Electric Vehicle Run-Off-Road Crash and Postcrash Fire

Coral Gables, Florida
September 13, 2021

On Monday, September 13, 2021, about 8:54 p.m. eastern daylight time, a 2021 Tesla Model 3, Long Range-Dual Motor electric car, occupied by a 20-year-old driver and 19-year-old passenger, was traveling north on Alhambra Circle in Coral Gables, Miami-Dade County, Florida.[1] The weather was clear, the road was dry, and the area was illuminated by streetlamps. As the car approached the signalized intersection with Coral Way, it accelerated, shifted into the southbound lane to pass another car, and then reentered the northbound lane. After this passing maneuver, the car continued to accelerate, running the red light. The driver then lost control, departed the roadway, and struck two trees in the center median. Both the driver and the passenger died. A postcrash fire engulfed the car; firefighters faced challenges in extinguishing the fire and reported that the car's batteries reignited at least once.

[1] (a) In this report, all times are eastern daylight time. (b) Visit ntsb.gov to find additional information in the public docket for this NTSB investigation (case no. HWY21FH011). Use the CAROL Query to search safety recommendations and investigations.

Figure 1. Still image of forward-facing video from witness vehicle at intersection of Alhambra Circle and Coral Way.[2] The witness vehicle was stopped at the red light. The postcrash fire is visible in the distance.

[2] For more detailed information about the witness vehicle video, see the *Coral Gables Video Study* in the public docket for this crash (case no. HWY21FH011).

Location	Alhambra Circle, Coral Gables, Florida
Date	September 13, 2021
Time	8:54 p.m. eastern daylight time
Vehicles involved	1
People involved	2
Injuries	2 fatal (driver, passenger)
Weather	Dry, clear, dark hour, roadway illuminated by streetlamps
Roadway information	South of the intersection with Coral Way, Alhambra Circle was a two-lane, undivided roadway with one northbound and one southbound lane. North of the Coral Way intersection, Alhambra Circle was a residential street with one 10-foot-wide lane in each direction divided by a 30-foot-wide median. Both lanes had a 5-foot-wide bike lane and no shoulder. The posted speed limit was 30 mph both north and south of Coral Way.

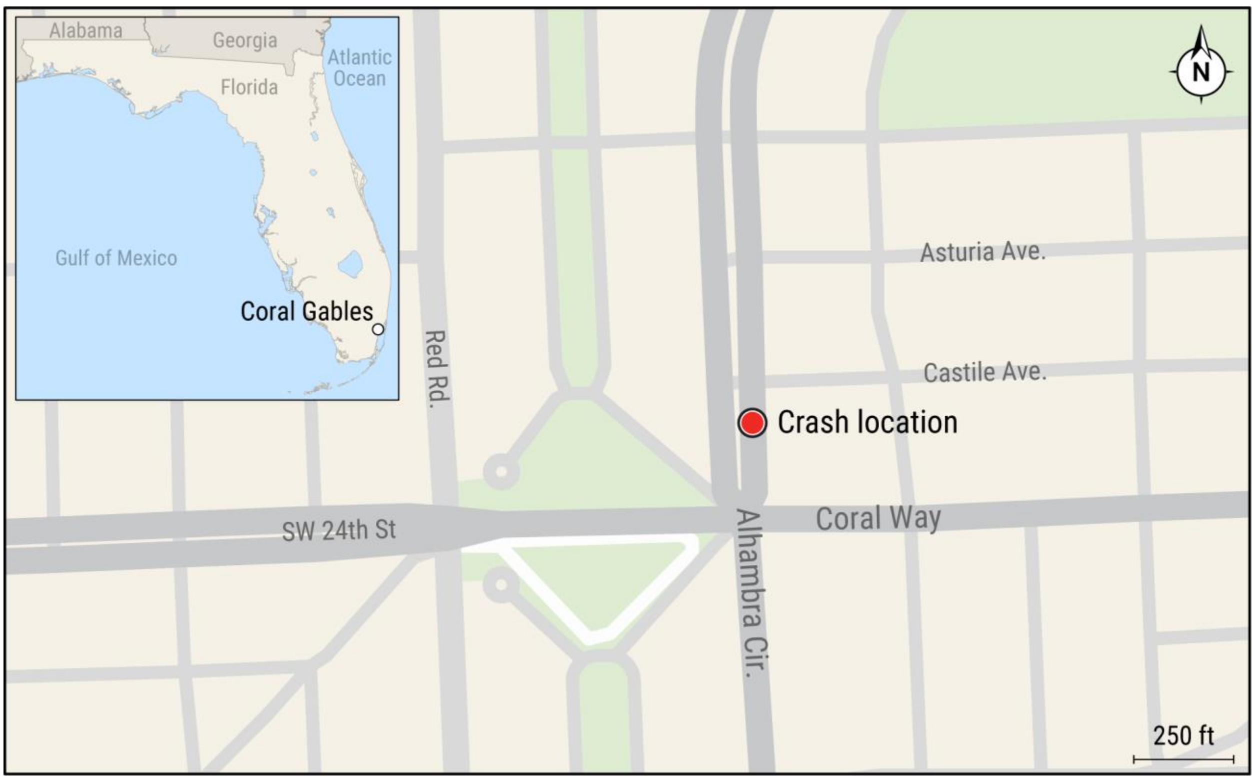

Figure 2. Area where crash occurred, as indicated by red circle. (Background source: Esri)

1. Factual Information

1.1 Event Sequence

National Transportation Safety Board (NTSB) investigators determined the crash sequence using data from the car's event data recorder (EDR) and from a forward-facing video camera on the non-involved vehicle that was passed by the car before the crash. The EDR collected and stored data associated with vehicle speed, acceleration, seat belt status, and airbag deployment.[3] The video provided information on traffic signal status and the car's lane-changing maneuvers.

The signal light cycled to yellow 7 seconds before the fatal crash with the second tree.[4] The car passed the witness vehicle and accelerated to a speed of 68 mph 5 seconds before the crash. It returned to the northbound lane and continued to accelerate as it neared the signalized intersection. Five seconds before the crash with the second tree, application of the accelerator pedal increased from 92% to 100% and remained at 100% until 2.6 seconds before the crash. The signal light cycled to red about 3 seconds before the crash, prior to the car reaching the intersection. It reached a top speed of 90 mph as it traversed the intersection, running the red light. As the car's speed peaked, the accelerator pedal decreased from 100% at 2.6 seconds to 0% at 1.8 seconds before the crash.

As the car crossed the intersection at high speed, its suspension became unweighted when it traversed the crown in the roadway and then fully compressed when it reached the north side of the intersection, resulting in the undercarriage contacting the road surface. The onset of road evidence appeared about 5 feet beyond the northernmost crosswalk, where gouge marks were observed on the roadway. After this contact occurred, the car's electronic stability control (ESC) entered a fault state.[5]

The car then continued north on the divided section of Alhambra Circle. Approximately 93 feet north of the initial gouge marks, two additional scuff marks accompanied by tire friction marks were observed. The tire friction marks indicated that the car yawed counterclockwise and moved toward the center median. The left front of

[3] The EDR was taken to the NTSB Recorder Laboratory, where the damaged data chip was repaired and installed into an exemplar EDR. The data extraction process yielded about 5 seconds of precrash and crash data, the maximum data available.

[4] Study of the forward-facing camera video from the witness vehicle provided positioning of the car about 2 seconds prior to what the EDR data provided, including information about the traffic signal timing.

[5] ESC detects a loss of traction and applies braking force to individual wheels to assist a driver in maintaining vehicle control. When the car entered a fault state, the system was no longer able to function in this capacity.

the car struck a tree (labeled as A in figure 3; damage to the first tree is outlined in yellow), after which it continued to yaw counterclockwise. Tire marks were observed on the road surface heading toward a second tree located 42 feet farther north, with which the passenger side of the car collided (labeled as B in figure 3; impact damage to this tree is also outlined in yellow). The car was traveling at approximately 81 mph immediately prior to impact with the second tree. The driver did not apply braking at any point during the approximately 5 seconds prior to the crash with the second tree.[6] The car struck the tree at the middle right (passenger) side, in between the A and B pillars.[7] The car rotated around the second tree due to the force at impact and came to rest on the north side of the second tree, as shown in the crash diagram (figure 4).[8]

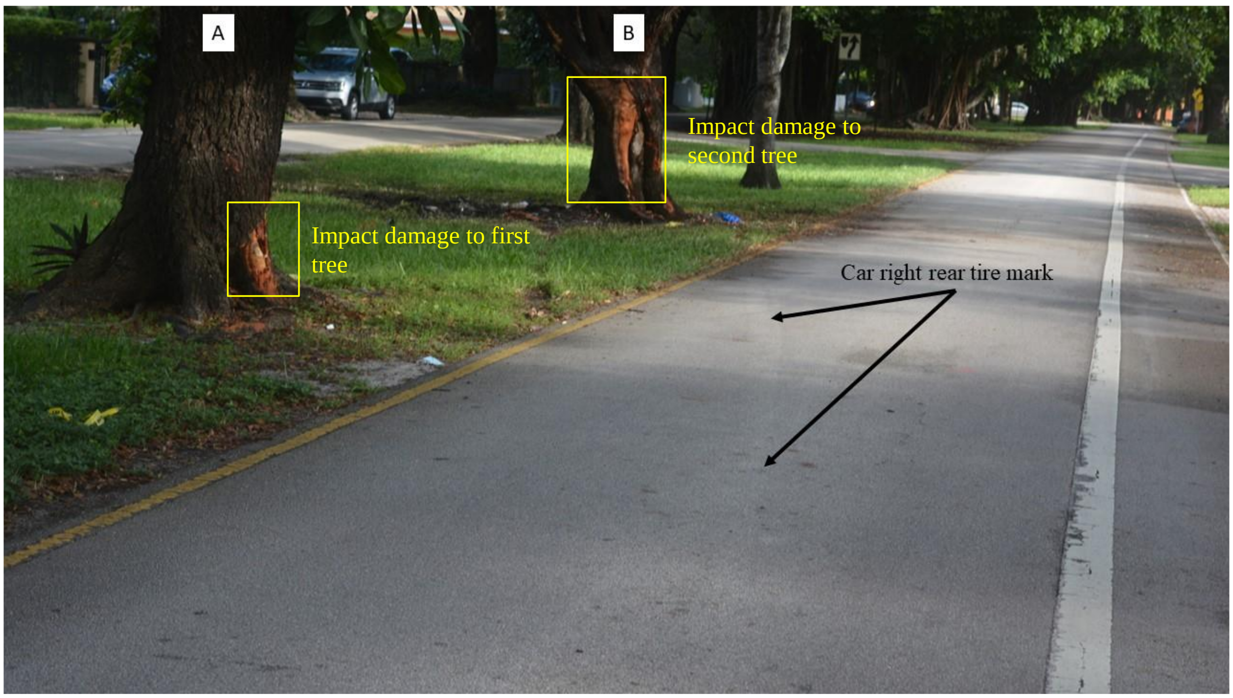

Figure 3. Alhambra Circle looking north from Coral Way intersection, with two trees struck by car visible on left. (Source: Coral Gables Police Department)

[6] Possible values for the service brake are "on" (brake pedal applied) and "off" (brake pedal not applied). The car's speed was calculated using four-wheel speed signals and inertial acceleration measurements.

[7] Pillars are labeled alphabetically from front to back; the A pillar is at the windshield of the car and the B pillar is in the middle of the passenger compartment, behind the front doors.

[8] The crash diagram was generated using data gathered by NTSB investigators on scene in conjunction with data received from the Coral Gables Police Department.

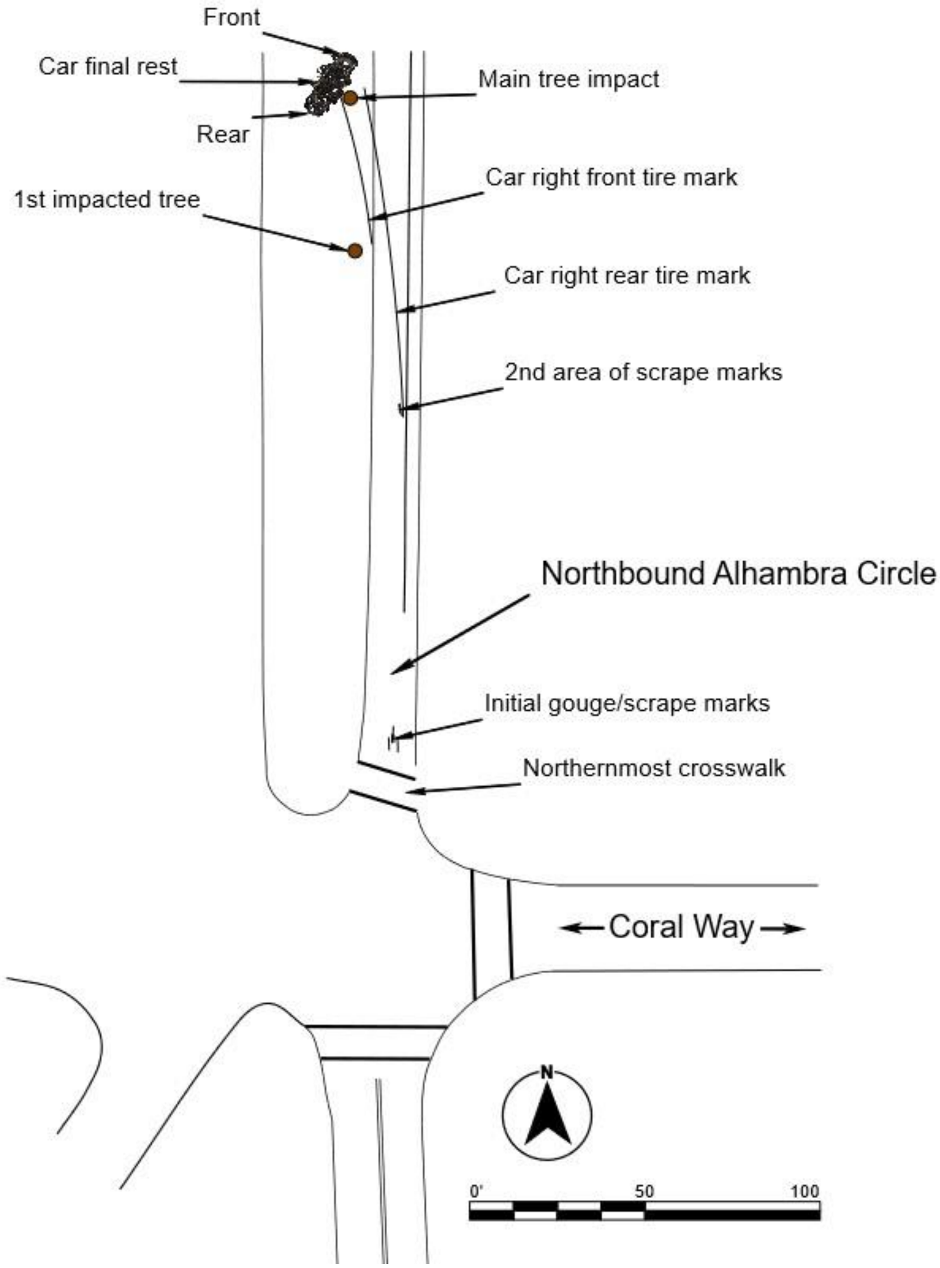

Figure 4. Crash scene diagram.

The impact to the car's right side between the A and B pillars caused significant intrusion into the passenger compartment as well as into the high-voltage lithium-ion battery case and enclosed battery modules. Damage to these battery modules resulted in a postcrash fire. The NTSB analysis of the witness vehicle's forward-facing camera video and witness statements indicated that the car was engulfed in fire within seconds after the crash. The car sustained severe thermal damage to the interior, roof, and both sides.

Both the driver and the passenger were fatally injured in the crash. Both were wearing seat belts when the crash occurred. Driver- and passenger-side airbags deployed, along with side curtain airbags and knee airbags. No carbon monoxide was found in the blood of the driver or passenger, and no soot was found in the airways of either occupant.

A witness reported the crash at 8:54 p.m. Responders from the Coral Gables Police Department (CGPD) and Coral Gables Fire Department (CGFD) were dispatched to respond at 8:55 p.m. The first officer from the CGPD arrived at 8:57 p.m.; at this time, the car was already engulfed in fire. The CGFD arrived at 9:01 p.m. and applied water to the fire at 9:05 p.m. The fire was initially extinguished at 9:09 p.m. One fire unit remained on scene to manage reignition events. At 9:33 p.m. the car began to emit smoke and additional water was applied to prevent further reignition, but no visible fire occurred. Fire units were cleared at 9:52 p.m. The CGPD reported that the car began to emit smoke again at 11:33 p.m. but did not require additional fire response. Interviews with members of the CGFD indicated that they have had general experience with electric vehicle battery fires and that these fires required "copious amounts of water." Tesla provides information for emergency responders regarding electric vehicle battery fires, but the responders to this crash reported that they did not consult any external sources or emergency response guides to extinguish the fire.[9]

1.2 Additional Information

1.2.1 Driver Information

The driver was a 20-year-old male from Coral Gables, Florida. He lived, worked, and attended school near the crash location. According to family members, the driver obtained his learner's permit at age 17 and held it for about 1 year.[10] At the time of the crash, the driver held a Florida class E non-commercial driver license with no endorsements and a corrective lenses restriction. His license was issued in February 2019 and was set to expire in 2027. The driver had no traffic violations or previous crashes. At the time of the crash, he had been licensed for about 2 years and 6 months.

[9] The Emergency Response Guide for the Tesla model 3 is available at https://www.tesla.com/sites/default/files/downloads/Model_3_Emergency_Response_Guide_en.pdf, accessed December 30, 2022.

[10] General information for Florida driver licenses is available at https://www.flhsmv.gov/driver-licenses-id-cards/general-information/, accessed November 21, 2023.

According to the driver's mother, he was healthy and had no diagnosed or suspected medical conditions. Postcrash toxicological testing was negative for alcohol and other tested-for drugs.[11] According to records obtained from the driver's cell phone service provider, he was not using his cell phone to talk or text when the crash occurred. No sources of outside distraction were observed at the scene or reported by witnesses. Additionally, investigators learned that the car had recently been acquired by the driver, and he had been driving it for about 6 days before the crash occurred.

1.2.2 Roadway Alignment

The vertical alignment for vehicles traveling on Alhambra Circle approaching Coral Way in the northbound direction consisted of a 1.2% upgrade slope.[12] Continuing northbound from the center of the intersection, the vertical alignment transitioned to a 1.1% downward grade leading toward the pedestrian crossing. The crossing had a width of about 11 feet. The vertical alignment of Alhambra Circle north of the pedestrian crossing also consisted of a 1.2% upgrade slope. The vertical alignment complied with guidance found in the Florida Department of Transportation (FDOT) design manual, which suggests avoiding grades above 3% at intersections (FDOT 2020).

1.2.3 High-Voltage Lithium-Ion Battery Damage

The car's battery compartment was located underneath the vehicle cabin area, as shown in figure 5. The car impacted the second tree on the passenger side, just forward of the B pillar (figure 6, left), and the intrusion reached the battery compartment.

[11] The test was negative for ethanol, amphetamines, opiates, cannabis, cocaine, phencyclidine, benzodiazepines, barbiturates, antidepressants, and antihistamines.

[12] The 1.2% slope was measured on Alhambra Circle to the center of the intersection with Coral Way. Slope measurements were obtained from an elevation survey completed by the City of Coral Gables during the on-scene investigation.

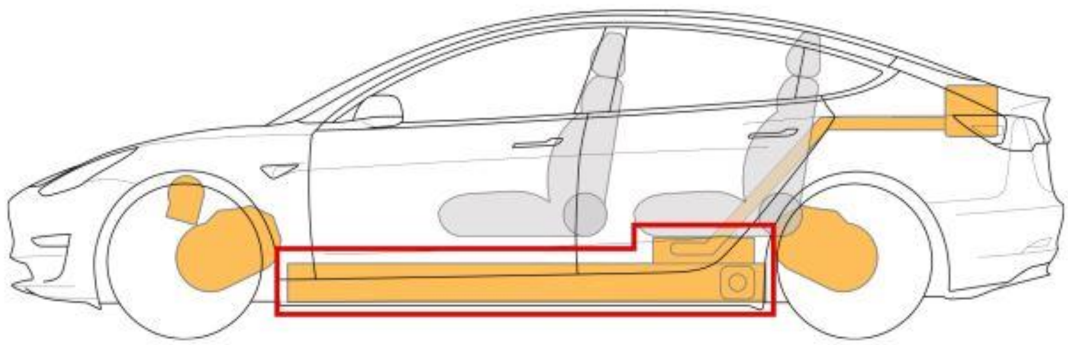

Figure 5. Diagram of Tesla Model 3 powertrain components shown in yellow, with battery location outlined in red. (Source: Tesla)

The car's high-voltage lithium-ion battery sustained severe damage to the entire right side, which caused a breach of the exterior battery case. The damage extended into the battery modules within, exposing portions of battery modules and dislodging individual battery cells.[13] Hundreds of battery cells were displaced and scattered in the wreckage and on the ground. The postcrash fire resulting from these damaged battery modules and individual cells destroyed much of the car's interior and burned through the battery casing on the underside of the car (figure 6, right).

Figure 6. Impact damage to passenger side and fire damage to car (left), with burn hole in battery case circled in red (right).

[13] The high-voltage lithium-ion battery in the Tesla Model 3 has four modules, and each module contains about 1,000 individual battery cells.

2. Analysis

Weather and roadway conditions were not factors in this crash; the weather was clear, and the roadway was dry. Although it was dark, visibility was not a factor, as the car's headlamps were on, the roadway was illuminated by streetlamps, and no unusual lighting conditions were present. Roadway design, traffic signal timing and operations, and signage were consistent with FDOT guidance for intersections and were not factors in this crash.

The car impacted the second tree at about the midpoint of its passenger side, with maximum velocity changes of 48 mph (longitudinal) and 46 mph (lateral). This impact exceeded applicable Federal Motor Vehicle Safety Standards (FMVSS) for vehicle crashworthiness as well as the design capability of vehicle occupant safety systems.[14] The crash impact caused blunt-force fatal injuries to the occupants, and the lack of detection of carbon monoxide and soot in the occupants' airways indicated that the postcrash fire did not contribute to the severity of the injuries. Given the severity of the crash, the responders being on scene within 3 minutes, and the efficiency in extinguishing the fire, the emergency response was timely and adequate.

Based on evidence of the moments leading up to the crash, the driver was actively engaged in the driving task. NTSB investigators found no evidence that the driver's performance in this crash was related to a medical condition. Distraction was also excluded as a factor; records from the driver's cell phone usage indicated that he was not talking or texting at the time of the crash. Postcrash toxicological tests were negative for alcohol and other drugs. The driver was properly licensed to operate the car and had no history of traffic violations or previous crashes. The driver was likely familiar with the route because he lived and attended school in the area.

2.1 Speeding and Driver Actions

Speeding heightens crash risk by increasing both the likelihood of a crash as well as the severity of injuries or damage in a crash. The National Highway Traffic Safety Administration (NHTSA) reports that in 2020, 29% of fatal crashes involved speeding behavior (11,258 fatalities from crashes where at least one driver was speeding). This represents an increase of 17% from 2019 (9,592 fatalities from speeding-related crashes in 2019). Furthermore, more than one-third of male drivers in the 15-to-20-year-old age group involved in fatal crashes were speeding at the time of the crash, the highest among all recorded age groups (NHTSA 2022).

[14] See FMVSS 214, "Side Impact Protection," 49 *Code of Federal Regulations* 571.214, accessed January 3, 2023.

2.1.1 Driver Decision to Accelerate through a Red Traffic Light

A yellow traffic light at an intersection is a warning to drivers that there is a change in the right of way and that drivers must stop if they are unable to remain within the speed limit and pass through the intersection before the signal turns red. The video from the witness vehicle showed that the traffic light at the intersection with Coral Way transitioned to yellow 7 seconds prior to impact with the second tree (and 5 seconds prior to the car entering the intersection).

The driver was already speeding prior to the onset of the yellow traffic light, and his decision to continue to accelerate rather than stop at the light was likely an attempt, although unsuccessful, to clear the intersection before the light turned red. Researchers have explored how drivers decide to respond to a yellow light (for example, Gazis and others 1960; see Papaioannou and others 2021 for a current overview). When a signal changes from green to yellow, the factors of vehicle speed, distance to the intersection, roadway conditions, and braking capability of the vehicle are all parameters that specify a range within which the driver has the option to stop at the yellow light or proceed through the intersection before the light turns red. Based on the EDR-recorded speed of 68 mph 5 seconds prior to the second tree impact, as well as the forward-facing video from the witness vehicle, the car could have stopped at the red light had the driver initiated braking within 264 feet of the intersection (see figure 7). Instead, the driver continued to accelerate until the light turned red, at which point he stopped accelerating but did not initiate any braking. The driver's choice to accelerate to a speed of 90 mph through the red light at the intersection with Coral Way led to his loss of control of the car and subsequent impact with two trees.

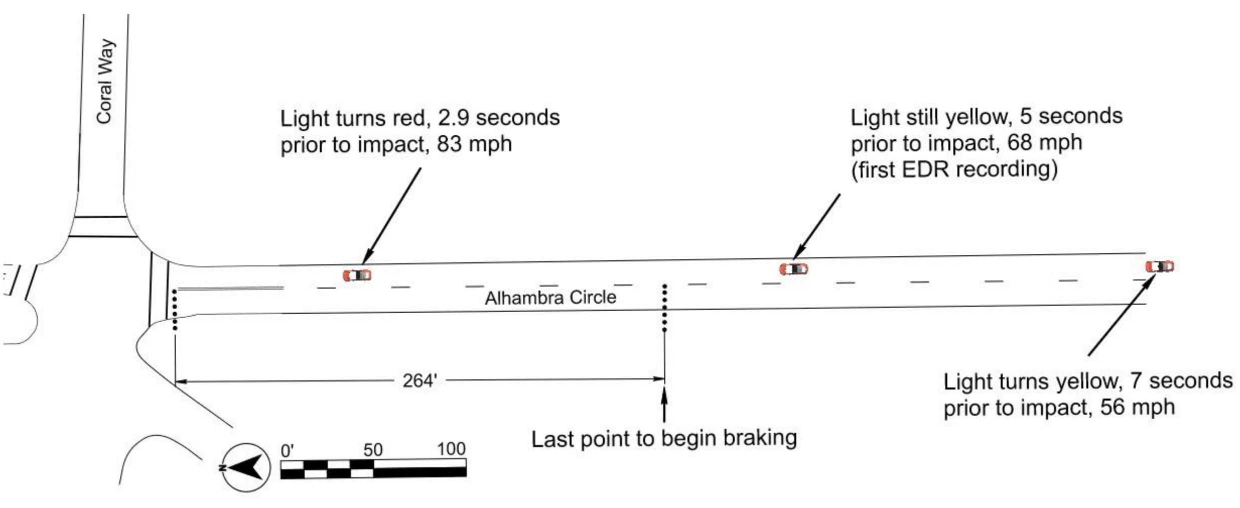

Figure 7. Calculated minimum stopping distance to traffic signal. The car positions are included for when the signal light turns yellow, the first EDR-recorded position, and when the signal light turns red, along with the time before impact with the second tree at each of these positions.

2.1.2 Excessive Speed and Loss of Control

In this crash, the 20-year-old driver accelerated to pass a vehicle, and once back in the northbound lane, continued to accelerate, likely to avoid stopping at the red light. Ultimately, the driver was traveling at three times the posted 30-mph speed limit. Figure 8 includes a diagram of the car's positions in the 5 seconds leading up to the crash, with speed, time, and distance annotated. Evidence obtained from the EDR showed that the car was traveling at 90 mph as it exited the intersection of Alhambra Circle and Coral Way.[15] As the car continued north and traversed the pedestrian crossing, its suspension became fully compressed due to the vertical grade change, and the speed of the car caused its undercarriage to engage the roadway surface, leaving gouge marks north of the crosswalk. When this evidence was aligned with the EDR data, investigators were able to determine that the undercarriage struck the roadway surface about 1.4 seconds prior to the crash with the second tree. The next recorded timestamp in the EDR data (1.2 seconds before the crash) showed that the ESC changed from inactive to a fault state.[16] Given these conditions, the driver had very little time to recover before crashing into the second tree, and the lack of ESC may have further contributed to the loss of control.

[15] EDR data indicated a top speed of 90 mph through the intersection as noted in section 1.1 of this report (Event Sequence); 89 mph is the reported speed corresponding to the timestamp at the onset of roadway evidence.

[16] Given the extent of the damage to the car from both the crash and the postcrash fire, a determination could not be made for the exact cause of the fault state.

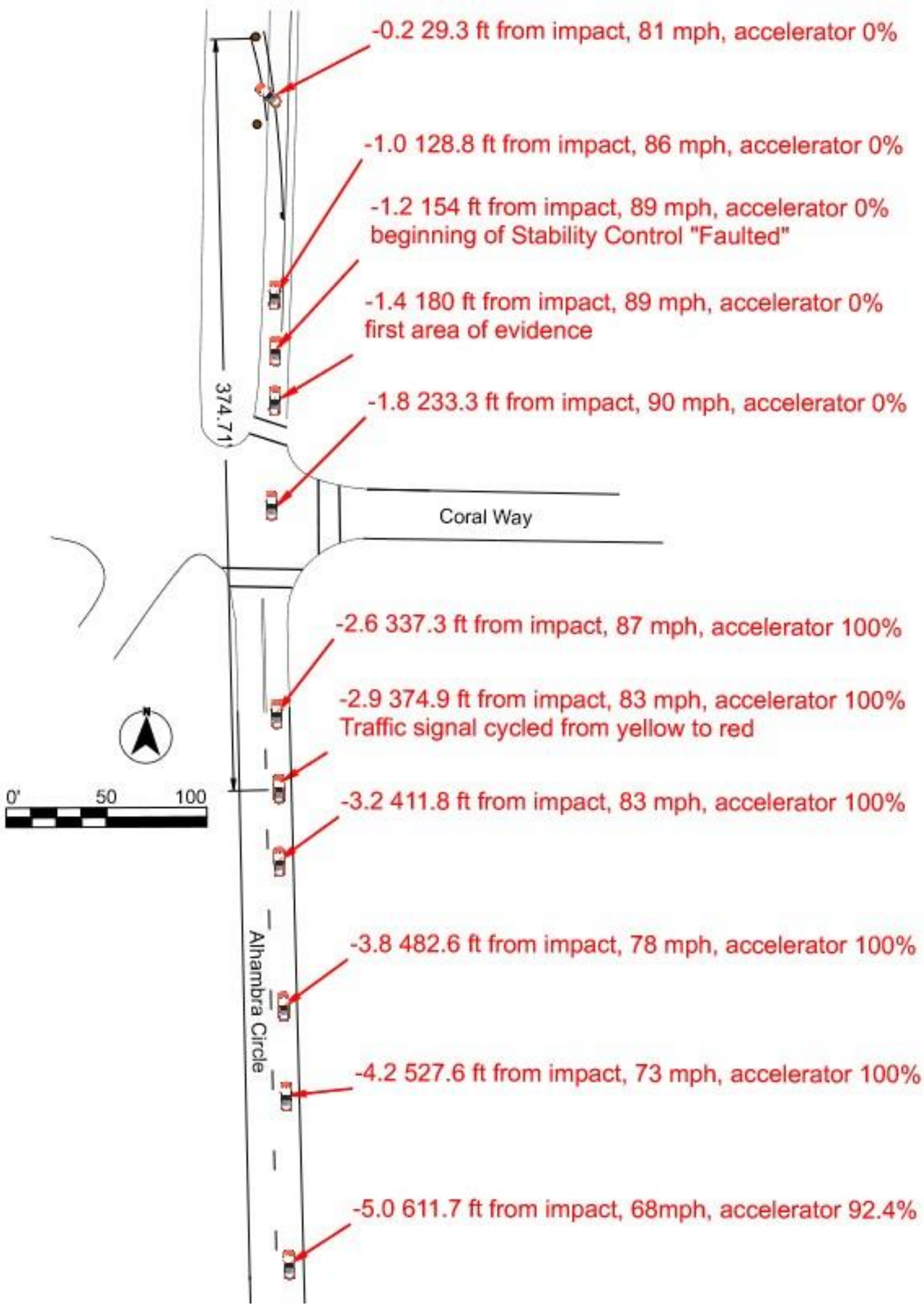

Figure 8. Approximate locations of car approaching area of impact, as interpolated from EDR data combined with roadway evidence. The light had already cycled to yellow prior to the first position plotted here. The service brake was off for the full duration.

After contact with the pavement, the car's suspension became unweighted, likely reducing lateral friction. The loss of friction in conjunction with the high speed caused the car to begin a counterclockwise yaw indicating loss of driver control. Although the EDR recorded changes in steering angle, it is unclear if these were the result of driver input or the car's motion itself. The car ultimately exited the roadway into the median, with its left front striking the first tree (tree bark was found embedded in the left front wheel of the vehicle) before it crashed into the second tree. EDR data showed a speed of 81 mph about 0.2 seconds prior to impact with the second tree; this was determined to be the most accurate speed at impact due to the lateral motion of the car.[17] The driver did not apply braking during the 5 seconds leading up to the crash.

The driver's decision to travel at an excessive speed was the primary causal factor in the loss of control and resulted in fatal injuries to the driver and passenger. An NTSB safety study, titled *Reducing Speeding-Related Crashes Involving Passenger Vehicles*, included several safety recommendations to multiple recipients such as NHTSA, the Federal Highway Administration, the US Department of Transportation, and the Governors Highway Safety Association (NTSB 2017). "Implement a Comprehensive Strategy to Eliminate Speeding-Related Crashes" is one of the focus areas of the NTSB's Most Wanted List of Transportation Safety Improvements.[18] One potential countermeasure relevant to this crash is intelligent speed adaptation systems.[19] These systems use an onboard GPS or road sign-detecting cameras to determine the speed limit and either warn drivers when they exceed it or prevent drivers from speeding by electronically limiting vehicle speed.

2.2 Postcrash Fire Response

The circumstances of this crash are similar to those of the three crashes investigated as part of the 2020 report *Safety Risks to Emergency Responders from Lithium-Ion Battery Fires in Electric Vehicles* (NTSB 2020). It is also notable that this crash was more severe and resulted in greater damage to the car and its high-voltage lithium-ion battery than the conditions under which electric vehicles are crash-tested to meet FMVSSs.[20] Furthermore, given the differences between vehicle makes and models and

[17] The car's tires would be scrubbing laterally and not rolling; as such, the car's speed would be underreported by the EDR at impact.

[18] See Implement a Comprehensive Strategy to Eliminate Speeding-Related Crashes, accessed October 19, 2022.

[19] Safety Recommendation H-17-24.

[20] See FMVSS 305, "Electric-Powered Vehicles: Electrolyte Spillage and Electrical Shock Protection," 49 *Code of Federal Regulations* 571.305, as well as FMVSS 208, "Occupant Crash Protection," 48 *Code of Federal Regulations* 571.208, accessed January 3, 2023.

the self-sustaining properties of lithium-ion battery fires, emergency responders require vehicle-specific information to safely extinguish these fires as well as to transport and store damaged lithium-ion battery-equipped vehicles. Vehicle manufacturers, including Tesla, provide emergency guidance documentation to mitigate the safety risks to first and second responders who encounter electric vehicle crashes and high-voltage lithium-ion battery fires. The NTSB has previously recommended that manufacturers of electric vehicles equipped with high-voltage lithium-ion batteries model their emergency response guides on current standards and industry practices, as well as provide vehicle-specific information on, among other topics, strategies to mitigate the risk of reignition (NTSB 2020).[21]

[21] Safety Recommendation H-20-32.

3. Conclusions

3.1 Probable Cause

The National Transportation Safety Board determines that the probable cause of the Coral Gables, Florida, crash was the driver's decision to travel at an excessive speed, which led to the failure of the driver to control his car.

3.2 Lessons Learned

Speeding is one of the most common factors associated with motor vehicle crashes in the United States. The NTSB has advocated for a comprehensive strategy that includes vehicle technologies, such as intelligent speed adaptation, to help reduce crashes caused by excessive speed. "Implement a Comprehensive Strategy to Eliminate Speeding-Related Crashes" is an issue area on the NTSB's current Most Wanted List of Transportation Safety Improvements.

Electric vehicle fires remain a challenge for emergency responders. Although the first responders to this crash extinguished the initial fire and managed reignition events safely, their response did not include consulting a vehicle-specific emergency response guide. The NTSB has recommended to manufacturers of electric vehicles equipped with high-voltage lithium-ion batteries that they provide their emergency response guides for how to extinguish electric vehicle fires in a standardized format, and also that they provide vehicle-specific information for safely extinguishing fires, mitigating reignition events, and transporting and storing damaged vehicles.

References

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NTSB investigators worked with the **Coral Gables Police Department** throughout this investigation.

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For more detailed background information on this report, visit the NTSB investigations website and search for NTSB accident ID HWY21FH011. 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–

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