February 2, 2023 HIR-23-02

Electric Vehicle Run-Off-Road Crash and Postcrash Fire

Spring, Texas
April 17, 2021

On April 17, 2021, about 9:07 p.m. central daylight time, a 2019 Tesla Model S P100D electric car was traveling west on Hammock Dunes Place—a residential road in Spring, Harris County, Texas—when it crashed and caught fire.[1] The crash trip originated at the driver's residence near the end of a cul-de-sac. The car traveled about 550 feet before departing the road at a leftward curve, driving over the right-side curb, hitting a storm sewer inlet and a raised manhole, sideswiping a tree, and running into a second tree (see figure 1). The crash damaged the front of the car's high-voltage lithium-ion battery case, where a fire started. As a result of the crash and the postcrash fire, the driver and passenger were fatally injured.

Figure 1. Car's path after departing right-side roadway toward final tree impact, marked by cones (left). A closer view of the impact site is shown on the right, with the tree that was sideswiped by the car on the left side of the image. (Background source: Tesla)

[1] (a) In this report, all times are central daylight time. (b) Visit ntsb.gov to find additional information in the public docket for this NTSB investigation (case no. HWY21FH007). Use the CAROL Query to search safety recommendations and investigations.

Location	Hammock Dunes Place, near Spring, Texas
Date	April 17, 2021
Time	9:07 p.m. central daylight time
Vehicles involved	1
People involved	2
Injuries	2 fatal
Weather	Dry, clear, dark
Roadway information	Private road located in a gated community

Figure 2. Area where crash occurred. (Background source: Google Maps)

1. Factual Information

1.1 Background

The crash occurred on Hammock Dunes Place, a private road located in a gated community maintained by the Carlton Woods Creekside Homeowners Association. In the vicinity of the crash, Hammock Dunes Place consisted of one eastbound and one westbound lane. Each of the travel lanes was approximately 13 feet wide, and the total width of the roadway was approximately 26 feet. There were no shoulders, and adjacent to the travel lanes was a 4-inch mountable curb approximately 12 inches wide. Although there were no posted speed limit signs along Hammock Dunes Place, the maximum speed was 30 mph.[2] There were no roadway markings (centerline or edge line markings), and street lighting was available along the westbound travel lane. The 9:07 p.m. crash occurred while it was dark outside.

The car was identified as a 2019 Tesla Model S P100D, four-door passenger car. A search of the safety recall database maintained by the National Highway Traffic Safety Administration (NHTSA) revealed no recalls or ongoing defect investigations for the car related to the circumstances of the crash. In addition, no precrash mechanical deficiencies were identified by the investigation. The driver was a 59-year-old male who held a valid Texas driver's license.

1.2 Event Sequence

On the night of the crash, the driver and his wife hosted two friends at their home, beginning at approximately 4:00 p.m. According to the driver's wife, he had an alcoholic drink, and then the group went to a restaurant, where he consumed additional alcohol during dinner. They left the restaurant around 8:30 p.m. and arrived back at the driver's home around 9:00 p.m. The driver's wife had driven the group to and from the restaurant in her vehicle, which was not the car involved in the crash. Upon arriving home, the driver entered the residence to retrieve the car's key card to show his friend the car. A security video obtained from the owner's residence showed the driver and 69-year-old male passenger getting into the front seats prior to driving away from the residence.

Around 9:07 p.m., the driver drove out of his driveway and onto the cul-de-sac, and then accelerated westward on Hammock Dunes Place, accompanied by the passenger in the front seat. The roadway initially had a straight section about 174 feet in length that led into a leftward curved section, 320 feet long with a radius of 250 feet. As

[2] See Texas Transportation Code §545.352, accessed January 4, 2023.

documented by roadway evidence, the car departed the roadway to the right, mounted the curb, traversed a storm sewer inlet, struck an elevated manhole cover, and sideswiped a tree (see figure 3). The car then impacted another tree before coming to final rest.

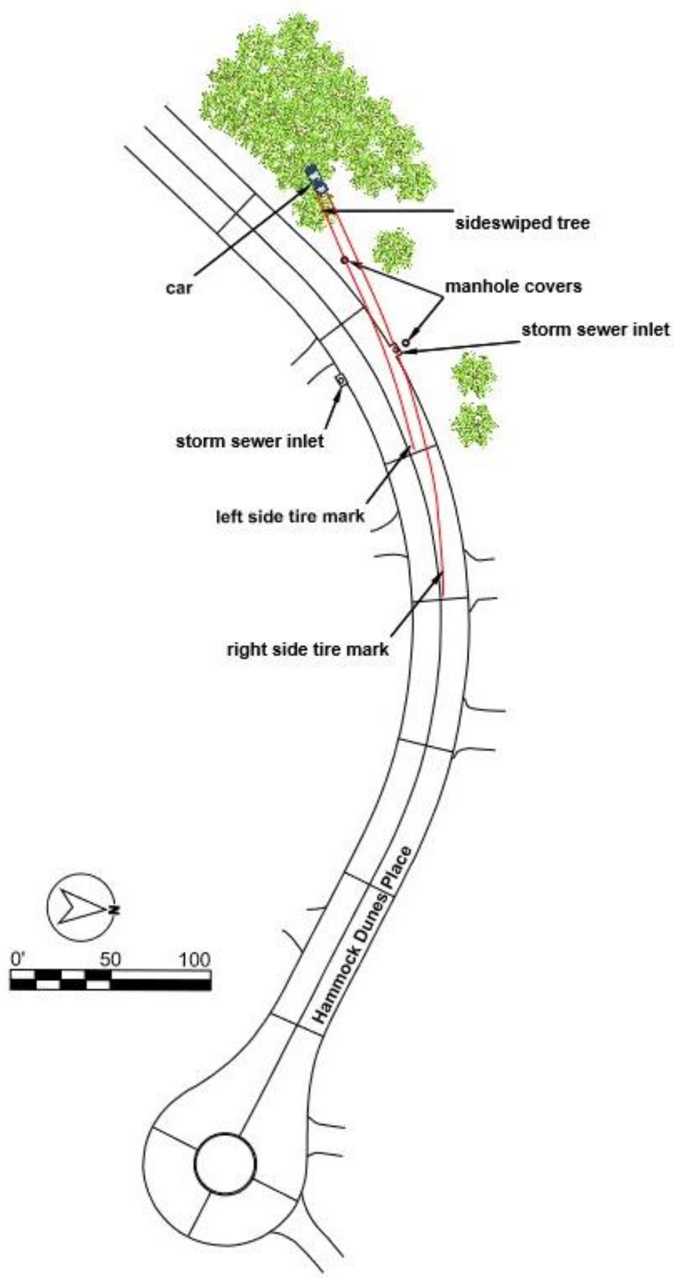

Figure 3. Crash diagram showing physical evidence and final rest position of car.

The car was equipped with an airbag control module and an event data recorder (EDR), which captured certain precrash data and crash parameters, including vehicle dynamics and safety system information, in relation to a crash or crash-like event. The

National Transportation Safety Board (NTSB) imaged the EDR to obtain data related to the crash. In the 5 seconds before impacting the tree, the car accelerated from 39 mph to a top speed of 67 mph 2 seconds before the final tree impact, which occurred at about 57 mph. The application of the accelerator pedal ranged from 8% to 98% during the 5 seconds of recorded data, and there was no evidence of braking. Precrash EDR data indicated that both the driver and passenger were restrained with the available lap/shoulder belts. As a result of the final impact with the tree, the front, curtain, and knee bolster airbags deployed, and both front seat belt pretensioners activated. The crash damaged the front of the car’s high-voltage lithium-ion battery case, where a fire started.

The Woodlands Fire Department Communication Center was notified through the 911 system at 9:24 p.m. The first 911 call at 9:24 p.m. described the incident as a “small outside fire.” At 9:28 p.m., the incident description was changed by the call operator to “Motor Vehicle Accident – Fire” when a second caller stated that a “car crashed into a tree and exploded.” The initial address given was incorrect, but the firefighters went to the correct location after seeing the fire from the other side of a pond, arriving on scene at 9:36 p.m.

Upon arrival, responders found two occupants in the car, one in the front passenger seat region and the other in the left rear seat region. The occupant in the rear seat was later identified as the car driver. The firefighters first used a preconnected line with water and extinguished the bulk of the fire in about 30 to 45 seconds.[3] They continued to apply water for about 90 seconds to fully extinguish the fire but noticed a localized area near the front of the car that continued burning. They used portable fire extinguishers with dry chemical on this localized fire. The flames were extinguished but then reignited.

The firefighters identified the car as a Tesla from the emblem at the center of a remaining wheel, realized that it was an electric vehicle, and proceeded with added caution. Responders then found Tesla’s Emergency Response Guide online through a web search and reverted to using water on the fire instead of fire extinguishers, in accordance with the guide’s instructions for how to extinguish a high-voltage lithium-ion battery fire.[4] About 45 minutes after the fire was completely extinguished, it reignited again. Firefighters elevated one side of the car about 8 inches to apply water to the bottom of the car and stop any additional reignition. Responders did not notice the instruction in the Tesla Emergency Response Guide to lift the car for better access to the

[3] The preconnected line was attached to the 500-gallon water tank on the fire truck.

[4] See the Emergency Response Guide for the 2012-2020 Tesla Model S: 2016_Model_S_Emergency_Response_Guide_en.pdf (tesla.com), accessed January 4, 2023.

battery but identified this strategy on their own. In total, approximately 20,000 gallons of water were used on the fire.

1.3 Additional Information

1.3.1 Injuries and Toxicology

According to his autopsy, the 59-year-old male driver's cause of death was blunt-force trauma and thermal injuries with smoke inhalation. Toxicological testing by the Federal Aviation Administration Forensic Sciences Laboratory detected ethanol at 0.151 grams per deciliter (g/dL) in the driver's blood, along with the sedating antihistamine medications chlorpheniramine and cetirizine, which are available over the counter.

According to his autopsy, the 69-year-old male passenger's cause of death was blunt-force trauma of the torso and extremities and thermal injuries.

1.3.2 Car Damage and Door Operation

The impact damage was concentrated to the front of the car with a maximum intrusion of approximately 32 inches. This intrusion resulted in damage to the high-voltage lithium-ion battery pack and the two battery modules nearest the front of the car. In addition, both the right and left front wheels and suspension components were displaced from the car.

The postcrash battery fire consumed most of the interior occupant cabin of the car, which limited the on-scene inspection (see figure 4). The plastic and fabric portions of the seat belts were destroyed in the fire, but the seat belt connectors for both the driver seat and left rear seat were found near where they would normally be located for each seating position. Investigators removed the steering wheel from the wreckage and sent it to the NTSB Materials Laboratory in Washington, DC, for further inspection. Detailed evaluation of the steering wheel revealed that the top of the rim between the 9 o'clock and 3 o'clock spokes was bent forward, toward the dashboard. The spoke at the 9 o'clock position was fractured and separated from the hub.

Figure 4. Interior of fire-damaged car, looking front to rear.

The frontal impact with the tree resulted in a power loss of the car's 12-volt system, which runs the non-traction power systems. During normal operation, the front door latches operate electronically with the pull of the interior lever. In the event of a 12-volt system power loss, the interior front doors open as usual using the interior door handles. The rear doors also have both electronic and mechanical latches; however, mechanically opening the rear door during a power loss requires additional steps. According to the owner's manual, during a loss of 12-volt system power, a rear-seated occupant must locate a small cutout in the carpet beneath the seat cushions and pull the mechanical release cable tab toward the center of the vehicle to manually open the rear door.[5] Inspection of the door latches and locking hardware was limited by postcrash fire damage.

1.3.3 Exemplar Vehicle Testing

The car was equipped with an advanced driver assistance system (ADAS) marketed as Autopilot that was composed of an adaptive cruise control system (Traffic Aware Cruise Control [TACC]) and a lane centering system (Autosteer). Information from the manufacturer indicated that the ADAS system could not be engaged on a roadway

[5] In a 2019 Tesla Model S P100D, there are two mechanical release tabs in the rear of the vehicle, one under the left rear seat position and one under the right rear seat position.

without lane markings.[6] The NTSB performed on-scene testing with an exemplar vehicle to document whether Autosteer and/or TACC could be engaged on this roadway. The testing also established the acceleration possible with TACC engaged and the maximum speed possible on this roadway.

2. Analysis

Weather and visibility were not factors in this crash, and investigators found no evidence of mechanical deficiencies in the 2019 Tesla Model S that would have caused or contributed to the collision. The emergency response, once notified, was timely and adequate.

On-scene exemplar vehicle testing confirmed the manufacturer-provided information that the car's Autopilot feature could not have been engaged on the roadway where the crash occurred, due to the lack of lane markings. Investigators found that the TACC system was capable of being engaged; however, testing showed that with TACC engaged, the maximum speed possible on this roadway was approximately 30 mph. The acceleration achieved with TACC engaged was lower than the acceleration documented in the car's EDR data. This evidence indicated that TACC was not engaged during the crash trip.

Due to the postcrash fire damage, the car doors and handles could not be evaluated. Therefore, it was not possible to determine whether the doors were manually operational following the power loss. Although the driver's seat was found vacant and the driver was found in the left rear seat, the available evidence suggests that the driver was seated in the driver's seat at the time of the crash and moved into the rear seat postcrash. Specifically, residential security video showed both the driver and passenger getting into the front seats prior to driving away from the residence. In addition, the EDR data showed active accelerator pedal inputs consistent with driver activity in the 5 seconds prior to the impact with the tree, and that the driver's seat belt was connected at the time of the crash.[7] Finally, the steering wheel examination conducted by the NTSB Materials Laboratory indicated an impact to the upper left quadrant, consistent with the driver loading the steering wheel during a frontal crash. In severe frontal crashes, despite

[6] In addition, the car manufacturer provided data that indicated no use of the Autopilot system at any time after the car was purchased by the driver in January 2021, including the timeframe up until the last transmitted timestamp on April 17, 2021.

[7] The EDR does not record driver occupancy of the seat, as the manufacturer assumes that the driver's seat is occupied. The EDR does record occupancy of the front passenger seat and the seat belt status for both positions.

the deployment of the driver's airbag, forward motion of a restrained driver can result in deformation of the steering wheel (Chen and Gabler 2013).

The 57-mph frontal impact with the tree resulted in extensive damage extending into the battery pack and damaging two of the battery modules within. These damaged high-voltage lithium-ion battery modules were the source of the postcrash fire. Emergency responders were able to find the online Emergency Response Guide to determine that water was the most effective method for extinguishing the battery fire. However, they did not notice language that was present in the guide that recommended lifting the car to provide better access to the battery. The NTSB has recommended that manufacturers of electric vehicles equipped with high-voltage lithium-ion batteries provide, in a standardized format, their emergency response guides for how to extinguish electric vehicle fires, and also that they provide vehicle-specific information.[8] Having the emergency response guides published in a clear, consistent format would improve their usefulness to emergency responders and make it quicker and easier to find the necessary information (NTSB 2020).

2.1 Alcohol-Impaired Driving

The driver's toxicology report showed a blood alcohol concentration (BAC) of 0.151 g/dL, which is almost twice the Texas limit of 0.08 g/dL for driving.[9] The effects of alcohol include psychomotor impairment, decreased inhibition, diminished alertness, confusion, problems with concentration, reduced visual focus, and slurred speech. Alcohol affects the capacity to drive safely by impairing information processing and reaction time as well as compromising judgment and coordination. The driver's additional use of two sedating antihistamines (chlorpheniramine and cetirizine) likely increased his level of impairment of judgment and psychomotor response as well as his degree of sleepiness, all increasing his level of impairment from alcohol.

It is widely recognized that the risk of being involved in a crash increases with higher BAC. Blomberg and others (2009) found a measurable effect of BAC on relative crash risk beginning at a BAC of 0.04 g/dL and increasing exponentially at BACs above 0.10 g/dL, with an adjusted relative risk of crash involvement of 29.5 at BACs of 0.16 g/dL, or twice the legal limit in most states.[10]

---

[8] Safety Recommendation H-20-32.

[9] See Driving Under the Influence (txdot.gov), accessed December 19, 2022.

[10] *Relative risk* is the likelihood of an occurrence (a crash) after exposure to a risk variable (alcohol consumption) as compared with the likelihood of its occurrence in a control or reference group (sober driving). An adjusted relative risk of 29.5 would mean that a driver with a BAC of 0.16 g/dL would be 29.5 times more likely to crash than a driver with a BAC of 0.00 g/dL (that is, a sober driver).

The NTSB has long been concerned about alcohol-impaired driving, which accounted for nearly 30% of highway fatalities in the United States in 2020 (NCSA 2022a). Since 1968, the NTSB has issued nearly 150 safety recommendations addressing impaired driving, and the issue area "Prevent Alcohol- and Other Drug-Impaired Driving" is on the NTSB's current Most Wanted List of Transportation Safety Improvements.[11] One such recommendation was issued to the states to establish a per se BAC limit of 0.05 or lower for all drivers.[12] Recently, the NTSB recommended that NHTSA require all new vehicles to be equipped with passive vehicle-integrated alcohol impairment detection systems, advanced driver monitoring systems, or a combination thereof, which are capable of preventing or limiting vehicle operation if driver impairment by alcohol is detected.[13] In this crash, had the car been equipped with this type of passive system, the trip may have been prevented altogether.

2.2 Excessive Speed

In this crash, the driver accelerated to a speed of 67 mph on a residential street with a speed limit of 30 mph, resulting in loss of control and roadway departure. Speeding—exceeding a speed limit or driving too fast for conditions—is one of the most common factors associated with motor vehicle crashes in the United States (NCSA 2022b), and "Implement a Comprehensive Strategy to Eliminate Speeding-Related Crashes" is an issue area on the NTSB's current Most Wanted List.[14] A vehicle technology-based solution, such as intelligent speed adaptation (ISA), can reduce speeding. The NTSB has recommended that NHTSA incentivize passenger vehicle manufacturers and consumers to adopt ISA systems by, for example, including ISA in the New Car Assessment Program.[15]

The driver's alcohol intoxication may have contributed to his decision to travel at excessive speed. Also, because the precrash travel distance was short, it is uncertain how effective currently available ISA systems providing only speed warnings could have been in preventing the crash. Only an ISA system that electronically limited the speed of the car (that is, a "closed" ISA system) may have meaningfully mitigated the severity of the crash. In addition, the effectiveness of a particular ISA system depends on its underlying

[11] See Prevent Alcohol- and Other Drug-Impaired Driving, accessed May 31, 2022.

[12] Safety Recommendation H-13-05.

[13] Safety Recommendation H-22-22.

[14] See Implement a Comprehensive Strategy to Eliminate Speeding-Related Crashes, accessed May 31, 2022.

[15] Safety Recommendation H-17-24.

speed limit detection technology. For ISA to have helped in this crash, where there were no posted speed limit signs, the system would have needed to rely on GPS maps and would only have been effective if the speed limit data for this location were complete and accurate.

3. Conclusions

3.1 Probable Cause

The National Transportation Safety Board determines that the probable cause of the Spring, Texas, electric vehicle crash was the driver's excessive speed and failure to control his car, due to impairment from alcohol intoxication in combination with the effects of two sedating antihistamines, resulting in a roadway departure, tree impact, and postcrash fire.

3.2 Lessons Learned

3.2.1 Alcohol Impairment and Excessive Speed

In this crash, and as the NTSB has previously noted in numerous crashes, alcohol impairment and excessive speed were significant causal factors. Since 1968, the NTSB has issued nearly 150 safety recommendations addressing impaired driving, and the issue area "Prevent Alcohol- and Other Drug-Impaired Driving" is on the NTSB's current Most Wanted List of Transportation Safety Improvements. Speeding is also one of the most common factors associated with motor vehicle crashes in the United States, and "Implement a Comprehensive Strategy to Eliminate Speeding-Related Crashes" is an issue area on the NTSB's current Most Wanted List. The NTSB has advocated for vehicle technologies—including passive vehicle-integrated alcohol impairment detection systems, advanced driver monitoring systems, and intelligent speed adaptation—to help reduce crashes caused by alcohol impairment and excessive speed. Requiring these technologies and/or incentivizing them through consumer information programs is necessary to achieve widespread installation.

3.2.2 Electric Vehicle Fires

The NTSB has recommended to manufacturers of electric vehicles equipped with high-voltage lithium-ion batteries that they provide information for how to extinguish electric vehicle fires in their emergency response guides in a standardized format, and also that they provide vehicle-specific information. Having the emergency response guides published in a clear, consistent format would improve their usefulness to emergency responders and make it quicker and easier to find the necessary information.

References

Blomberg, R.D., R.C. Peck, H. Moskowitz, M. Burns, and D. Fiorentino. 2009. "The Long Beach/Fort Lauderdale Relative Risk Study." *Journal of Safety Research* 40 (4), 285-292.

Chen, R. and H.C. Gabler. 2013. "Incidence and risk of direct steering wheel impact in vehicles equipped with advanced airbags." Paper presented at the Proceedings of the Twenty-Third International Technical Conference on the Enhanced Safety of Vehicles, Paper No. 13-0463, Seoul, Korea, May 2013. https://www-esv.nhtsa.dot.gov/Proceedings/23/isv7/main.htm

NCSA (National Center for Statistics and Analysis). 2022a. *Alcohol-impaired driving: 2020 data*. Traffic Safety Facts. Report No. DOT HS 813 294. Washington, DC: NHTSA.

________. 2022b. *Speeding: 2020 data*. Traffic Safety Facts. Report No. DOT HS 813 320. Washington, DC: NHTSA.

NTSB (National Transportation Safety Board). 2020. *Safety Risks to Emergency Responders from Lithium-Ion Battery Fires in Electric Vehicles*. Safety Report NTSB/SR-20/01. Washington, DC: NTSB.

NTSB investigators worked with the **Harris County Constable's Office** throughout this investigation.

The National Transportation Safety Board (NTSB) is an independent federal agency dedicated to promoting aviation, railroad, highway, marine, and pipeline safety. Established in 1967, the agency is mandated by Congress through the Independent Safety Board Act of 1974, to investigate transportation accidents, determine the probable causes of the accidents, issue safety recommendations, study transportation safety issues, and evaluate the safety effectiveness of government agencies involved in transportation. The NTSB makes public its actions and decisions through accident reports, safety studies, special investigation reports, safety recommendations, and statistical reviews.

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 investigations website and search for NTSB accident ID HWY21FH007. 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