



National Transportation Safety Board

Washington, DC 20594

Highway Accident Brief

Collision Between Car Operating with Partial Driving Automation and Truck-Tractor Semitrailer Delray Beach, Florida, March 1, 2019

Accident Number:	HWY19FH008
Accident Type:	Intersection collision involving partially automated vehicle
Location:	Southbound US Highway 441, Delray Beach, Palm Beach County, Florida
Date and Time:	Friday, March 1, 2019, 6:17 a.m. eastern standard time
Vehicle 1:	2018 Tesla Model 3
Vehicle 2:	2019 International truck-tractor in combination with 2008 Vanguard semitrailer
Fatalities:	1
Injuries:	0

Crash Description

At 6:17 a.m. on March 1, 2019, a 2018 Tesla Model 3 passenger car was southbound in the right lane of the 14000 block of US Highway 441 (US 441), also known as State Road 7, in Delray Beach, Palm Beach County, Florida, when it struck a 2019 International truck-tractor in combination with a semitrailer. The combination vehicle (truck), operated by FirstFleet, Inc., was traveling east on a private driveway/access road for the Pero Family Farms agricultural facility (address: 14095 US 441) and was attempting to cross the southbound lanes of US 441 and turn left into the northbound lanes.¹ As the truck approached the stop sign on the right side of the driveway at the intersection with US 441, it slowed but did not come to a full stop before beginning to cross the southbound lanes of the highway. The car driver, traveling at a recorded speed of 69 mph, did not apply the brakes or take any other evasive action to avoid the truck, which was crossing in front of him at about 11 mph.²

¹ (a) FirstFleet is a privately owned company with its principal place of business in Murfreesboro, Tennessee. FirstFleet is a registered interstate motor carrier that employs 2,940 drivers and owns 2,847 trucks and close to 10,000 trailers. The company is divided by region and has 105 locations throughout the continental United States. FirstFleet provides contract services to Pero Family Farms. (b) Pero Family Farms LLC is a large agricultural firm that employs hundreds of workers and operates 24 hours a day, 7 days a week.

² The 69-mph speed of the Tesla was obtained from the event data recorder (EDR) that reported on information stored in the car's restraint control module. Tesla was able to communicate with the crash-involved vehicle through a data link to Tesla's virtual private network established via Wi-Fi. Tesla provided the National Transportation Safety Board (NTSB) with a 26-page EDR report, vehicle Carlog data, forward-facing video leading up to the crash, and imagery from additional cameras mounted on the vehicle. The truck's estimated speed of 11 mph was determined using video from the car's forward-facing camera. For additional information, refer to the Video Study in the [public docket](#) for this investigation (HWY19FH008).

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The car hit the left side of the semitrailer just aft of the trailer's midpoint. The roof of the car was sheared off as the vehicle underrode the semitrailer and continued south. Postcrash, the car coasted to a stop in the median between the southbound and northbound lanes, about 1,680 feet from where it struck the semitrailer (figure 1). The 50-year-old male car driver died as a result of the crash. The 45-year-old male truck driver was uninjured.

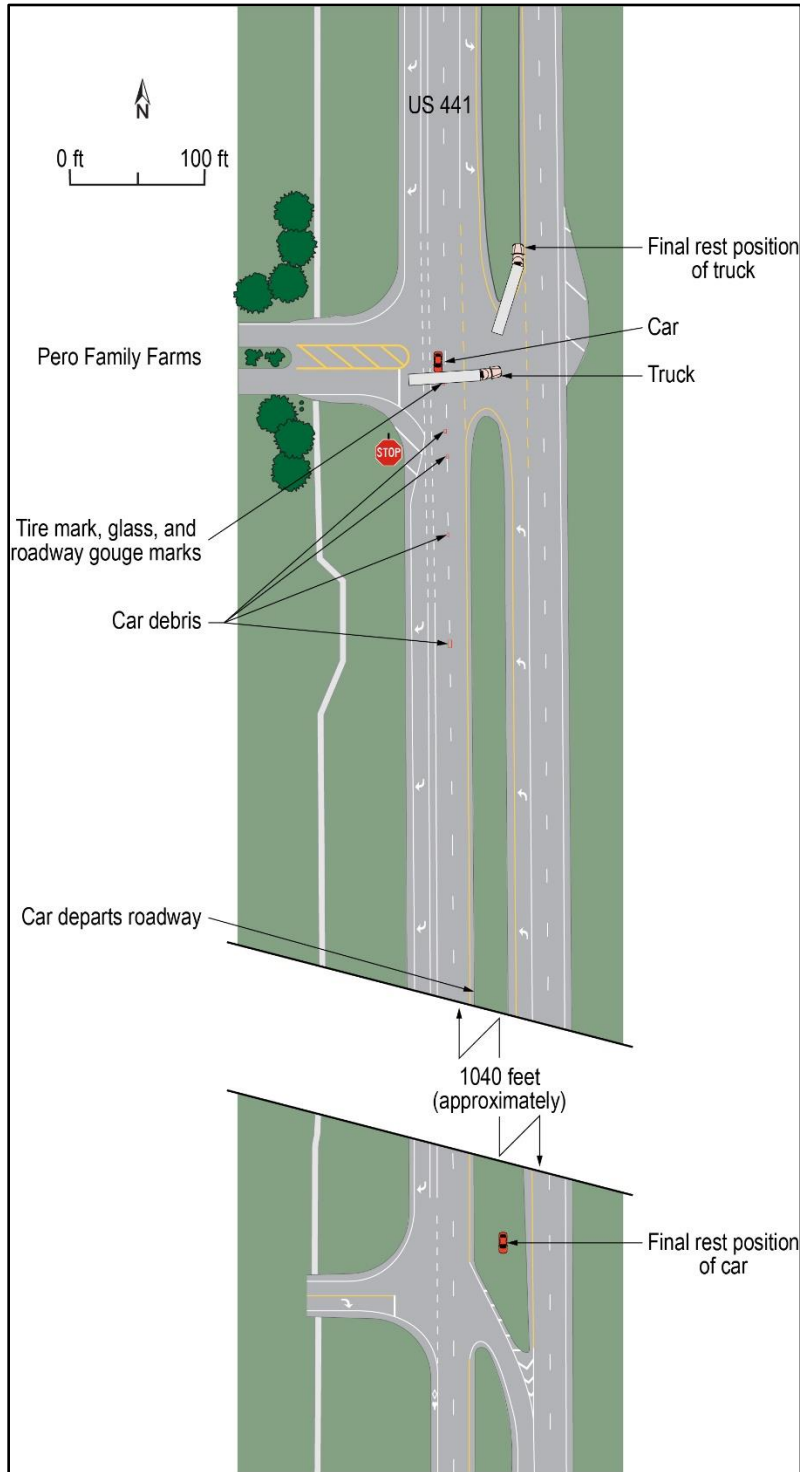


Figure 1. Diagram showing positions of car and truck at impact and final rest.

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System performance data from the car showed that the driver was operating with the Tesla Autopilot technology package engaged at the time of the collision. Autopilot is a combination of advanced driver assistance systems (ADASs) that regulate vehicle speed and lane positioning through automated control of braking, steering, and throttle. The major subsystems associated with Autopilot operation are traffic-aware cruise control (TACC) and Autosteer. TACC is an adaptive cruise control system that provides longitudinal control (acceleration and deceleration). Autosteer is a lane-keeping assist system that provides lateral control (steering) of the vehicle within its lane. When Autopilot is activated, the ADAS is considered an SAE Level 2 system (partial automation).³ The performance of the Autopilot system is discussed later in this report.

Security Camera Information

Video footage from security cameras at Pero Family Farms shows the view east along the driveway/access road for the agricultural facility toward the road's intersection with US 441.⁴ The video depicts another passenger car, traveling south in the left lane of US 441, crossing in front of the truck about 4 seconds before the crash. After the first passenger car passes, the truck begins to cross the southbound lanes. The security video then shows the Tesla striking the left side of the truck's semitrailer.⁵

Video from Tesla Forward-Facing Camera

The Tesla Model 3 recorded video from its forward-facing camera. The company provided the NTSB with video from the camera covering about 6 seconds immediately preceding the collision.⁶ Figure 2 shows still images from the camera during the last 5 seconds before the crash.⁷

³ Refer to [SAE International J3016](#) "Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles" (June 2018).

⁴ Refer to the Security Video report in the public docket for additional information. The security video shows that the truck slowed but did not come to a full stop at the stop sign.

⁵ The semitrailer's brakes activated momentarily about 1 second before the crash.

⁶ Tesla also provided the NTSB with a series of still images from all eight of the car's cameras. The eight cameras included three forward-facing cameras (long-range, short-range, and wide-angle), two rearward-facing side-angle cameras (mounted under each sideview mirror), two forward-facing side-angle cameras (mounted on each B-pillar), and one rearview camera (mounted above the license plate).

⁷ The images do not reflect exactly what the driver would have seen due to differences related to human and camera vision (such as sensor and lens quality and resolution).

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	<p>Time to Collision = 5 seconds Distance to Impact = 506 feet</p> <p>Tractor-trailer combination vehicle visible and exiting a private driveway from an agricultural facility.</p>
	<p>Time to Collision = 4 seconds Distance to Impact = 405 feet</p> <p>Tractor-trailer combination vehicle begins to cross right turn lane of US 441 ahead of Tesla.</p>
	<p>Time to Collision = 3 seconds Distance to Impact = 304 feet</p> <p>Tractor-trailer combination vehicle begins to encroach into lane of travel occupied by Tesla.</p>
	<p>Time to Collision = 2 seconds Distance to Impact = 202 feet</p> <p>Tractor-trailer combination vehicle blocking Tesla's path and entering "fast lane" to left of Tesla's lane of travel.</p>
	<p>Time to Collision = 1 second Distance to Impact = 101 feet</p> <p>Tractor-trailer combination vehicle still in motion and completely blocking all US 441 southbound lanes.</p>

Figure 2. Still images from car's forward-facing camera showing southbound view during 5 seconds leading to crash. (Source: Tesla Inc.; images cropped by NTSB)

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Highway Information

US 441 is classified as an urban principal arterial roadway. Between State Road 804 to the north and State Road 806 to the south, US 441 has two traffic lanes in each direction, divided by an earthen median. In the 5-mile stretch of US 441 that encompasses the crash location, there are a combined 34 intersecting roadways and private driveways and 17 median crossovers. The intersecting roadways and driveways give access to several large agricultural facilities, housing developments, and recreational parks, as well as to a cemetery. Traffic traveling on US 441 is not controlled by signals along the stretch. The posted speed limit is 55 mph.

At the crash location, US 441 has two 12-foot-wide travel lanes in each direction (figure 3). The median is 25 feet wide. In the southbound direction, a 12-foot-wide left-turn lane allows vehicles to cross the highway and proceed north. A 12-foot-wide right-turn lane provides access to the private driveway into the Pero Family Farms agricultural facility on the west side of the highway. Bicycle lanes, each 5 feet wide, border both sides of the highway. The driveway to Pero Family Farms is divided into two lanes, with a center median, and is controlled by a stop sign on the south side. There is no artificial lighting near the intersection. However, the crash occurred just before the beginning of civil twilight, when some ambient lighting was available.⁸

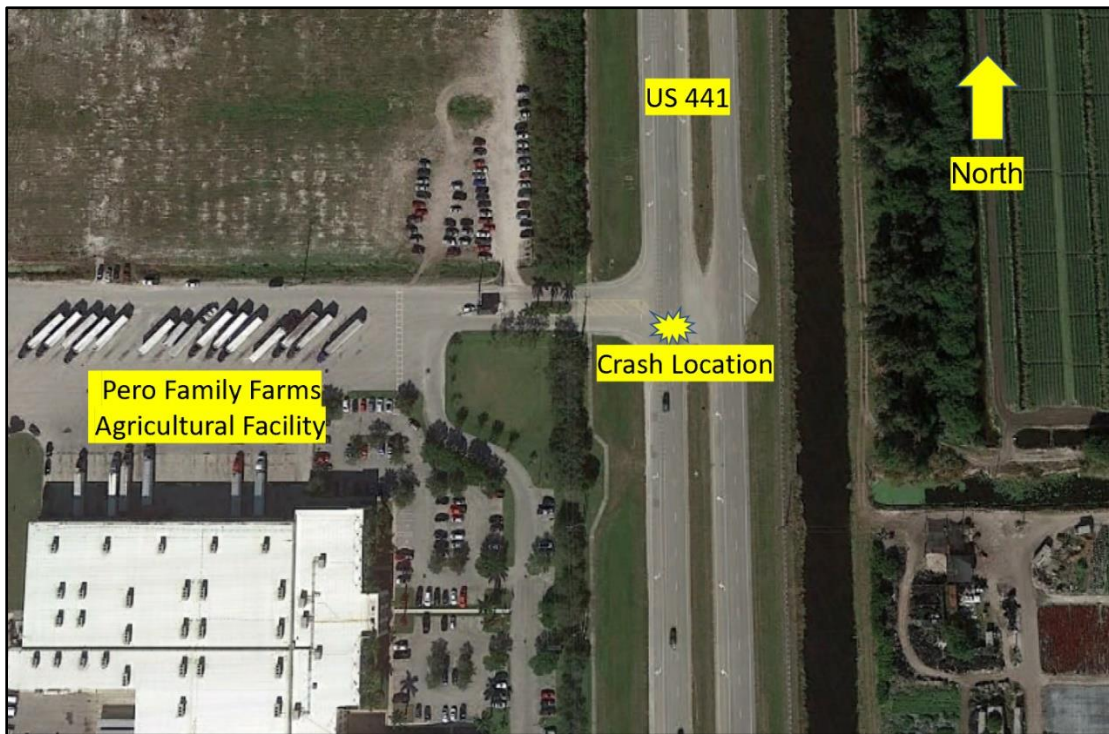


Figure 3. Satellite image of US 441 in Delray Beach showing crash location. (Source: Google Earth image dated January 2019, annotated by NTSB)

⁸ The weather was clear and the road was dry. Civil twilight is the period preceding sunrise when the geometric center of the sun is 6 degrees below the horizon. During civil twilight, natural light is sufficient to engage in typical outdoor activities without artificial lighting. On the day of the crash, civil twilight began at 6:21 a.m., and sunrise was at 6:44 a.m.

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The Florida Department of Transportation (FDOT) is the controlling authority for US 441.⁹ The 2017 annual average daily traffic report found that 25,500 vehicles per day traveled US 441 in the corridor encompassing the crash location. Heavy trucks accounted for 6.4 percent of the vehicles.¹⁰

By Florida state law, drivers are required to stop before entering US 441, to proceed after ensuring that the roadway is clear, and to grant the right of way to all approaching vehicles close enough to constitute an immediate hazard.¹¹ Security officers at the front gate of Pero Family Farms estimated that 100 large commercial vehicles enter or exit the facility daily.

Truck Driver Information

Background

The 45-year-old male truck driver held a Florida class A commercial driver's license, with no restrictions and with endorsements for double or triple trailers and tankers. His license was renewed in January 2016, with an expiration date of November 2024. His medical certificate, valid for 2 years, was due to expire in November 2019. The driver's Florida license history showed that he was involved in a property damage crash while driving a commercial vehicle in February 2017, for which he was cited. The driver's record also contained a 2016 conviction for speeding (in a noncommercial vehicle).

The truck driver started working for FirstFleet in December 2015. FirstFleet dispatched him on local routes for his first 3 months of employment to familiarize him with the Tampa Bay region. Before the crash, the driver worked 55 to 60 hours a week making deliveries throughout Florida. He did not have a set route and was dispatched by FirstFleet for pickup and delivery trips. The driver's electronic logs show that he had an adequate sleep opportunity before the crash. Cell phone records show that the driver was not engaged in a phone conversation and was not texting at the time of the crash.

Medical/Toxicology

Based on personal medical records, pharmacy records, and an interview with the truck driver, it was determined that the driver had a history of epilepsy for which he was taking the seizure medicine levetiracetam.¹² The driver reported having had three seizures in his lifetime but said that he had not experienced a seizure since age 14. A security video of the truck before the crash shows no erratic movements or loss of vehicle control. No evidence suggests that the truck driver's medical condition was a factor in the crash.

The truck driver had refractive surgeries on both eyes in 2012. In the postcrash interview, the driver described being able to "read with my right eye" and "see my distance in my left eye." The driver's eye correction is commonly referred to as monovision or blended vision. Monovision

⁹ In 2000, FDOT drafted a proposal to widen US 441 in this region to three lanes in each direction. Construction on the project had not begun as of the date of this report.

¹⁰ At the intersection and immediate approach to the intersection of US 441 and the private driveway to the agricultural facility, seven crashes occurred from 2010 to 2014. Five crashes involved rear-end or angle collisions.

¹¹ Refer to Florida statute 316.125.

¹² The driver did not reveal his history of seizures or epilepsy or his use of any medication in either the 2015 or the 2017 Department of Transportation commercial driver fitness examination.

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typically results in some loss of depth perception; however, since both eyes are still working together, a person can see clearly at any distance and can adapt to the loss of depth perception. Based on the results of visual acuity tests performed as part of a commercial driver's examination in November 2017, the truck driver's uncorrected distant visual acuity met the standards for each eye individually and bilaterally.

A sample of the truck driver's blood was not taken by law enforcement officers for drug testing, and the driver was not taken to a hospital after the crash. FirstFleet ordered the driver to submit to a postcrash urinalysis and breath test.¹³ A urine sample was collected at 11:56 a.m. (5 hours 40 minutes after the crash). The sample was negative for the common drugs of abuse.¹⁴ A breath test taken about the same time as the urine sample was negative for alcohol.

Collision Trip

The truck driver told investigators that on the day of the crash, he began his shift about 2:00 a.m. in Temple Terrace, Florida. He arrived at Pero Family Farms in Delray Beach at 5:49 a.m. and released his trailer in a grass field used for parking. He connected an empty trailer, did a pretrip inspection of the trailer, and then proceeded toward the entrance/exit gate. The driver said that after exiting the facility, he pulled up to the stop sign and surveyed the southbound traffic. He said that he noticed two southbound vehicles. He thought the vehicle in the right lane "flickered their lights," which he interpreted as meaning that the driver would slow to allow him to cross US 441.¹⁵ He added that it was difficult to judge the speed of the vehicles due to the nighttime conditions.

He said that he thought he had plenty of time to cross US 441, so he proceeded into the intersection with the intent of making a left turn onto northbound US 441. When his tractor entered the median crossover area, he felt a push against the trailer. He drove the tractor forward about 10 feet and exited the cab to inspect his trailer. He saw debris and scuff marks on the left side of the trailer but did not see another vehicle. The driver then called his company to inform it that he had been involved in a hit-and-run crash. The driver added that he was just about to call 911 when he noticed first responders to the south of him. He learned shortly afterward that the driver of the passenger car had died in the collision.

Car Driver Information

Background

The 50-year-old male car driver had a Florida class E noncommercial driver's license that was issued in 2012 and was due to expire in October 2020. The driver had a "Safe Driver" designation on his license. According to Florida statutes, the "Safe Driver" designation indicated that, when the

¹³ Motor carriers are required to conduct toxicology testing of crash-involved drivers following a fatal crash. See 49 *Code of Federal Regulations* (CFR) Part 382.

¹⁴ The sample was tested for marijuana, phencyclidine, cocaine, opiates, and amphetamines.

¹⁵ Vehicle Carlog data showed that the Tesla's headlights were in a low beam status, which did not change for at least 45 seconds before the crash, indicating that the crash car was not the source of the "flickering" headlights the truck driver mentioned.

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driver renewed his license in 2012, he did not have any revocations, disqualifications, or suspensions for the preceding 7 years or any moving violation convictions for the preceding 3 years.¹⁶

The driver's family reported that he was in good health and did not take prescription medication. They said that he went to bed each night before 10:00 p.m. and would usually wake about 5:20 a.m., and that he generally slept through the night without waking. Cell phone records show that the driver was not engaged in a phone conversation and was not texting at the time of the crash.

Toxicology

The Palm Beach County Medical Examiner's office forwarded toxicological specimens to the Federal Aviation Administration Forensic Sciences Laboratory for analysis. The analysis indicated that the car driver did not have alcohol or other common drugs of abuse in his system.¹⁷

Collision Trip

On the day of the collision, the car driver left home about 6:05 a.m. and traveled 9.6 miles to the US 441 intersection where the crash occurred. The driver took that route daily on his way to work, and he was familiar with the road and the vehicle's control systems.¹⁸ Based on data from the vehicle, the car was traveling in the right lane of US 441 when, 12.3 seconds before the impact, the driver activated TACC at a cruise speed of 69 mph. The driver engaged Autosteer 2.4 seconds later, which activated the Autopilot partial automation driving system. Autopilot's driver monitoring system can detect driver-applied steering wheel torque; the system did not detect wheel torque for the final 7.7 seconds before the collision. The car's forward collision warning (FCW) and automatic emergency braking (AEB) systems did not activate before the crash. There was no evidence of system- or driver-applied braking or steering before impact.

Vehicle Information

Truck

The combination vehicle consisted of a three-axle International truck-tractor connected to a two-axle, 53-foot Vanguard semitrailer. The truck's gross vehicle weight rating (GVWR) was 52,350 pounds, and its overall length was 68.4 feet.¹⁹ NTSB investigators inspected the truck and semitrailer in Tampa, Florida, after the collision. The inspection was limited to assessing the vehicle's overall condition and documenting any damage. None of the truck's major vehicle operating systems were damaged, and collision damage was limited to the semitrailer. Damage to the semitrailer included impact damage to the lower edge of the sidewall rails on both sides of the semitrailer and on

¹⁶ Florida statutes Title 23, chapter 322, section 121.

¹⁷ The drug classes included in the test were amphetamines, opiates, marijuana, cocaine, phencyclidine, benzodiazepines, barbiturates, antidepressants, and antihistamines.

¹⁸ The driver bought the car in December 2018. His wife stated that he researched Tesla vehicles for several years before purchasing one. His wife said that she had ridden in the Tesla with her husband when he used the Autopilot option and described him as vigilant on those occasions.

¹⁹ GVWR is the total maximum weight a vehicle is designed to carry when loaded, including the weight of the vehicle itself plus fuel, passengers, and cargo. At the time of the collision, the semitrailer was unladen, and the overall weight of the combination vehicle was well below the GVWR.

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the undercarriage between the opposing damaged rails (figure 4). The lower edge of the trailer measured 3.6 feet high and correlated with damage to the car.



Figure 4. Left side of combination vehicle. Damage to lower edge of semitrailer sidewall rails is circled in red.

The combination vehicle's lighting system was illuminated during the inspection. The headlights and the trailer's side amber marker lights were clearly visible. As required by federal regulations (49 CFR 393.11 and 393.13), the trailer was equipped with red-and-white conspicuity reflective tape along the lower edge on both sides of the trailer.

Car

The Tesla Model 3 sustained major damage that included separation of the glass roof panel and forward-facing surfaces of both the A- and B-pillars just below where the roof met the pillars and rearward displacement of the headrest on the front passenger seat (figure 5). The trunk lid was displaced aft of its original position, and the right rear quarter-panel was buckled.

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Figure 5. Right side of car in postcrash damaged condition.

Autopilot Performance

In evaluating the crash, investigators examined the performance of the car's Autopilot system and collision avoidance technologies. Autopilot helps navigate a roadway by detecting lane markings and predicting the car's path in its travel lane. Specifically, TACC uses information from the forward-facing camera and radar sensor to determine if a vehicle is in front of the car in the same lane. Autosteer lane-keeping assist uses information from the car's forward-facing camera, radar sensor, and ultrasonic sensors to detect lane markings and the presence of other vehicles and objects.

In most cases, Autosteer attempts to center the car in the travel lane. When Autopilot is active, the system (1) monitors the traveling path, (2) maintains the set cruise speed, (3) maintains the car's position in the traveling lane, (4) brakes when it detects slower-moving vehicles ahead of the car, and (5) decelerates and follows a slower-moving vehicle at a preset following distance.

TACC was activated 12.3 seconds before the crash, with a set cruise speed of 69 mph. Autosteer was activated 9.9 seconds before the crash. Because no lead vehicle was ahead of the car, TACC maintained the cruise speed of 69 mph until impact.

The Tesla owner's manual contains several warnings about Autosteer and the importance of a driver keeping his or her hands on the wheel, such as the following:

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(1) Autosteer is a hands-on feature. You must keep your hands on the steering wheel at all times; (2) Autosteer is intended for use only on highways and limited-access roads with a fully attentive driver. When using Autosteer, hold the steering wheel and be mindful of road conditions and surrounding traffic. . . . Never depend on Autosteer to determine an appropriate driving path. Always be prepared to take immediate action. Failure to follow these instructions could cause serious property damage, injury or death.

Autopilot Driver Monitoring System

Based on system design, in an SAE-defined Level 2 partial automation system such as Autopilot, it is the driver's responsibility to monitor the automation, maintain situational awareness of traffic conditions, understand the limitations of the automation, and be available to intervene and take full control of the vehicle at any time. In practice, however, the NTSB and researchers have found that drivers are poor at monitoring automation and do not perform well on tasks requiring passive vigilance.²⁰

When Autosteer is engaged, the Autopilot system monitors driver-applied changes to the steering wheel torque (driver's hands on the steering wheel). If drivers remove their hands from the steering wheel for a time, the system produces a series of "hands-off" warnings, starting with a visual alert. The time between the detection of hands-off operation and the display of a visual warning depends on (1) vehicle speed, (2) presence of lead vehicle, (3) lateral acceleration, (4) type of roadway, (5) detection of system errors (which would prompt an immediate warning), (6) driver application of pedals, and (7) miscellaneous factors, such as presence of a construction zone. In the Delray Beach crash, the Autopilot system did not detect driver-applied steering wheel torque for 7.7 seconds before the crash. Tesla informed the NTSB that "no hands-off steering wheel warning was presented to the driver because the approximate 8-second duration was too short to trigger a warning under the circumstances."²¹

Following the investigation of a fatal crash in Williston, Florida, which occurred in a scenario similar to that of the Delray Beach crash, the NTSB concluded that the way the Tesla Autopilot system monitored and responded to the driver's interaction with the steering wheel was not an effective method of ensuring driver engagement.²² As a result, the NTSB recommended that Tesla and five other manufacturers of vehicles equipped with SAE Level 2 driving automation systems take the following action:

²⁰ The NTSB has discussed the issue of automation complacency in several reports. See, for example, its recent report on a fatal collision in Tempe, Arizona, and the cited research (*Collision Between Vehicle Controlled by Developmental Automated Driving System and Pedestrian, Tempe, Arizona, March 18, 2018*, Highway Accident Report NTSB/HAR-19/03).

²¹ At the time of the crash, the timing of the first visual alert was a function of a linear vehicle speed-based escalation. For example, at a speed of 25 mph, if the system did not detect driver-applied steering wheel torque, an alert would be sent after 60 seconds. At 90 mph, the alert would be sent after 10 seconds. At 69 mph, the speed of the Tesla before the crash, the first visual alert would occur after about 25 seconds. (At 69 mph, the Tesla would have been traveling over 2,530 feet in 25 seconds.)

²² See *Collision Between a Car Operating with Automated Vehicle Control Systems and a Tractor-Semitrailer Truck Near Williston, Florida, May 7, 2016*, Highway Accident Report NTSB/HAR-17/02.

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H-17-42

Develop applications to more effectively sense the driver's level of engagement and alert the driver when engagement is lacking while automated vehicle control systems are in use.

With regard to Safety Recommendation H-17-42, the other five manufacturers responded to the NTSB describing the actions they planned to take, or were taking, to better monitor a driver's level of engagement.²³ Tesla was the only manufacturer that did not officially respond to the NTSB about the recommendation.²⁴

Autopilot Operational Design Domain Limitations

SAE J3016 discusses the need for manufacturers to accurately describe ADAS features and clearly define the level of driving automation, its capabilities, and its operational design domain (ODD)—the conditions under which driving automation is intended to operate. Examples of such conditions include roadway type, geographic location, weather conditions, speed range, lighting conditions, and other manufacturer-defined system performance criteria or constraints. Tesla has described its operating conditions and limitations based on the Autopilot system design and published them in the vehicle owner's manual. The conditions pertaining to ODD include the following:

- Designed for use on limited-access highways.
- Designed for areas with no cross traffic and clear lane markings.
- Not for use on city streets where traffic conditions are constantly changing.
- Not for use on winding roads with sharp curves.
- Not for use in inclement weather conditions with poor visibility.

Although these operating conditions and limitations are communicated to owners and drivers in the owner's manual, the Autopilot firmware does not restrict the system's use on the basis of functional road classification. The system can be used on any roads that have adequate lane markings. That allows a driver to activate the partial driving automation systems at locations and under circumstances for which their use is not appropriate, safe, or included in the manufacturer's design, such as roadways that have cross traffic.

The Delray Beach highway operating environment, like the cross-traffic conditions in Williston, was clearly outside the Autopilot system's ODD. The highway did not have limited access and had 34 intersecting roadways and private driveways in the 5-mile region encompassing the crash location. After the Williston crash, the NTSB concluded that if automated control systems do not automatically restrict their operation to those conditions for which they were designed and are

²³ Safety Recommendation H-17-42 was addressed to Volkswagen Group of America, BMW of North America, Nissan Group of North America, Mercedes-Benz USA, Volvo Car USA, and Tesla Inc. Recommendation H-17-42 is classified "Open—Acceptable Response" to all manufacturers except Tesla. The recommendation to Tesla is classified "Open—Await Response."

²⁴ Tesla provided the NTSB with a diagram describing changes to the timing of hands-off-wheel alerts that were implemented after the Williston crash. The revised timing includes more frequent alerts when driver-applied steering wheel torque is not detected and an Autopilot lockout if too many alerts occur in a single drive cycle.

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appropriate, the risk of driver misuse remains. The NTSB recommended that Tesla and other manufacturers of Level 2 automation take the following action:

H-17-41

Incorporate system safeguards that limit use of automated vehicle control systems to those conditions for which they were designed.

Tesla did not officially respond to the NTSB regarding Safety Recommendation H-17-41.²⁵ In communications with the NTSB during its investigation of a fatal 2018 crash in Mountain View, California, Tesla made the following statement:²⁶

[U]nder the SAE J3016, operational design domain limits are not applicable for Level 2 driver assist systems, such as Autopilot, because the driver determines the acceptable operating environment. Autopilot can be safely used on divided and undivided roads as long as the driver remains attentive and ready to take control.

Today's SAE Level 2 systems can assess a vehicle's location and current roadway type or classification and determine whether the roadway is appropriate to the system's ODD. After the Williston crash, the NTSB established the need for additional oversight of manufacturers to ensure that partial driving automation systems are only used in conditions for which they were designed. The NTSB recommended that the National Highway Traffic Safety Administration (NHTSA) take the following action:

H-17-38

Develop a method to verify that manufacturers of vehicles equipped with Level 2 vehicle automation systems incorporate system safeguards that limit the use of automated vehicle control systems to those conditions for which they were designed.

In a response letter to the NTSB regarding Safety Recommendation H-17-38, NHTSA stated the following:²⁷

NHTSA has no current plans to develop a specific method to verify manufacturers of vehicles equipped with Level 2 systems incorporate safeguards limiting the use of automated vehicle control systems to those conditions for which they were designed. Instead, if NHTSA identifies a safety-related defect trend in design or performance of a system, or identifies through its research or otherwise, any incidents in which a system did not perform as designed . . . it would exercise its authority as appropriate.

²⁵ Safety Recommendations H-17-41 and -42 were addressed to the same recipients. Safety Recommendation H-17-41 is classified as "Open—Acceptable Response" for all recipients except Tesla, for which the classification is "Open—Await Response."

²⁶ See the NTSB's report on the Mountain View crash for additional information (*Collision Between a Sport Utility Vehicle Operating With Partial Driving Automation and a Crash Attenuator, Mountain View, California, March 23, 2018*, Highway Accident Report NTSB/HAR-20/01).

²⁷ Safety Recommendation H-17-38 is currently classified "Open—Unacceptable Response."

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Occurring nearly 3 years after the Williston crash, the fatal Delray Beach crash involved a Tesla operating not only outside its ODD but also in an environment similar to that of the Williston crash.

Collision Avoidance System Limitations

The Autopilot system and collision avoidance systems did not identify the crossing truck as a hazard and did not attempt to slow the car. In addition, the driver did not receive an FCW alert, and the AEB system did not activate. Tesla informed the NTSB that the installed FCW and AEB systems were not designed to activate for crossing traffic or to prevent crashes at high speeds.²⁸ The Tesla AEB system is a radar/camera fusion system designed for front-to-rear collision mitigation or avoidance. According to the company, the system requires agreement from both the radar and the camera to initiate AEB; complex or unusual vehicle shapes can delay or prevent the system from classifying the vehicles as targets or threats. In this crash, according to Tesla, the Autopilot vision system did not consistently detect and track the truck as an object or threat as it crossed the path of the car. In addition, at no time was there an object detection match between the car's vision system and its radar data.

NTSB Investigations

In its investigation of the fatal crash in Mountain View, California, the NTSB examined common issues regarding the safety of ADASs that provide partial automation. The final report incorporates lessons learned from the crashes in Williston and Delray Beach, Florida, in Culver City, California, and in Mountain View regarding the Tesla Autopilot system.²⁹

Discussion

In this crash, the truck driver reported seeing southbound traffic on US 441 but did not yield the right of way to the car, which was close enough to constitute an immediate hazard. In video from the security camera and from the Tesla's forward-facing camera, the truck can be seen proceeding east on the intersecting private driveway and crossing US 441 in the car driver's forward view. An attentive car driver would have seen the truck in time to take evasive action. At no time before the crash did the car driver brake or initiate an evasive steering action. In addition, no driver-applied steering wheel torque was detected for 7.7 seconds before impact, indicating driver disengagement, likely due to overreliance on the Autopilot system.

The Autopilot system did not send a visual or audible warning to the driver to put his hands back on the steering wheel. The collision avoidance systems did not warn or initiate AEB due to the system's design limitations. The environment was outside the ODD of the Autopilot system, and Tesla does not limit Autopilot operation to the conditions for which it is designed. Further, NHTSA

²⁸ The FCW and AEB systems on the market today are designed and tested to detect vehicle targets that are traveling along the same longitudinal path of a vehicle. NHTSA's FCW testing is conducted at speeds of up to 45 mph as part of the New Car Assessment Program.

²⁹ The NTSB's investigation of the Culver City crash is reported in *Rear-End Collision Between a Car Operating with Advanced Driver Assistance Systems and a Stationary Fire Truck, Culver City, California, January 22, 2018*, Highway Accident Brief NTSB/HAB-19/07.

**Collision Between Car Operating with Partial Driving Automation and Truck-Tractor Semitrailer
Delray Beach, Florida, March 1, 2019**

does not have a method of verifying that manufacturers implement appropriate system safeguards for vehicles with Level 2 automation.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the Delray Beach, Florida, crash was the truck driver's failure to yield the right of way to the car, combined with the car driver's inattention due to overreliance on automation, which resulted in his failure to react to the presence of the truck. Contributing to the crash was the operational design of Tesla's partial automation system, which permitted disengagement by the driver, and the company's failure to limit the use of the system to the conditions for which it was designed. Further contributing to the crash was the failure of the National Highway Traffic Safety Administration to develop a method of verifying manufacturers' incorporation of acceptable system safeguards for vehicles with Level 2 automation capabilities that limit the use of automated vehicle control systems to the conditions for which they were designed.

Report Date: January 22, 2020

For more details about this crash, visit the [NTSB public docket](#) and search for NTSB accident ID HWY19FH008. The docket includes such information as police reports, photographs, driver and witness statements, data on previous crashes, and highway engineering reports.

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]).
