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

TECHNICAL RECONSTRUCTION GROUP CHAIRMAN'S FACTUAL REPORT

A. CRASH INFORMATION & CRASH SUMMARY

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

B. TECHNICAL RECONSTRUCTION GROUP

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C. DETAILS OF THE TECHNICAL RECONSTRUCTION INVESTIGATION

The Technical Reconstruction Group for this investigation was convened for the purpose of providing on-scene documentation of the crash location and involved vehicles, and to assist in the analysis of collision events and causation factors. In support of these tasks the group relied upon information and documentation provided by the Alabama Law Enforcement Agency (ALEA). 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. Introduction, Collision Site Description and Data Sources

The collision events involved numerous vehicles and several individual collisions, all which appeared to have occurred in a rapid succession. The most serious events occurred near the northern end of the northbound I-65 bridge that crosses Pigeon Creek in Butler County, Alabama. Initially a total of 19 motor vehicles were listed by ALEA as having been involved in some manner of collision within the area. A total of 15 vehicles were impounded and made available for examination by NTSB investigators. Of the vehicles examined, two were combination commercial vehicles with the remainder being light duty vehicles. A post-crash fire partially or fully consumed several vehicles including the two combination vehicles. The interactions of vehicles associated with fatal and serious injuries became a primary focus for investigation.

The crash events occurred June 19, 2021, under daylight but wet weather conditions.

1.1. Collision Location

The collision events occurred on the northbound roadway of Interstate 65. The more serious events involved two combination vehicles and numerous light duty vehicles that began near the northern end of a bridge located approximately 1,000 feet north of mile marker 138. The bridge passes over a ravine through which the Pigeon Creek flows. The collision site was examined on June 22, 2021, two days after the events. While the full scope of collision events spanned a larger area, roadway surface scarring consistent with a collision was located at the approximate geographic coordinates of 31.94561667ºN (latitude) and -86.55875ºW (longitude). A post-crash fire that burned five vehicles was approximately centered in the highway median about 100 feet north of the bridge. This area was located at the approximate geographic coordinates of 31.94591667ºN (latitude) and -86.55850ºW (longitude). The collision location was just south of the Butler County line as depicted **Figure 1**.

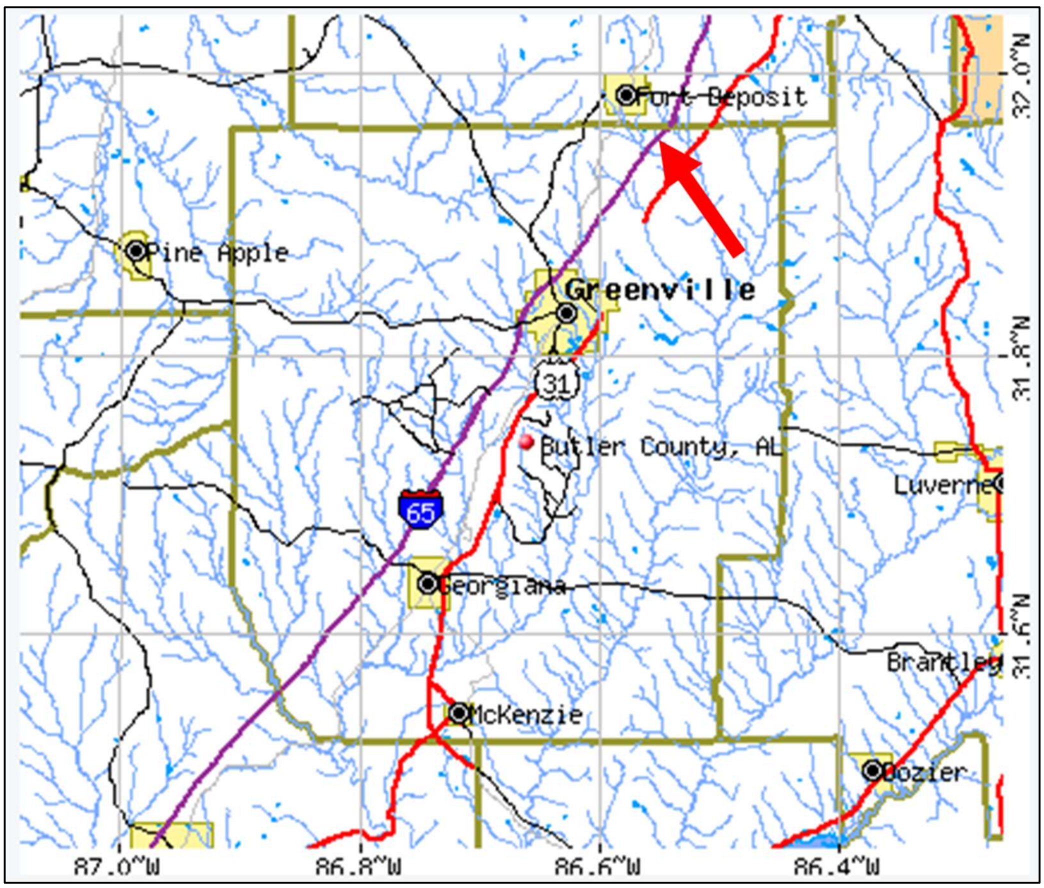

Figure 1: Map depicting Butler County and relative location of crash.

The crash site, including roadway evidence and vehicle positions of rest were documented by ALEA investigators using sUAS and total station equipment, and photographs.[1] The data collected by ALEA was provided to NTSB investigators for investigative support. Roadway evidence that included some tire marks, road surface scars and bridge rail damage were observed and documented by NTSB investigators with photographs and sUAS support. **Figure 2** is a modified Google Earth images depicting the approximate locations of areas of interest.

Figure 2: Modified Google Earth image depicting approximate relative location of the major impact area and vehicle positions of rest in the median.

1.2. General Highway Description

The collision events occurred on the northbound roadway of Interstate 65. The highway surface was of asphalt construction, excluding the Pigeon Creek bridge. Generally, the highway exhibits a north-south heading with two travel lanes in each direction with an earthen median separating the two roadways. In the area of the collision events, the highway exhibited a north/south heading of 44/224 degrees respectively. The Pigeon Creek bridge features separate bridge structures with concrete decks for the north- and southbound roadways. Off the bridge, travel lanes were approximately 12 feet wide with shoulder widths of approximately 10.5 and 4.5 feet for the right and left shoulders respectively. Atop the 272-foot northbound bridge span, lane widths decreased to about 11.5 feet while shoulder widths decreased to about 2.5 feet. Along the

[1] sUAS – small unmanned aerial system (i.e., drone).

entire length of the bridge deck, raised concrete curbing was contiguous with both outboard shoulder edges.

The most severe collision events began on the bridge over Pigeon Creek. As referenced in the *NTSB Highway Factors Group Factual Report*, the bridge began about 139 feet into a tangent segment of highway.[2] Preceding the bridge was a sweeping 11,420-foot radius rightward horizontal curve that extended over a distance of 2,440 feet. The curve began about 2,579 feet before the bridge and 1,340 feet into a descending vertical grade.

The northbound bridge was located along a descending vertical grade that began about 3,920 feet before the bridge. As referenced, the area of the collision events atop the bridge occurred within a sag vertical curve exhibiting about a 1.6 percent descending grade near the area of impact. The descending vertical grade, including the sag transition exhibited an overall length of about 4,384 feet.

The travel lanes were delineated by pavement striping and exhibited cross slope grades for drainage. The posted speed limit is 70 mph.

Additional information is available in the *NTSB Highway Factors Group Factual Report*.

1.3. Sight Line

Physical obstructions to the driver sightline approaching the bridge were a function of the rightward curve and tree line. The tree line and a slightly elevated embankment were set back about 40 feet from the pavement. Subjective observations under clear daylight conditions revealed that the entire bridge could be seen from a distance of at least 1,900 feet south of the bridge from the right lane. Line of sight from the right lane was more directly affected by the tree line. **Figure 3** depicts a photograph of the approach to the bridge from the right travel lane.

[2] Note that some mathematical averaging was applied as the bridge decks are installed at a skewed angle relative to highway travel lanes.

Figure 3: Northbound sightline to bridge over Pigeon Creek from a distance of about 1,900 feet.

1.4. Weather

Video recorded by several parties depict light rain falling at the time of the more significant collision events. The highway was wet and tire spray was observed. Weather information is detailed in the *NTSB Meteorology Specialists Factual Report*.

2. Roadway Evidence

Following the collision events, most of the involved vehicles were clustered near the north end of the Pigeon Creek bridge at about mile point 138.18. Examination of the highway area around the bridge revealed the most significant roadway evidence of the collision events. Physical evidence was substantially limited to pavement surface scrub marks and scarring, impact damage to the bridge rail and soil disruption in the median north of the bridge. Evidence of guardrail impacts south of the bridge were also observed.

Pavement surface scrub marks, scuffing and scarring were observed in both travel lanes and shoulders on the bridge. As noted, the bridge deck shoulder widths decrease to about 2.5 feet with contiguous raised concrete curbing and railing along the outside of the shoulder. Pavement scarring exhibited characteristics of linear scrapes and surface scrubbing or cleaning. Surface scarring along the shoulder areas frequently angled toward the raised curbing that likewise exhibited additional evidence of scarring and scrubbing.

Along the right half of the roadway, the onset of pavement surface evidence was observed about 11 feet from the south end of the bridge deck. The onset of contact evidence to the bridge rail began about 30 feet from the south end of the parapet.[3] While some evidence of scrubbing to the raise curbing was observed along almost the entire length of the bridge, the most prominent evidence of bridge rail contact was observed about 164 feet from the south end of the rail. Within the right travel lane, surface scratches were observed near the middle of the lane about 62.5 and 148 feet from the south end of the bridge deck. These surface scratches were light and individually measured no more than about 3.8 feet in length.

Similar to the right side of the roadway, the left side exhibited evidence of roadway surface scarring and bridge rail contact. The onset of observable contact to the bridge rail appeared approximately 27 feet from the south end of the rail. Scrubbing and pavement scratches within the left shoulder appeared about 34 feet from the south end of the bridge deck with evidence of raised curbing contact appearing shortly thereafter. Nearly the entire length of the bridge rail exhibited evidence of contact in the form of scrapes, scarring and occasional material transfer embedded in the concrete near several of the vertical supports. Most of the material transfer was black in color and exhibited characteristics similar to rubber or plastic.

The upper horizontal surface of the raised curbing exhibited tire mark impressions at various locations. In particular, tire impressions characteristic of a dual wheel assembly traversed a significant length of the bridge beginning an estimated 30 feet from the south end until fading near the area of significant rail damage. Other, shorter tire impressions, some arcing, appeared further northward along the curb.

Significant displacement of the bridge rail was observed about 222 feet from the south end of the rail.[4] In total, about 24 feet of bridge rail was removed for repair. Evidence of contact with the left side ridge rail continued to the north end terminus.

Within the left travel lane, surface scarring in the form of multiple scrapes and scratches was observed beginning about 209 feet from the south end of the bridge deck. The scarring covered a distance of about 60 feet from about the middle of the lane and outward toward the left shoulder. Additional surface scarring was observed about 16 feet further north and continued to end of bridge deck. Some asphalt pavement gouging north of the bridge deck was also observed but its age could not be discerned.

Although none of the roadway surface or bridge rail evidence could be linked to contact by specific vehicles, it did not exhibit an aged appearance and the location of evidence toward the northern end of the bridge, including the left side bridge rail damage was consistent with video acquired from one of the involved combination vehicles. Likewise, several vehicles exhibited damage consistent with concrete curb or bridge rail contact.

Within the highway median approximately 100 feet north of the northern end of bridge, an area of charred and fluid-soak soil was centered. Numerous areas of soil rutting were observed

[3] An approximate 16.5-foot angled concrete transition joined the double W-beam steel guardrail south of the bridge with the bridge rail.
[4] Approximately 220 feet measured at the road surface due to angular orientation of the bridge deck joints.

although none could be discerned as definitively related to the collision events. The median exhibited an overall width of about 45.5 feet in this area.

South of the bridge, the median barrier exhibited impact damage at two locations. The area nearest the bridge was about 41 feet south of the bridge and exhibited bowing toward the median characteristic of a vehicular impact. The second area was located about 187 feet south of the bridge. At this location the terminal end treatment for the steel W-beam guardrail was displaced. At this location the median cable barrier terminated and a steel W-beam guardrail that joined the bridge rail began.

Figure 4 is a screen capture of the 3D point cloud created through NTSB sUAS photographs. The image depicts a northward view across the bridge with areas of interest highlighted.

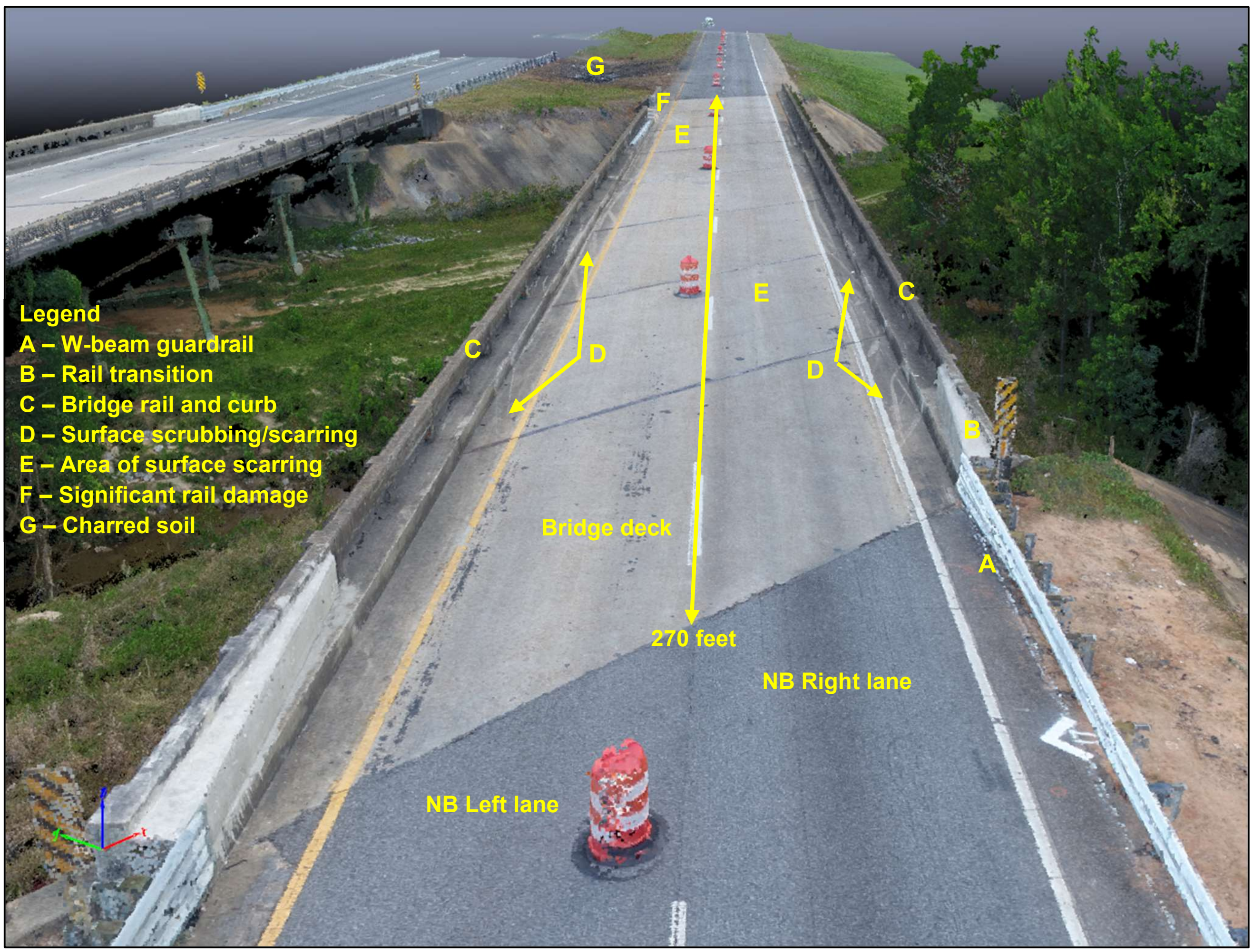

Figure 4: Screen capture of photogrammetric 3D point cloud depicting northbound roadway bridge over Pigeon Creek with areas of evidentiary interest marked.

3. Vehicles

Preliminary information provided by ALEA identified 19 motor vehicles as being associated with some aspect of a collision event. Subsequent analysis revealed that several vehicles had been involved in multiple collision and impact events. The final events involved the two combination vehicles. **Table 1** provides a summary (in no specific order) of the vehicles preliminarily identified and whether they were available for examination by NTSB investigators and involved in the post-crash fire. Additional vehicle information is available in the NTSB *Vehicle Factors Group* factual report.

Table 1: Preliminary vehicle identification

Vehicle Identification	Available for Examination	Multiple Areas of Damage	Fire Involved
2020 Volvo VAH 2020 Cottrell auto transporter trailer	Yes	Yes	**Yes**
2005 Freightliner Cascadia 2009 Wabash National Corporation van trailer	Yes	Yes	**Yes**
2017 Ford F-350 Transit Van	Yes	Yes	**Yes**
2020 Ford Explorer	Yes	Yes	No
2017 VW Passat	Yes	Yes	**Yes**
2019 Ford F-150 King Ranch Crew Cab	Yes	Yes	**Yes**
2016 Ram 1500	Yes	Yes	**Yes**
2021 Chrysler Pacifica	Yes	Yes	No
2020 Acura TLX	Yes	Yes	No
2017 Buick Lacrosse	Yes	Yes	No
2017 Kia Sedona (Grey)	Yes	Yes	No
2019 Hyundai Santa Fe	Yes	No – single vehicle	No
2016 Toyota Tacoma with utility trailer	Yes	Yes	No
2017 Toyota Camry	Yes	Yes	No
2017 Kia Sedona (White)	Yes	Yes	No
2021 Jeep Grand Cherokee	**No**	Unknown	No
2011 Honda Odyssey	**No**	Unknown	No
2004 Honda Odyssey	**No**	No	No
2011 Kia Sorento	**No**	Unknown	No

As noted, 15 of the 19 vehicles listed were impounded by ALEA and made available for examination by NTSB investigators. Two vehicles not impounded, the 2021 Jeep Grand Cherokee and 2004 Honda Odyssey, were identified in scene photographs or sUAS video.

Figure 5 depicts a screen capture of the three-dimensional photogrammetric point cloud created from sUAS photographs taken by ALEA investigators. The image depicts the post-event positions of rest for 14 of the vehicles referenced in Table 1. Post-event positions of two additional vehicles were identified through ALEA scene photographs, although at least one of the vehicles had been moved before being photographed.

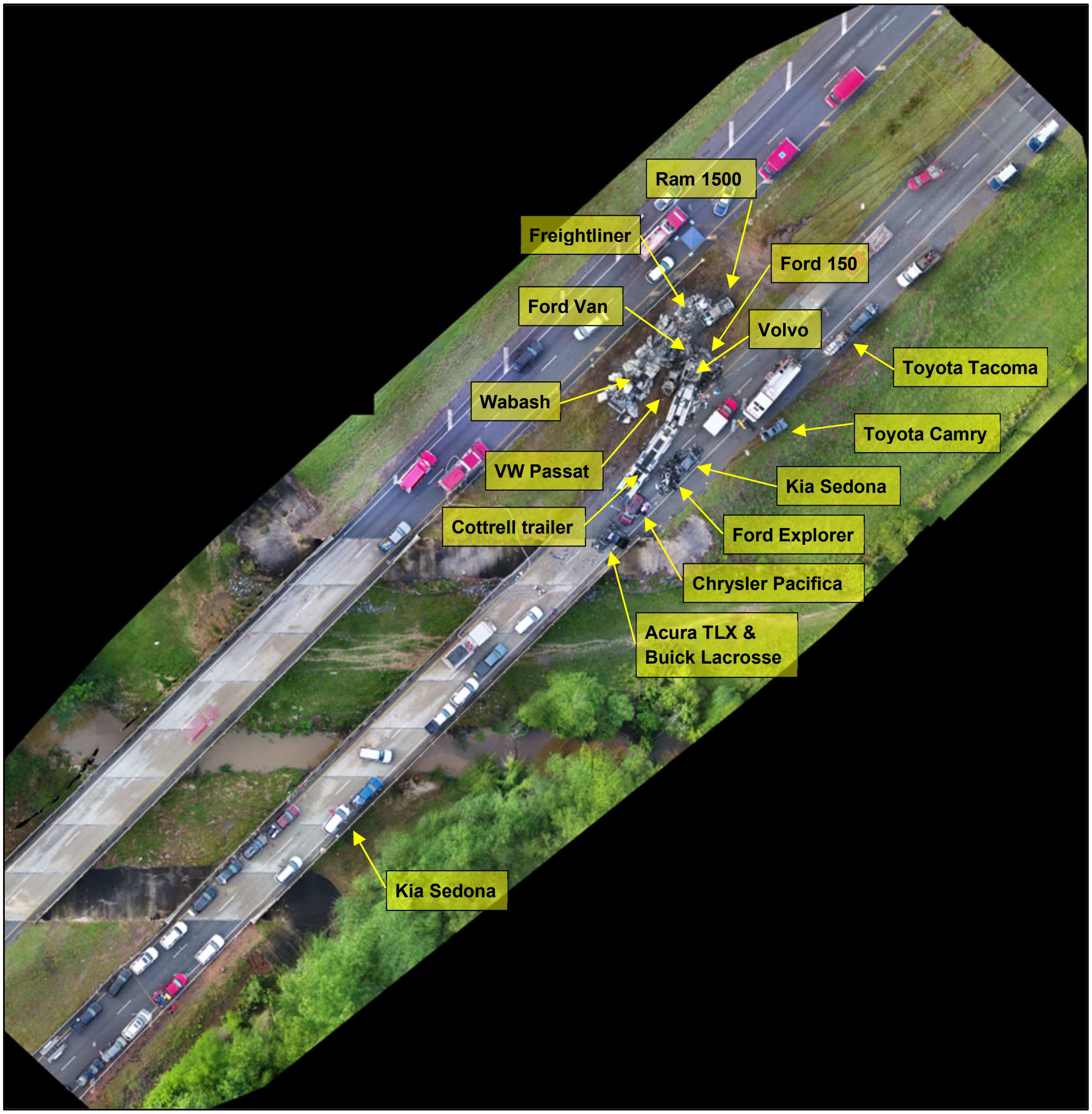

Figure 5: Screen capture of photogrammetric 3D point cloud depicting crash scene and post-collision vehicle positions or rest. Vehicles referenced in this report are identified by yellow tags.

3.1. Vehicle Documentation -Scanned Vehicles

While the 15 vehicles impounded were examined and photographed by NTSB investigators, nine were laser scanned to document the extent of damage as three-dimensional point clouds.[5]

3.1.1. 2020 Volvo VAH truck-tractor in combination with 2020 Cottrell CX-09LSFA auto hauling semitrailer

The vehicle was identified as a stinger-steered automobile transporter that consisted of a three-axle truck tractor coupled to a two-axle semitrailer. A stinger-steered combination is designed and used specifically for the transport of assembled vehicles in which the fifth wheel is located on a drop frame located below and behind the rearmost axle of the power unit. When viewed at the towing storage facility the truck tractor and trailer were still coupled. The truck tractor forward of the cab backwall had been consumed by fire. Exterior components at the front, and along both sides of the truck tractor exhibited deformation consistent with contact damage, albeit more prominent along the right (passenger) side. Both sides of the trailer exhibited paint damage in the form of scraping, but this was also more prominent along the right side.

The left (driver's) side fuel tank had been consumed by fire while the right-side tank was found intact. **Figures 6-8** depict a screen captures of the colorized three-dimensional scan point cloud from different perspectives. **Figure 9** is a photograph depicting the damage along the right (passenger) side of the Cottrell trailer.

Figure 6: Screen capture of the 3D scan project point cloud depicting the left side of the Volvo combination.

At its position of final rest, the Volvo combination was located approximately 106 feet north of the bridge as measured from the last deck slab to the front of the truck tractor. Most of the Volvo truck tractor was in the median, angled slightly westward relative to the roadway. The right side drive axle wheels remained on the roadway pavement. The Cottrell trailer was similarly angled slightly westward but less than that of the tractor. The tandem axle wheels remained on the pavement and the rear of the trailer occupied the entire left travel lane.

[5] Scanning was completed using the FARO Focus^{3D} X330 laser scanner. Documented subjects were scanned from multiple positions, registered, and rendered into three-dimensional (3D) point clouds using FARO Scene® software.

Figure 7: Screen capture of the 3D scan project point cloud depicting the left side of the Volvo combination.

Figure 8: Screen capture of the 3D scan project point cloud depicting the right side of the Volvo combination.

Figure 9: Photograph depicting paint damage along the right side of the Cottrell semitrailer.

3.1.2. 2017 Ford Transit van

The vehicle was identified as a full-size van configured for multiple passenger transport. When examined at the storage facility the vehicle exhibited extensive deformation and the complete consumption of nonmetallic components by fire. Evidence of multiple impacts was observed at the front and rear that included an upward displacement of the vehicle structure at the rear just forward of the rear axle. The vehicle was so heavily damaged that additional evidence of contact was indiscernible. Displacement of some body structure was due to recovery operations. **Figures 10** and **11** depict screen captures of the colorized three-dimensional scan point cloud.

At final rest following the collision events, the Transit van was located about 21 feet into the median and 106 feet north of the bridge, as measured to its estimated center of mass. The van was roughly facing southwestward with the rear of the vehicle engaged with the left front corner of the Volvo truck tractor and the overturned Ford F-150 pickup that was perpendicular with the front of the Volvo truck tractor. The rear of the Transit van appeared to partially override the F-150.

Figure 10: Screen capture of 3D scan point cloud depicting the right side of the Ford Transit van.

Figure 11: Screen capture of photogrammetric point cloud depicting the interior of the Ford Transit van.

3.1.3. 2017 Ford Explorer

The vehicle was identified as a sport utility vehicle (SUV). When examined at the storage facility the vehicle exhibited extensive body deformation and occupant compartment displacement. While evidence of contact damage extended across the entire rear of the vehicle, the area of initial contact was at the right rear that resulted in greater displacement of the vehicle body structure along the right (passenger) side. The left front similarly exhibited evidence of contact damage that also resulted in the detachment of the left front wheel. The roof exhibited gouging and scraping to the painted surface that was consistent with the vehicle having overturned. **Figure 12** depicts a screen capture of the colorized three-dimensional scan point cloud.

At final rest following the collision events, the Explorer was located overturned on its roof in the right travel lane about 39 feet north of the bridge, as measured in the right travel lane. The vehicle was facing southward fully within the right travel lane between the 2017 Kia Sedona to the north and 2021 Chrysler Pacifica to the south. The Explorer was in contact with the Kia and parallel to the midsection of the Cottrell trailer that occupied the left lane.

Figure 12: Screen capture of 3D scan point cloud depicting the right side of the Ford Explorer.

3.1.4. 2020 Acura TLX

The vehicle was identified as a four-door sedan. When examined at the towing storage facility the vehicle exhibited extensive body deformation at the front, rear and along the right (passenger) side. The left rear exhibited evidence of a significant impact that also resulted in displacement of the axle. Contact damage at the right front was indicative of contact damage. The entire right (passenger) side exhibited damage and blue color material transfer consistent with a sideswipe contact. **Figure 13** depicts a screen capture of the colorized three-dimensional scan point cloud.

At final rest the Acura was facing southward in the right travel lane at the north end of the bridge. The vehicle's front wheels were atop the bridge deck while the rear wheels were on the asphalt roadway. The Buick Lacrosse was on top of the driver side of the Acura with the undercarriage in contact with driver side roof, the front of the vehicle on the ground and the rear vertically raised above the Acura. The Buick was oriented at a right angle to the Acura.

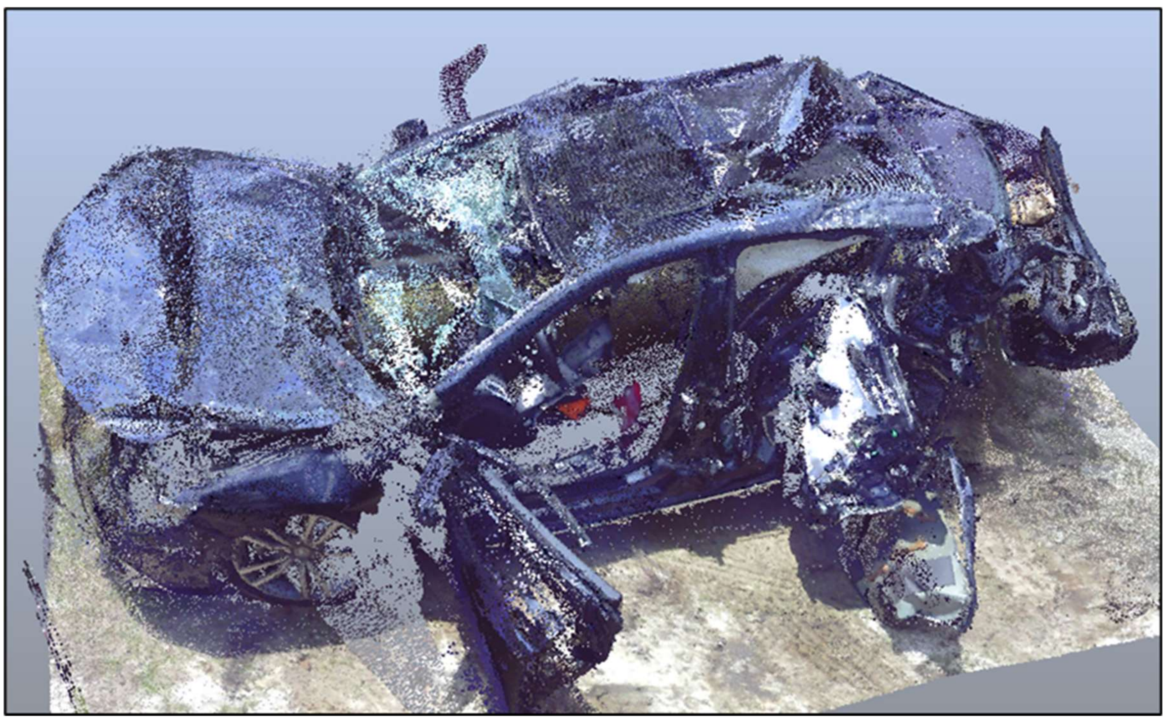

Figure 13: Screen capture of 3D scan point cloud depicting the left side of the Acura TLX.

3.1.5. 2017 Buick Lacrosse

The vehicle was identified as a sport utility vehicle crossover. When examined at the storage facility the vehicle exhibited extensive body deformation at the front, rear and along both sides. The rear exhibited evidence of a colinear impact at the bumper level that resulted in the forward displacement of the trunk. The left and right sides exhibited evidence characteristic of sideswipe contact. Along the left (driver) side, the damage extended along the entire length of the vehicle above the lower rocker panel. The trailing edge of the left front fender was displaced vertically upward. Damage to the right (passenger) side included front and rear wheels and the rocker panel below both doors. The damage characteristics were indicative of concrete scraping or grinding. Further damage above the lower edges of the doors exhibited blue color material transfer within the paint gouges and scrapes. The front bumper cover also exhibited scraping and paint damage. The left side exhibited vertical scraping while the right side exhibited scraping and grinding that was more horizontal and angled downward toward the outboard edge. The grinding and scraping across the right front of the vehicle transitioned to the similar damage along the right side. **Figure 14** depicts a screen capture of the colorized three-dimensional scan point cloud.

At final rest the Buick was facing eastward in the right travel lane at the north end of the bridge. The vehicle's undercarriage was on top of the driver side of the Acura with the front bumper resting against the raised concrete curb on the east side of the bridge. The Buick was oriented at a right angle to the Acura facing eastward.

Figure 14: Screen capture of 3D scan point cloud depicting the left side of the Buick Lacrosse

3.1.6. 2021 Chrysler Pacifica

The vehicle was identified as a sport utility vehicle crossover. When examined at the storage facility the vehicle exhibited extensive body deformation at the front, rear and along both sides. Damage at the front of the vehicle was characteristic of a colinear impact with some indication of underride. Damage to both sides of the vehicle was characteristic of sideswipe contact. Entrapped within the damage at the right-side front door was dark colored fiberglass body panel that was consistent with the left rear lower fender skirt from the Buick. The rear exhibited impact damage at the bumper level that resulted in some forward displacement of the body and loss of the rear bumper cover. **Figure 15** depicts a screen capture of the colorized three-dimensional scan point cloud.

At final rest following the collision events, the Chrysler was located facing southward in the right travel lane directly north of the Acura and south of the Ford Explorer about 18 feet north of the bridge as measured within the right travel lane to the estimated center of mass. The vehicle was completely within the right travel lane.

Figure 15: Screen capture of 3D scan point cloud depicting the right side of the Chrysler Pacifica.

3.1.7. 2017 Kia Sedona (grey)

The vehicle was identified as a minivan. When examined at the storage facility the vehicle exhibited significant front and rear body deformation in addition to evidence of sideswipe contact to the left and right sides. Contact damage at the rear exhibited characteristics of impact at both the left and right rear corners. Damage to the left rear corner exhibited evidence of upward vertical motion while the damage at the right rear appeared centered above the bumper line and extended the full vertical height of the vehicle. Frontal damage exhibited evidence of underride that extended across the full vehicle width. Both left and right sides exhibited inward deformation of the exterior door panels and numerous longitudinal scrapes. The outer sheet metal to the left (driver) side front door and front fender were displaced from the vehicle. **Figure 16** depicts a screen capture of the colorized three-dimensional scan point cloud.

At final rest following the collision events, the Kia was located facing northward in the right travel lane directly north of, and it contact with, the Ford Explorer about 52 feet north of the bridge. The vehicle was fully within the right travel lane.

Figure 16: Screen capture of 3D scan point cloud depicting the left side of the Kia Sedona.

3.1.8. 2017 Toyota Camry

The vehicle was identified as a four-door sedan. When examined at the storage facility the vehicle exhibited contact damage at the front, rear and to both sides. Impact damage at the rear extended across the full width of the vehicle but exhibited greater displacement at the left rear. The left (driver) side exhibited evidence of contact at the left front fender and both side doors. The frontal impact damage appeared concentrated slightly to the left (driver) side of the vehicle centerline and generally appeared to be colinear. The right (passenger) side rear door exhibited contact damage that included inward displacement of the exterior door panel and some tearing to the sheet metal. **Figure 16** depicts a screen capture of the colorized three-dimensional scan point cloud.

At final rest the Toyota was located facing mostly northward in the grass just off the highway's northbound right shoulder about 96 feet north of the bridge. Soil furrows corroborated the vehicle's departure from the paved shoulder at an angle of about 13°.

Figure 17: Screen capture of 3D scan point cloud depicting the right side of the Toyota Camry.

3.1.9. 2017 VW Passat

The vehicle was identified as a four-door sedan. When examined at the storage facility the vehicle exhibited evidence that it had been entirely engulfed in fire. It also exhibited extensive body deformation consistent with an impact at the rear with lesser contact deformation at the front. Both sides of the vehicle likewise exhibited contact evidence. Contact damage at the rear appeared to originate at the right (passenger) side rear. Frontal damage exhibited evidence of underride with apparent contact at both the left and right side of the hood. While the left side front door exhibited little deformation, the trailing end of the left side rear door exhibited inward deformation and longitudinal scarring of the sheet metal. Tearing of the exterior door sheet metal to both right side doors was observed. **Figure 18** depicts a screen capture of the colorized three-dimensional scan point cloud.

At final rest the VW was located about 13 feet into the median and 91 feet north of the bridge. The vehicle was roughly southward and was parallel with the left side of the Volvo truck tractor. The rear of the VW appeared to be adjacent to the tractor cab with scene photographs depicting the two vehicles to possibly be in contact. The Wabash trailer was parallel with the right side of the VW. Separation between the VW and trailer was three feet or less.

Figure 18: Screen capture of 3D scan point cloud depicting the right side of the VW Passat.

3.2. Non-Scanned and Non-examined Vehicle Documentation

Of the 19 motor vehicles initially referenced by law enforcement investigators as having some connection with the crash events, 15 were impounded and made available for examination. In addition to the nine (9) vehicle that were 3D laser scanned, another six (6) were examined and photographed. Of the remaining four (4) vehicle initially referenced, two were located in law enforcement photographs and two are otherwise not further identified.

3.2.1. 2005 Freightliner Cascadia truck-tractor in combination with 2009 Wabash National Corporation van trailer

The vehicle was identified as a combination vehicle that had consisted of a three-axle truck tractor coupled to a two-axle van body semitrailer. When examined at the storage facility both the tractor and semitrailer had been substantially consumed and structurally compromised by the post-crash fire. Generally, only the vehicle frame and metallic components at or below the frame level remained. It is estimated that approximately the forward one-third of the semitrailer remained attached to the tractor. The fifth wheel coupler remained connected with the trailer's king pin plate with portions of the frame normally above the tractor drive axles attached. The aft section of the trailer frame that included the axles and trailing frame to the rear of the vehicle were separate from the tractor. **Figures 19 and 20** depict photographs of the truck tractor and semitrailer remnants.

Figure 19: Photograph depicting remnants of the 2005 Freightliner truck tractor as viewed from the left side.

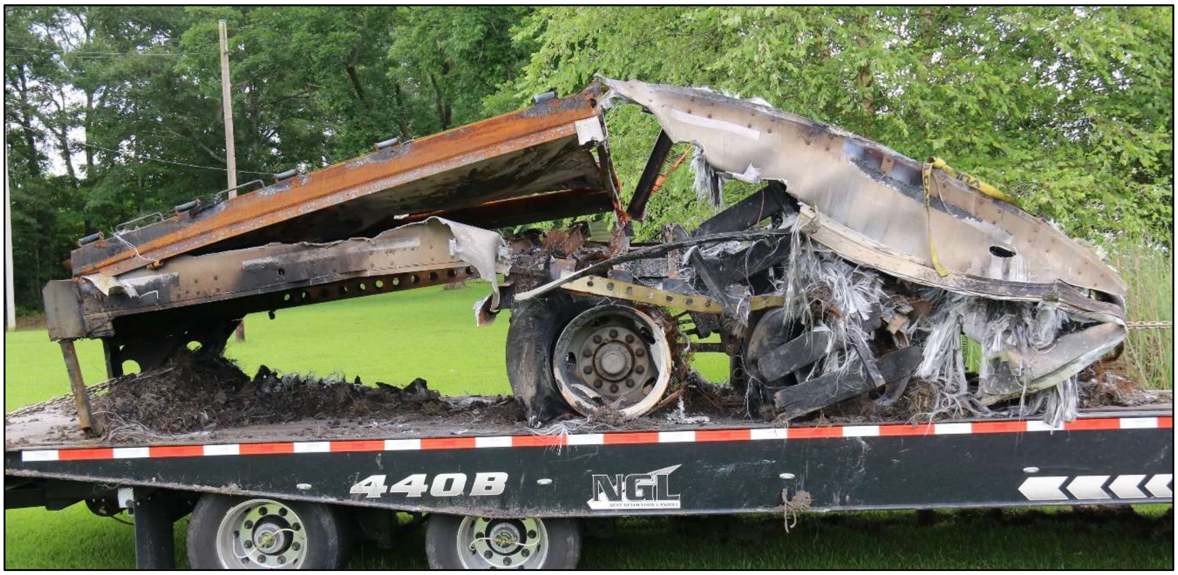

Figure 20: Photograph depicting remnants of the 2009 Wabash semitrailer from the axles rearward as viewed from the right side

While there were insufficient remains of the Freightliner-Wabash combination to discern all potential areas of contact between this and other vehicles, the front bumper and right side of the tractor did exhibit evidence consistent with contact damage. The right end of the bumper outboard of the frame rail connection was bent inward and the lower portion between the frame rails was displaced rearward. The left end outboard of the frame rail appeared undamaged. Limited scene photographs depicting a portion of the right side of the tractor depicts displacement of structures between the cab and front of the trailer including the area likely to have included right-side fuel tank. **Figure 21** is a photograph depicting the front of the Freightliner.

Figure 21: Photograph depicting the front bumper of the Freightliner truck tractor.

At final rest the front of the Freightliner combination was in the median about 135 feet north of the bridge and 30 feet (estimated truck tractor CG) into the median from the northbound roadway pavement edge. The combination vehicle was mostly parallel with the roadways. The vehicle was somewhat parallel with the Volvo combination although the front of the Freightliner was about 26 feet further north of the front of the Volvo. Approximately 10.5 feet separated the two combination vehicles at their closest point. The Ford Transit van was observed wedged between the right side of the Wabash trailer just behind the Freightliner drive axles and the overturned Ford F-150 and left front corner of the Volvo truck tractor. The F-150 was overturned and positioned perpendicular at the front of the Volvo.

3.2.2. 2019 Hyundai Santa Fe

The vehicle was identified as a four-door sport utility vehicle and had been impounded by law enforcement investigators. When examined at the storage facility, it was apparent that the left front tire had been replaced. The lower left front fender trim and front facia just forward of the wheel well exhibited longitudinal scrapes. Similarly, the left rear wheel rim flange and several inches of the wheel spokes radially extending inward from the flange exhibited scrapes and gouges. The damage was consistent with a curb sideswipe contact. **Figure 22** is a photograph of the left side of the Hyundai.

Figure 22: Photograph depicting the left side of Hyundai Santa Fe. The left front wheel has been replaced.

Replacement of the left front tire near the crash site was corroborated by law enforcement investigators who prepared a report stating that the vehicle had sustained wheel damage after the left side wheels made contact with the raised curb adjacent to the left lane on the Pigeon Creek bridge. Video data acquired from a HUB Group truck depicted the Hyundai as having been stopped along the left shoulder about 170 feet north of the bridge rail when the significant collision events began. The video depicts the vehicle's right-side wheels centered within the left shoulder area or slightly closer to the left lane edge line. The left side of the vehicle was in the median. Another passenger vehicle was similarly stopped on the left shoulder and median several vehicle lengths further north of the Hyundai.

Law enforcement site documentation revealed that at some time after the collision events, the Hyundai moved an estimated 180 feet further north along the median.

3.2.3. 2019 Ford F-150 King Ranch Crew Cab

Remnants of the Ford F-150 were recovered from the crash scene and impounded by law enforcement investigators. Examination of the vehicle at the storage facility revealed the vehicle to be inverted and near fully consumed by the post-crash fire. What remained of the front bumper exhibited some deformation damage consistent with direct contact. The aft portion of the longitudinal frame rails behind the rear axle exhibited a vertically downward displacement.

As observed in scene documentation, the F-150 was essentially facing westward (front toward the median) and was situated at nearly a right angle to the front the front of the Volvo truck tractor. UAV imagery depicted the front of the Volvo to be engaged with the forward end (near the front axle) of the pickup truck. While the Ford is estimated to have overturned toward its right side about 135° once the post-crash fire was extinguished, witness imagery taken before the truck was consumed by fire depicts the truck on its right side tilted slightly past 90°.

At final rest, the F-150 was positioned about 109 feet north of the Pigeon Creek bridge. **Figure 23** is a photograph of the vehicle remains while at the towing storage facility.

Figure 23: Photograph depicting the remnants of the Ford F-150 after recovery from the crash site.

3.2.4. 2016 Ram 1500

Remnants of the Ram 1500, a four-door pickup truck, were recovered from the crash scene and impounded by law enforcement investigators. Examination of the vehicle at the towing storage facility revealed the vehicle to be upright but near fully consumed by the post-crash fire. While much of the body sheet metal was intact, evidence of contact damage was apparent at several locations. Contact deformation was visible to the right rear panel rearward of the wheel well. The vehicle front end and both left, and right front fenders exhibited displacement that trended rearward. Similarly, the left-side cab doors exhibited deformation that trended rearward. There was some tearing to the lower section of the left rear cab door and likely displacement of the rear axle.

As observed in scene documentation, the Ram was essentially facing southward in the median partially alongside and parallel with the right side of Freightliner truck tractor. The right front wheel area of the Ram appeared as though it could be in contact with the right front wheel area of the Freightliner. At final rest, Ram was positioned about 132 feet north of the Pigeon Creek bridge and 22 feet into the median from the left pavement edge of the northbound roadway. **Figure 24** is a photograph of the vehicle remains while at the towing storage facility.

Figure 24: Photograph depicting the 2016 Ram pickup after recovery as viewed from the left front.

3.2.5. 2016 Toyota Tacoma towing a light-duty utility trailer

The vehicle was identified as an extended cab SR-5 model pickup truck. When examined at the storage facility the vehicle exhibited contact damage to the right front end consistent with an impact. The damage was concentrated outboard of the approximate longitudinal centerline of the vehicle. The vehicle was outfitted with a typical frame mounted trailer hitch receiver and ball mount (drawbar). Examination revealed that the hitch ball and drawbar had been displaced forward and slightly upward, indicative of a rear-end impact.

As depicted in scene photographs, the Tacoma had been towing an unidentified light duty trailer that was laden with material covered by a tarp. The trailer had been impounded and was briefly examined while stored atop the deck of a rollback tow truck. The trailer was a tandem axle flat deck trailer with low steel perimeter railing and a steel mesh headwall. The trailer exhibited contact damage at the left rear that was indicative of an impact. The A-frame exhibited some deformation rearward of the coupler and some of the cargo had displaced the mesh headwall forward. **Figures 25 and 26** are photographs of the Tacoma and the towed trailer respectively.

As depicted in scene photographs, following the crash events the Tacoma and trailer remained coupled and were stopped on the northbound right shoulder about 166 feet north of the bridge as measured to the estimated center of mass for the pickup truck.

Figure 25: Photograph depicting the 2016 Tacoma pickup as viewed from the right front.

Figure 26: Photograph depicting the light duty utility trailer towed by the Tacoma as viewed from the left rear.

3.2.6. 2017 Kia Sedona (White)

The vehicle was identified as a minivan that was towed and stored by law enforcement investigators. Examination of the vehicle revealed evidence of contact across the full width of the vehicle front end that appeared to be more concentrated to the left side. Along the right of the vehicle there was evidence consistent with a sideswipe contact that extended rearward from the front door to the rear fender. Blue colored material transfer was observed about the middle of the frontal damage.

Law enforcement sUAS photographs depicted the position of final rest for the Kia as being on Pigeon Creek bridge, just north of the mid-point or about 108 feet south of the northern end. The imagery depicts the vehicle as directly behind and in near contact with a blue color pickup truck. **Figure 27** is a photograph depicting the frontal damage to the Kia.

Figure 27: Photograph depicting the left front of the 2017 Kia Sedona.

3.2.7. 2021 Jeep Grand Cherokee

While referenced in the list of vehicles associated with the crash events, the Jeep was otherwise not identified. Law enforcement sUAS imagery does depict a Jeep vehicle having a body configuration consistent with the Cherokee model as stopped on the northbound right shoulder about 350 feet north of the bridge. The aerial images do not depict any obvious damage to the vehicle.

3.2.8. 2004 Honda Odyssey

While referenced in the list of vehicles associated with the crash events, the Honda was otherwise not identified. Terrestrial scene photographs do depict a Honda Odyssey having a body style consistent the 2004 model year as stopped in the median beside the Hyundai Santa Fe at its final position about 350 feet north of the bridge.

The photographs depict contact damage at the right rear of the vehicle. **Figure 28** is a law enforcement photograph of the vehicle.

Figure 28: Photograph of Honda Odyssey, 2004 vintage, stopped in median and exhibiting damage to the right rear. Photograph was provided by ALEA (law enforcement) investigators.

3.2.9. 2011 Honda Odyssey

Although referenced in the list of vehicles associated with the crash events, the Honda has not been otherwise identified.

3.2.10. 2011 Kia Sorento

Although referenced in the list of vehicles associated with the crash events, the Kia has not been otherwise identified.

4. Electronic Data

Vehicle dynamics or performance data, including crash data, can be electronically recorded by numerous methods in varying formats. Data may originate and be recorded within OEM or aftermarket systems and may be stored onboard or external to the vehicle. The vehicles associated with the crash events were classified as both light duty and heavy duty. These vehicles differ in both design architecture and operational characteristics. Subsequent to the crash events, certain vehicle performance data was acquired for analysis. In most instances the data was related solely to the vehicle from which it was acquired and its value regarding other vehicles was of limited value.

4.1. Light Duty Vehicles

With limited exceptions, light duty vehicles (GVWR of 3,855 kg/8,500 pounds or less) manufactured on or after September 1, 2012, if equipped with an event data recorder must comply with rules promulgated under 49 Code of Federal Regulations Part 563. As defined by Part 563, an event data recorder *(EDR) means a device or function in a vehicle that records the vehicle's dynamic time-series data during the time period just prior to a crash event (e.g., vehicle speed vs. time) or during a crash event (e.g., delta–V vs. time)*. The regulations define data elements, sample rate, range, accuracy, and resolution. In most all cases, the light duty EDR function is retained within the vehicle supplemental restraint system (SRS) control module – typically the airbag control module (ACM). EDR records are therefore activated or triggered by sensing within the module. ACM EDR data can generally be read by commercially available equipment although not all vehicles can be accessed by the same equipment. For this crash, law enforcement investigators attempted to image data from those vehicle ACMs that were not destroyed by crash events. Crash survivability is not a requirement of light vehicle EDRs.

In most instances crash data generally depicting the crash pulse and certain precrash data were available from a successful ACM download. Most ACM EDRs are capable of recording multiple events depending upon acceleration direction and magnitude. Events not reaching a threshold for being "locked" can be overwritten by subsequent events of greater magnitude. When data is "locked", subsequent events may not be recorded. As a result, data depicting multiple events may not include all events in the chain of events and may not accurately describe the chronology of the multiple event crash.

Of the 13 light vehicles impounded by law enforcement investigators, the ACM EDRs were successfully imaged for six (6) vehicles. No EDR imaging was possible for the four vehicles that sustained extensive fire damage. The three remaining vehicles were manufactured by Hyundai and Kia that required a different download imaging system that was not immediately available. The Bosch Crash Data Retrieval (CDR) system was used by law enforcement investigators to image the recovered EDR data. The six vehicles for which EDR records were acquired included –

- 2020 Ford Explorer
- 2020 Acura TLX
- 2017 Buick Lacrosse
- 2020 Chrysler Pacifica
- 2017 Toyota Camry
- 2017 Toyota Tacoma

While not all the vehicles experienced a deployment of a supplemental restraints such as an airbag or seat belt pretensioner, impacts to the vehicles were sufficient to activate the data recording. Only a brief summary of the imaged data is provided below, and the individual records should be consulted for specifics.

4.1.1. 2020 Ford Explorer

Two records were recovered. The first record indicated a frontal impact that resulted in a maximum recorded change in velocity of 23.49 mph that occurred over 253.5 milliseconds from time zero or module wake-up.[6] The frontal airbags and knee bolsters deployed during this event at 27- and 24 milliseconds respectively. The frontal airbag second stage deployed at 41 milliseconds. The record indicates that the "wake up threshold" was reached at "time zero."

The second record was recorded as a Side/Rollover event. Longitudinal and lateral accelerometer traces during the second event exhibited numerous occurrences of clipping that result when the sensor range is exceeded. The record indicates that the ACM energy reserve was used to deploy the side curtains about 1.2 seconds after time zero.[7] The roll event was triggered at 1.7 seconds. No system trouble codes (diagnostic trouble codes or DTC) were reported prior to the first event. DTCs related to the body control module and RCM lateral acceleration sensor were reported with the second record but were crash related.

Five (5) seconds of precrash data that conveyed several vehicle system and operational parameters was also retrieved. Select data indicated that at five seconds before time zero the vehicle speed was reported as 81.5 mph. The vehicle service brakes were indicated as "on" at the start of the record, there was no reported throttle application, and the cruise control was not engaged.[8,9] The record indicated that the longitudinal deceleration (braking) continued to increase eventually attaining what can be described as hard braking. At about 3.7 and 3.5 seconds before time zero braking exceeded 0.3g and 0.4g respectively. The antilock braking system (ABS) engaged about 2.9 seconds before time zero. Lateral acceleration – related to steering – began to increase about 2.8 seconds before time zero with increased steering wheel angle recorded between 2.7 and 1.4 seconds. The final indicated speed that appeared reasonably accurate was about 27 mph.

The record indicates the vehicle was equipped with Collision Mitigation by Braking (CMbB) that was enabled but did not engage. As noted in references, "CMbB applies automatic braking when it determines with certainty that a collision with another vehicle is unavoidable in both high and low speed situations. The function assumes the driver has ultimate authority and will not interfere with any potential evasive maneuver initiated by the driver" meaning driver braking input will take priority.

As further described, "Ford's CMbB precrash sensors consist of a camera and radar to sense vehicles on the road ahead and an electronic control unit (ECU), which determines whether a collision is imminent based on the position, speed and direction of other vehicles. Using estimates of collision threat and driver intent, the CMbB system provides driver warning and enhanced brake

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[6] "Time zero" or Event Beginning of any event (First Record or Second Record) is defined as the first algorithm wake up during that event. All the Precrash, At Event, Delta V Data, deployment times etc., are relative to "time zero".
[7] Ford identifies their vehicle airbag control modules (ACM) as "restraint control modules (RCM)."
[8] Service brakes reported as "on" indicates that the brake lamp switch at the foot pedal has been activated. This parameter does not indicate brake system application pressure or force, although this data may be recorded as a separate parameter.
[9] Reporting of precrash data parameters are asynchronous.

control when needed. Depending on speed and road factors, the braking can automatically reduce vehicle speed by five miles per hour or more before an impact."

Regarding occupant seat belt status, the record indicated a "belted" condition for seating positions that included the driver, front passenger, 2nd row driver side, and 2nd row passenger side.

4.1.2. 2020 Acura TLX

One record indicating a rear impact was acquired from the Acura ACM. The data indicate the vehicle was stopped and sustained a rear-end impact that produced a 12 mph change in velocity. As reported, the seat belt pretensioners and side airbags deployed at time 0.[10] The frontal passenger and driver airbags exhibited a stage one deployment 125 and 127 milliseconds later respectively. At the onset of the five second precrash record the vehicle speed was reported as 26 mph although the service brakes and antilock system were active. No throttle application was reported during the five-seconds or precrash data. The indicated speed loss was indicative of emergency braking (averaging about 0.6g). Between three (3) and two (2) seconds before time 0 the vehicle speed was reported as zero, indicating that the vehicle was stopped at least two seconds before being struck.

The record indicates the *Forward Collision Warning* and *Collision Mitigation Braking System* was "on". While the systems were active, "No Warning" was commanded for the Forward Collision Warning alert and the Collision Mitigation Braking System was "Not Engaged" during the five-second precrash period.

4.1.3. 2020 Chrysler Pacifica

The record acquired from the Chrysler reported a total of six (6) events although only three (3) were recorded. While the non-recorded events were associated with the crash events, they were either of lesser severity or were not recorded as a previous event data had been locked in memory. The first event (stored as event #1) indicated a frontal impact that resulted in the deployment of the frontal airbags (53 milliseconds after time 0) and a reported change in velocity of 14.3 mph.[11] Seat belt pretensioners were also deployed during this event. No diagnostic trouble codes were recorded until after the first airbag deployment event. Subsequent DTCs were related to the deployment. The record indicates a time interval of less than five seconds to the next event.

The second record (stored as event #4) exhibited a positive 21.7 mph change in velocity consistent with a rear-end impact. Approximately four (4) seconds separated this event from the

[10] Time 0 is established by whichever of the following occurs first: (1) the change in longitudinal velocity at the SRS control unit equals or exceeds 0.8km/h over a 20ms timeframe; or (2) the change in lateral velocity at the SRS control unit equals or exceeds 0.8km/h over a 5ms timeframe; or (3) the occupant restraint control algorithm is activated; or (4) a commanded deployment of any type of non-reversible deployable restraint device (e.g. airbag or seatbelt pretensioner). If the time to deploy equals 0, then the command to deploy occurred at T0 or the device was not commanded to deploy during the event.

[11] Time 0 is defined as "beginning of the crash event". T0 is the time at which the ACM algorithm is activated, a specific delta-V is exceeded, or a non-reversible restraint device is deployed. Time 0 may be defined differently for front, side, rear, and roll-over events. If multiple algorithm decisions (i.e.: frontal, side, rear and/or rollover) are made before the first recorded event ends, all of those events are part of the same event record and "Time 0" is defined as the "Time 0" from the first recorded event.

previous event. Approximately 1.6 seconds of precrash data for this event indicates that the vehicle speed was 0 mph, and the service braking were active.

The third record (stored as event #5) similarly reported a positive change in velocity of 4.3 mph indicating another impact at the rear of the vehicle. Approximately ½ second separated this event from the previous event. The data indicate a vehicle speed of 0 mph before this vent.

Five seconds of precrash data that preceded the first frontal impact was contained in the record. At five seconds before time 0 the vehicle speed was reported as 83 mph with the service brakes "off". At 4.6 seconds before time 0 the service brakes were "on". At 1.5- and 1.0-seconds antilock brake system engagement and "maximum" braking are respectively reported. The final data reported data sample at 0.1 seconds before time 0 reported the vehicle speed as 30 mph. At 0.9 seconds before time 0 the record indicates *brake intervention* by the electronic stability program. Based on indicated speed loss, the vehicle averaged about a 0.52g deceleration during braking.

While the *Forward Collision Warning System* was reported as "on", data also indicated that it was "present but not tracking" indicating that no objects ahead of the vehicle are being tracked by the system.

4.1.4. 2017 Buick Lacrosse

The imaging report acquired from the Buick reported a total 7 events within the multi-event (dynamic event) counter and provided data for three (3) deployment or deployment threshold events. The sensing and diagnostic module (GM terminology for the airbag control module) has the capacity to store three events. Deployment event records are locked in memory and once the memory space is locked, no additional events or previous events not locked will be retained.

The first record (stored as deployment event counter and multi-event counter #1) was consistent with a rear-end impact that produced a positive or forward change in velocity of 18 mph. As a result of this impact the seat belt pretensioners for the driver and front seat passenger were deployed at 63 milliseconds after time 0 or module "wake-up".[12]

The second event (stored as deployment event counter #2 and multi-event counter #4) was also consistent with a rear-end impact that produced a positive or forward change in velocity of 24.2 mph. The interval between the previous event (not recorded) was 1,830 milliseconds (1.83 seconds), as measured between the start of the two events.

The third event (stored as deployment event counter #3 and multi-event counter #6) was also consistent with a rear-end impact that produced a positive or forward change in velocity of 16.2 mph. The interval between the previous event (not recorded) was 370 milliseconds, as measured between the start of the two events. The data indicate that events of lesser magnitude occurred within very short time periods the recorded events. Diagnostic trouble codes related to the pretensioner deployments during the first event were indicated in records 2 and 3. After the

[12] Time 0 is when the cumulative DV of over 0.8 km/hr is reached within a 20 msec time period in the longitudinal direction for a front/rear event, or within a 5 msec time period in the lateral direction for a side impact event.

initial deployment of the seat belt pretensioners, no additional supplemental restraint deployments were commanded.

Precrash data covering a five second interval were reported for each of the three recorded events. At five seconds before time 0 the reported vehicle speed was 16.8 mph with the service brakes “on”. During the subsequent two seconds the vehicle slowed at a rate consistent with a light braking application (average of about 0.1g). During the subsequent 1.5 seconds, the vehicle continued to slow and came to a stop or 0 mph at 1.5 seconds before time 0. During the final 1.5 seconds of braking, average deceleration was about 0.37g characteristic of hard or emergency braking. The vehicle remained at 0 mph until the rear-end impact.

The five-second precrash data for the second record indicates that an initial speed of 0 mph with the service brakes “on”. Approximately ½ second later (4.5 seconds before record 2 time 0) the service brakes report “off” and the reported speed increases to 19.3 mph. The rate of speed increase would be consistent with a rear-end impact as the rate exceeds the vehicle’s performance capability and the engine RPM does not change. At 3.5 seconds before time 0 the service brakes are indicated as “on”, and at 2.5 seconds the reported speed is again 0. At 2.0 seconds the service brakes are again reported as “off” and the speed increases to 8.7 mph. Again, the rate of speed increase would be consistent with a rear-end impact as the rate exceeds the vehicle’s performance capability. The engine RPM decreases and drops to zero, indicating the engine likely stalled.

The five-second precrash data for the third record overlaps record 2 and reports the vehicle speed decreasing to 0 mph. The engine RPM and throttle remain at zero, indicating the engine had stalled.

4.1.5. 2017 Toyota Camry

The imaged airbag ECU (electronic control unit) acquired from the Toyota Camry reported a total 8 trigger events and provided data for five records – two front/rear, two side and one rollover.[13] The first trigger event (#1) was reported as a rollover indicating some roll toward the driver’s side of the vehicle with a peak roll angle of 1.3°. There was no indication of a trigger threshold event preceding this.

The next recorded event was trigger #4 that reported a positive change in velocity of 5.5 mph indicative of a rear-end impact. The record indicated a previous event that was classified as front/rear. No supplemental restraints were deployed, and no diagnostic trouble codes were identified.

The third record was trigger #6 that was reported as a left side impact with no supplemental restraints having been deployed. Lateral accelerations were mostly positive corroborating a left side impact. The record indicated a previous event that was classified as a side impact. No supplemental restraints were deployed, and the airbag warning lamp was reported as “on”.

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[13] The airbag ECU has two recording pages (memory maps) to store precrash data. Additionally, to store post-crash data, the airbag ECU has two recording pages for each accident type: two pages for frontal and rear crash, two pages for a side crash, and two pages for rollover event. Additionally, the recording trigger judgment threshold value differs depending on the collision type (i.e., frontal crash, rear crash, side crash, or rollover event).

The fourth record was trigger #7 that was reported as a right-side impact with no supplemental restraints having been deployed. Lateral accelerations were mostly negative corroborating a right-side impact. The record indicated a previous event that was classified as a side impact. No supplemental restraints were deployed, and the airbag warning lamp was reported as “on”.

The fifth and final record was trigger #8 that was reported as a frontal impact that created a 5.1 mph change in velocity. No supplemental restraints were reported as having been deployed. The record indicated a previous event that was classified as a side impact. No supplemental restraints were deployed, and the airbag warning lamp was reported as “on”.

Two records containing approximately five (5) seconds of precrash data were acquired from the module. These records preceded trigger events 6, 7, and 8 with events 7 and 8 sharing the same precrash data. No precrash data pages were associated with trigger events 1 and 4. The two precrash records appeared to overlap although the data associated with trigger 6 began about one second earlier. A small discrepancy in the data was observed at time 0 for the first record, although the data indicate a likely impact about this time.

The precrash records indicate an initial speed of about 10.6 mph with some moderate braking with low brake oil pressure indicated. The data indicate some initial alternation between brakes on and off (speed fluctuation appeared relative to brakes “on” versus brakes “off”). Between 4 and 4.5 seconds from the start of the earliest record substantial speed changes appear that reveal acceleration rates inconsistent with vehicle performance capability. Significant changes in steering angle between left and right also occur about this time likely indicating an unwritten event (impact) has occurred prior to time 0. About this time the brakes are reported as “on” and brake oil pressure approaches near maximum value. Reported speed at time 0 for the two records (about 1 second apart) were between 11 and 13 mph.

4.1.6. 2017 Toyota Tacoma

The imaged airbag ECU (electronic control unit) acquired from the Toyota Tacoma reported a total 11 trigger events and provided data for four records classified as two front/rear and two rollover events. The two roll events were identified as trigger events 7 and 8. These two events indicated no reference to any previous event and no supplemental restraint deployments were present.

The other two records were classified as front/rear events and identified as trigger events 10 and 11. Trigger #10 reported a 5.8 mph positive change of velocity indicative of a rear-end impact. Similarly, trigger event #11 reported a 7 mph change in velocity, also indicative of a rear-end impact. No supplemental restraints were deployed, and no diagnostic trouble codes were reported.

Two records containing approximately five (5) seconds of precrash data were acquired from the module. These records were associated with trigger events 10 and 11, the two rear-end impacts. No precrash data pages were associated with the rollover classified events. The two precrash records did not overlap and appeared separated by about 6.5 seconds. The precrash data for trigger 11 (more recent) reports a vehicle speed of zero with no engine RPM indicating the vehicle was likely stalled and stopped. Trigger event 10 reported an initial speed of 6.2 mph for the first two seconds, followed by a decrease to 5.6 mph. The engine RPMs are reported as zero indicating the vehicle engine was likely stalled.

4.2. Heavy Vehicle Data

Electronic event data recorded in heavy vehicles is not standardized and if event or vehicle performance data is recorded it can be in a proprietary format. A typical source of event data is the electronic engine control module (ECM) associated with most heavy-duty diesel engines.[14] In this crash both heavy vehicles sustained intense fire damage that destroyed the engine ECM and any opportunity to recovery any possible stored data. Both vehicles involved in this crash utilized third party telematics systems that were able to transmit certain vehicle performance data to their respective carriers. NTSB investigators were able to acquire some of that data to assist with the investigation.

4.2.1. 2020 Volvo VAH truck-tractor in combination with 2020 Cottrell CX-09LSFA auto hauling semitrailer

During the initial phase of the investigation representatives of the motor carrier provided NTSB investigators with a 10 second video depicting forward-facing imagery from a perspective that appeared consistent with being mounted relative to the upper middle portion of the windshield. The video depicted approximately five (5) seconds of imagery before the combination unit struck the Ford Explorer - the first vehicle it made contact with – and continued for five (5) after that contact. The video was the product of an event notification from a telematics system that had been in operation aboard the vehicle.

The carrier had subscribed with Samsara to provide certain fleet management products which included the forward-facing camera and telematics capability to communicate certain data including event notification. In a general description, the system includes an internet-connected forward-facing camera system with a high-definition camera and a vehicle gateway module. The gateway module provides the telematics cellular communication, includes a GNSS-GPS receiver, and may be configured to interface with other vehicle systems via SAE J1939 communications protocol. As part of the subscription service, Samsara provided an internet-based dashboard through which the carrier could access any data transmitted from the vehicle – including this collision event.

The video display included a date and time counter (hh:mm:ss CDT), vehicle speed and representative roadway speed limit. Information conveyed to NTSB investigators was that the time displayed indicated the time the data was transmitted by the gateway module and the displayed speed was extracted from the engine ECM. The video and some subsequent data were transmitted via cellular service automatically when a prescribed event threshold was met.

Event trigger thresholds were generally described in terms of acceleration and included harsh braking, turns, throttle acceleration and "crash". The crash event trigger threshold was preset

[14] Event data can typically refer to hard braking (sudden decelerations), last stop records or fault codes. When events are triggered, data such as vehicle speed, throttle, engine RPM, etc. may be recorded in a time series format associated with the event.

and is proprietary to Samsara. Harsh braking and turning thresholds can be user defined and were reported as 0.47g and 0.32g respectively, for this vehicle. The crash event threshold was not disclosed.

Other data sent in addition to the video imagery included position information (GPS – latitude and longitude), accelerator pedal position and brake lamp switch activation. This data covered about 56 seconds between 14:20:53 and 14:21:49.[15] As previously mentioned, the position data originated in the gateway module. The accelerator pedal position, ECU speed and brake switch data originated with the engine ECM. While this data was provided as time-series, it was communicated asynchronously. Review of the data also substantiated that the vehicle position data (lat/lon) updated every 5-6 seconds while the other data was reported at one-second intervals. The video data conveyed that the impact with the Ford occurred about 14:21:36-14:21:37 hours.

The data supplied, absent the position coordinates, is combined graphically in **Figure 29**. As depicted in the graph, the speed sources – GPS, engine ECM and video display – exhibit a divergence as braking progresses.

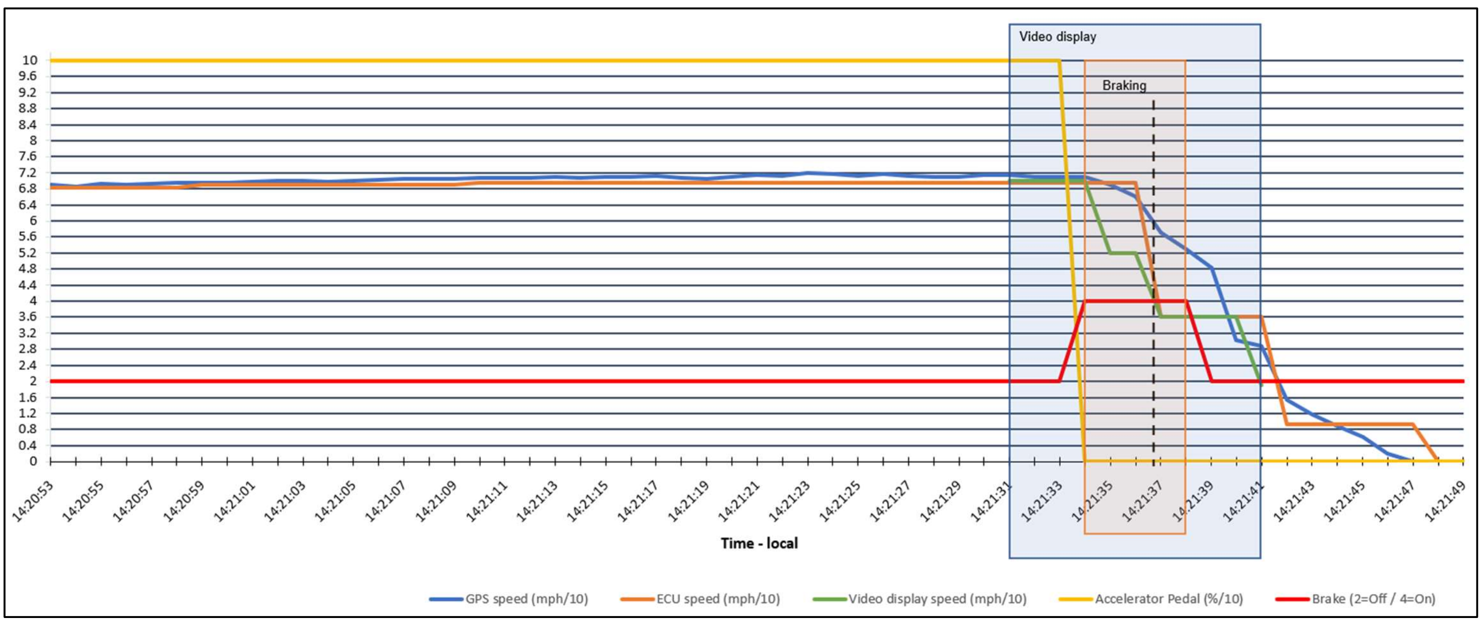

Figure 29: Graphical depiction of certain time-series data received via the telematics system and provided by the carrier.

Additional information regarding the forward-facing video is available in two reports prepared by the NTSB Office of Research and Engineering titled *Video Study* and *Onboard Image Recorder – Outward Facing Video Specialist's Factual Report*.

[15] Time was converted from PDT, as reported, to CDT.

4.2.2. 2005 Freightliner Cascadia truck-tractor in combination with 2009 Wabash National Corporation van trailer

During the investigation NTSB investigators received certain hard copy records related to carrier operations for the Freightliner combination. Of interest were certain data dated the day of the crash titled Battery Health. The data entries included date, time, location (relative address), position (latitude/longitude), "status", speed, heading (cardinal or intercardinal direction), and battery voltage. The data reported at intervals between 2 and 173 seconds (2m:53s). Additional document labeling indicated the data was likely part of the ELD telemetry that was sent by the vehicle to the carrier. The document indicated the system was managed by LB TECHNOLOGY INC., a Memphis-based fleet services software company providing transportation technology systems. No additional information was available.

On the day of the crash, the record indicated an "ignition on" status for the Freightliner at 09:44:32.[16] At 10:14:22, vehicle status indicates a heading change, and the truck appears to begin the trip for the day. About 12:23 the vehicle enters I-65 northbound from I-10. While traveling north on I-65, the data indicate the vehicle traveled at an average speed of 69.3 mph. The highest speed sample recorded was 75 mph, which appeared about 55 minutes before the crash. In total, the truck had been traveling on I-65 for about one hour, 57 minutes before the crash. While the low rate of data reporting was insufficient to assess the speed of the vehicle as it approached the crash site, the last reported speed consistent with a free-flowing travel appeared about two minutes before the crash with a reported speed of 73 mph.

At 14:21:41 the record indicates the status as "EMERGENCY CRASH ALERT!!!!" Approximately three seconds preceding this entry was a status of "Cornering." The position coordinates placed the crash alert about 150 feet from the northern end of the Pigeon Creek bridge in the highway median. The "cornering" position entry was observed to be just south of the northern end. Both locations were established using the reported position (lat/lon) coordinates with Google Earth.

4.3. Witness Video Data

During the investigation a commercial vehicle driver with Hub Group, Inc. was identified as a witness and subsequently interviewed by NTSB investigators. In his statement, the driver described traveling northbound toward the Pigeon Creek bridge during a light but constant rainfall. As he approached the bridge, he described visual atmospheric conditions that appeared as fog or a mist, such as that rising from tires, that initially obscured the recognition of taillights on vehicles ahead. As he neared the bridge vehicle tail and brake lamps became visible or recognizable. He recalled seeing a vehicle ahead of him swerving from lane to lane and traffic slowing rapidly. After crossing the bridge, he observed (by looking in truck mirrors) vehicles behind him begin to collide. Shortly after there were multiple collisions a small fire began which quickly grew in size.

The Hub Group truck was outfitted with a SmartDrive System that included a forward-facing video camera. The company provided investigators with a 30-second video clip that began about 9 seconds before the truck reached the bridge. While the video depicted a field of view

[16] Time was converted from EDT, as reported, to CDT.

forward of the truck, no additional operational data (e.g., real-time clock, vehicle speed, etc.) were displayed. The imagery did have a time and date saved watermark.

As lead vehicles become recognizable within the video several can be observed to be slowing rapidly with one passenger car suddenly entering the truck's lane of travel (right lane) while another vehicle appeared to be fishtailing between lanes on the bridge. The Hub Group truck noticeably slows, and it appears that a pickup and U-Haul rental truck engage in minor contact in the left lane as they pass the truck. After crossing the bridge, the Hub Group truck pulls to the right shoulder and stops. Simultaneously the pickup and U-Haul trucks are observed pulling onto the left shoulder and median.

Using the proprietary SmartDrive company portal and software dashboard, Hub Group was able to provide additional data and more succinct timing. That data indicated the video segment started about 9.25 seconds before the truck reached the bridge. As the truck reached the bridge it had slowed to about 43 mph, was braking and had attained a deceleration rate of 0.25g. As it reached the north end of the bridge, the truck speed had decreased to 14 mph and the separation of traffic ahead was increasing. About 24 seconds after the start of the video the Hub Group truck passed the Hyundai Santa Fe and another vehicle, both of which were stopped on the left shoulder and median. Within 30 seconds from the start of the video the truck had come to a stop on the right shoulder. By this time, the driver reported that numerous collisions, including those involving the other combination vehicles, had already occurred.

D. REFERENCES

- NTSB Highway Factors Group factual report
- NTSB Vehicle Factors Group factual report
- NTSB Video Study report

E. DOCKET MATERIAL

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

None

END OF REPORT

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/