Technical Reconstruction Group Factual Report

Avenal, CA

HWY21FH003
(19 Pages)

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

TECHNICAL RECONSTRUCTION GROUP CHAIRMAN'S FACTUAL REPORT

A. CRASH INFORMATION

Location:	State Route 33 (South Lost Hills Road), 2 miles south of Sutter Avenue, Avenal, CA
Vehicle #1:	2013 Dodge Journey SUV
Operator:	28-year-old male (fatally injured)
Vehicle #2:	2007 Ford F-150 pickup truck
Operator:	34-year-old female (fatally injured)
Occupants:	7 occupants ranging in ages 6 to 15 (fatally injured)
Date:	January 1, 2021 (Friday)
Time:	Approximately 8:00 p.m. (Pacific standard time)
NTSB #:	**HWY21FH003**

B. TECHNICAL RECONSTRUCTION GROUP

Eric Gregson – Highway Crash Investigator
NTSB Office of Highway Safety
490 L'Enfant Plaza East, S.W., Washington, DC 20594

C. CRASH SUMMARY

For a summary of the crash, refer to the *Crash Summary* in the docket for this investigation.

D. DETAILS OF THE TECHNICAL RECONSTRUCTION INVESTIGATION

The Technical Reconstruction Group for this investigation was convened for the purpose of providing an analysis of collision events and causation factors. In support of these tasks the group reviewed documentation provided by the California Highway Patrol (CHP).

1. Introduction

The collision events involved a total of two (2) vehicles – a Dodge and a Ford. The event was a head on collision within the northbound lane of State Route 33 (South Lost Hills Road).[1] At final rest, the vehicles were approximately 27 feet apart. The location of the crash was identified by the Global Positioning Satellite (GPS) coordinates 36° 01' 47" N by 120° 10' 27" W.[2] This position was located less than 45 feet north of mile post marker FRE 1.00.

Figure 1: Google map image of SR-33 and the crash scene. Location of the crash is indicated by red pin

NTSB investigators examined documented evidence that was received from CHP. Site documentation data acquired by CHP investigators before the scene was cleared included photographs and scene scanning with a Leica P30 scan station. Three-dimensional laser scanning was conducted of the scene and both vehicles after the collision scene was cleared by CHP investigators.

The collision events occurred along a straight section of highway that had no discernable changes in elevation. **Figure 2** depicts the approximate location of area of interest overlaid atop Google Earth imagery.

The events were initiated after the southbound Dodge right-side tires departed the right roadway edge onto loose gravel. Following a left steering input, the right-side tires returned to the roadway while the vehicle yawed in a counterclockwise rotation. The Dodge traveled across the southbound travel lane in a southeast direction, towards the centerline. As it crossed over the center line the Dodge collided in an offset head-on orientation with a northbound traveling Ford. The Ford over-rode the front of the Dodge causing it to rotate counterclockwise. The Dodge came to

[1] State Route 33 (SR-33) is a north-south highway but at the crash location has a northwesterly – southwesterly orientation.
[2] Approximate position where the collision occurred based on coordinates by CHP.

final rest in the southbound travel lane facing in a northeasterly direction. The Ford came to final rest adjacent the northbound side of the roadway facing in a northwesterly direction.

1.1. Collision Location and Basic Highway Description

Figure 2: Imagery depicting the section of State Route 33 on which the collision events occurred.

The collision events occurred along a straight segment of roadway just north of FRE 33 MM 1.00[3]. Following the events, the involved vehicles were in an area around MM 1.00 with the Ford approximately 35 feet north of the mile post marker. Through the area of the collision the roadway had a posted speed limit of 55 miles per hour.

SR-33 was an asphalt paved, two-lane roadway with one lane in each direction. The Dodge was traveling southeast on SR-33 and the Ford was traveling northwest. The asphalt surfaced roadway had a cross section that measured approximately 28-feet-wide. The travel lanes were approximately 12-feet-wide with approximate two-foot-wide paved shoulders. The lanes were divided by a 6-inch-wide dashed yellow center line pavement stripe. The shoulders were delineated from the travel lanes by a 6-inch-wide solid white pavement stripe. There were no rumble strips milled into the edge of the roadway. Where the Dodge departed the roadway there was an approximate 1-inch drop off from the edge of asphalt to the earthen material. Along the north bound side there was an approximately 1.5-inch drop off from asphalt to earthen material. **Figure 3** is a cross section diagram of State Route 33 showing the lane measurements along with changes in elevation. The diagram was generated from the scan data provided by CHP.

[3] Mile post markers increased in the north direction.

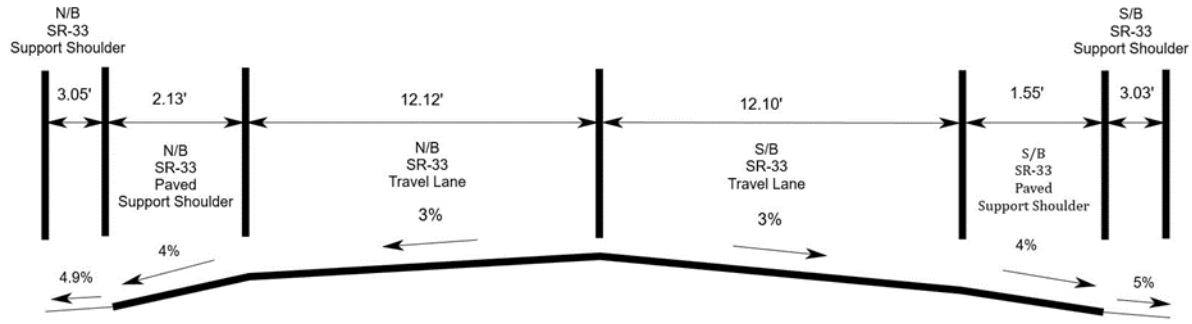


Figure 3: Cross-section of SR-33 depicting lane and shoulder widths of northbound and southbound travel lanes. Percent cross-slope is also depicted in the figure.

2. Roadway Evidence – Pre-Collision

Preceding the collision, the Dodge had been traveling southbound. A single tire mark in the earthen material adjacent the southbound edge of the roadway was discovered approximately 193 feet[4] north of the area of impact with the Ford. The mark was arcing in a southwesterly direction toward the southbound lane for approximately 81 feet where it transitioned onto the roadway. After entering the roadway, the mark continued in a leftward arc, crossing the southbound lane, leading to the area of impact in the northbound travel lane. Approximately 64 feet south of the first mark, a second tire mark appeared in the earthen material. The second mark arced to the left paralleling the first mark continuing to the area of impact. There were two additional tire friction marks discovered in the southbound lane. Both marks initiated at a vertex and separated as they continued toward the area of impact. Both marks arced to the left, the left mark continued for approximately 77 feet and the right mark for 54 feet. **Figure 4** is a photograph depicting the beginning of the first tire mark. The documentation of the tire mark can be seen in the photograph and is marked by the orange flags.

2.1. Area of Impact

To reference the location of the Dodge to the tire fiction marks, an initial position of the Dodge prior to impact was established[5]. The impact between the Dodge and the Ford was determined to be in the northbound lane. Just prior to this location the tire friction marks from the Dodge ended. **Figure 5** is a photograph depicting the area of impact. The southbound travel lane of SR-33 is the left lane in the photograph[6].

[4] Measurement was taken along the vehicle's path of travel to impact.
[5] The discernable conclusion of the tire friction marks was used to approximate the location of the Dodge across the centerline of the roadway. The location was approximately 182 feet south of the onset of the initial tire mark.
[6] The Dodge would have been traveling toward the reader in the photograph.

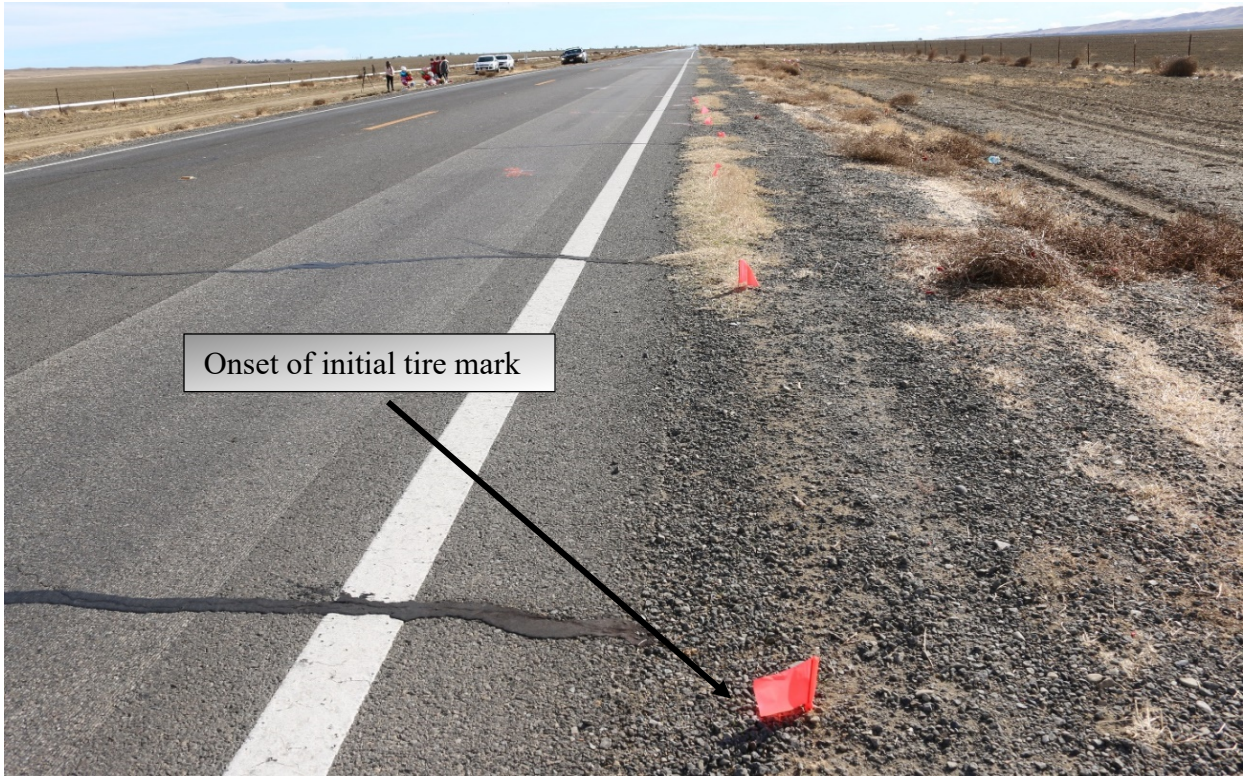


Figure 4: Southbound view of SR-33. Orange flags depict a tire mark deposited by the Dodge on the unimproved dirt/gravel. (Source: California Highway Patrol)

2.2. Post Impact Evidence

There was a circular fluid spray pattern that rotated counterclockwise a complete 360°. Located within the fluid pattern was multiple scrape marks (metal scars). Located in the "eye" of the fluid spray, offset approximately 2 feet, were two scrape marks that paralleled each other measuring approximately 8 feet in length[7]. The scrapes followed the same circular path as the fluid spray. There were also several other scrape marks located within the "eye" of the fluid that were consistent with the Dodge post impact travel. Additional scrape marks were located approximately 9 feet southeast of the area of impact, in the northbound travel lane. There were three marks that measured approximately 1 foot and were parallel to each other. **Figure 6** depicts the post impact marks deposited by both the Dodge as well as the area of impact in the northbound travel lane.

[7] Measurements were taken from the scene scan data that was provided by the CHP.

Figure 5: Northbound view of SR-33 depicting tire marks, fluid debris, scrapes, and gouges in the northbound lane. (Source: California Highway Patrol).

The Dodge came to rest nearest the area of impact. It had traveled approximately 14 feet to the northwest. It came to rest across the southbound travel lane facing in a northeasterly direction.

The Ford departed the roadway approximately 6 feet from the area of impact. At final rest the Ford was located off the roadway, adjacent the northbound lane, oriented northwesterly about 27 feet[8] northeast of the area of impact.

Identified in the northbound travel lane was another area of scrape/gouge marks. The marks were located approximately 12 feet southeast of the previously described marks and 7 feet from center lane line. Also located in the scrape marks was a small area of fluid spray.

As a result of the collision various components were displaced from the Dodge and Ford. The more substantial components included the left front wheel assembly and spare tire from the Ford. The left front wheel assembly was located to the northeast of the Ford final rest. The spare tire was located south of the final rest.

[8] As measured from the approximate center of the vehicle (CG)

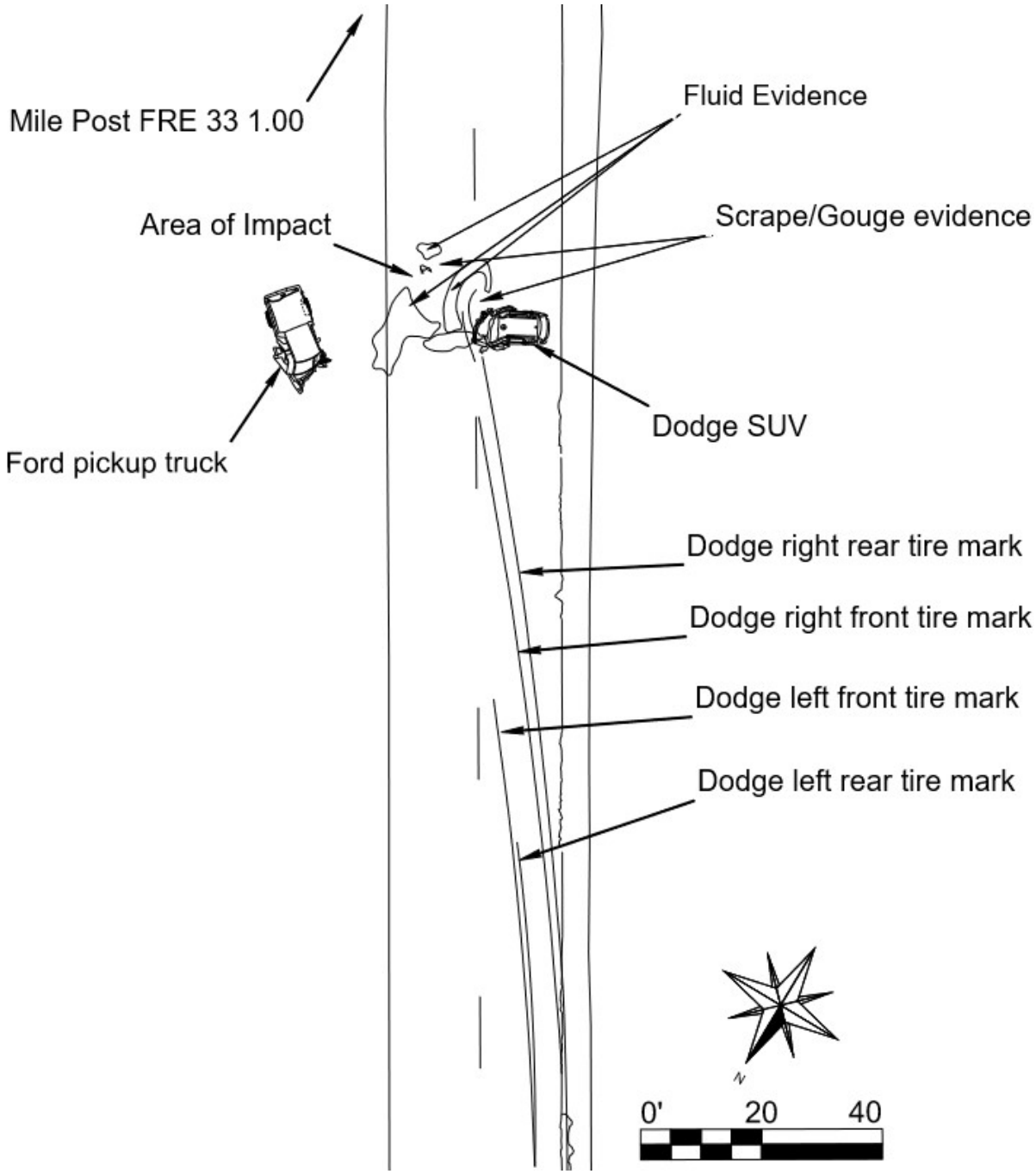


Figure 6: Diagram depicting post-collision positions of final rest for the Dodge SUV and Ford pickup truck. Also shown is the pre-collision and post-collision physical evidence marks.

3. Vehicle Documentation

3.1. Dodge Journey

The Dodge was scanned by the CHP. Scanning captured all exterior surfaces, while being stored at the local towing facility. **Figure 7** and **Figure 8** depict three-dimensional scans of the vehicle.

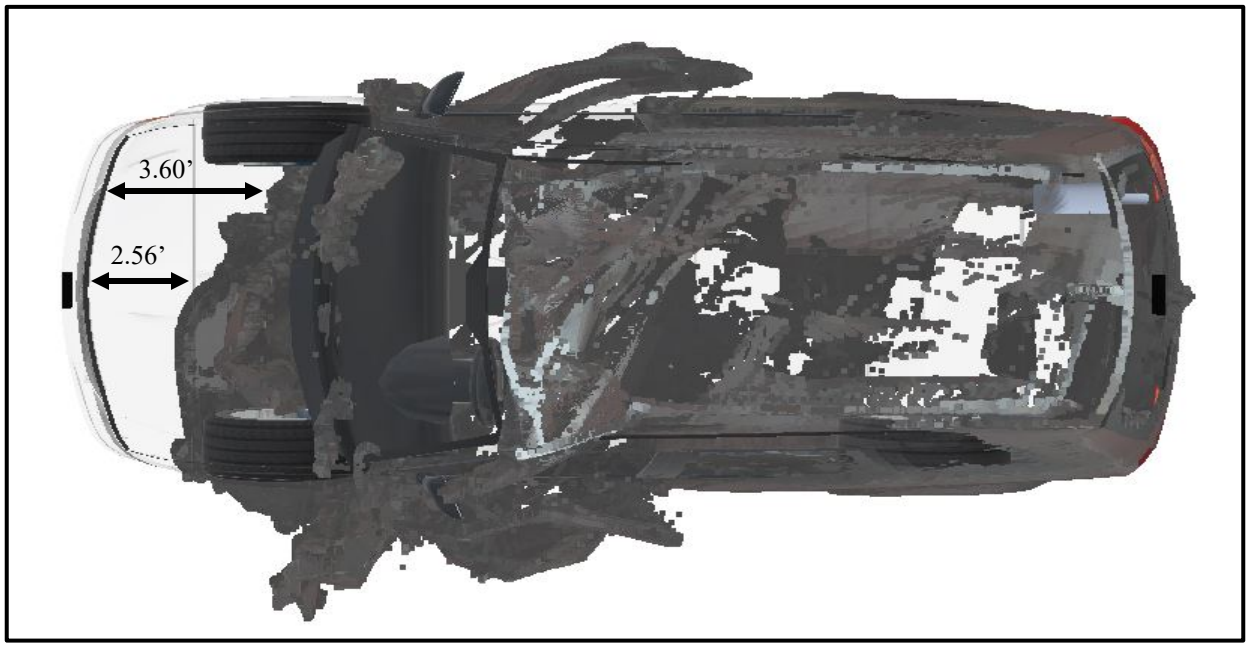


Figure 7: Overhead view of the 3D scan image of Dodge Journey overlaid on an exemplar vehicle. Measurements represent extent of crush damage and are for reference only. (Scan image source: California Highway Patrol).

At its position of final rest, the Dodge remained upright across the southbound travel lane. Overall, the vehicle exhibited impact evidence at the front which traveled up to the roof. The right-front (passenger side) had been pushed back to the front firewall. The right front tire was turned left with the top pushed inwards towards the engine compartment. The front bumper was pushed inwards and upwards along with other engine components. Both front roof support structures, and, "A" pillars, were bent down and inwards towards the passenger compartment. The front roofline was bent back and up. There was scraping to the paint on the right front fender, that had been pushed inwards against the firewall. Scrapes in the paint was also evidenced on both the "A" pillars as well as the roofline. The dashboard and steering column had been pushed downward and in towards the driver and front passenger seat. The back of the driver's seat had shifted to the right toward the passenger seat because of the collision forces. The top of the dashboard, steering wheel, and the driver's seatback had evidence of fire damage. There was also fire evidence along the front edge of the roofline. It was noted that oil and other fluids were on the ground underneath the engine. The tires mounted on the Dodge were Doral SDL 65A in size 215/55/R17. The original

equipped manufacturer (OEM) recommended tire size was 255/70/R17. **Table 1** shows dimensional data for the Dodge.

Figure 8: 3D scan image of the Dodge Journey depicting damage to front and right passenger side of the vehicle. An inset photo is included in the upper right-hand corner of the figure depicting an undamaged Dodge Journey. (Source: California Highway Patrol).

Table 1 provides certain dimensional data for the vehicle[9].

	Inches	Feet	
Overall length	192	16.00	
Wheelbase	114	9.50	
Front overhang	37	3.08	
Rear overhang	41	3.42	
Overall width	72	6.00	
Maximum height	67	5.58	
CG from front axle	50.16	4.18	
CG from rear axle	63.84	5.32	
CG from ground	26.73	2.23	
Curb weight			3801 lbs.

[9] Reference 4N6XPRT Systems Expert AutoStats v6.0.1

3.2. Ford F-150

The Ford was scanned by the CHP. Scanning captured all exterior surfaces, while being stored at the local towing facility. **Figure 9** and **Figure 10** depict three-dimensional scans of the vehicle.

Figure 9: 3D scan image of the Ford pickup truck depicting damage to left side of the vehicle. An inset photo is included in the lower left-hand corner of the figure depicting an undamaged Ford. (Source: California Highway Patrol).

At its position of final rest, the Ford was upright, off the northbound side of the roadway. Overall, the Ford exhibited impact damage to the front, left (drivers) side and undercarriage.

The Ford had been completely burned. The front facia parts of the Ford were torn from the frame. The front bumper was bent back towards the engine and downwards. The was engine displaced rearward and downward. The engine displacement caused the passenger compartment floor pan to deform upwards. The left front tire and wheel had been torn from the Ford and the left fender was torn back towards the firewall. The right fender was intact, however had been pushed outward from the Ford. The right front wheel was turned left with the bottom bent upwards under the undercarriage. The left side of the firewall and support for the "A" pillar had been pushed backwards towards the "B" pillar. The left side rocker panel was buckled and pushed upwards. The Ford bed was displaced from the frame and the distance between wheel well and tire was increased. It had sustained severe overall fire damage because of the collision.

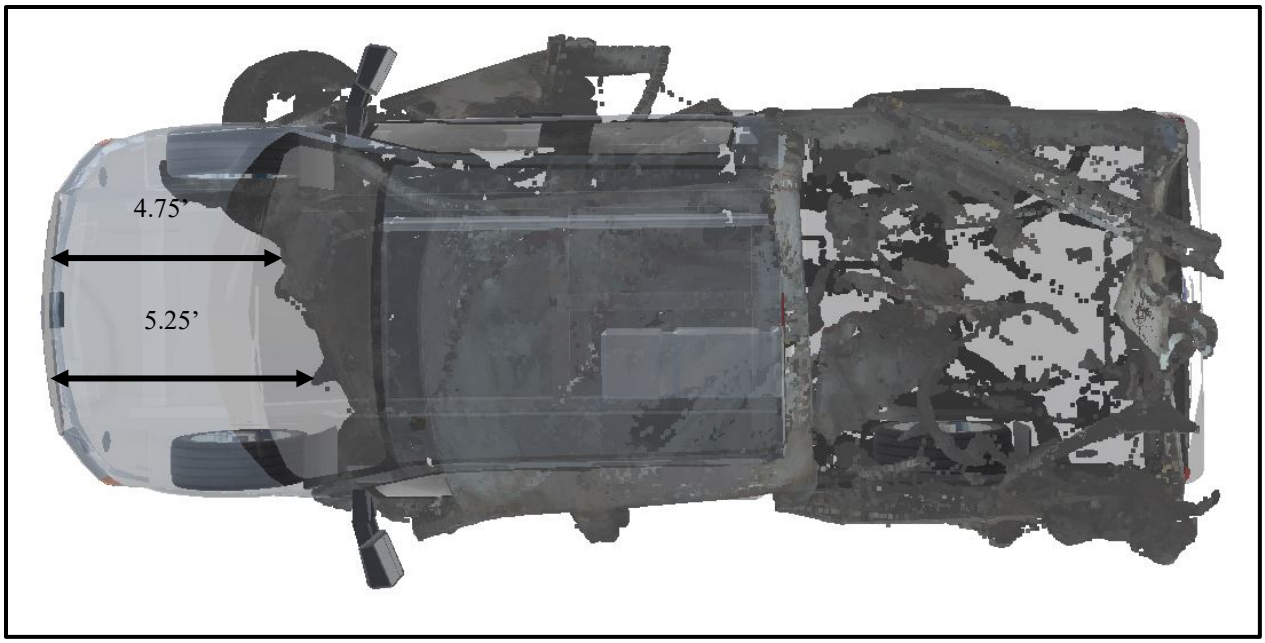


Figure 10: Overhead view of the 3D scan image of Ford pickup truck overlaid on an exemplar vehicle. Measurements represent extent of crush damage and are for reference only. (Scan image source: California Highway Patrol).

It was noted that the tires mounted on the Ford were Gladiator Xcomp A/T in size 33/12.50/20LT and all four tires matched. The original equipment manufacturer (OEM) recommended tire size was P255/70/R17. Table 2 displays the data for the Ford.

Table 2 shows dimension data for the Ford.

	Inches	Feet	
Overall length	224	18.67	
Wheelbase	139	11.58	
Front overhang	36	3.00	
Rear overhang	49	4.08	
Overall width	79	6.58	
Maximum height	75	6.25	
CG from front axle	61.16	5.10	
CG from rear axle	77.84	6.49	
CG from ground	28.84	2.40	
Curb weight			5554 lbs.

4. Roadway friction testing

On March 16th, 2021, testing was conducted near the collision site to identify potential sliding friction value (also referred to as drag factor) between a passenger vehicle tire and the road surface. Testing was conducted by equipping a 2016 Dodge Charger two-wheel drive passenger car with a Vericom Data Logger. The testing was conducted with the antilock brake system enabled. The antilock brake system was then disabled, and testing was again conducted. A total of six tests, three with antilock braking and three without antilock braking were conducted.

The data was analyzed with the Vericom software package, which allowed the braking and skidding portion of the test to be isolated and graphically depicted. **Table 5** summarizes the average drag factors acquired from each test. Screen captures of the data graphs and tables as presented by the software for the tests can be found in Appendix A.

Test	Initial Test Speed	Average Deceleration from Test	Average Deceleration of Group
Test 1: Antilock Brakes - enabled	40.8 mph	.878g	.88g
Test 2: Antilock Brakes - enabled	41 mph	.878g	
Test 3: Antilock Brakes - enabled	40.6 mph	.892g	
Test 4: Antilock Brakes - disabled	41.6 mph	.709g	.71g
Test 5: Antilock Brakes - disabled	40.2 mph	.711g	
Test 6: Antilock Brakes - disabled	40.5 mph	.716 g	

Table 5

5. Event Data Recorders

Both vehicles were equipped with pyrotechnically deployed supplemental occupant restraints that included frontal airbags and seat belt pretensioners. In the event of a deployment command, or non-deployment command where the command algorithm has enabled[10], certain data can be recorded. The recording data defines the capability of the airbag control module (ACM) as an EDR. The EDR functionality of the Dodge ACM is compatible with the requirements of Title 49 Code of Federal Regulations Part 563[11].

Access to the Ford EDR was through the Powertrain Control Module[12] (PCM). The PCM was in the engine compartment on the passenger cowl. During normal operation of the vehicle, the PCM records data from certain electronic control modules. The recording begins when the ignition is turned "on" and continues until it is switched "off", or the vehicle suffers power failure. The data is recorded in the PCM in a circular buffer, sequentially until the buffer is full, at which time the information is then overwritten, and the process repeats itself.

[10] Algorithm Enable or (AE) represents the point in time where the vehicle has begun to undergo an acceleration rate sufficient for the airbag system to begin monitoring the rate of acceleration over time, to determine if the deployment of the vehicle's supplemental safety systems is warranted. Due to this, AE will happen after the collision but before the supplemental system deploys.

[11] According to Title 49 *Code of Federal Regulations,* 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.

[12] Powertrain Control Module or (PCM) is a computer that controls most engine and drivetrain functions. It is generally a combined controller consisting of the engine control unit and the transmission control unit.

Figure 11: Image of engine compartment of Ford pickup truck. There is a zoomed window focusing on the PCM of the Ford. (Source: California Highway Patrol).

The PCM differs from the ACM. The ACM can store non-deployment level events, however the PCM will not record until a sufficient severity is reached to deploy restraint control devices. When a deployment level event does occur, the ACM sends a Restraint Deployment Signal[13] to the PCM. After the signal is received the PCM will then lock the data and store 20 seconds of pre-crash data and 5 seconds of post-crash data.

The PCM in the Ford was destroyed due to the fire caused by the collision damage. **Figure 11** shows the location of the PCM, the zoom window displays the damage extent of the PCM. Because of the extensive damage to the Ford PCM the data that the EDR would have recorded was not able to be imaged from the module.

[13] Restraint Deployment Signal or RDS is a signal sent by the Airbag Control Module to the PCM if the ACM commands a deployment of the airbags or seatbelt pretensioners. The PCM monitors the signal and records if the signal has been received from the ACM.

The EDR for the Dodge was in the ACM. For this vehicle the ACM was in the center tunnel. The module was removed from the vehicle by CHP. When the ACM was removed it was discovered that it had sustained significant damage as a result of the collision. The CHP investigators attempted an image of the ACM utilizing the Bosch Crash Data Retrieval tool version 21.0. During the imaging process an error message was received stating "Collect Data Failed!". The error message is often likely the result of lack of communication between the software and the module. In this case it is apparent that the lack of communication between the software and the module was due to the damage sustained from the collision event. **Figure 12** shows the damage to the Dodge ACM.

Figure 12: Image of damaged ACM that had been removed from the Dodge Journey. (Source: California Highway Patrol).

As a result of the damage to the Dodge ACM, Mecanica Scientific Services was engaged to conduct a chip swap[14]. The chip that needed to be swapped is an Electronically Erasable Programmable Read Only Memory (EEPROM)[15]. Mecanica obtained two surrogate modules for the procedure. According to their report[16] the first chip swap was unsuccessful. They were able to identify the correct EEPROM and successfully completed the chip swap. The ACM was then imaged utilizing the Bosch Crash Data Retrieval tool. As the data was imaged from the ACM it was simultaneously interpreted by the CDR software and output in a user readable format.

[14] Chip Swap is the process in which the chip inside the ACM which stores the EDR data is removed from the damaged ACM and is attached to an exemplar module. The exemplar module is then imaged. The data obtained from the EDR would be the data from the inoperable ACM.
[15] EEPROM is a type of non-volatile computer memory used for data storage. Memory is not lost when the power is disconnected.
[16] Additional information is contained in Mecanica Scientific Services report submitted by John Grindey, COO / Crash Reconstruction Expert. Full report can be found in the report attachments.

The data reported a total of 24,120 ignition cycles at the time of the imaging with no reported Diagnostic Trouble Codes (DTC). The complete file recorded status was "no". Mecanica provided NTSB investigators with the 29-page EDR report for evaluation.

The EDR reported that the ACM serial number was T02JF027328012. In reviewing the photographs provided by CHP it was determined that the serial number on the original ACM removed from the Dodge matched the reported serial number. It was also noted that the original Vehicle Identification Number (VIN)[17] matched the Dodge VIN. These two identified numbers confirm that the EEPROM chip was from the Dodge and the data thereafter is from the Dodge.

The Dodge ACM image reported the total number of events to be one, with multiple supplemental systems deployed that could be related to this collision. The report recorded both stages of the driver and passenger front airbags, driver and passenger knee airbags, and driver and passenger seatbelt buckle and retractor pretensioners. Also reported were the left and right-side seat airbags, and the left and right-side curtain airbags. The Operation System Time[18] reported 214,748,360.75 second which is 994.20 hours.

5.1. Pre-Collison data

The pre-collision, or pre-deployment data consists of a continuous loop of data elements captured at 100ms (0.1) second intervals extending back from the point where the airbag control algorithm was activated. The requirements for establishing an event differ depending on event type, deployment vs. non-deployment. An event record includes crash data related to activation of the supplemental restraint system and pre-deployment vehicle performance. The term "time zero" is the point where the ACM algorithm was enabled.

This ACM was designed to record a variety of data from the within the vehicle. During the review of the data if was determined that the module did not write the data to the EEPROM. In the report table where the data is displayed "interrupted", and "SNA" was reported in the data blocks. Within the Data Limitations section of the EDR report it states that "During an event, if power to the ACM is lost, all or part of the event data record may not be recorded. An event may be displayed in the Event(s) Recovered section of the report and Interrupted will be displayed for pre-collision recorder status." There was no pre-collision data recorded for the collision as there was a power interruption. Within the ACM there is a small battery reserve, however, the reserve is for the deployment of safety systems and not for the recording of data. The full 29-page report can be found in the attachments.

[17] Original VIN – is captured by the ACM and then recorded as the original VIN after 10 consecutive ignition cycles of capturing the same number. Once it has been recorded, the number cannot be changed. – Information from the Data Limitations section.

[18] Operation System Time – the cumulative lifetime timer for the ACM. It indicates the total amount of time the ACM has been powered up.

E. REPORT ATTACHMENTS

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

Reconstruction Group Attachment – Mecanica Scientific Services Report.

Reconstruction Group Attachment – 2013 Dodge Journey EDR Report.

Reconstruction Group Attachment – Vehicle Specifications Dodge Journey SUV

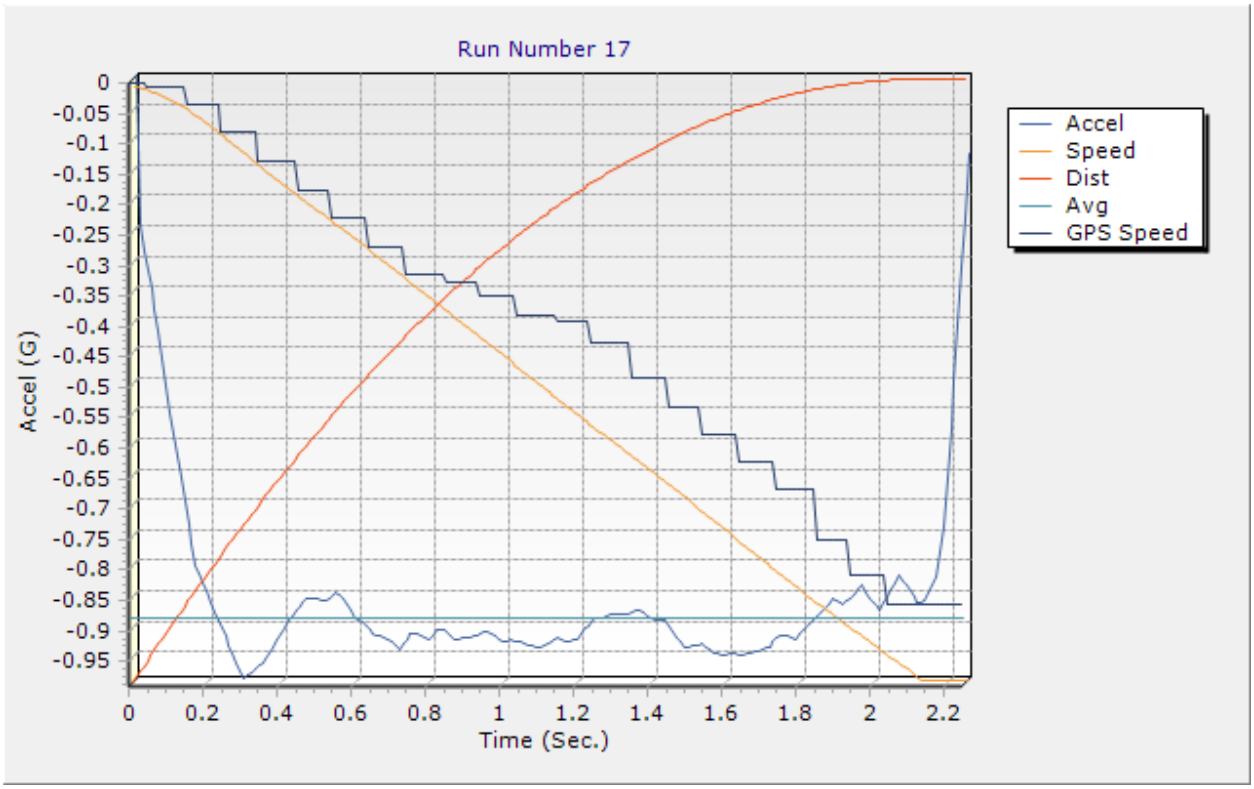
Reconstruction Group Attachment – Vehicle Specifications Ford F-15 Pickup Truck

END OF REPORT

Eric J. Gregson
Highway Accident Investigator (Technical Reconstructionist)

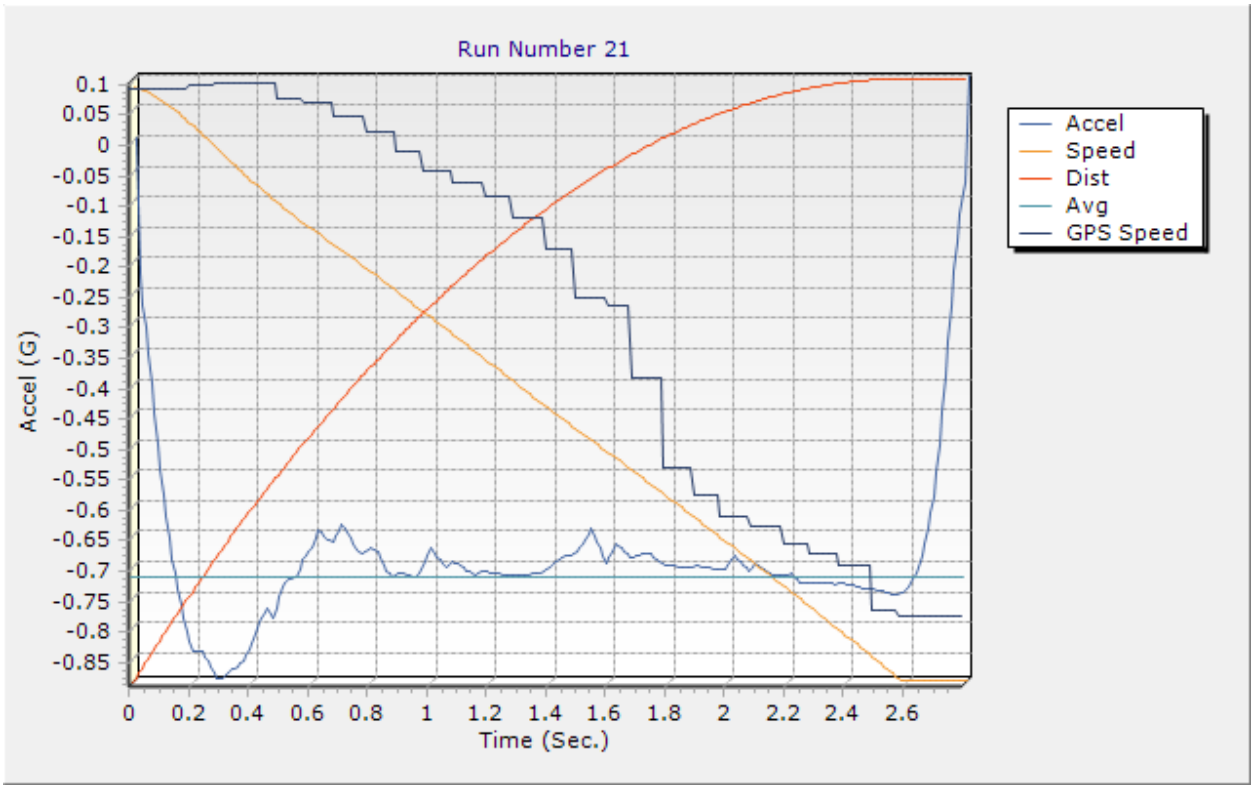
Appendix A – Site skid testing data graphs and tables

Test Series 1: Roadway ABS activated



Average Table ABS						
Vehicle	Run #	Time Secs	Accel G	Speed MPH	Dist ft.	GPS Speed MPH
548737	16	2.120	-0.878	40.84	64.992	42.67
548737	17	2.130	-0.878	41.03	65.757	41.70
548737	19	2.080	-0.892	40.68	64.050	41.07
Averages		**2.110**	**-0.883**	**40.85**	**64.933**	**41.81**

Test Series 2 – Non-ABS



Average Table Non-ABS						
Vehicle	Run #	Time Secs	Accel G	Speed MPH	Dist ft.	GPS Speed MPH
548737	20	2.680	-0.709	41.67	82.612	41.73
548737	21	2.580	-0.711	40.23	76.394	40.59
548737	22	2.580	-0.716	40.52	77.574	40.63
Averages		**2.613**	**-0.712**	**40.81**	**78.860**	**40.98**