of the other sources of the reported incidents include complaints/claims, which account for approximately 12% of the reports. Other sources, including media, field reports, law enforcement, and testing; each account for less than 3% of these reports.

<sup>121</sup> (a) The [study](#) was published by the Partnership for Analytics Research in Traffic Safety in September 2024. Participating automakers were Ford, General Motors, Honda, Hyundai, Mazda, Mitsubishi, Stellantis, Subaru, and Toyota. (b) Vehicles with lane centering systems are also equipped with ACC, thus providing the combined functionality necessary for L2 capability.

reporting requirements. Specifically, airbag activation (whether or not a vehicle's airbags deployed) is not included in the transmitted parameters.

Ford only became aware of the San Antonio and Philadelphia crashes from a message board post in one case and an inquiry from the NTSB (after the police were unable to obtain information on the system) in the other case. In both cases, the manufacturer's awareness of the crashes was delayed by days or weeks, which can compromise understanding of the events. Combined, these reporting disparities and the large number of new vehicles equipped with L2 capabilities in recent years suggest that crashes involving vehicles operating with an L2 system are likely underreported.

The NTSB concludes that the San Antonio and Philadelphia crashes revealed limitations in the Ford Motor Company's design of its telematics data collection programs, which do not transmit direct crash parameters such as airbag deployment. These limitations restrict the automaker's ability to identify relevant crashes and comply with the reporting requirements of NHTSA's L2 SGO.

The NTSB also concludes that the San Antonio and Philadelphia investigations, which revealed delays in manufacturer awareness of crashes involving active L2 systems and reporting disparities across manufacturers in both the number of incidents reported and the information sources for the reports, show that the NHTSA's L2 SGO incident database likely does not reflect the full extent of L2-related crashes in the United States or the factors that contribute to these crashes.

***Needed Improvements to the L2 SGO.*** A telematic program that transmits information about restraint system deployment, along with basic information about current or recent L2 system engagement, would more reliably inform automakers of crashes meeting L2 SGO reporting requirements. For example, both Ford vehicles in the San Antonio and Philadelphia crashes were equipped with Ford's ACN system, 911 Assist. When enabled, this system automatically alerts emergency operators of a crash and provides the vehicle's location using the driver's paired cell phone. However, the system requires manual activation of the feature through the vehicle's infotainment console. In the San Antonio crash, 911 Assist did not make a call, indicating that the feature likely was not enabled. In the Philadelphia crash, the system successfully made a 911 call, but the crash data transmitted to the Ford Motor Company did not, nor were they designed to, include any ADAS-related information, including whether BlueCruise was active. Although Ford's Telematic One data program should contain sufficient information to identify crashes and L2 system operation status, this program was never intended to serve L2 SGO requirements and, as evidenced by these two crashes, was not designed to capture crash-related data.

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Importantly, Ford and other automakers are not required to transmit these data or even record any variables indicating L2 system engagement. The current L2 SGO approach relies on automakers to proactively learn about crashes involving their vehicles that meet the reporting requirements; however, without standardized detection systems for automatically notifying the automakers of relevant crashes, reporting of applicable incidents will remain incomplete. The NTSB concludes that when automakers lack a mechanism to become informed about incidents involving their vehicles that meet the reporting criteria specified in NHTSA's L2 SGO—as was the case for Ford in the San Antonio and Philadelphia crashes—the completeness of L2 SGO incident data cannot be assured, and the automakers' ability to investigate these incidents and the safety risks associated with L2 systems are likely to be limited.

As discussed, Ford's telematic data collection programs have the capability of transmitting information regarding incidents that meet L2 SGO reporting requirements, but these programs were not designed for this purpose. ACN systems are an additional example of an existing, widespread technology that is capable of transmitting critical vehicle data when crashes occur.<sup>122</sup>

Therefore, the NTSB recommends that NHTSA require manufacturers to equip new L2-capable passenger vehicles with a telematic system that notifies the manufacturer of crashes meeting NHTSA's reporting requirements in SGO 2021-01.

### **2.3.1.3 Recording of L2 and ADAS Information**

***Data-recording Limitations in San Antonio and Philadelphia Crashes.*** In the San Antonio crash, the BlueCruise module did not capture the crash, missing BlueCruise and other ADAS data as well as forward-facing camera images. Ford suggested that the recording failure might have resulted from a sudden loss of electrical power needed for data storage. However, SAPD postcrash scene photographs and body camera footage showed that the Ford's hazard lights were flashing, an indication that the vehicle had power after the crash. The investigation was unable to determine the specific reason for the BlueCruise module's failure to record the crash. The telematic data collection program that transmits continuous BlueCruise-related information captured only a segment of the crash trip, missing the final 5 minutes and 30 seconds before the San Antonio crash. Further, it was not designed to capture crash-related events such as airbag deployment or AEB activation.

In the Philadelphia crash, although the BlueCruise module captured the crash, the module was designed to record only 2 seconds of precrash data, which limited

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<sup>122</sup> According to [Consumer Reports](#), 16 automakers in the United States offer ACN at no cost—typically for 5 years—on at least some of their 2024 vehicle models, and ACN has been a [required component in vehicles in the EU](#) since 2018.

the assessment of the movement of the detected Genesis ahead, its motion relative to the Ford, and whether this was a cut-out scenario. Further, although the forward-facing camera recorded images of the stationary vehicles, the images' resolution was very low. The telematic data collection program that transmits continuous BlueCruise-related information did not record any portion of the crash trip. Accessing BlueCruise and other ADAS-related data required the Ford Motor Company's support, and Ford also needed to obtain a special tool from the DMS vendor to retrieve the data from the module. Without this support, NTSB and local law enforcement would not even have been able to determine whether the Ford vehicles were operating in BlueCruise mode when the crashes occurred. Moreover, by Ford's design, some important information was not recorded: the status of Intelligent ACC was not captured at all, and FCW activation was recorded only by the main BlueCruise module.

Although the NTSB ultimately obtained valuable information for understanding these crashes and the functionality and limitations of various ADAS features, most of this information came from Ford's voluntary recording of ADAS-related data through in-vehicle modules and telematic data collection programs, and both crashes revealed substantial deficiencies in data recording. The NTSB concludes that the circumstances of the San Antonio and Philadelphia crashes demonstrate that without federal requirements for the recording of L2 data, critical precrash information (such as L2 or ADAS activation) and crash information (such as driver or system evasive actions and system hazard detection) remains inconsistent and inaccessible to local law enforcement, safety investigators, regulators, and automakers.

**Regulations and Broader Discussion.** The Ford vehicles in both crashes were equipped with an EDR located in the ACM. The EDRs recorded the parameters required by 49 *CFR* Part 563. However, these data did not—nor were they required to—include any information pertaining to L2 system operation. Further, although the ACMs on both vehicles recorded a few variables pertaining to the collision mitigation system (specifically AEB), the EDR regulation does not require these data to be recorded. In 2024, NHTSA amended 49 *CFR* Part 563 to extend the required recording duration from 5 seconds to 20 seconds and increase the frequency from 2 Hz to 10 Hz. However, this amendment has no impact on the recording of data pertaining to vehicle automation and crash mitigation systems.<sup>123</sup>

Because there are no federal mandates requiring manufacturers and designated operators to capture information related to L2 system operation, the data that are needed to evaluate L2 system involvement in crashes are recorded inconsistently or not at all. In 2017, 4 years before NHTSA established the L2 SGO, the NTSB recognized the need for these recorded data following our investigation of

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<sup>123</sup> The [final rule](#) was published in December 2024, with an effective date of January 17, 2025.

the Williston, Florida, crash (NTSB 2017). In our report on that investigation, we recommended:

*To the USDOT:* Define the data parameters needed to understand the automated vehicle control systems involved in a crash. The parameters must reflect the vehicle's control status and the frequency and duration of control actions to adequately characterize driver and vehicle performance before and during a crash. ([H-17-37](#))

*To NHTSA:* Use the data parameters defined by the US Department of Transportation in response to Safety Recommendation H-17-37 as a benchmark for new vehicles equipped with automated vehicle control systems so that they capture data that reflect the vehicle's control status and the frequency and duration of control actions needed to adequately characterize driver and vehicle performance before and during a crash; the captured data should be readily available to, at a minimum, National Transportation Safety Board investigators and National Highway Traffic Safety Administration regulators. ([H-17-39](#))

*To NHTSA:* Define a standard format for reporting automated vehicle control systems data, and require manufacturers of vehicles equipped with automated vehicle control systems to report incidents, crashes, and vehicle miles operated with such systems enabled. ([H-17-40](#))

Because neither the USDOT nor NHTSA had initiated appropriate action related to these 2017 safety recommendations, Safety Recommendations H-17-37, -39, and -40 were classified Open–Unacceptable Response in 2020. These safety recommendations were intended not only to make the operation of automation systems and their components transparent and accessible to all crash investigators but also to standardize their data reporting to ensure their safe operation.

USDOT and NHTSA inaction on these recommendations continued after the change in classification of these recommendations. The NTSB commented on NHTSA's 2022 NPRM, which led to the eventual amendment of the EDR regulation, urging the agency to implement these safety recommendations and expressing our concern that the narrow scope of the NPRM "does not adequately address the rapidly increasing prevalence of vehicles equipped with L2 systems."<sup>124</sup>

Further, the USDOT and NHTSA's 2024 fall agenda of planned regulatory actions included a proposal to issue an ANPRM to further amend 49 CFR Part 563 to

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<sup>124</sup> See again NHTSA's notice of proposed rulemaking "[Event Data Recorders](#)," and the NTSB's [response](#).

include additional data elements that would allow for assessment of the safety data of vehicles equipped with partial automation systems.<sup>125</sup> However, NHTSA terminated this planned action and removed it from the agenda of planned regulatory actions in 2025.<sup>126</sup>

The consequences of not acting on these safety recommendations are apparent in the San Antonio and Philadelphia Ford BlueCruise investigations. The deficiencies in data recording identified in these investigations also expose a second limitation of the L2 SGO: a lack of appropriate requirements for data recording means that the reported incidents themselves may be missing critical information needed for assessing the safety of these systems.

The inaction by the USDOT and NHTSA is alarming given that automakers are already required to record comprehensive ADAS and L2 system data in other jurisdictions. As of July 2022, the European Union has mandated that new models of passenger vehicles be equipped with EDRs that record, along with basic vehicle parameters, the state and rate of activation of all safety and accident-avoidance systems for the 30 seconds before a triggered event.<sup>127</sup> The mandate, which was extended to all new passenger vehicles by July 2024, is gradually being transitioned to all commercial vehicles. Although the EU's EDR requirements do not explicitly mention partial automation, the requirements for capturing all safety and accident-avoidance systems—such as AEB, lane departure warning, ACC, and automatic lane steering—would effectively also capture L2-related information.

The NTSB concludes that inaction by the USDOT and NHTSA in establishing requirements for recording automated vehicle control system data—including the supporting ADAS features—continues to enable non-standardized and inconsistent data collection, hindering crash investigations and NHTSA's oversight of potential safety defects associated with L2 systems as well as limiting the broader usefulness of NHTSA's L2 SGO incident database in revealing incidents and crashes involving partial automation.

Although NHTSA's establishment of the L2 SGO database—which requires automakers to report incidents and crashes involving vehicles operating in partial automation mode along with relevant parameters—addresses some elements of Safety Recommendation H-17-37, NHTSA's continued inaction in mandating recording requirements necessitates that the NTSB adopt a new approach to ensure consistent and comprehensive data collection and safety assessment of L2 systems

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<sup>125</sup> See the [agenda 2127-AM67](#), with publication ID of Fall 2024.

<sup>126</sup> See the [agenda 2127-AM67](#), with publication ID of Spring 2025.

<sup>127</sup> For more information, see [Regulation \(EU\) 2019/2144](#) of the European Parliament and of the Council, and the [regulation addendum](#).

and their supporting ADAS. Therefore, the NTSB recommends that NHTSA amend 49 CFR Part 563, "Event Data Recorders," to require that all new L2-capable passenger vehicles record data elements related to these systems, including at a minimum:

- system availability;
- engagement and activation denial;
- driver alerts; and
- system faults for AEB, FCW, DMS, lane departure prevention, lane centering, partial automation system operation, and any other systems deemed necessary.

The NTSB also classifies Safety Recommendations H-17-37 and -39 Closed–Unacceptable Action/Superseded. In addition, although the L2 SGO addresses many elements of Safety Recommendation H-17-40, the SGO incident database is limited by the lack of (1) a requirement to record L2- and other ADAS-related data, (2) an effective means of ensuring manufacturer or operator awareness of applicable crashes, and (3) the ability for crash investigators to readily access the data. Therefore, the NTSB classifies Safety Recommendation H-17-40 Closed–Unacceptable Action/Superseded.

## 2.3.2 Driver Monitoring System Limitations

### 2.3.2.1 San Antonio and Philadelphia Crash Investigations

The circumstances of the San Antonio and Philadelphia crashes, particularly the lack of any driver response to the stopped vehicles ahead, indicated that both Ford drivers were distracted and disengaged from the driving task moments before the crashes. The available DMS data from both vehicles provided some details about the nature of that disengagement.

**San Antonio Crash.** In the San Antonio crash, the DMS data indicated that the driver was alternating glances between the infotainment console and the windshield in the 5 seconds before the crash, with considerably longer fixations on the infotainment console. The driver's glance pattern for the 5 seconds before the crash was as follows (refer to figure 8 for a visual representation):

- Infotainment console (1.4 seconds)
- Forward roadway (0.4 seconds)
- Infotainment console (1.6 seconds)
- Forward roadway (0.4 seconds)
- Infotainment console (1 second)
- Forward roadway (0.2 seconds)

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This pattern showed that the driver spent only 1 total second (across three separate glances) of the final 5 seconds before the crash looking at the roadway, with no single forward glance exceeding 0.4 seconds. These brief on-road glances (0.4, 0.4, and 0.2 seconds) were insufficient for the driver to detect the stationary Honda as a hazard and to reengage with the driving task but were sufficient for the DMS module to characterize the driver as *attentive*.

Specifically, each on-road glance reset the DMS countdown for the system to issue a DMS alert to the driver. Although individual off-road glance duration is critical for assessing a driver's momentary distraction risk, each of the Ford driver's three longer glances at the infotainment console was below NHTSA's recommended maximum off-road glance time (2 seconds) in the agency's distraction guidelines for designing in-vehicle electronic devices.<sup>128</sup> However, the pattern of glances over an extended period—combining both frequency and duration of on-road and off-road glances—can more accurately reveal disengagement from the driving task (Morando and others 2019, Gaspar and Carney 2019). Euro NCAP recognized the importance of analyzing scanning patterns by requiring detection of accumulated repeated off-road glances as part of its DMS performance requirements for top safety ratings.<sup>129</sup> By contrast, the Ford Mach-E's DMS implementation did not identify these gaze patterns as indicative of driver distraction.

The NTSB concludes that Ford's DMS implementation, which allowed brief driver glances to the forward roadway to reset the distraction alert timer, does not effectively mitigate visual distraction and driver disengagement following off-road glances.

Although the in-vehicle DMS module recorded only 5 seconds of data, telematic data showed that the Ford driver in the San Antonio crash received two eyes-off-road alerts for longer continuous off-road glances (after 5 or 8 seconds) at 29 and 8 seconds before the crash.<sup>130</sup> Based on the DMS data showing 4 seconds of total off-road glances in the last 5 seconds before the crash, as well as the two earlier bi-modal alerts (each of which indicating off-road glances of at least 5 seconds), the

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<sup>128</sup> (a) In situations where the first bi-modal alert is issued when a driver is glancing at distant in-vehicle locations, such as the floor, longer on-road glances are needed to reset the countdown. This was not the case in the San Antonio crash, and according to Ford, such situations are atypical. (b) For more information on NHTSA's guidelines for designing in-vehicle electronic devices, published in 2013, see [79 Federal Register 24818](#).

<sup>129</sup> Euro NCAP requires vehicles to include eye/head-tracking-based DMSs to receive top safety ratings. Section 2.3.2.2 describes Euro NCAP's DMS assessment criteria.

<sup>130</sup> The initial alert occurs after 5 seconds of continuous off-road gaze. As described in section 1.1.3.2, if the initial alert is visual-only (displayed in the instrument cluster) and the driver fails to return their gaze to the forward roadway, the system presents a bi-modal alert 3 seconds later.

Ford driver was looking away from the forward roadway for a total of 14–20 seconds in the last 30 seconds before the crash.

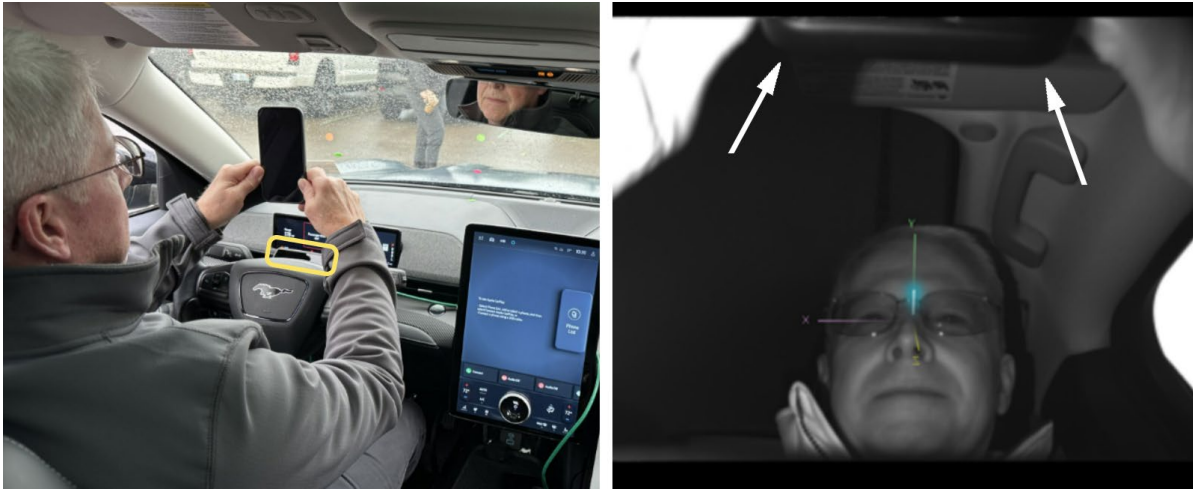
The NTSB concludes that in the San Antonio crash, the Ford driver's repeated off-road glances, combined with his insufficient, brief on-road glances to detect the stationary vehicle ahead, demonstrate the risks of accumulated glances away from the roadway and highlight the need for prolonged glance pattern evaluation in DMS implementation.

**Philadelphia Crash.** Telematic data showed that the Ford driver in the Philadelphia crash received an eyes-off-road alert for an extended continuous off-road glance (5 or 8 seconds) 26 seconds before the crash occurred.

DMS module data indicated that the driver was looking toward the windshield for the last 5 seconds before the crash. The single driver-facing image that the DMS module captured 2 seconds before the crash showed the driver sitting upright and facing forward with both eyes open, her left hand holding a partially visible rectangular object with her thumb wrapped around it. Although the steering wheel was not visible in the image, based on the locations of the other objects in the vehicle, the rectangular object was positioned at the top of the steering wheel, and the driver's forearms were resting on the steering wheel.

However, despite this indication of forward attention, other evidence—such as the driver looking ahead but not responding, her impairment, and her likely use of a cell phone at the time of the crash—prompted NTSB investigators to examine the operation of the DMS and determine the extent to which a driver may be able to engage in non-driving-related activities while using hands-free BlueCruise without the DMS detecting a lack of attention to the forward roadway.

Investigators examined whether holding a cell phone out of the DMS camera's view (either vertically or horizontally) but within the driver's line of sight to the forward roadway—such as resting on top of the steering wheel—could result in the DMS module mischaracterizing the driver's gaze (see figure 23). Using an exemplar Ford Mach-E and exemplar driver, investigators recreated the crash-involved driver's in-vehicle positioning (as captured by the DMS camera 2 seconds before the crash) by adjusting the seat and steering wheel column and matching the positioning of the driver's body and arms.



**Figure 23.** Forward- (left) and driver-facing (right) views of the exemplar driver in the vertical phone test position. The DMS camera is annotated in yellow in the left image, and the arrows in the right image show the position of the driver's hands holding the cell phone.

The exemplar driver was instructed to focus his gaze on each of the investigator-placed markers on the windshield and top of the dashboard (just below the windshield), as well as on the phone in applicable conditions. The examination determined that because of the DMS camera's location on top of the steering wheel column facing toward the driver's face, the DMS camera could not capture obstructions between the top of the steering wheel and the front windshield that would block the driver's view of the forward roadway. When the exemplar driver looked directly at the cell phone held both horizontally and vertically, the DMS consistently categorized the driver's gaze as 'Front Windshield,' indicating that the system had determined that the driver was looking at the forward roadway. The DMS accurately categorized the driver's gaze when looking just below the windshield as being directed toward an off-road categorization zone. Appendix C provides the detailed methodology and results of this evaluation.

The NTSB concludes that in the Philadelphia crash, the limitations of Ford's DMS in distinguishing between forward roadway attention and attention to objects positioned in the driver's line of sight to the roadway would have permitted the Ford driver to use her phone in a distracting manner without receiving a DMS alert.

### **2.3.2.2 Summary and Discussion**

Driver distraction or inattention is a frequent cause of crashes that the NTSB investigates. This inattention typically results from various forms of distraction (motor, visual, or cognitive), fatigue, impairment, or a combination of these factors.

Previous L2-related NTSB investigations focused largely on improving L2 system safety by reducing system limitations and enhancing driver engagement.

However, decades of research across various industries have conclusively shown that humans have significant limitations in maintaining attention and vigilance, making them poorly suited for automation monitoring tasks and susceptible to complacency (Parasuraman, Molloy, and Singh 1993; Metzger and Parasuraman 2001; Funk and others 1999). These challenges frequently result in drivers disengaging from automation monitoring tasks, thus increasing the risk of crashes.

Naturalistic and on-road research provides valuable insight into driver disengagement by examining how drivers use L2 systems across various automakers in the real world. Numerous studies have found drivers more likely to engage in secondary (non-driving-related) activities when operating a vehicle in L2 mode compared to manual driving. This increased disengagement manifested as greater visual-manual interaction with in-vehicle or portable devices (Reagan and others 2021, Reagan and others 2025) and longer mean and maximum eyes-off-road glance durations (Gaspar and Carney 2019, Morando and others 2021).

In each of the NTSB's previous L2-related investigations, the probable causes of the crashes included driver inattention or distraction stemming from overreliance on automation. Driver distraction or disengagement from the driving task during partial automation operation manifests in two forms: (1) unintentional, such as mind-wandering, typically due to insufficient stimuli requiring attention, and (2) intentional misuse, such as texting or watching videos. Our investigation of the Mountain View crash revealed a clear example of intentional misuse, as the driver was playing a game on his phone during the vehicle's L2 engagement (NTSB 2020a). In other L2-related crash investigations, driver disengagement was determined by a lack of response to obvious hazards that would have afforded sufficient time for attentive drivers to react (NTSB 2017, 2019, and 2020b).

In previous L2-related investigations, the NTSB identified two primary deficiencies related to driver disengagement: reliance on detection of driver-applied steering wheel torque as a method of inferring driver engagement and the lack of standards for systems that monitor driver engagement. To address these recognized issues, and as a result of the Mountain View crash investigation, the NTSB issued several new safety recommendations and reiterated and/or classified several others (NTSB 2020a). One recommendation was reiterated to six automakers who at the time manufactured vehicles with L2 capabilities that relied on driver-applied steering wheel torque as the sole method of inferring driver engagement, directing them to develop a more effective method of determining driver engagement while using these systems ([H-17-42](#)).<sup>131</sup> Ford did not make vehicles with L2 capabilities during this

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<sup>131</sup> Safety Recommendation H-17-42 is classified Open–Acceptable Response for five automakers and Open–Unacceptable Response for one automaker.

time and was not among the automakers to whom we issued or reiterated the recommendation.

The NTSB also issued several recommendations regarding the development of standards for monitoring driver engagement:

*To NHTSA:* For vehicles equipped with Level 2 automation, work with SAE International to develop performance standards for driver monitoring systems that will minimize driver disengagement, prevent automation complacency, and account for foreseeable misuse of the automation. ([H-20-3](#))

*A companion recommendation to SAE International:* For vehicles equipped with Level 2 automation, work with NHTSA to develop performance standards for driver monitoring systems that will minimize driver disengagement, prevent automation complacency, and account for foreseeable misuse of the automation. ([H-20-7](#))

*To NHTSA:* After developing the performance standards for driver monitoring systems recommended in Safety Recommendation H-20-3, require that all new passenger vehicles with Level 2 automation be equipped with a driver monitoring system that meets these standards. ([H-20-4](#))

The two recommendations to NHTSA were classified Open–Acceptable Response in 2021, and the recommendation to SAE International is classified Open–Await Response. In NHTSA’s June 2020 correspondence with the NTSB, the agency stated that it continues to conduct research on DMSs and has liaisons on two SAE International technical committees related to vehicle automation that are examining DMS issues. In 2022, NHTSA published a request for comments regarding upgrades to NCAP, which included a 5- and 10-year roadmap for emerging technologies, including DMSs.<sup>132</sup> In our response, the NTSB noted that these “are far from novel technologies,” are already implemented in many vehicles, and are rated elsewhere in the world.

In a recent meeting with NTSB investigators, NHTSA reported that although SAE International has demonstrated a lack of interest in participating in development of performance standards for DMSs, NHTSA has continued DMS-related research—including work supporting requirements in the Infrastructure Investment and Jobs Act (section 24209)—and has sufficient expertise to develop performance standards

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<sup>132</sup> See [87 Federal Register 13452 \(March 9, 2022\)](#); for the NTSB’s response, see [Docket ID 2021-0002-1530](#).

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independently.<sup>133</sup> In November 2025, NHTSA presented the initial results of some of this research in a public meeting.<sup>134</sup>

Although NHTSA has not yet made regulatory progress on developing standards for DMSs, such standards exist elsewhere. The EU has mandated the inclusion of advanced driver distraction warning systems in new-model vehicles since 2024, and for all new vehicles starting in July 2026.<sup>135</sup> These systems are required to monitor driver gaze and issue warnings when distractions are detected, whether during manual driving or in partial automation mode. In addition, Euro NCAP has required that vehicles include eye-tracking-based DMSs to receive top safety ratings.<sup>136</sup> Euro NCAP's performance requirements for such DMSs include numerous descriptive and performance requirements, including detecting:

- *Long distraction*: Gaze away from the forward roadway longer than 3 seconds (after which a visual/auditory alert is issued);
- *Short distraction*: Repeated glances away from the roadway, including cumulative 10 seconds of looking away from the forward roadway within a 30-second time period. A clock reset requires a 2-second gaze to the forward roadway; and
- *Phone use*: Including holding a phone in the 9-11 or 1-3 o'clock region on the steering wheel, the uppermost position below the windshield view.

The IIHS has also established testing protocols for assessing DMSs within the operation of L2 systems, evaluating numerous elements including eye- and head-tracking accuracy, drivers' physical distraction (such as holding a rectangular object representing a cell phone), and resistance to driver manipulation of the hands-on requirement (such as attaching a weight to the steering wheel).<sup>137</sup>

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<sup>133</sup> (a) "NHTSA-NTSB meeting to discuss partial automation mode investigations." July 31, 2025, virtual. Attendees at this meeting included staff from the NTSB's Office of Highway Safety and Office of Safety Recommendations and Communications as well as from NHTSA's Office of Defects Investigation, Human Factors/Engineering Integration, and Advanced and Emerging Technology Division. (b) NHTSA also described its DMS-related research in responding to NTSB Safety Recommendation [H-25-20](#) about DMS requirements in vehicles with gross vehicle weight ratings greater than 10,000 pounds.

<sup>134</sup> NHTSA presented some of the initial results of that research during the agency's [Safety Research Portfolio public meeting](#) in November 2025.

<sup>135</sup> See European Union Economic Commission [regulation 2024/1721](#).

<sup>136</sup> See the Euro NCAP Safe Driving Driver Engagement Protocol ([version 1.1](#), October 2025) for assessment of driver engagement.

<sup>137</sup> See the [IIHS testing protocols](#) for ratings of partial driving automation systems, published in March 2024. IIHS has also published [ratings](#) for various elements of partial automation systems.

Compared to Euro NCAP requirements, which specify more stringent performance criteria, the DMSs on the crash-involved Ford vehicles had several limitations:<sup>138</sup>

- could not detect drivers' phone use, particularly when held at the top of the steering wheel, as was likely in the Philadelphia crash;
- allowed longer off-road gazes before alerting (5 seconds compared to Euro NCAP's 3 seconds); and
- did not account for repeated shorter off-road glances, which may have been a factor in the San Antonio crash.

The Ford vehicles in the Philadelphia and San Antonio crashes were equipped with both a steering wheel torque monitoring system and an eye/head tracker. Unlike with the steering wheel torque method, the DMS camera provides direct information about where the driver is looking. However, as evidenced by these two crashes, eye/head tracker-based DMSs also have limitations related to their implementation and are subject to inherent system constraints and driver misuse.

Even with the DMS limitations exposed in these two crashes—limitations that reflect broader challenges in DMS implementation—Ford's inclusion of both driver-applied steering wheel torque and driver gaze monitoring when operating in partial automation mode represents an improvement over implementations that rely solely on steering wheel torque detection. Ford's approach demonstrates the industry's evolution toward more comprehensive driver monitoring solutions. However, the EU mandate for DMS inclusion and Euro NCAP performance requirements for top safety ratings demonstrate both the DMS technology's maturity and its higher performance capabilities.

The NTSB concludes that an urgent need exists for standardized US-based DMS performance requirements, as demonstrated by:

- the DMS deficiencies observed in the San Antonio and Philadelphia crashes and in previous NTSB investigations;
- NHTSA's ongoing research and plans to develop objective and repeatable procedures for assessing DMS effectiveness in eliminating driver distraction; and
- the more stringent performance testing protocols already implemented by Euro NCAP and the IIHS.

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<sup>138</sup> Although the Ford Mach-E vehicles involved in the two crashes also had the capability to monitor the driver's engagement through driver-applied steering wheel torque, this monitoring applies only when operated in hands-required BlueCruise mode.

Because of the need to issue a new, more appropriate recommendation to more broadly address the ongoing safety issue of DMS limitations, the NTSB recommends that NHTSA require that all new L2-capable passenger vehicles be equipped with DMSs capable of minimizing driver disengagement, automation complacency, and misuse of vehicle automation by, at a minimum:

- providing warnings about accumulated short glances over a prolonged period of time;
- differentiating genuine on-road glances from attention directed to objects, such as cell phones, located in the driver's forward line of sight; and
- issuing initial and subsequent multi-modal alerts at intervals that minimize eyes-off-road duration.

Due to NHTSA's ongoing DMS-related research, the NTSB classifies Safety Recommendations H-20-3 and -4, Closed–Acceptable Action/Superseded. Because of SAE International's lack of response and collaboration with NHTSA on this subject, the NTSB classifies Safety Recommendation H-20-7 Closed–Unacceptable Action/No Response Received.

The NTSB also recommends that the Ford Motor Company revise the DMSs in its new vehicles to detect and provide warnings about accumulated short distractions over a prolonged period of time; differentiate genuine driver on-road glances from attention directed to objects, such as cell phones, located in the driver's forward line of sight; and issue initial and subsequent multi-modal alerts at intervals that minimize eyes-off-road duration.

### **2.3.3 Deficiencies in Ford's L2 Implementation, and Overall Lack of Federal Guidelines for L2 Implementation and ADAS Integration**

#### **2.3.3.1 San Antonio and Philadelphia Crash Investigations**

The San Antonio and Philadelphia crashes not only serve as a reminder of the limitations of partial driving automation systems and their supporting ADAS in responding to hazards but also highlight that the mere presence of a DMS does not automatically eliminate driver disengagement. The investigations of these crashes also identified some L2 implementations that are potentially beneficial and others that present increased safety risks.

***Intelligent ACC Integration.*** BlueCruise engagement on Ford's L2-equipped vehicles does not require concurrent engagement of Intelligent ACC, which automatically adjusts maximum cruise speed based on detected posted speed limits

either via vehicle mapping data or detection of road signs by the forward-facing camera. Because neither Intelligent ACC engagement nor the speed limit determination is recorded by any data-recording source (in-vehicle modules or telematic data collection programs), Intelligent ACC engagement or lack of engagement in these crashes can only be inferred.

In the San Antonio crash, the Ford's impact speed was about 5 mph above the speed limit, within the +20-mph cruise speed tolerance range of Intelligent ACC; therefore, system engagement could not be determined. Even if engaged, the system would have allowed this speeding activity.

In the Philadelphia crash, the Ford was traveling at 71–72 mph in a 45-mph work zone, which exceeded the maximum Intelligent ACC tolerance of 20 mph over the speed limit. The vehicle's high-fidelity mapping system included the posted speed limit of 55 mph at the crash location. However, considering that camera-detected speed limits take precedence over mapping data when a discrepancy occurs, and that 45-mph speed limit signs in the work zone area were regulatory and clearly visible, the camera system should have been able to accurately detect the 45-mph speed limit. The fact that the vehicle's travel speed of 71–72 mph exceeded the maximum Intelligent ACC tolerance of 20 mph over the 45-mph speed limit indicated that Intelligent ACC was not engaged.

Had this system been engaged by the driver or automatically required during BlueCruise operation, the potential safety benefit would have depended on the driver-set cruise speed tolerance level; because the level can be set up to 20 mph above the speed limit, the Ford would have been traveling up to 65 mph as it approached the stationary vehicles. This design implementation would have negated the safety benefits typically provided by such systems, permitting excessive speed and making it more challenging for the driver and vehicle sensor systems to detect hazards and mitigate a crash. The safety benefits of Intelligent ACC in the Philadelphia crash could have been realized only if the system had been both engaged and configured with a lesser speed tolerance above the roadway speed limit.

Allowing drivers to set their cruise speed 20 mph above the posted speed limit during BlueCruise operation has the potential to increase crash risk. Although this approach allows drivers to accept responsibility for their speed choices, it also relies on them to assess the overall level of risk, including system limitations. Section 1.1.2.1 of this report discusses AEB engagement challenges with nighttime conditions and stationary object detection, especially at highway speeds. Expecting drivers to understand these limitations while assessing the risks of speeding during L2 operation is not an effective safety strategy. This safety challenge is particularly evident considering that hands-required BlueCruise mode has a maximum operational speed of 113 mph, which is considerably beyond the current capabilities

of AEB systems, as well as beyond the expected performance parameters of the new FMVSS 127 requirements.<sup>139</sup>

**AEB Integration.** Our investigations determined that AEB did not engage on either Ford Mach-E vehicle, nor did the sensor system request engagement. Our investigations also determined that although AEB is enabled by default at the beginning of each ignition cycle, drivers can disable the system, including during BlueCruise operation. Although AEB was not disabled in either crash and the vehicle did not request activation, permitting drivers to disable this critical safety system while operating in partial automation mode represents a safety risk, as it removes a layer of protection, especially during L2 operations when driver attention may be reduced.

**Other Factors in BlueCruise Implementation.** The Philadelphia crash occurred in a work zone featuring a reduced speed limit, narrowed lanes, limited shoulders, and construction warnings. These factors increased driving complexity, but the roadway curvature and reduced lane widths remained within BlueCruise's geographic operational domain. The L2 system was not designed to adapt its functionality (such as by reducing cruise speed tolerance) or modify driver engagement requirements (such as by lowering alert thresholds) in response to these more challenging conditions. Although the NTSB recognizes that BlueCruise as well as L2 systems from other manufacturers include various environmental and roadway thresholds for operation—such as roadway type, lane marking quality, and weather conditions—modulating the maximum cruise speed tolerance in work zones would represent a system-based adaptation to more complex roadway conditions.

Ford's restriction of hands-free BlueCruise to designated Blue Zone roadways represents a beneficial safety implementation, ensuring that the feature operates only in specifically designated environments.<sup>140</sup> This system-based geofencing prevents L2 system use on roads where the system is not designed to operate (part of its geographic operational design domain) and therefore does not rely on driver compliance with manual restrictions. However, hands-required BlueCruise can be engaged on most roadways with appropriate lane markings. While not a factor in

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<sup>139</sup> In 2023, following an investigation of a North Las Vegas, Nevada, crash in which a manually driven vehicle at speeds above 100 mph crashed into a minivan, causing multiple fatalities, the NTSB issued Safety Recommendation [H-23-20](#) to passenger vehicle manufacturers to install as standard equipment ISA systems that, at a minimum, warn the driver when the vehicle exceeds the speed limit (NTSB 2023).

<sup>140</sup> Following our Williston, Florida, crash investigation, the NTSB issued Safety Recommendation [H-17-41](#) to six automakers who had vehicles with L2 capabilities at the time, directing them to implement system-based safeguards to prevent partial automation systems from being used in conditions for which they were not designed (NTSB 2017). Ford was not among these automakers because it did not make vehicles with L2 capabilities at that time.

these crashes, this less restrictive approach could allow system activation in more challenging and potentially unsuitable conditions.

Ford's implementation of BlueCruise permitted cooperative steering, which allows drivers to make minor steering adjustments in the lane without the system deactivating.<sup>141</sup> However, in these crashes, neither Ford driver used this capability as intended in the moments before the crash: based on the DMS-captured images, the San Antonio driver was not touching the steering wheel, and the Philadelphia driver appeared to be resting her forearms on the steering wheel.

Ford's implementation of its partial vehicle automation system incorporated safeguards that addressed previous NTSB recommendations to other automakers, including system-based geofencing and camera-based monitoring of driver engagement. However, the NTSB concludes that the San Antonio and Philadelphia crashes revealed implementation deficiencies, including allowing drivers to disable the AEB system, not requiring the concurrent engagement of vehicle-equipped Intelligent ACC (active ISA), permitting hands-free partial automation in work zones with reduced speed limits, and allowing Intelligent ACC to be configured with cruise speed tolerances up to 20 mph above posted speed limits.

Therefore, the NTSB recommends that the Ford Motor Company modify its BlueCruise system for new vehicles to require that the AEB system is engaged and that the Intelligent ACC system uses appropriate speed tolerances to mitigate excessive speeding, taking into consideration the system's operational capabilities as well as traffic and highway complexity.

### **2.3.3.2 Broader Discussion**

The NTSB's previous investigations of L2 crashes involving Tesla vehicles, combined with the current Ford investigations, reveal significant differences in L2 system implementation approaches across at least two automakers. These differences span from methods for determining driver engagement (steering wheel torque monitoring versus camera-based DMS) to approaches for ensuring L2 operation on appropriate roadways (relying on driver adherence versus implementing system-based restrictions). Although the Ford vehicles in the San Antonio and Philadelphia crashes were newer-model vehicles compared to the Tesla vehicles from our previous investigations, substantial implementation differences continue to exist across manufacturers.

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<sup>141</sup> *Cooperative steering* enables shared control between driver and automation and represents an L2 implementation approach that attempts to maintain driver engagement by design rather than by relying solely on the DMS (see Fuchs, Sakai, and Tamura 2024).

In the past 2 years, Consumer Reports and the IIHS have independently initiated ratings of L2 systems.<sup>142</sup> These rating systems evaluate various aspects of L2 functionality and implementation, DMS capabilities, integration of other ADAS features, and ease of misuse. However, although both organizations produced varied ratings across manufacturers, their assessments of some of the same vehicles also differed from each other. These initial attempts at holistic evaluation of L2 systems highlight the variety of implementation approaches across automakers and the need for authoritative consensus on safe L2 implementation practices.

Even for crashworthiness—where NCAP has established performance criteria and testing protocols—vehicles receive varying safety ratings. For systems and components without minimum performance standards, even greater performance variability would be expected. Moreover, L2 systems present a more complex implementation challenge with multiple components and a human driver as the critical element.

Earlier in this report, we discussed L2-related research and driver disengagement risk. Other studies have shown that drivers exhibit different levels of disengagement across L2 systems, with later-generation systems providing longer continuous automated steering leading to considerably more secondary task engagement than earlier systems from the same automaker (Reagan and others 2025). The method of lane keeping that an L2 system uses—either lane centering or lane assistance that allows within-lane variability—can also substantially impact drivers' levels of disengagement. Specifically, L2 systems that allow shared steering control between the driver and the automation result in less precise lane centering but also improve driver engagement (Fuchs, Sakai, and Tamura 2024).<sup>143</sup> Drivers' expectations and experience also play a significant role in their interaction with L2 systems. An IIHS study showed that owners of L2-capable vehicles from three different manufacturers all indicated being more likely to engage in non-driving activities while using their L2 system and believed it was safer to engage in such activities during L2 operation than during manual driving (Mueller, Cicchino, and Calvanelli 2024). That study also showed that implementation differences resulted in a dangerous misalignment between system capabilities and driver perceptions. Vehicle owners' comfort with treating their L2 systems as fully self-driving varied considerably across manufacturers, ranging from 52% to 12%. Owners with higher comfort levels in viewing their systems as fully self-driving also reported higher engagement in non-

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<sup>142</sup> [Consumer Reports](#) initiated its ratings in 2023, and the IIHS started rating L2 systems in 2024.

<sup>143</sup> Systems with lowered override torque thresholds (reducing the steering force a driver must apply before the system yields control) enable easier shared control between driver and automation but also reduce path tracking performance (resulting in less precise lane centering with more lateral variability within the lane). Because the system's imperfect lane tracking is perceptible to the driver, it discourages overreliance on the automation and helps prevent disengagement. However, this benefit is limited to hands-required L2 systems.

driving-related activities. The dangers of such misalignment can occur even when drivers detect an upcoming hazard but expect the automated system to respond (Victor and others 2018). These concerns are particularly acute when drivers are unfamiliar with the vehicle they are operating, such as in rental situations.

However, familiarity with a system and its limitations (for example, through the vehicle owner's manual or a dealership demonstration) is only an initial step. Through continued use of an L2 system, drivers develop an updated mental model of the system's capabilities and limitations based on their experience. Drivers may learn to trust the system to navigate through certain situations without the need for driver intervention, such as a straight section of roadway with sparse traffic. This familiarity may lead them to disengage from the driving task, but because partial automation systems have inherent perceptual and functional limitations, they will eventually fail. Any driver disengagement—whether within the operational constraints of the system's DMS (as in the San Antonio crash), intentional misuse (as in the Philadelphia crash), or unintended mind-wandering—represents a risk that, when coinciding with a partial automation failure, can be fatal.

Lack of familiarity with system capabilities was not a factor in the San Antonio and Philadelphia crashes, nor was it a factor in the NTSB's previous investigations involving L2 systems. Monitoring and effectively detecting driver disengagement—and reorienting driver attention to the driving task—is only one approach to addressing the challenge of maintaining driver engagement during L2 operation. Given the limited effectiveness of directives and warnings against driver disengagement, implementing vehicle automation systems that promote driver engagement by design is a stronger approach.

Manufacturers' expectations for how drivers will use their L2 systems (usually presented as instructions to drivers in vehicle owner's manuals) frequently diverge considerably from drivers' real-world use, as the NTSB has discussed in previous investigations.<sup>144</sup> Marketing campaigns for L2-capable vehicles may also contribute to driver misperceptions about system capabilities. A recent naturalistic study illustrates this divergence. When operating in L2 mode that requires hands on the steering wheel (monitored by driver-applied steering wheel torque), drivers received, on average, the initial warning for having hands off the steering wheel every 3.2 miles (Mueller and others 2025).

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<sup>144</sup> The Tesla driver's interaction with the steering wheel in the Williston crash provides an illuminating example. The Autopilot (Tesla's L2 system) inferred the driver's engagement by monitoring driver-applied steering wheel torque. Data showed that of the 37 minutes that Autopilot was engaged during that crash trip, the system had detected driver-applied torque for a total of 25 seconds. For more information, see NTSB 2017.

These studies indicate that the nature of L2 system implementation— independent of any driver monitoring approach—can directly affect both driver perception of system capability and the degree to which drivers disengage from the driving task. Aligning system design with driver expectations and actual usage patterns, as well as promoting driver engagement by design, is therefore a critical aspect of safe L2 system implementation. As explored earlier in section 2.3.3, the concurrent engagement of safety-critical components is also essential to mitigate system performance limitations. These components include AEB and active ISA (which Ford refers to as Intelligent ACC), as well as adaptive implementations that respond to environmental changes such as traffic and highway complexity and weather conditions.

However, no comprehensive guidelines or industry best practices currently exist for the safe implementation of L2 systems, which explains the current divergence in both system design and assessment methodologies. Although the USDOT has developed four iterations of an automated vehicle policy, the policy focuses only on higher-level automation (SAE Levels 3-5).<sup>145</sup> Although both Consumer Reports and the IIHS rated Ford BlueCruise favorably compared to other manufacturers' L2 systems, the San Antonio and Philadelphia crashes revealed implementation limitations and deficiencies.

The IIHS and Consumer Reports also do not evaluate ACC performance; neither does NHTSA's NCAP. By contract, Euro NCAP began evaluating ACC performance in 2024, including ACC response to stationary vehicles.<sup>146</sup> Although this testing would not apply to the 2022 Ford Mach-E, Euro NCAP's more advanced testing framework illustrates one approach to improving the safe implementation of L2 systems and underscores the absence of equivalent evaluation criteria in the US.

The Ford Mach-E's maximum allowable cruise speed of 113 mph during hands-required BlueCruise operation was not a factor in the San Antonio or Philadelphia crashes, but it is clearly excessive and is well above both the expected capabilities of NHTSA's forthcoming AEB mandate and the assessment speeds used in Euro NCAP's protocols. Therefore, any guidelines or industry best practices for L2 implementation should address vehicles' maximum allowable cruise speed and account for the performance limitations of associated safety systems.

The San Antonio and Philadelphia crashes revealed several beneficial design elements in Ford's BlueCruise implementation, such as geofencing for hands-free

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<sup>145</sup> The USDOT has developed four iterations of its automated vehicles policy (1.0-4.0), starting with the [first AV policy](#) in 2016.

<sup>146</sup> Euro NCAP's Safe Driving Vehicle Assistance Protocol ([version 1.1](#), October 2025) includes evaluation of the performance of ACC alone. The protocol includes approaching a stationary vehicle when traveling at speeds up to 130 kph (80.8 mph).

operation and more comprehensive driver monitoring. However, these crashes also revealed that significant opportunities remain to enhance L2 system safety through more holistic design approaches, including requiring concurrent engagement of critical safety systems. Additionally, the limitations of several L2 design elements uncovered in these investigations—even advanced ones such as a camera-based DMS—highlight the need for holistic implementation of L2 systems across automakers.

Without authoritative guidelines or industry best practices for L2 system implementation, automakers are developing their own approaches to partial automation, balancing convenience, functionality, and safety considerations. The variation in L2 implementations, along with research showing the impact of those varied implementations on risk-related metrics such as driver disengagement levels, underscores the need for authoritative guidance to ensure consistent safety-focused design principles. Although the USDOT and NHTSA have established numerous automation-related programs, L2 implementation standards or even guidelines are lacking. NHTSA’s previously referenced distraction guidelines for designing in-vehicle electronic devices serve as an example of a non-mandate approach that became an industry-accepted reference. Additionally, the USDOT recently established the Highly Automated Systems Safety Center of Excellence (HASS COE) with a Congressional mandate to review and assess the safety of automated technologies.<sup>147</sup>

The NTSB concludes that the lack of federal guidance for L2 systems in passenger vehicles has led to safety-critical design gaps in mitigating known system limitations, enhancing safety redundancy by ensuring concurrent engagement of safety technologies, and promoting driver engagement by design.

The USDOT oversees NHTSA as well as HASS COE and other programs related to vehicle automation that may fall outside of NHTSA’s jurisdiction.<sup>148</sup> Therefore, the NTSB recommends that the USDOT issue comprehensive guidelines for vehicle manufacturers implementing partial vehicle automation systems that address known system limitations, including:

- integration and concurrent engagement of other safety-critical technologies (such as AEB, active ISA, and DMS);
- promoting driver engagement by design;
- reducing the safety risks associated with automation complacency and misuse; and

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<sup>147</sup> The [HASS COE](#) was created in 2020 by the [Further Consolidated Appropriations Act](#).

<sup>148</sup> In addition to HASS COE, the Federal Highway Administration’s [Automated Vehicle Activities and Resources](#) are another example of an initiative within the USDOT but outside of NHTSA.

- setting maximum operational speeds for automation systems based on overall system capabilities.

## 3 Conclusions

### 3.1 Findings

1. None of the following were factors in the San Antonio crash: (1) the licensing of either driver; (2) the Ford driver's experience with his vehicle; (3) intoxication of the Ford driver; (4) the mechanical condition of the Ford; (5) highway factors; or (6) weather.
2. None of the following were factors in the Philadelphia crash: (1) the licensing of the Ford driver; (2) the mechanical condition of the Ford; (3) highway factors; or (4) weather.
3. The emergency responses to both the San Antonio and Philadelphia crashes were timely and adequate.
4. In the San Antonio crash, the reasons for the Honda being stopped in the center lane could not be determined, but the Honda driver's alcohol impairment could have contributed.
5. The Ford driver in the San Antonio crash did not respond to the stationary vehicle ahead, despite having adequate opportunity to identify the hazard and initiate an evasive maneuver, due to distraction from use of the vehicle's infotainment system and overreliance on the vehicle's partial automation.
6. The Ford driver in the Philadelphia crash did not respond to the stopped vehicles ahead, despite having adequate opportunity to identify the hazard and initiate an evasive maneuver, due to a combination of potentially interacting factors, including:
  - impairment from substance use;
  - disengagement from the driving task, likely due to cell phone use and overreliance on the vehicle's partial automation; and
  - speeding, which reduced the duration of clear line of sight to the stopped Elantra.
7. The National Highway Traffic Safety Administration's failure to meet the statutory date for completing a final rule requiring advanced impaired driving technology on all new passenger vehicles continues to expose the public to dangers posed by impaired drivers.
8. If the Ford in the Philadelphia crash had been traveling at the posted speed limit of 45 mph instead of 72 mph, the forward collision warning and automatic emergency braking systems would have been more likely to alert

the driver sooner or mitigate the crash, based on the Ford Mach-E performance in the existing testing protocols.

9. The circumstances of the San Antonio and Philadelphia crashes—stationary lead vehicle, striking vehicle traveling at highway speed, and nighttime conditions—were likely outside the capabilities of the Ford vehicles' collision avoidance systems (forward collision warning and automatic emergency braking) available at the time of the crash but are addressed in the performance parameters of the recently issued Federal Motor Vehicle Safety Standard 127.
10. The San Antonio and Philadelphia crashes revealed limitations in the Ford Motor Company's design of its telematics data collection programs, which do not transmit direct crash parameters such as airbag deployment. These limitations restrict the automaker's ability to identify relevant crashes and comply with the reporting requirements of the National Highway Traffic Safety Administration's SAE International Level 2 Standing General Order.
11. The San Antonio and Philadelphia investigations, which revealed delays in manufacturer awareness of crashes involving active SAE International Level 2 (L2) systems and reporting disparities across manufacturers in both the number of incidents reported and the information sources for the reports, show that the National Highway Traffic Safety Administration's L2 Standing General Order incident database likely does not reflect the full extent of L2-related crashes in the United States or the factors that contribute to these crashes.
12. When automakers lack a mechanism to become informed about incidents involving their vehicles that meet the reporting criteria specified in the National Highway Traffic Safety Administration's SAE International Level 2 (L2) Standing General Order (SGO)—as was the case for Ford in the San Antonio and Philadelphia crashes—the completeness of L2 SGO incident data cannot be assured, and the automakers' ability to investigate these incidents and the safety risks associated with L2 systems are likely to be limited.
13. The circumstances of the San Antonio and Philadelphia crashes demonstrate that without federal requirements for the recording of SAE International Level 2 (L2) data, critical precrash information (such as L2 or advanced driver assistance systems activation) and crash information (such as driver or system evasive actions and system hazard detection) remains inconsistent and inaccessible to local law enforcement, safety investigators, regulators, and automakers.

14. Inaction by the US Department of Transportation and National Highway Traffic Safety Administration (NHTSA) in establishing requirements for recording automated vehicle control system data—including the supporting advanced driver assistance systems features—continues to enable non-standardized and inconsistent data collection, hindering crash investigations and NHTSA’s oversight of potential safety defects associated with SAE International Level 2 (L2) systems as well as limiting the broader usefulness of NHTSA’s L2 Standing General Order incident database in revealing incidents and crashes involving partial automation.
15. The Ford Motor Company’s driver monitoring system implementation, which allowed brief driver glances to the forward roadway to reset the distraction alert timer, does not effectively mitigate visual distraction and driver disengagement following off-road glances.
16. In the San Antonio crash, the Ford driver’s repeated off-road glances, combined with his insufficient, brief on-road glances to detect the stationary vehicle ahead, demonstrate the risks of accumulated glances away from the roadway and highlight the need for prolonged glance pattern evaluation in driver monitoring system implementation.
17. In the Philadelphia crash, the limitations of the Ford Motor Company’s driver monitoring system (DMS) in distinguishing between forward roadway attention and attention to objects positioned in the driver’s line of sight to the roadway would have permitted the Ford driver to use her phone in a distracting manner without receiving a DMS alert.
18. An urgent need exists for standardized US-based driver monitoring system (DMS) performance requirements, as demonstrated by:
  - the DMS deficiencies observed in the San Antonio and Philadelphia crashes and in previous National Transportation Safety Board investigations;
  - the National Highway Traffic Safety Administration’s ongoing research and plans to develop objective and repeatable procedures for assessing DMS effectiveness in eliminating driver distraction; and
  - the more stringent performance testing protocols already implemented by the European New Car Assessment Programme and Insurance Institute for Highway Safety.
19. The San Antonio and Philadelphia crashes revealed implementation deficiencies, including allowing drivers to disable the automatic emergency braking system, not requiring the concurrent engagement of vehicle-equipped Intelligent Adaptive Cruise Control (ACC) (active intelligent speed

assistance), permitting hands-free partial automation in work zones with reduced speed limits, and allowing Intelligent ACC to be configured with cruise speed tolerances up to 20 mph above posted speed limits.

20. The lack of federal guidance for SAE International Level 2 systems in passenger vehicles has led to safety-critical design gaps in mitigating known system limitations, enhancing safety redundancy by ensuring concurrent engagement of safety technologies, and promoting driver engagement by design.

## **3.2 Probable Causes**

### **3.2.1 San Antonio, Texas, Crash**

The National Transportation Safety Board determines that the probable cause of the San Antonio, Texas, crash was the driver's failure to respond to the stationary vehicle ahead due to distraction, likely from the in-vehicle navigation system, stemming from overreliance on the vehicle's hands-free partial automation system and disengagement from the driving task. Contributing to the crash was the inability of the Ford vehicle's partial automation system, including its automatic emergency braking system, to detect and respond to the stationary vehicle ahead. Also contributing to the crash was the location of the stationary vehicle, which may have been stopped in the center lane of the highway due to the impairment of its driver.

### **3.2.2 Philadelphia, Pennsylvania, Crash**

The National Transportation Safety Board determines that the probable cause of the Philadelphia, Pennsylvania, crash was the driver's failure to respond to the stationary vehicles ahead due to impairment from alcohol that may have been worsened by cannabis use, as well as distraction, likely from cell phone use, stemming from overreliance on and misuse of the vehicle's hands-free partial automation system. Contributing to the crash was the driver's operation of the vehicle about 27 mph over the speed limit in a work zone. Further contributing to the crash was the Ford Motor Company's inadequate integration of its active speed management system with its partial automation system, which permitted excessive speed, including in a work zone.

## 4 Recommendations

### 4.1 New Recommendations

As a result of this investigation, the National Transportation Safety Board makes the following new safety recommendations:

#### **To the US Department of Transportation:**

Issue comprehensive guidelines for vehicle manufacturers implementing partial vehicle automation systems that address known system limitations, including:

- integration and concurrent engagement of other safety-critical technologies (such as automatic emergency braking, active intelligent speed assistance, and driver monitoring system);
- promoting driver engagement by design;
- reducing the safety risks associated with automation complacency and misuse; and
- setting maximum operational speeds for automation systems based on overall system capabilities. (H-26-1)

#### **To the National Highway Traffic Safety Administration:**

Require manufacturers to equip new SAE International Level 2-capable passenger vehicles with a telematic system that notifies the manufacturer of crashes meeting your reporting requirements in Standing General Order 2021-01. (H-26-2)

Amend 49 *Code of Federal Regulations* Part 563, "Event Data Recorders," to require that all new SAE International Level 2-capable passenger vehicles record data elements related to these systems, including at a minimum:

- system availability;
- engagement and activation denial;
- driver alerts; and
- system faults for automatic emergency braking, forward collision warning, driver monitoring system, lane departure prevention, lane centering, partial automation system operation, and any other systems deemed necessary. (H-26-3)

Require that all new SAE International Level 2-capable passenger vehicles be equipped with driver monitoring systems capable of

minimizing driver disengagement, automation complacency, and misuse of vehicle automation by, at a minimum:

- providing warnings about accumulated short glances over a prolonged period of time;
- differentiating genuine on-road glances from attention directed to objects, such as cell phones, located in the driver's forward line of sight; and
- issuing initial and subsequent multi-modal alerts at intervals that minimize eyes-off-road duration. (H-26-4)

**To the Ford Motor Company:**

Revise the driver monitoring systems in your new vehicles to detect and provide warnings about accumulated short distractions over a prolonged period of time; differentiate genuine driver on-road glances from attention directed to objects, such as cell phones, located in the driver's forward line of sight; and issue initial and subsequent multi-modal alerts at intervals that minimize eyes-off-road duration. (H-26-5)

Modify your BlueCruise system for new vehicles to require that the automatic emergency braking system is engaged and that the Intelligent Adaptive Cruise Control system uses appropriate speed tolerances to mitigate excessive speeding, taking into consideration the system's operational capabilities as well as traffic and highway complexity. (H-26-6)

## **4.2 Previously Issued Recommendation Reiterated in This Report**

As a result of its investigation, the National Transportation Safety Board reiterates the following safety recommendation:

**To National Highway Traffic Safety Administration:**

Require that all new vehicles be equipped with passive vehicle-integrated alcohol impairment detection systems, advanced driver monitoring systems, or a combination thereof; the systems must be capable of preventing or limiting vehicle operation if driver impairment by alcohol is detected. ([H-22-22](#))

Safety Recommendation H-22-22 is reiterated in section 2.2.3 of this report.

### 4.3 Previously Issued Recommendations Classified in This Report

As a result of its investigation, the National Transportation Safety Board classifies the following safety recommendations:

#### **To US Department of Transportation:**

Define the data parameters needed to understand the automated vehicle control systems involved in a crash. The parameters must reflect the vehicle's control status and the frequency and duration of control actions to adequately characterize driver and vehicle performance before and during a crash. ([H-17-37](#))

Safety Recommendation H-17-37 is classified Closed–Unacceptable Action/Superseded in section 2.3.1.3 of this report. This recommendation is superseded by Safety Recommendation H-26-3, which is classified Open–Unacceptable Response.

#### **To National Highway Traffic Safety Administration:**

Use the data parameters defined by the US Department of Transportation in response to Safety Recommendation H-17-37 as a benchmark for new vehicles equipped with automated vehicle control systems so that they capture data that reflect the vehicle's control status and the frequency and duration of control actions needed to adequately characterize driver and vehicle performance before and during a crash; the captured data should be readily available to, at a minimum, National Transportation Safety Board investigators and National Highway Traffic Safety Administration regulators. ([H-17-39](#))

Safety Recommendation H-17-39 is classified Closed–Unacceptable Action/Superseded in section 2.3.1.3 of this report. This recommendation is superseded by Safety Recommendation H-26-3, which is classified Open–Unacceptable Response.

Define a standard format for reporting automated vehicle control systems data, and require manufacturers of vehicles equipped with automated vehicle control systems to report incidents, crashes, and vehicle miles operated with such systems enabled. ([H-17-40](#))

Safety Recommendation H-17-40 is classified Closed–Unacceptable Action/Superseded in section 2.3.1.3 of this report. This recommendation is superseded by Safety Recommendation H-26-3, which is classified Open–Unacceptable Response.

For vehicles equipped with Level 2 automation, work with SAE International to develop performance standards for driver monitoring systems that will minimize driver disengagement, prevent automation complacency, and account for foreseeable misuse of the automation. ([H-20-3](#))

Safety Recommendation H-20-3 is classified Closed–Acceptable Action/Superseded in section 2.3.2.2 of this report. This recommendation is superseded by Safety Recommendation H-26-4, which is classified Open–Await Response.

After developing the performance standards for driver monitoring systems recommended in Safety Recommendation H-20-3, require that all new passenger vehicles with Level 2 automation be equipped with a driver monitoring system that meets these standards. ([H-20-4](#))

Safety Recommendation H-20-4 is classified Closed–Acceptable Action/Superseded in section 2.3.2.2 of this report. This recommendation is superseded by Safety Recommendation H-26-4, which is classified Open–Await Response.

**To SAE International:**

For vehicles equipped with Level 2 automation, work with the National Highway Traffic Safety Administration to develop performance standards for driver monitoring systems that will minimize driver disengagement, prevent automation complacency, and account for foreseeable misuse of the automation. ([H-20-7](#))

Safety Recommendation H-20-7 is classified Closed–Unacceptable Action/No Response Received in section 2.3.2.2 of this report.

**BY THE NATIONAL TRANSPORTATION SAFETY BOARD**

JENNIFER L. HOMENDY  
Chairwoman

THOMAS CHAPMAN  
Member

MICHAEL E. GRAHAM  
Vice Chairman

JOHN DELEEUW  
Member

**Report Date: March 31, 2026**

## Appendixes

### Appendix A: Investigations

The National Transportation Safety Board (NTSB) received notification of the San Antonio, Texas, crash on March 14, 2024, and launched investigators from the Office of Highway Safety to address vehicle automation, human performance, survival, and technical reconstruction factors. The team included staff from the NTSB's Transportation Disaster Assistance Division. The NTSB's Office of Research and Engineering participated in the investigation.

The San Antonio Police Department and the Ford Motor Company were parties to the San Antonio investigation.

The NTSB received notification of the Philadelphia, Pennsylvania, crash on April 2, 2024, and launched investigators from the Office of Highway Safety to address vehicle automation, human performance, and technical reconstruction factors. The team included staff from the NTSB's Transportation Disaster Assistance Division. The NTSB's Office of Research and Engineering participated in the investigation.

The Pennsylvania State Police and the Ford Motor Company were parties to the Philadelphia investigation.

## Appendix B: Consolidated Recommendation Information

Title 49 *United States Code* 1117(b) requires the following information on the recommendations in this report.

For each recommendation—

(1) a brief summary of the Board’s collection and analysis of the specific accident investigation information most relevant to the recommendation;

(2) a description of the Board’s use of external information, including studies, reports, and experts, other than the findings of a specific accident investigation, if any were used to inform or support the recommendation, including a brief summary of the specific safety benefits and other effects identified by each study, report, or expert; and

(3) a brief summary of any examples of actions taken by regulated entities before the publication of the safety recommendation, to the extent such actions are known to the Board, that were consistent with the recommendation.

### To the US Department of Transportation:

#### H-26-1

Issue comprehensive guidelines for vehicle manufacturers implementing partial vehicle automation systems that address known system limitations, including:

- integration and concurrent engagement of other safety-critical technologies (such as automatic emergency braking, active intelligent speed assistance, and driver monitoring system);
- promoting driver engagement by design;
- reducing the safety risks associated with automation complacency and misuse; and
- setting maximum operational speeds for automation systems based on overall system capabilities.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in [section 2.3.3.2, Broader Discussion](#). Information supporting (b)(1) and (b)(2) can be found on pages 87-91; (b)(3) is not applicable.

**To the National Highway Traffic Safety Administration:****H-26-2**

Require manufacturers to equip new SAE International Level 2-capable passenger vehicles with a telematic system that notifies the manufacturer of crashes meeting your reporting requirements in Standing General Order 2021-01.

Information that addresses the requirements of 49 USC 1117(b), as applicable, can be found in [section 2.3.1.2, Crash Notification and Reporting of L2 Incidents to NHTSA](#). Information supporting (b)(1) and (b)(2) can be found on pages 69-72; (b)(3) is not applicable.

**H-26-3**

Amend 49 *Code of Federal Regulations* Part 563, "Event Data Recorders," to require that all new SAE International Level 2-capable passenger vehicles record data elements related to these systems, including at a minimum:

- system availability;
- engagement and activation denial;
- driver alerts; and
- system faults for automatic emergency braking, forward collision warning, driver monitoring system, lane departure prevention, lane centering, partial automation system operation, and any other systems deemed necessary.

Information that addresses the requirements of 49 USC 1117(b), as applicable, can be found in [section 2.3.1.3, Recording of L2 and ADAS Information](#). Information supporting (b)(1) and (b)(2) can be found on pages 72-76; (b)(3) is not applicable.

**H-26-4**

Require that all new SAE International Level 2-capable passenger vehicles be equipped with driver monitoring systems capable of minimizing driver disengagement, automation complacency, and misuse of vehicle automation by, at a minimum:

- providing warnings about accumulated short glances over a prolonged period of time;
- differentiating genuine on-road glances from attention directed to objects, such as cell phones, located in the driver's forward line of sight; and

- issuing initial and subsequent multi-modal alerts at intervals that minimize eyes-off-road duration.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in [section 2.3.2.2, Summary and Discussion](#). Information supporting (b)(1) and (b)(2) can be found on pages 79-84; (b)(3) is not applicable.

### **To the Ford Motor Company:**

#### **H-26-5**

Revise the driver monitoring systems in your new vehicles to detect and provide warnings about accumulated short distractions over a prolonged period of time; differentiate genuine driver on-road glances from attention directed to objects, such as cell phones, located in the driver's forward line of sight; and issue initial and subsequent multi-modal alerts at intervals that minimize eyes-off-road duration.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in [section 2.3.2.2, Summary and Discussion](#). Information supporting (b)(1) and (b)(2) can be found on pages 79-84; (b)(3) is not applicable.

#### **H-26-6**

Modify your BlueCruise system for new vehicles to require that the automatic emergency braking system is engaged and that the Intelligent Adaptive Cruise Control system uses appropriate speed tolerances to mitigate excessive speeding, taking into consideration the system's operational capabilities as well as traffic and highway complexity.

Information that addresses the requirements of 49 *USC* 1117(b), as applicable, can be found in [section 2.3.3.1, San Antonio and Philadelphia Crash Investigations](#). Information supporting (b)(1) and (b)(2) can be found on pages 84-87; (b)(3) is not applicable.

## Appendix C: Driver Monitoring System Examination

NTSB investigators, with assistance from the Ford Motor Company, using non-commercially available tools and a proprietary process, conducted a basic examination of the Ford Mach-E driver monitoring system (DMS) to determine the extent to which a driver may be able to engage in non-driving-related activities while using hands-free BlueCruise. Specifically, the evaluation examined conditions under which the system might incorrectly categorize a driver's gaze as being directed toward the forward roadway (Front Windshield zone). As an example of such conditions, investigators examined whether holding (and looking at) a cell phone out of the DMS camera's view but in the driver's line of sight to the forward roadway could result in miscategorization of the driver's gaze. A cell phone was used as a representation of objects of similar dimensions.

The examination was conducted at a Ford facility in Dearborn, Michigan, on November 21, 2024, using an exemplar 2022 Ford Mach-E and an exemplar driver of similar height to the crash-involved driver in the Philadelphia, Pennsylvania, crash. Ford emulated DMS activation and connected an external display to the DMS module, allowing investigators to view live data, including gaze tracking, DMS-categorized zones of interest, and live-image output of the driver-seat area. This setup enabled the vehicle to remain stationary during evaluation.

Investigators recreated the crash-involved driver's in-vehicle positioning. First, they adjusted the steering wheel column so that the DMS camera view (seen through the live feed) matched the field of view (horizontal and vertical span) captured by the DMS module during the crash. Next, they positioned the exemplar driver to match the crash-involved driver's positioning—specifically, the angle and distance to the driver's face; field of view of the driver's-seat area; and visible positioning of hands, forearms, shoulders, and fingers.

The exemplar driver was instructed to hold a cell phone vertically with only its bottom visible in the live-image feed, matching the location of the object seen in the crash-captured image.<sup>149</sup> Figure 24 shows the exemplar driver's positioning through the live-image feed. In this position, the exemplar driver sat very close to the steering wheel with his forearms pressed against it while holding the cell phone between his hands (see figure 25).<sup>150</sup>

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<sup>149</sup> The phone was 6 inches long and 3 inches wide.

<sup>150</sup> Because the exemplar driver was a male who was 3 inches taller than the female crash-involved driver, the fit in the driver's seat and proximity to the steering wheel may not be an exact match.



**Figure 24.** Driver-facing DMS live-image feed view of the exemplar driver in the vertical phone test condition.



**Figure 25.** Forward-facing view of exemplar driver in the vertical phone test condition.

The exemplar driver focused his gaze on several locations under different phone-use conditions: (1) holding a phone horizontally, (2) holding a phone vertically, and (3) not holding a phone. Investigators placed markers on the windshield near the bottom edge (on both sides) of the DMS-defined Front

Windshield gaze zone.<sup>151</sup> These locations were chosen (by NTSB investigators) to assess whether driver fixation below the Front Windshield zone might be misclassified as looking at the forward roadway. Investigators also placed a marker on top of the steering wheel as a fixation target for the no-phone condition (see figure 26).

When prompted, the exemplar driver fixated on each marker, including the cell phone in the two applicable conditions. The driver verbally confirmed each fixation (saying “done”), at which point the DMS-determined gaze zone categorization was recorded. Table 6 presents the results.



**Figure 26.** Fixation locations targeted by the exemplar driver. The two markers highlighted by yellow arrows are within the Front Windshield gaze zone, and the two markers highlighted by orange arrows are outside this zone. The pink marker on top of the steering wheel was obscured by the cell phone during the with-phone conditions. (Note: The apparent additional markers above the yellow arrows are reflections of the bottom markers.)

<sup>151</sup> The markers were placed approximately 2.6-3.0 inches from each side of the bottom border of the Front Windshield gaze zone to account for the DMS camera's maximum gaze-tracking visual angle error rate of 4.1°. Based on this error rate and a 36-inch distance from the exemplar driver's eyes to the bottom border of the Front Windshield gaze zone, the corresponding liner size of the visual angle error at the border is 2.6 inches.

**Table 6.** DMS categorization of gaze zones for exemplar driver's fixation points.

Phone Condition	Exemplar Driver's Gaze Fixation	DMS-Categorized Gaze Zone
<b>No phone</b>	Top of the steering wheel	Instruments
<b>No phone</b>	Windshield; right side	Front Windshield
<b>No phone</b>	Below windshield; right side	Instruments
<b>No phone</b>	Windshield; left side	Front Windshield
<b>No phone</b>	Below windshield; left side	Instruments
<b>Phone held horizontally</b>	Phone	Front Windshield
<b>Phone held horizontally</b>	Windshield; right side	Front Windshield
<b>Phone held horizontally</b>	Below windshield; right side	Instruments
<b>Phone held horizontally</b>	Windshield; left side	Front Windshield
<b>Phone held horizontally</b>	Below windshield; left side	Instruments/Front Windshield <sup>a</sup>
<b>Phone held vertically</b>	Phone	Front Windshield
<b>Phone held vertically</b>	Windshield; right side	Front Windshield
<b>Phone held vertically</b>	Below windshield; right side	Instruments
<b>Phone held vertically</b>	Windshield; left side	Front Windshield
<b>Phone held vertically</b>	Below windshield; left side	Instruments

<sup>a</sup> The size of the horizontally held phone required the exemplar driver to move his head considerably for fixation. This resulted in the DMS-categorized zone to alternate between the Instruments and Front Windshield zones.

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The NTSB is an independent federal agency charged by Congress with investigating every civil aviation accident in the United States and significant events in the other modes of transportation—railroad, transit, highway, marine, pipeline, and commercial space. We determine the probable causes of the accidents and events we investigate and issue safety recommendations aimed at preventing future occurrences. In addition, we conduct transportation safety research studies and offer information and other assistance to family members and survivors for each accident or event we investigate. We also serve as the appellate authority for enforcement actions involving aviation and mariner certificates issued by the Federal Aviation Administration (FAA) and US Coast Guard, and we adjudicate appeals of civil penalty actions taken by the FAA.

The NTSB does not assign fault or blame for an accident or incident; rather, as specified by NTSB regulation, "accident/incident investigations are fact-finding proceedings with no formal issues and no adverse parties ... and are not conducted for the purpose of determining the rights or liabilities of any person" (Title 49 *Code of Federal Regulations* section 831.4). Assignment of fault or legal liability is not relevant to the NTSB's statutory mission to improve transportation safety by investigating accidents and incidents and issuing safety recommendations. In addition, statutory language prohibits the admission into evidence or use of any part of an NTSB report related to an accident in a civil action for damages resulting from a matter mentioned in the report (Title 49 *United States Code* section 1154(b)).

For more detailed background information on this report, visit the [NTSB Case Analysis and Reporting Online \(CAROL\) website](#) and search for NTSB accident IDs HWY24FH006 and HWYFH008. Recent publications are available in their entirety on the [NTSB website](#). Other information about available publications also may be obtained from the website or by contacting –

National Transportation Safety Board  
Records Management Division, CIO-40  
490 L'Enfant Plaza, SW  
Washington, DC 20594  
(800) 877-6799 or (202) 314-6551