NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF HIGHWAY SAFETY
WASHINGTON, D.C.

TECHNICAL RECONSTRUCTION and HIGWAY FACTORS GROUP CHAIRMAN'S FACTUAL REPORT

CORAL GABLES, FLORIDA – HWY21FH011

A. CRASH INFORMATION & CRASH SUMMARY

Refer to the *Crash Information and Crash Summary Report* in the docket for this investigation.

B. TECHNICAL RECONSTRUCTION/HIGHWAY GROUP

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C. DETAILS OF THE TECHNICAL RECONSTRUCTION/HIGHWAY INVESTIGATION

The Technical Reconstruction Group for this investigation was convened for the purpose of providing the on-scene documentation of the crash location and involved vehicle, and to assist in the analysis of the collision events and causation factors. In support of these tasks the group reviewed documentation provided by the City of Coral Gables Police Department (CGPD) and the City of Coral Gables. Data was obtained that included highway design plans, and traffic signal phasing and timing diagrams.

Factual reports prepared by other NTSB investigative groups should be consulted for information related to other aspects of the investigation, including information used within this report.

1. Basic Collision Scenario

The events began when a 2021 Tesla Model 3 had been traveling northbound on Alhambra Circle which was a residential road in Coral Gables, Florida. The Tesla passed another vehicle and accelerated to a high speed. The operator of the Tesla lost control of the vehicle after crossing the intersection with Coral Way. The Tesla traveled from the travel lane into the grass median where it collided with two trees.

NTSB investigators examined and documented the collision site and other roadway and environmental features on September 21st, 2021, eight days after the collision using ground photography and three-dimensional laser scanning. Site documentation data acquired by the CGPD investigators before the scene was cleared included ground-based photographs and evidence documentation with an electronic total station.[1]

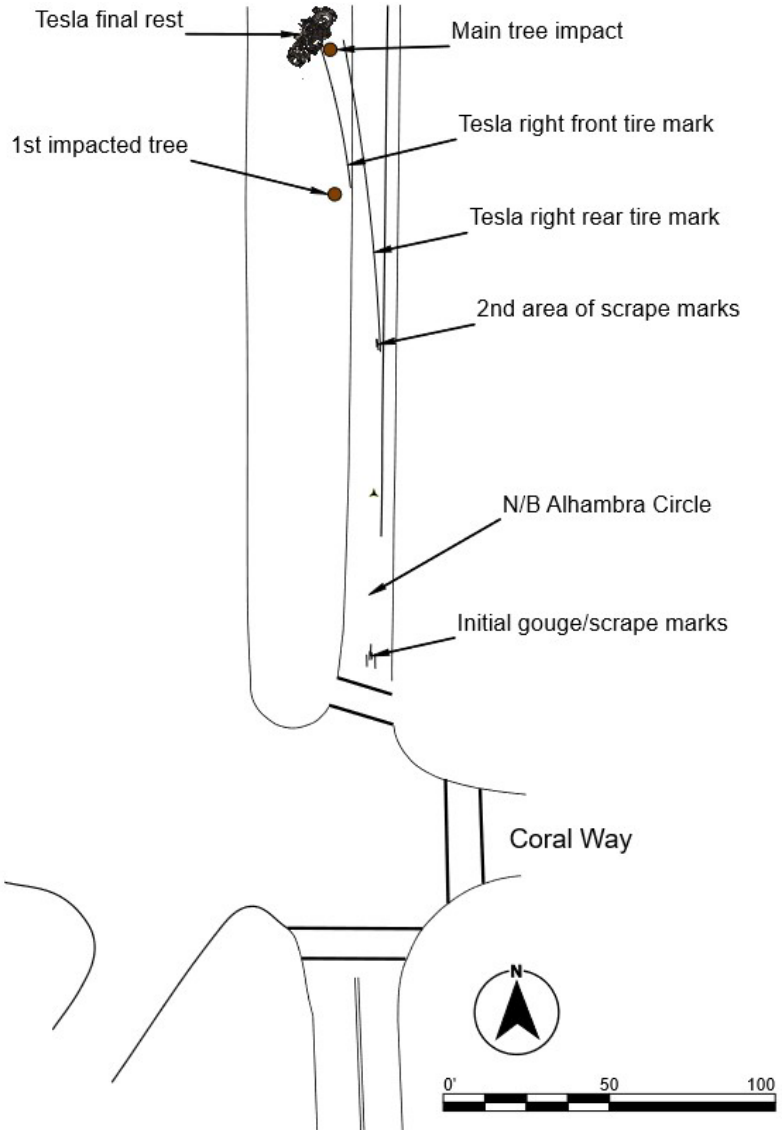


Figure 1: Diagram created from NTSB on scene scan data, and total station data received from Coral Gables Police Department.

[1] Total station technology combines both an electronic distance measuring (EDM) capability along with that of a theodolite. The theodolite is electronic, it senses azimuth and zenith angle readings and feeds them into an onboard computer. The EDM value of slope and distance is fed in the same computer module. The distance is converted automatically to horizontal by multiplying it by the sine of the zenith angle and converted to vertical difference of elevation by multiplying it by cosine of the zenith angle.

2. Prefatory Data

2.1 Crash Location

The collision occurred on Alhambra Circle, in Coral Gables, Miami Dade, Florida. **Figure 2** is a crash map that depicts the crash location which was located at the global position of 25° 44' 57" N and 80° 44' 6" W. **Figure 1** contains an inset map with a close-up aerial view of the location.

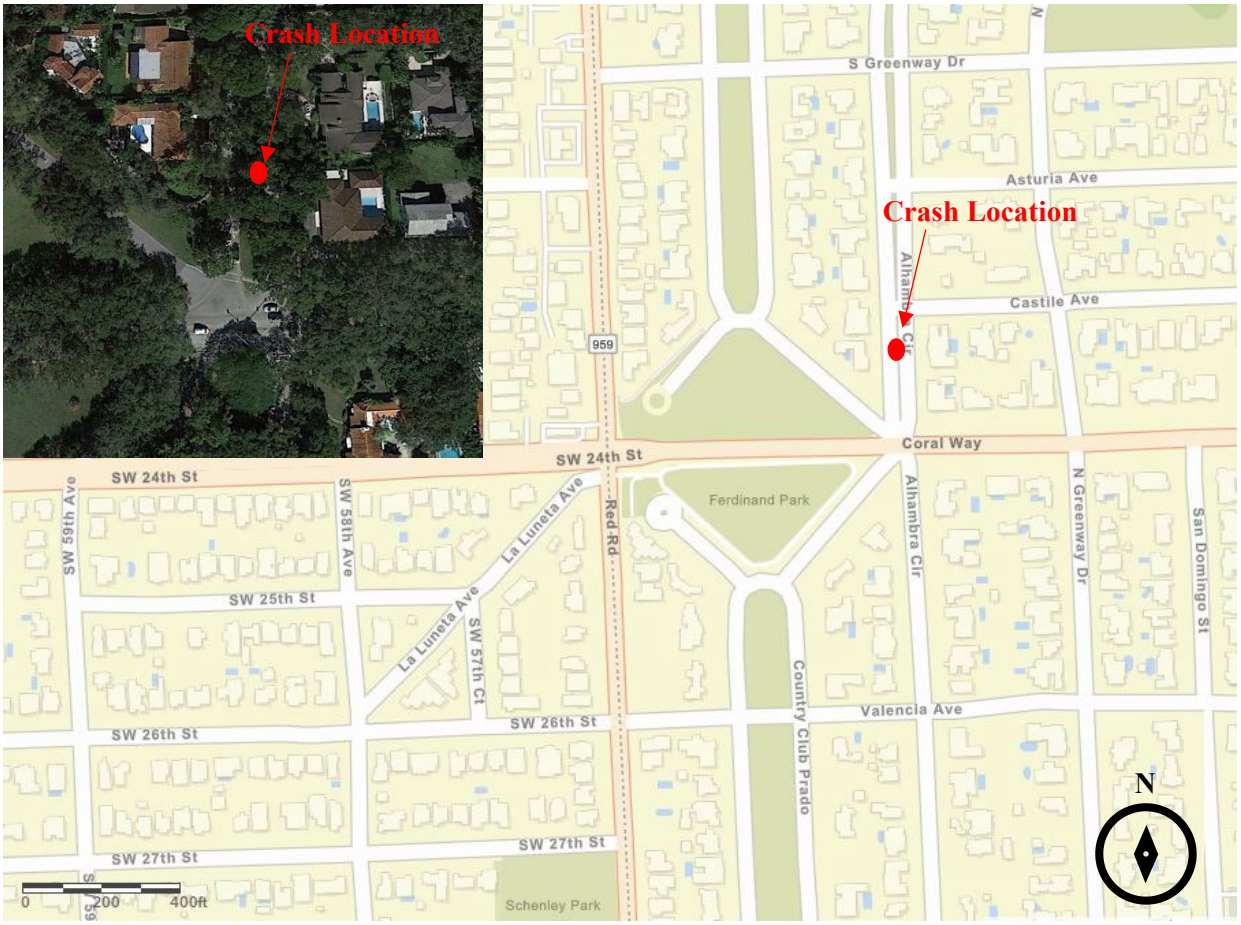


Figure 2: Crash map (Source: Miami Dade ArcGIS and Google Earth revised).

3. Roadway Data

3.1. Typical Section

The typical section for Alhambra Circle in the vicinity of the collision consisted of two travel lanes, one northbound lane, and one southbound lane. The lanes were divided by a grass median which measured approximately 30 feet in width. The median was aligned with oak trees. The main tree impacted was the fourth tree in line. Traveling north the first four trees were approximately

6.3, 7.0, 4.6, and 4.8 feet from the solid yellow line.[2] Each of the travel lanes was approximately 10 feet wide with an approximate 5 feet wide bike lane that was delineated from the travel lane by a solid white line. There was a solid yellow line adjacent the left edge of the northbound travel lane and solid white line along the right edge. The total width of the roadway was approximately 15 feet. There were no paved shoulders.

Alhambra Circle south of the Coral Way intersection was a two-lane undivided roadway with one lane northbound and one lane southbound. The roadway was constructed of asphalt.

3.2. Horizontal and Vertical Alignment

The horizontal alignment in the vicinity of the crash was on a straight section of Alhambra Circle. The straight section began approximately 1,936 feet or .36 miles prior to the area of the collision.

The vertical alignment for vehicles traveling on Alhambra Circle approaching Coral Way in the northbound direction consisted of a 1.2% upgrade slope.[3] Continuing northbound from the center of the intersection the vertical alignment transitioned to a 1.1% downward grade leading into the cross pan. The cross pan had a width of about 11 feet. The vertical alignment of Alhambra Circle after the cross pan consisted of a 1.2% upgrade slope. **Figure 3** is a profile diagram of the vertical alignment changes for northbound Alhambra Circle crossing Coral Way.

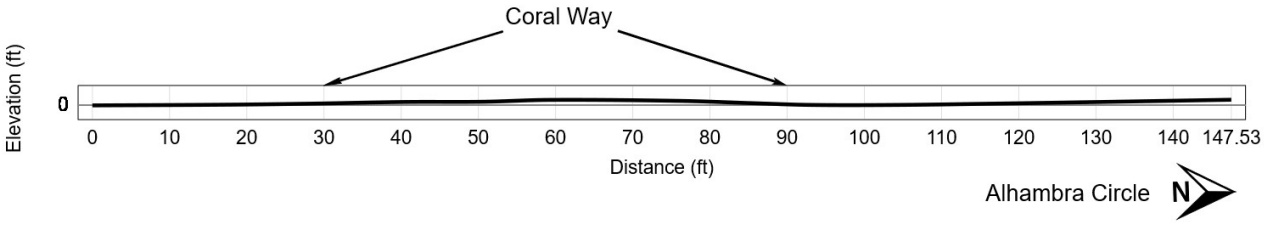


Figure 3: Diagram of Alhambra Circle elevation profile.

3.3. Speed Limit

The posted regulatory speed limit for Alhambra Circle in the vicinity of the crash was 30 miles per hour (mph). There was a posted speed limit located approximately 1,212 feet north of Coral Way on Alhambra Circle. The next posted speed limit sign, traveling northbound, was located about 75 feet north of Coral Way.

3.4. Roadway Markings

The roadway marking delineating the right edge consisted of a permanent 4-inch-wide solid white line. The roadway marking delineating the left edge consisted of a permanent 4-inch-wide

[2] The American Association of State Highway and Transportation Officials (AASHTO) Roadside Design Guide recommends a clear zone of 7 -10 feet, measured from the travel portion, on a roadway with a design speed of 40 mph.

[3] 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

solid yellow line. There was a 6-inch-wide solid white line that separated the bicycle lane from the travel lane. All the roadway markings were retroreflective.

3.5. Roadway Lighting

There was roadway lighting available along Alhambra Circle. The streetlamps were approximately 12 feet in height and alternated along both sides of the roadway. There was a streetlamp located at the southeast corner of the Alhambra Circle and Coral Way intersection. The next streetlamp was located approximately 111 feet north along the right side of the roadway. The streetlamp was 21 feet north of the final rest of the Tesla.

3.6. Traffic Control

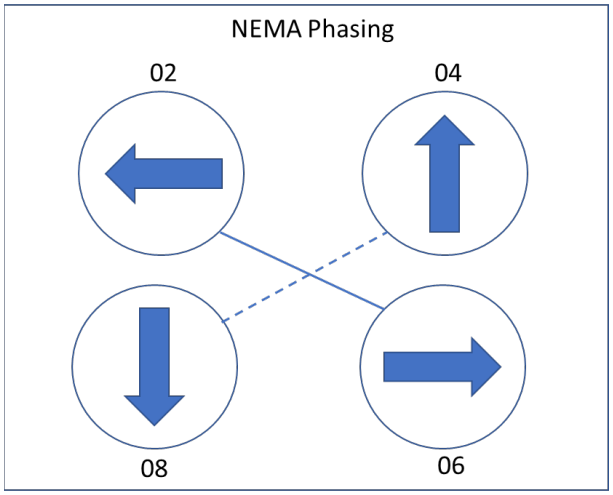
The intersection was reported to operate under NEMA[4] four-phase full traffic actuated mode where Coral Way approaches run concurrently, and Alhambra Circle run concurrently.

The signal heads are mounted on signal mast arms with support poles located in the northeast, southwest, and southern median. Each approach direction was faced with two signal heads. All signal heads display 8-inch red, yellow, and green circular lamps. **Figure 4** is a photograph depicting the traffic signals and supports.

Figure 4: Photograph depicting traffic signals and signal supports looking northbound on Alhambra Circle. (Source: NTSB)

[4] NEMA – National Electrical manufacturers Association

Figure 5 depicts the NEMA phasing diagram and describes the direction of each phase.



Phase	Direction
2	Westbound Coral Way
4	Northbound Alhambra Circle
6	Eastbound Coral Way
8	Southbound Alhambra Circle

Figure 5: NEMA phasing diagram and direction description

Loop detection is used for traffic detection in the proximity of the stop line on the north and southbound approaches for Alhambra Circle. The loop detectors were installed around the stop lines on Alhambra Circle. Traffic on Coral Way, phases 02 and 06 would remain green until an activation is received from the loop detectors. The signal controller is programmed to then proved a timed yellow and red cycle before activating the green signal for Alhambra Circle.

The City of Coral Gables also provided data on the signal timing and Table 1 provides a summary of the basic timing for the traffic signal affecting the direction traveled by the Tesla.

Table 1: Basic signal timing for the Tesla direction of travel.

Condition (Interval)	Northbound Alhambra Circle (Phase 4)
Minimum green	7 seconds
Vehicle extension	3.5 seconds
Maximum green	50 seconds
Yellow	4 seconds
Red clearance	2 seconds

3.7. Crash History

Coral Gables provided a 3-year crash history for the area of Coral Way and Alhambra Circle. The data concluded that there were 27 total crashes and of the 27 there were 3 injury crashes and one fatal crash. Table 2 provides a summary of the crash totals.

Table 2: Summary of the crash data for Coral Way and Alhambra Circle.

	2019	2020	2021
Fatal	0	0	1
Serious Injury	0	0	0
Total Injury	1	1	1
Total Crashes	7	10	10

4. Roadway Evidence Identification

Preceding the collision, the Tesla had been traveling northbound. The onset of evidence appeared in the northbound lane north of the intersection with Coral Way. The evidence began approximately 5 feet north of the northern most crosswalk line and consisted of five large gouge marks coupled with minor scuff marks which all paralleled each other. The area of the evidence was about 8 feet in length and 2.5 feet in width. The lengths of each gouge mark are summarized in Table 3.

Table 3: Summary of gouge mark data.

	Length “ft”	Distance from white line
A	3.67	7.61
B	2.70	6.73
C	3.68	6.43
D	2.18	6.13
E	4.52	5.06
F	2.59	5.90
G	3.52	5.64

Figure 6 is a photograph depicting the area gouge marks listed in the Table 3. The documentation of the gouge marks can be seen in the photograph and are marked by the yellow evidence marker (2).

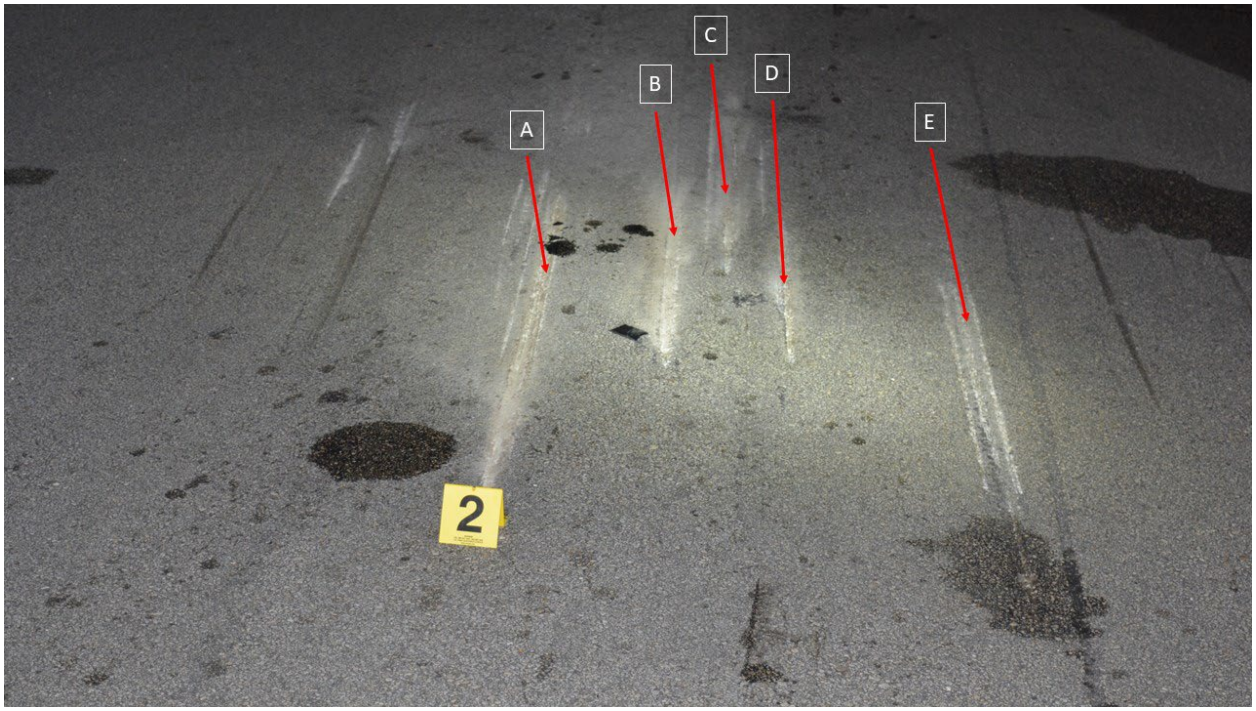


Figure 6: Image depicting the initial gouge mark evidence in the northbound Alhambra travel lane. (Source: Coral Gables Police Department)

Observed approximately 93 feet north of the initial onset of evidence were two additional scuff marks. The scuff marks paralleled each other and were approximately 0.26 feet apart. **Figure 7** is a photograph showing the two scuff marks the night of the collision. The documentation of the marks can be seen in the photograph and are marked by the yellow evidence marker (3).

There was a tire friction mark identified by CGPD investigators which began in the area of the two scuff marks. The tire friction mark was photographed and documented with a start point and end point utilizing the electronic total station. The friction mark was arcing in a northwesterly direction toward the median for approximately 80 feet where it transitioned onto the grass median. After entering the grass, the tire friction mark became a tire furrow. The tire furrow continued northwesterly for approximately 15 feet where it terminated.

Located approximately 48 feet to the northwest of the two scuff marks was a large tree which was located approximately 5.5 feet west of the roadway edge in the grassy median. There were two areas of bark missing from the east side of tree as well as from an exposed root. From the ground to the top of the missing bark measured about 1.5 feet.

Adjacent the tree, to the east, beginning at the edge of the roadway was a tire furrow. The furrow traveled northwesterly at an approximately 12° angle in relation to the roadway. The furrow paralleled the first tire furrow and continued for about 43 feet where it terminated.

In the area where the two tire furrows terminated was a second oak tree that was located approximately 5 feet from the edge of the roadway. This tree displayed evidence of impact damage.

On the south side of the tree was a large area of missing bark. The area extended from the ground up the main trunk of the tree and continued up a main branch.

Figure 7: photograph depicting the second area of evidence marks. (Source: Coral Gables Police Department)

The area of missing bark measured approximately 5.5 feet upwards from the ground. The tree showed signs of fire damage as well as the ground around the base of the tree.

5. Vehicle Documentation

The Technical Reconstruction Group photographed, and 3D laser-scanned the exterior of the vehicle involved in the collision. The involved vehicle had been secured at a local tow yard by CGPD investigators. A more detailed examination and documentation of the vehicle was undertaken by the NTSB Survival Factors and Vehicle Factors Group.

5.1. 2021 Tesla Model 3 Dual Motor

The only vehicle involved in the collision was a passenger vehicle identified as a 2021 Tesla Model 3 (Tesla). **Figure 8** depicts the three-dimensional scan of the vehicle.

Figure 8: Screen capture depicting the Tesla's top left side as viewed in the point cloud rendered from the three-dimensional scans through the FARO Scene software.

Overall, the vehicle exhibited catastrophic damage. Fire damage had consumed the interior, roof, and right and left sides. The right side of the vehicle had separated from the frame resulting in the rear of the vehicle partially separating. There was visible intrusion on the right side of the vehicle that began around the right "A" pillar extending rearward to about the midline of the vehicle. The front passenger seat was crushed and had been pushed rearward into the rear seating area. The floor pan was torn open exposing the vehicles high voltage lithium-ion battery case. The left front wheel assembly had been torn from the vehicle. According to measurements obtained from the scene by CGPD investigators the left wheel assembly was located approximately 107 feet northwest of the first tree impact. The wheel was cracked with the rim broken and pushed upward toward the center of the wheel. The tire sidewall exhibited a tear in the rubber that lined up with the break in the wheel rim.

Scene photographs depict that at final rest, approximately 187 feet north of the first area of evidence, the Tesla was oriented northeast in the grass median. The Tesla was on the north side of the second impacted tree.

Table 4 provides certain dimensional data for the vehicle.[5]

[5] Reference 4N6XPRT Systems Expert AutoStats v6.1.1

Table 4: Dimensional Data for an exemplar 2021 Tesla Model 3

	Inches	Feet	
Overall length	185	15.42	
Wheelbase	113	9.42	
Front overhang	33	2.75	
Rear overhang	39	3.25	
Overall width	73	6.08	
Maximum height	57	4.75	
Curb weight			3,549 lbs.

6. Electronic Event Data

The 2021 Tesla Model 3 had an airbag control module (ACM) mounted under the center console. The ACM monitored three-dimensional acceleration, roll rate, and commanded the actuation and/or deployment of the supplemental restraint systems (SRS). Located within the ACM was an Event Data Recorder (EDR). The EDR records certain parameters in relation to an SRS activation.

The Tesla was equipped with a pyrotechnically deployed SRS that included frontal airbags, seat airbags, curtain airbags, knee bolster airbags, and seatbelt pretensioners. In the event of a deployment command, or non-deployment command, where the command algorithm has enabled, certain data can be recorded. The recording of certain "event" data defines the capability of the ACM as an EDR. The EDR functionality is compatible with the requirements of *49 Code of Federal Regulations* Part 563.[6]

Pre-deployment or pre-crash data is reported at discrete intervals extending back from when the algorithm was enabled. Pre-crash data includes certain vehicle performance parameters. The parameters can include SRS deployment timing, longitudinal change in velocity (Δv) and lateral acceleration as related to time zero. The end of an event is typically the moment at which the cumulative Δv within a 20ms period does not change by more than 0.5 mph or the moment at which the crash detection algorithm of the ACM resets. Some events may lead to the recording of different duration data as provided by 49 *CFR* Part 563.

NTSB investigators were able to locate and recover the ACM from the vehicle. Due to the extensive thermal damage the ACM was photographed and shipped to NTSB Office of Research and Engineering for the imaging. Investigators were able to identify the chip which contained the recorded data. The chip was harvested, repaired, and implanted into an exemplary ACM. The data

[6] According to Title 49 *Code of Federal Regulation*, Part 563 event data recorder (EDR) means a device or function in a vehicle that records the vehicle's dynamic time-series data during the time 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. For the purposes of this definition, the event data do not include audio and video data. This part relates to vehicles manufactured on or after September 1st, 2012.

on the EDR was interpreted by the Tesla EDR Retrieval Program software.[7] Information regarding the chip repair and replacement are addressed in the *NTSB Recorders Report* prepared by the Office of Research and Engineering.

6.1. Tesla Model 3

The ACM was imaged direct to module[8] by NTSB investigators. The data reported one event with multiple supplemental systems deployed. Review of the data determined that the single event recorded was associated with the impact with the second tree..

The pre-crash data reported certain vehicle parameters for up to five seconds before time zero (algorithm enable) at 0.2ms intervals. While the data is reported in discrete 0.2ms intervals, it can be received and processed by the ACM asynchronously.

The single reported event occurred on ignition cycle 161 and the ignition cycle run time was 30.1 minutes. The reported seatbelt status for the driver and passenger was "belted". The report showed deployment was commanded at a time of 17ms, of the first row left retractor pretensioner, left outboard lap pretensioner, first row right seat side airbag, right curtain airbag, first row right retractor pretensioner, right outboard lap pretensioner. At 24ms deployment of the driver and passenger 1st stage frontal airbag, and the driver and passenger knee airbag were commanded. The driver and passenger 2nd stage frontal airbag were commanded to deploy at 29ms and at 30ms the left curtain airbag was deployed. The longitudinal crash pulse recorded in 10ms intervals for 250ms. The peak change in longitudinal velocity was reported as 77 km/h (48 mph) at 240ms. The peak change in lateral velocity was reported as 74 km/h (46 mph) at 140ms.

The Tesla had accelerated from 68 mph to a top speed of 90 mph. The Tesla then decelerated to 52 mph at time zero.[9] The accelerator pedal percentage fluctuated from a low of 0.0% to a high of 100%. The service brake was reported as "off" for the five seconds, the stability control reported as "Not Engaged" at the 5 second data point until the 1.4 second data point. From the 1.2 second data point to time zero the stability control reported as "Faulted". The EDR also recorded steering wheel angle. The steering wheel was reported as either a negative or positive value. A positive value indicated right-hand steering while a negative value indicated left-hand steering. The values reported ranged from -5° to 3° with a peak steering value of 118° reported at 0.4 seconds.

Table 5 provides a summary of select pre-crash data as reported by the EDR.

[7] Software version 20.20.1 was utilized to image the data. The information was then uploaded to Tesla who interpreted the data and returned a report.
[8] Direct to module is an imaging process in which the Tesla EDR Retrieval software is connected directly to the module connection.
[9] Time zero – is the point where the ACM algorithm was activated in any sensing direction.

Table 5: Summary of select pre-crash data from EDR report.

Time	5.0	4.6	4.0	3.6	3.0	2.6	2.0	1.6	1.0	0.6	0.0
Speed MPH	68	72	77	80	84	87	89	90	86	87	52
Accelerator Percent	92.4	93.2	100.0				31.2	0.0			87.2
Service Brake	Off										
Stability Control	Not Engaged								Faulted		
ABS Activity	Off										
Steering Angle	0					-2	2	3	-5	70	28

Figure 9 below shows the reported steering wheel angle in relation to the pre-crash time series data.

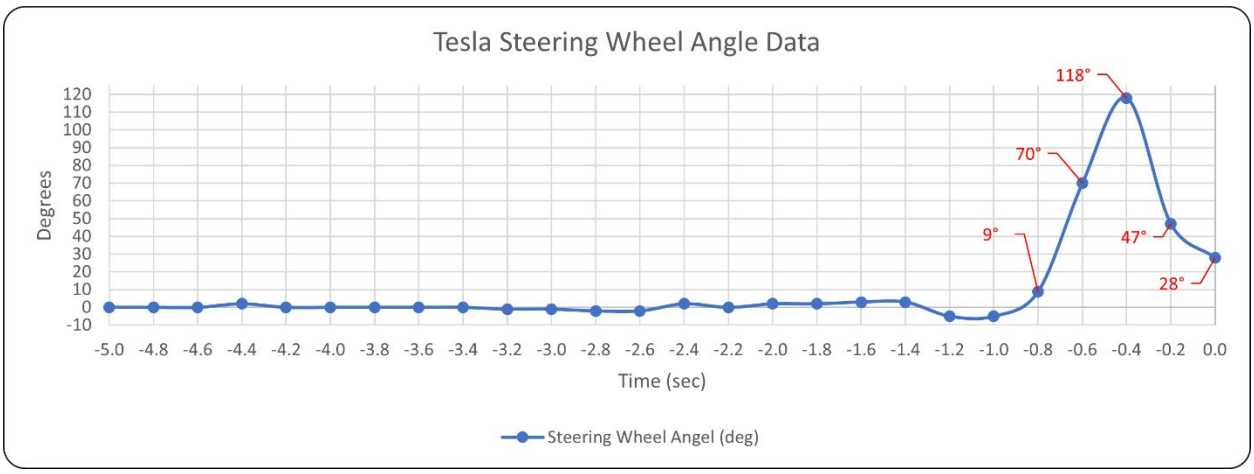


Figure 9: Graph depicting the reported steering wheel angle data.

D. REFERENCES

[1] NTSB Video Study

E. DOCKET MATERIAL

The following attachments are included in the docket for this investigation:

LIST OF ATTACHMENTS

Reconstruction Group Attachment – Vehicle Specification Tesla Model 3

Reconstruction Group Attachment – 2021 Tesla EDR Report

Highway Factors Group Attachment – As built plans for Alhambra Circle in Coral Gables, FL

Highway Factors Group Attachment – Intersection phasing information for Alhambra Circle and Coral Way.

Highway Factors Group Attachment – Alhambra Circle and Coral Way Detail Elevations

Highway Factors Group Attachment – Crash History Alhambra Circle and Coral Way

END OF REPORT

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Highway Accident Investigator