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

TECHNICAL RECONSTRUCTION GROUP CHAIRMAN'S FACTUAL REPORT

A. CRASH INFORMATION

Location:	US Highway 83 (US-83) near milepost 553.4 in Uvalde County, 6.5 miles north of Concan, Texas
Vehicle 1:	2007 Dodge Ram quad-cab 3500 pickup truck
Operator 1:	Private owner
Vehicle 2:	2004 Ford E-350 cutaway chassis with a 13-passenger Turtle Top Vanterra medium-size bus body
Operator 2:	First Baptist Church of New Braunfels
Date:	Wednesday, March 29, 2017
Time:	Approximately 12:20 p.m. CDT
NTSB #:	**HWY17MH011**

B. TECHNICAL RECONSTRUCTION GROUP

Robert Squire - Accident Investigator, Group Chairman
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 Report* in the docket for this investigation.

D. DETAILS OF THE TECHNICAL RECONSTRUCTION GROUP INVESTIGATION

The Technical Reconstruction Group provided investigative support through documentation of the collision scene and the motor vehicles involved in the collision. Additional factual data was also coordinated through the review of documentation provided by other NTSB investigative groups.

Primary documentation involved photography and 3D laser scanning techniques. Photographs were taken in digital format, while scanning was accomplished using the FARO Focus^{3D} x330 laser scanner.[1] Multiple scans of a subject were then processed into three-dimensional point clouds for further analysis. Three scan projects that included the crash site, and the two involved vehicles were completed. Video documentation of the immediate approach to, and through the area of the crash was also conducted following the routes of both vehicles.

Factual reports prepared by other NTSB investigative groups should be consulted for additional information.

1. Collision Overview, Site Location and Documentation

The crash involved an offset frontal impact between a 2007 Dodge Ram 3500 pickup truck (Dodge) and a 13-passenger medium-size bus on a 2004 Ford E-350 chassis (Ford). The collision occurred when the Dodge, traveling northbound on US Highway 83 (US-83) entered the opposing travel lane and collided with the Ford that was traveling southbound. The collision occurred about six miles north of Concan, TX near highway milepost marker 553.4.

The NTSB Technical Reconstruction Group examined the collision site on April 5, 2017. The site and other relevant features were documented through photographs, video, geographic coordinate (GPS) acquisition and 3D scanning. As part of their on-scene investigation, Texas Department of Public Safety (TxDPS) investigators marked the location of certain roadway evidence and documented about 300 feet of the highway around the crash site using a total station. NTSB personnel subsequently scanned approximately 935 feet of the highway that included about 485 feet south, and 450 feet north of the collision location respectively.

US-83 through the area of the collision, is a two-lane, north-south highway with a single travel lane in each direction. Separation of the travel lanes was delineated by double-yellow line pavement striping. The site of the collision was located within a 1,432.7-foot radius curve that transitioned from a heading of 335°/135° (NNW/SSW) at the southern tangent to 32°/212° (NNE/SSW) at the northern tangent. At the collision site the highway exhibited a NNE/SSW heading of 22°/202°. The curve was approximately 1,445.4 feet in length.

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[1] The FARO Focus^{3D} is a high-speed terrestrial laser scanner used for 3D documentation. The scanner creates point cloud scans that are combined or linked from multiple positions to create a cohesive three-dimensional point cloud rendering of the subject target. The laser will only capture features within the direct line of sight to the scanner. Areas obstructed to the laser or where surfaces fail to provide a reflection will exhibit the background color. The point cloud data can be imported into a CAD application for additional analysis.

Figure 1 depicts a Google Earth image of US-83 through the area of the collision. The area of impact and geometric curve tangents are illustrated.

Figure 1: Google Earth image of US-83 depicting the collision site relative to the northern end of the curve. Imagery dated 11/2014.

The roadway speed limit was posted at 70 mph. Additional information regarding the highway is available in the NTSB Highway Factors Group factual report.

The onset of roadway evidence appeared approximately 287 feet south of the northern end of the curve (curve point of tangent) and was primarily confined to the southbound travel lane.[2] Excluding displaced debris, such as vehicle components, scene evidence consisted of road surface metal scars, tire friction marks and fluid debris stains that extended over a linear distance of about 13 feet, as measured from the first onset southward to the approximate midpoint of the vehicle positions of rest. The metal scars and tire friction marks exhibited a southwestward orientation that began near the center of the southbound lane and extended toward the right shoulder. Roadway evidence extended no further than approximately 6.2 feet into the southbound travel lane as measured from the edge line. The tire friction marks appeared further south from the onset of the metal scars and were related to the rotation of the Ford. Similarly, the metal scars were consistent with deformation of the Ford that resulted in the transmission case and surrounding structure to contact the pavement. All the roadway evidence was related to the post-impact movement of the vehicles. No pre-collision roadway evidence, created by either of the involved vehicles, was observed.

Other tire friction marks attributed to emergency braking undertaken by a witness traveling behind the Ford were observed north of the roadway evidence. That evidence consisted of two linear, parallel friction marks that ended approximately 17 feet north of the onset of the collision evidence. Those marks extended northward for a total distance of approximately 156 feet with some lateral displacement partially onto the right shoulder.

As depicted in TxDPS scene photographs, the two vehicles remained in contact at final rest. While the vehicles were oriented head-on at final rest, they were offset to one another by about 25°. At final rest, the Ford and Dodge exhibited headings toward the south-southeast and northwest respectively.

During post-impact movement the Ford exhibited a counter-clockwise rotation that terminated at a 39° angle relative to its initial lane of travel (southbound). At its position of final rest, the Ford occupied the entire southbound shoulder with the vehicle front occupying about half of the travel lane and its left rear corner resting atop the guardrail. The Dodge likewise exhibited a counter-clockwise rotation that ended at a 64° angle relative to its initial lane of travel (northbound). At final rest, the Dodge occupied the entire southbound lane and approximately half of the northbound lane.

Figure 2 is a two-dimensional scaled diagram depicting the post-collision positions of rest for the vehicles and roadway evidence. Vehicle placement was based on vehicle dimensions, 3D scan data, and TxDPS total station data.

[2] The location of the collision relative to the beginning/end of the curve was determined by highway stationing data.

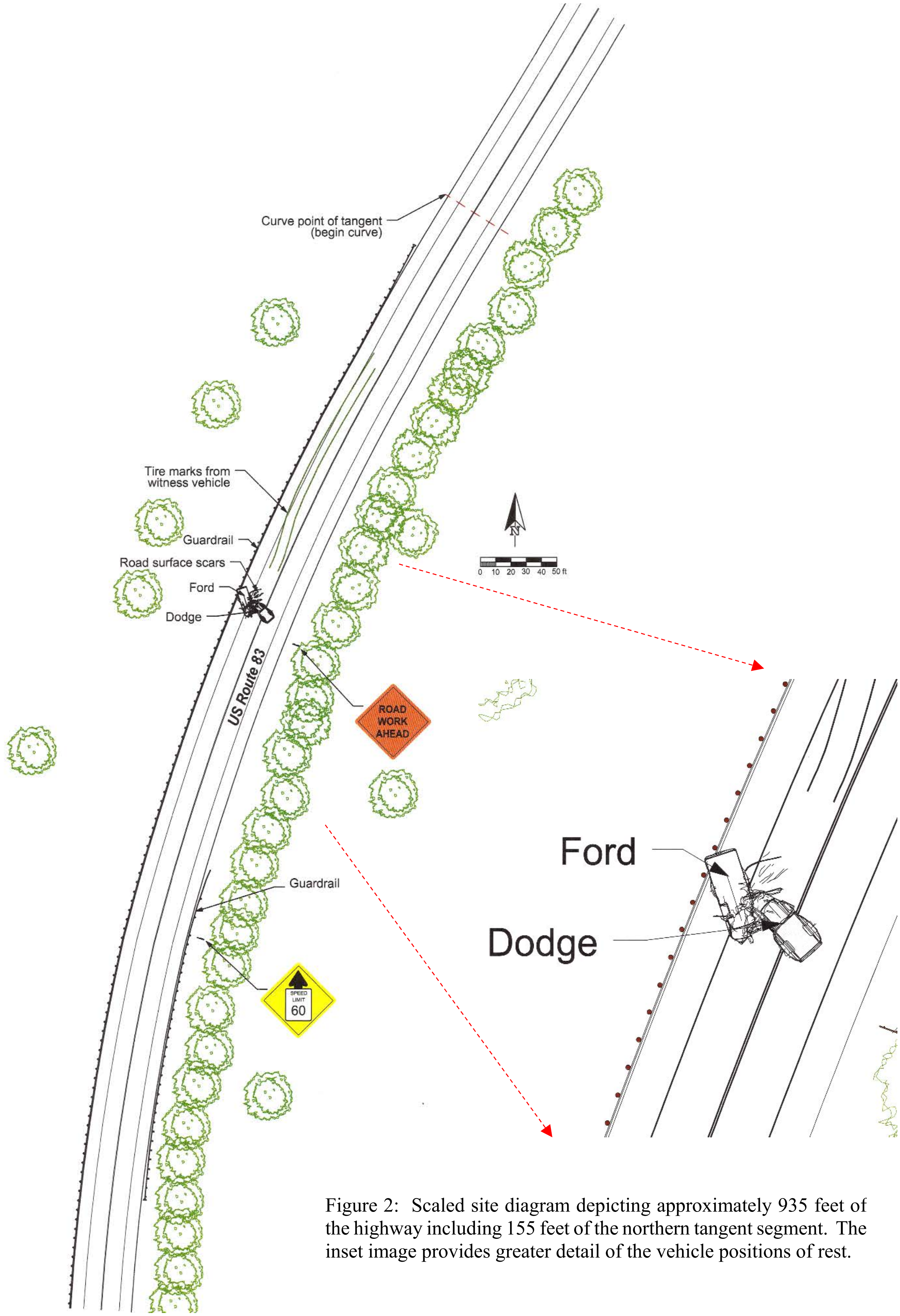


Figure 2: Scaled site diagram depicting approximately 935 feet of the highway including 155 feet of the northern tangent segment. The inset image provides greater detail of the vehicle positions of rest.

Within the area of the collision, 3D scan data identified the longitudinal roadway grade as about 3.49% - descending in the southbound direction.

2. Vehicle Identification and Documentation

2.1. Ford

The vehicle was configured as medium-size bus with the installation of a body (having 12-passenger seating arrangement) on a 2004 Ford E-350 chassis that retained the OEM (original equipment manufacturer) cab and forward seating positions (driver and right-front passenger). The vehicle was examined and three-dimensionally scanned on April 4, 2017, from 13 positions, including two from the interior.

The vehicle sustained an offset frontal impact at the driver's side with direct contact damage having overlapped about 37 inches of the vehicle's lateral width, as measured relative to the sidewall at the front axle position. The damage exhibited characteristics of the Dodge having overridden the frame and bumper and then displacing the body and forward structures rearward. Some forward structures at the driver's side were displaced rearward as much as 62 inches (measurement includes free space). Additional damage and intrusion about the driver's-side cab resulted from the collision-induced rotation of the Dodge. **Figures 3 and 4** depict 3D scan images and damage patterns exhibited by the Ford.

Figure 3: The image depicts linked 3D scans of the Ford bus as viewed looking toward the left front of the vehicle where the impact damage was concentrated.

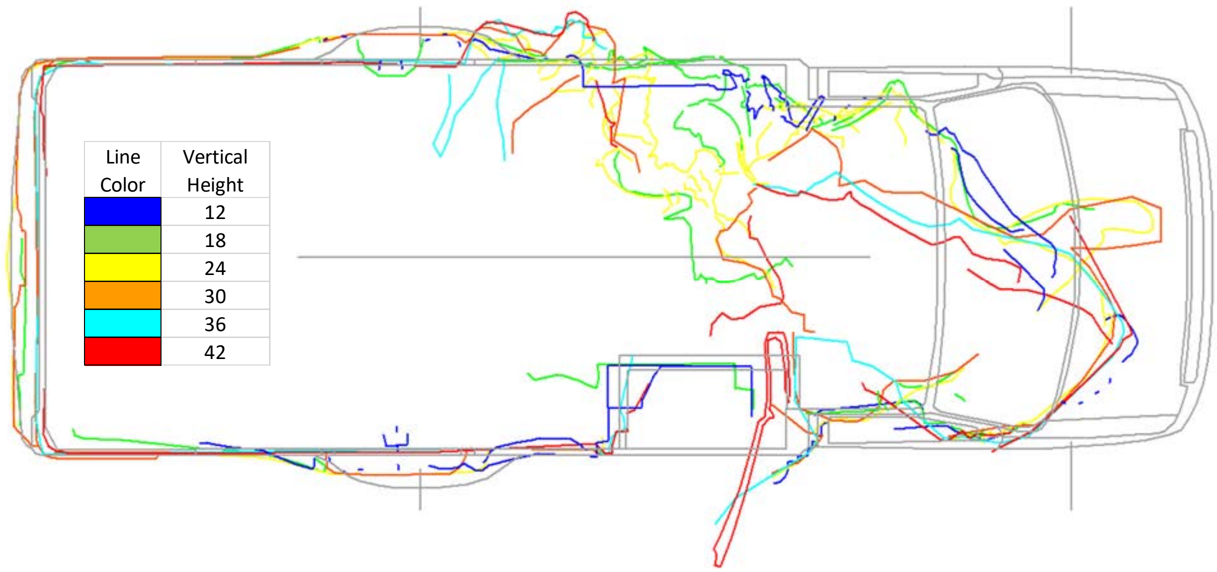


Figure 4: Image depicts a two-dimensional, top-down illustration of damage to the Ford atop an undamaged outline. Damage outlines were drawn from the 3D scan data at six-inch vertical intervals beginning at approximately the axle height.

2.2. Dodge

The vehicle was identified as a 2007 Dodge Ram 3500, quad cab pickup truck. The vehicle was examined and three-dimensionally scanned on April 4, 2017, from 10 positions.

The vehicle sustained an offset frontal impact at the driver's side with direct contact overlapping about 37 inches of the vehicle's lateral width, as measured relative to the vehicle side at the front axle position. The damage exhibited characteristics of the Dodge having overridden the frame and bumper of the Ford resulting in not only the rearward displacement of components, but also a lateral offset to the frame and structures forward of the cab. Three-dimensional scan data depicted a leftward (toward driver's side) shift of the forward frame rails of about 40-42°, while other components exhibited even greater offset. Measurement of the rearward displacement of the forward structure was complicated by the lateral offset. **Figures 5 and 6** depict 3D scan images and damage patterns exhibited by the Dodge.

Figure 5: The image depicts linked 3D scans of the Ford bus as viewed looking toward the left front of the vehicle where the impact damage was concentrated.

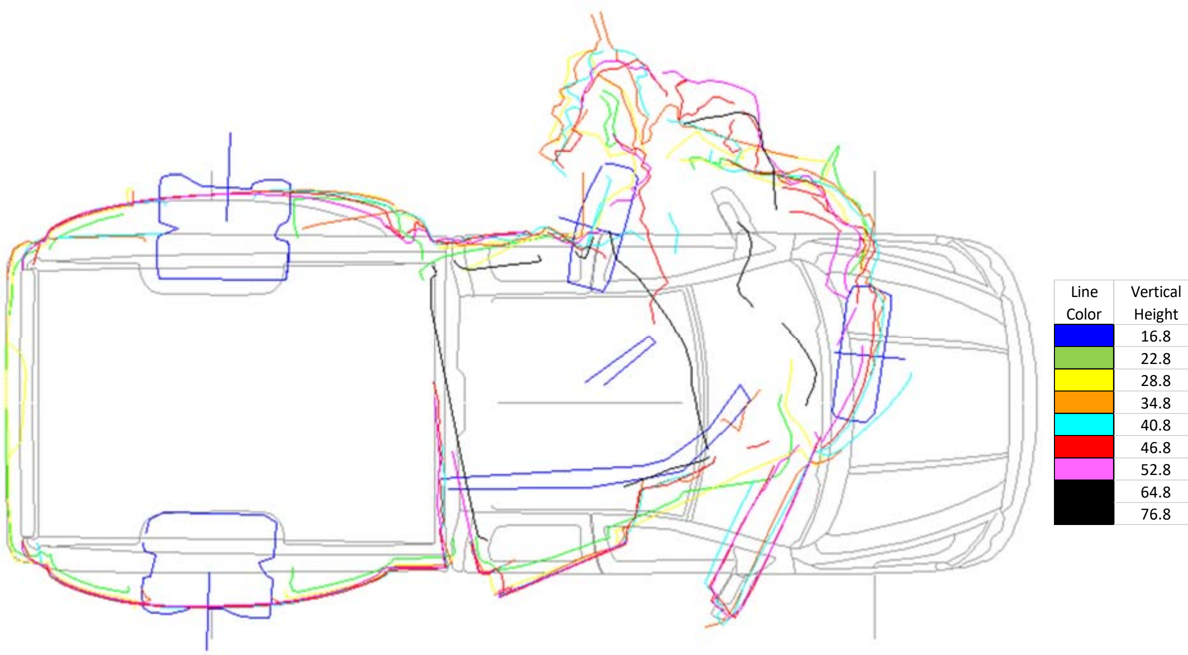


Figure 6: Image depicts a two-dimensional top-down illustration of damage to the Dodge atop an undamaged outline. Damage outlines were drawn from the 3D scan data at six-inch vertical intervals beginning at approximately the axle height.

Further vehicle information is available in factual reports prepared by NTSB Survival and Vehicle Factors Groups.

2.3. Impact Orientation

As exhibited by the vehicle damage, the collision involved a colinear, offset impact. The relative frontal overlap for both vehicles was approximately 47%. Following the impact, both vehicles exhibited a post-impact counterclockwise rotation and some southward movement. As the Ford rotated, its right rear corner impacted and overrode the guardrail that was contiguous with the road edge. The vehicles remained in contact with one another and exhibited no discernible separation following maximum engagement. The rotation appeared to pivot about the left front wheels of the two vehicles.

Figure 7 depicts a two-dimensional rendering of a colinear impact representing the offset between the two vehicles. It should be noted that the actual relative approach angle could vary slightly as well as the lateral offset within the southbound travel lane. There was no evidence to indicate the precise approach heading of either vehicle. The lateral position within the lane and distance from the onset of the roadway scars was estimated based on probable impact speed and time to maximum engagement.

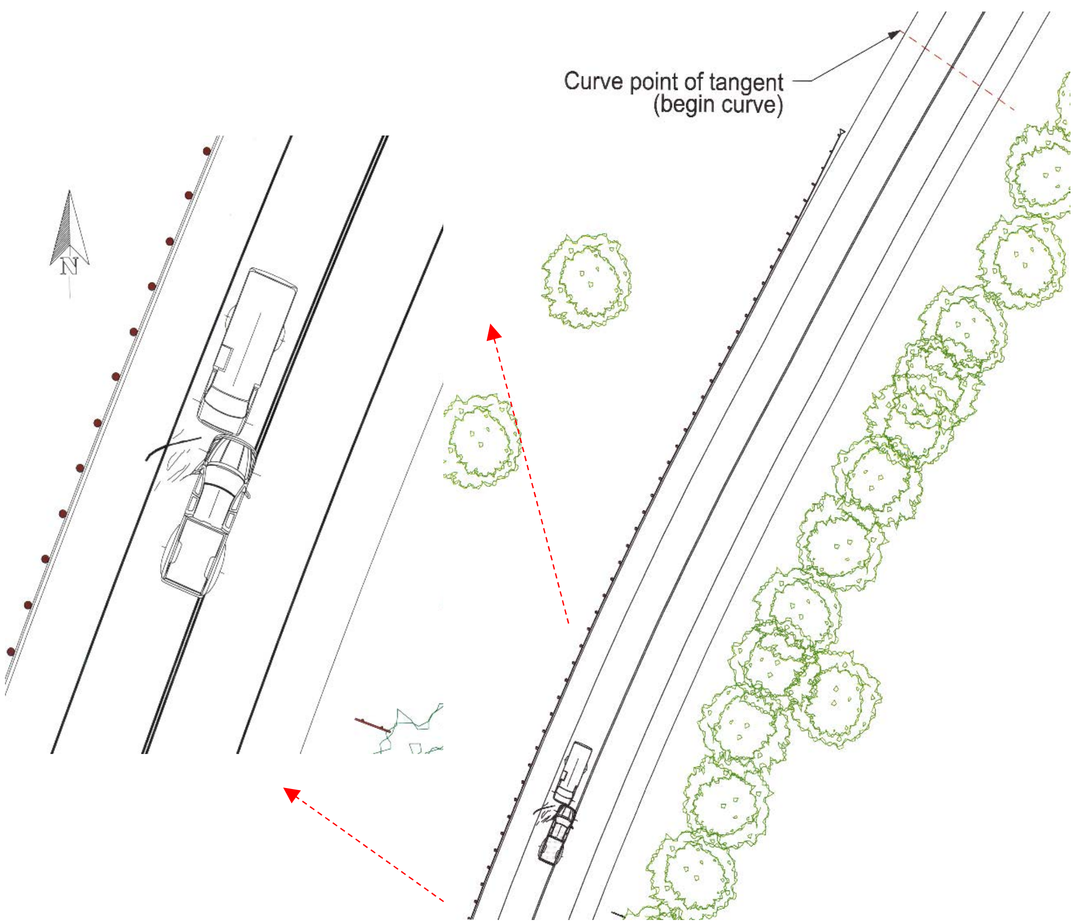


Figure 7: Scaled diagram depicting lateral offset of the Ford and Dodge at impact. Also depicted is the area of impact relative to roadway evidence and the end of the highway curve.

OEM specifications indicate that a nominal five (5) inch overlap in the vertical height of the vehicle front bumpers while in a static condition should exist. The vertical height of the Ford front bumper is reported at 24 inches with a typical width of nine (9) inches, while the Dodge is reported at 31 inches high and 12 inches wide. As conveyed in the NTSB Vehicle Factors Group factual report, the combination of larger tires and a suspension lift on the Dodge may have raised the vehicle approximately five (5) inches, thereby negating the anticipated overlap.

3. Vehicle Airbag Module - Event Data

Both vehicles were equipped with frontal airbag supplemental restraint systems (SRS), which exhibited deployments as a result of the impact. While the airbag control modules (ACM) of both vehicles had the capability to record certain deployment event data, these vehicles preceded the requirements of 49 CFR Part 563 and the type of data recorded within the respective modules would vary.[3]

3.1. Dodge

TxDPS investigators initiated data imaging from the Dodge, which was interpreted by the Bosch Crash Data Retrieval (CDR) software.[4] The CDR report conveyed that communication between the ACM and the software had been established by providing certain system configuration and ACM data. The configuration data indicated that the restraint system was also configured for seatbelt pretensioners at the outboard frontal seating positions. Configuration data also identified the ACM supplier (TRW), part number and serial number.

Based on the vehicle model year, the ACM would have only recorded deployment events. Despite the reporting of certain system configuration data, event data, including airbag deployment timing, crash pulse data, and pre-crash data were not recorded. As conveyed by certain fields in the CDR report, event data was apparently not written to the ACM memory.[5]

3.2. Ford

The Ford ACM was recovered, but had to be sent to the supplier, Continental Automotive Systems, Inc., for imaging. In the report provided by Continental, the imaged data contained information regarding the deployment event and SRS trouble/fault codes.[6] At the time the module data was imaged, nine (9) fault codes were listed; seven of which were related to the crash and airbag deployment with four (4) of those indicated as active. The only active fault code not associated with the crash involved a communication test in the firing loop enable circuit that had been set approximately 220 (key-on) hours before the crash.[7] The fault did not inhibit the airbag

[3] 49 CFR Part 563 defines the minimum data set to be recorded if a manufacturer decides to install an EDR (event data recorder) in their vehicle, along with requirements for the range and accuracy of that data. Part 563 is applicable to vehicle manufactured after September 1, 2010 and applies to vehicle with a GVWR of 8,500 pounds or less.
[4] Software version 17.2.1 was used for the initial imaging and interpretation. A subsequent data interpretation was conducted using version 17.3, although the results were unchanged.
[5] Certain data elements represent default data or no data received.
[6] Report titled Continental Automotive Systems, Inc. Field Event Analysis Report.
[7] The active, non-crash fault code was identified as "ZKEN".

deployment, but Continental advised that it should have attempted to illuminate the airbag warning lamp.

Regarding deployment data, both the seatbelt pretensioners and frontal airbags were commanded to deploy 19 milliseconds after module algorithm wake-up. Crash pulse data was provided from the module's accelerometer for a period of 210 milliseconds for the longitudinal (x) and lateral (y) axes individually. In addition to graphs for the two axes depicting acceleration, measured in g's, and velocity change, measured in km/h, data tables were also provided. The report also provided similarly formatted data that was recorded for the front crash sensor (EFS). The data was reported at one (1) millisecond intervals.

Based on the data as reported, the maximum cumulative change in velocity along the longitudinal and lateral axes were reported as 53.5 km/h (33.2 mph) and 19.4 km/h (12.0 mph) respectively. Examination of the data, however, concluded that the magnitude of the acceleration and change in velocity were underreported at certain time intervals. The graphs (combined in figure 8) depicted data clipping at certain sample times beginning around 40 milliseconds.[8] While the data depicted maximum reported longitudinal and lateral acceleration values as 61 and 30g's respectively, Continental advised that these are the accelerometer limits (thresholds). With the acceleration underreported, the cumulative change in velocity would likewise be underreported. The data profile indicates that without clipping the magnitude would have been greater.

Figure 8 provides a single graph depicting the individual longitudinal and lateral acceleration (g's) and velocity change (Δv) data, as well as a combined ("x" and "y" data) change in velocity and calculated PDOF (as reflected at the distinct time samples).

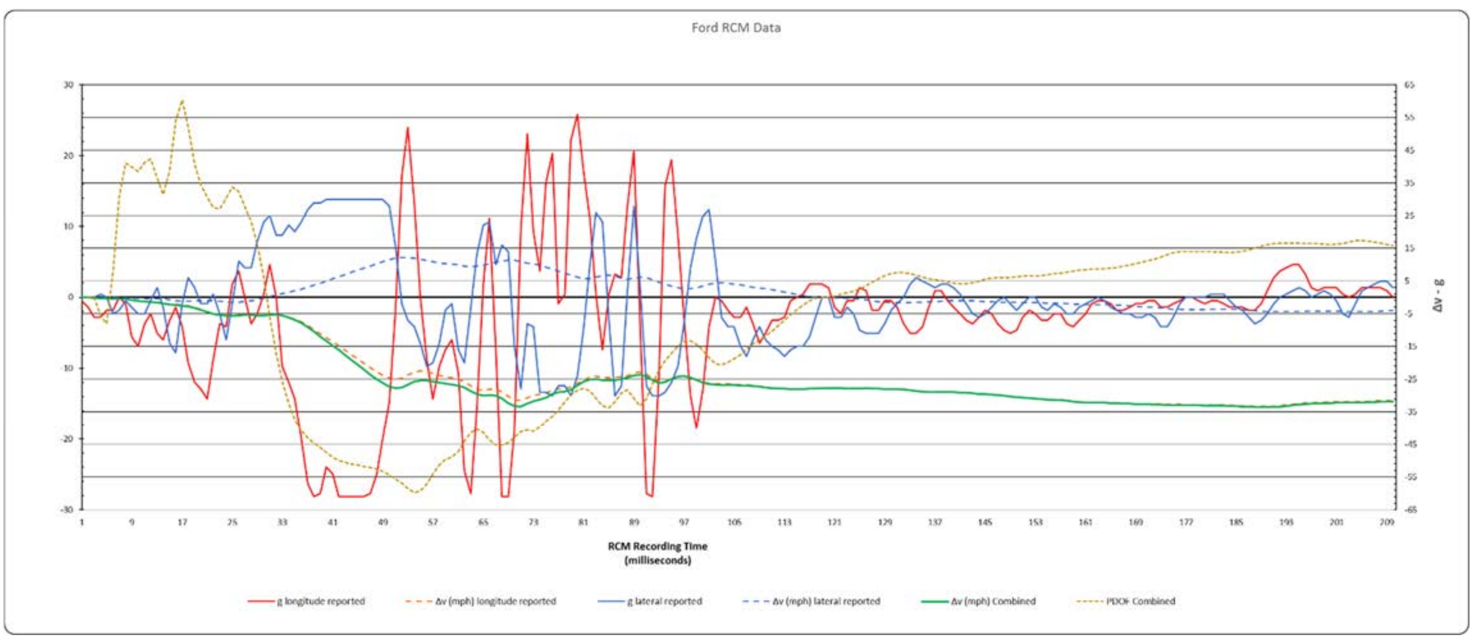


Figure 8: Graph illustrating ACM reported acceleration and change in velocity as reported by the Ford's airbag control module.

[8] "Clipping" is a distortion in a signal when the sensor constraints on the range of data it can measure are exceeded. The data chart illustrates hard clipping where the signal is strictly limited at the threshold, producing a flat cutoff

The front crash sensor referenced in the report assists with crash detection and enabling of the deployment command algorithm. While longitudinal acceleration data detected by the sensor was recorded within the ACM, it provided no additional insight for the crash. The module was capable of recording 60 milliseconds of acceleration and (calculated) velocity change at one (1) millisecond intervals as reported by the sensor, but stopped at 19 milliseconds when the airbag deployment was commanded.

E. REPORT APPENDICES

Appendix 1 Highway curve elements and nomenclature

F. REFERENCES

[1] NTSB Vehicle Factors Group factual report

[2] NTSB Highway Factors Group factual report

[3] NTSB Recorder Specialist factual report

G. DOCKET MATERIAL

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

LIST OF ATTACHMENTS

None

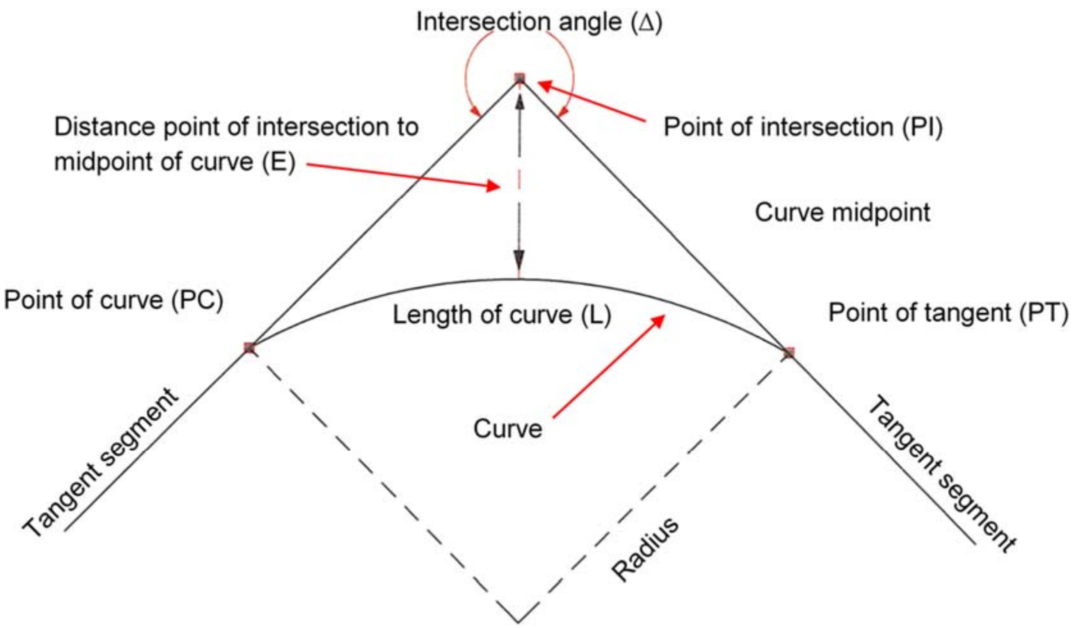
LIST OF PHOTOGRAPHS

None

END OF REPORT

Robert Squire
Highway Accident Investigator

Appendix 1 - Elements of a curve and nomenclature



PC	Point of curve (beginning of curve)
PT	Point of tangent (end of curve)
PI	Point of intersection, point at which the two tangent segments would intersect without the curve. Forms the total angle of the curve
Δ	Intersection angle. Total angular change between two tangent segments.
E	Distance from point of intersection between tangent segments measured perpendicular to midpoint of curve along centerline
Midpoint	Midpoint of the curve arc.
L	Length of curve, the horizontal length of the curve from PC to PT as measured along the centerline
R	Curve radius