National Transportation Safety Board
Office of Highway Safety
Washington, DC 20594

HWY23MH004

TECHNICAL RECONSTRUCTION

Group Chair's Factual Report

October 17, 2023

TABLE OF CONTENTS

A. CRASH INFORMATION

Location: Williamsburg, York County, VA
Date: December 16, 2022
Time: 1:36 am EST
Vehicles: 2022 Freightliner Cascadia truck tractor with 2020 Great Dane semitrailer
2000 International bus

B. TECHNICAL RECONSTRUCTION GROUP

Group Chair — Robert Squire
National Transportation Safety Board
Office of Highway Safety
Washington, DC

Group Member — Eric Gregson
National Transportation Safety Board
Office of Highway Safety
Washington, DC

C. SUMMARY

For a summary of the crash, refer to the Crash Summary Report, which can be found in the NTSB public docket for this investigation.

D. DETAILS OF THE INVESTIGATION

The Technical Reconstruction Group was convened for this investigation to assist with providing on-scene documentation of the crash location and the involved vehicles; and to facilitate an analysis of certain collision events and causation factors. In support of these tasks the group relied upon information, data and documentation provided by the Virginia State Police (VSP) and Virginia Department of Transportation (VDOT). Factual reports prepared by other NTSB investigative groups should be consulted for information related to other aspects of the investigation, including information referenced within this report.

The crash involved the collision of two commercial motor vehicles, a 2022 Freightliner Cascadia truck tractor in combination with a 2020 Great Dane semitrailer (Freightliner combination) and a 2000 International 3400 chassis upfitted with an Eldorado bus body (Eldorado bus). Following the initial impact, both vehicles departed the roadway and entered the highway median.

The highway and vehicles were examined during the week of December 18, 2022. This report will focus on factual information and data acquired by the group.

1.0 Introduction, Crash Location and Documentation

The crash events occurred on the eastbound roadway of Interstate 64 (I-64) near mile marker 240.4 just west of the Lakeshore Drive/Colonial National Historic Parkway overpass and northeast of the Williamsburg, VA city limits (see **Figure 1**). While I-64 is designated as an east-west highway, through the area of the crash the eastbound roadway exhibits a heading of about 140° south-southeast. The collision occurred on a tangent segment of the highway with an ascending grade of 2.96% that began about 1,188 feet west of the initial area of impact. The eastbound roadway has three travel lanes as well as left- and right-side contiguous shoulder areas. On approach to the overpass the left shoulder pavement and median were separated by a W-beam guardrail.

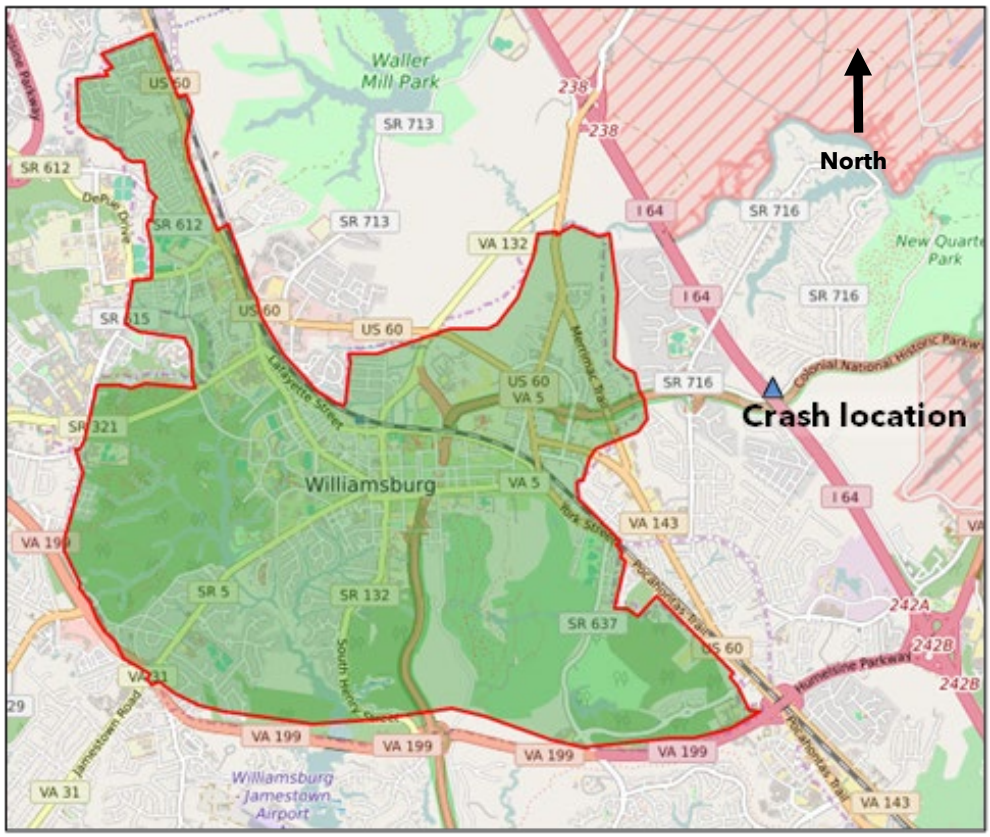

Figure 1: Area map depicting Williamsburg city boundary relative to the crash location (source Williamsburg zip code map by Zipdatamaps).

The east- and westbound roadways are divided by an earthen median that in the area traversed by the Freightliner combination have descending embankments from the respective roadway pavements thereby creating a wide ditch at the bottom. The descending embankment from the eastbound roadway exhibits a slope of about 24° and descends about 8½ feet below the left shoulder pavement edge. At this location, the westbound roadway is about five feet lower than the eastbound roadway. The overall median width in this area measured about 44 feet.[1] **Figure 2** depicts a cross section of the 3D point cloud.

Figure 2: Cross-sectional image of median within the area traversed by the Freightliner combination as rendered in the 3D point cloud.

Additional highway details are available in the NTSB *Highway Factors Group Chair* factual report.[2]

1.1 Post-Collision Scene Documentation and Roadway Evidence

When examined by NTSB investigators, the roadway pavement surface in the collision area exhibited light scrapes and scratches superimposed with intermittent darker scuff marks consistent with tire friction marks. These surface marks were discernible beginning in the center travel lane and angled eastward toward the left shoulder. Painted reference marks applied by VSP investigators highlighted the path of the surface marks. The surface marks continued across the travel lanes and left shoulder where they terminated and transitioned to surface furrows in the median.

The approximate area of initial impact between the two vehicles was identified as having been in the right travel lane about 381 feet west of the Lakeshore Drive/Colonial National Historic Parkway overpass based on an analysis of the forward-facing video acquired from the Freightliner (see NTSB *Video Study* for methodology). Consequently, the initial area of impact was identified as being about 70 feet further west of the discernible roadway marks.

[1] Unless otherwise noted, all measurements have been rounded to the nearest whole foot.
[2] At the time of the crash, the highway environment was dark with no supplemental lighting. Light rain precipitation and mist were reported. As reported and observed in law enforcement scene photographs, the road and median surfaces were wet.

The pavement marks diverged along two paths as they crossed into the left travel lane. The trajectory of one path, consistent with that of the Eldorado bus, ended at an area of guardrail deformation consistent with an impact. Within this deformation was evidence of black colored material transfer. About 14 feet east of this impact area the guardrail was displaced (separated), and soil furrows appeared in the median beginning at the pavement edge. Following the trajectory of these surface marks, the guardrail impact occurred about 144 feet from the area of initial impact. The visible road surface marks indicate an angular heading of 30-35° relative to the guardrail.

The second path of roadway surface marks continued further eastward until they crossed onto the left shoulder and transitioned to surface furrows in the median about 268 feet from the initial area of impact. The heading of the marks relative to the guardrail was about 18-21°. These marks and the subsequent furrows through the median were consistent with the path of travel for the Freightliner combination.

Approximately 190 feet of the median guardrail was fully displaced from the vertical support posts beginning about 51 feet west of its anchorage point with the concrete overpass rail. Scene photographs provided by VSP investigators depict a continuous segment of guardrail draped across the forward cab and engine compartment of the Freightliner truck tractor and trailing back across the median. The guardrail remained connected at the eastern end. Several vertical support posts were bent toward the median in a manner consistent with having been overrun by the Freightliner combination.

The median surface exhibited soil furrows consistent with both vehicles having departed the pavement and entered the median after the guardrail had been displaced. The western most area of furrows were consistent with the Eldorado bus having rotated as it entered the median and were consistent with VSP scene photographs. The Freightliner combination continued along an angled trajectory (averaging about 27° relative to the roadway) across the median over a distance of about 140 feet before coming to rest against the backside of the westbound roadway median guardrail (just west of the westbound roadway bridge rail).

The site was photographically documented using a small unmanned aerial system (sUAS, i.e., aerial drone) that were processed using Pix4DMapper photogrammetry software from which a three-dimensional point cloud and orthomosaic image were rendered for analysis.[3] The overall project covered about 1,100 feet of the eastbound roadway, median and part of the westbound roadway.

[3] Pix4DMapper is a photogrammetry software package designed to use overlapping photographic images to generate 3D point clouds. Additional outputs from the generated point cloud include 3D models (textured mesh), digital surface and terrain models, and 2D orthomosaic maps. An orthomosaic is an image with high detail and resolution made by combining many smaller images and is corrected for lens distortion, camera tilt, perspective, and topographic relief.

Figure 3 is a screen capture of the rendered orthomosaic map focusing on the area of the collision. **Figures 4 and 5** depict cropped images to illustrate greater detail.

Three-dimensional scanning was completed using the FARO Focus3D X330 laser scanner. Documented subjects included the median area where the two vehicles had come rest and the two vehicles. The scans were rendered into three-dimensional (3D) point clouds using FARO Scene® software for further analysis.

Figure 3: Screen capture depicting a portion of the photogrammetry project orthomosaic image capturing road surface and median evidence as well as the displaced eastbound shoulder guardrail.

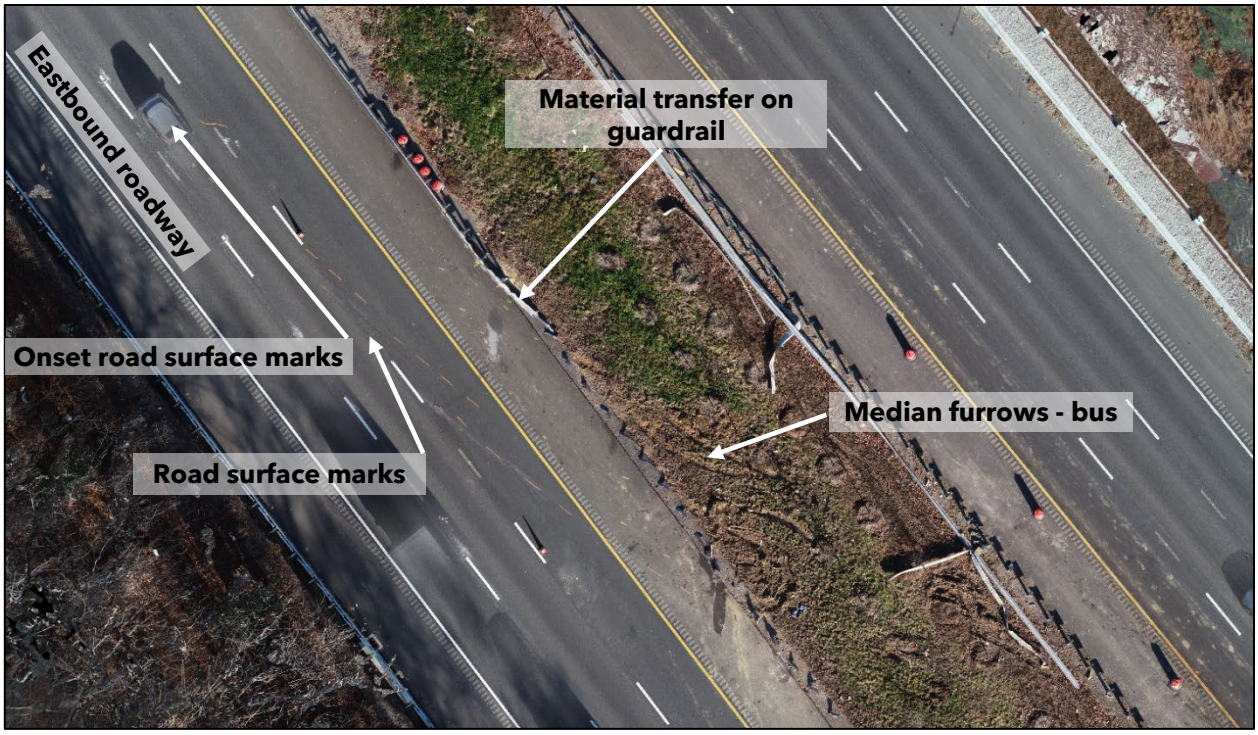

Figure 4: Screen capture depicting a cropped portion of the photogrammetry project orthomosaic image highlighting initial road surface and median evidence at the crash location.

Figure 5: Screen capture depicting a cropped portion of the photogrammetry project orthomosaic image highlighting median evidence and displaced guardrail further east at the crash location.

As identified through median surface furrow evidence and VSP scene photographs, both vehicles came to final rest in the median. As measured to its approximate CG, the Eldorado bus came to rest about 217 feet southeastward from the initial area of impact and about 72 feet from the guardrail contact evidence. At final rest, the bus exhibited a heading of about 150° relative to its original heading on the roadway.

As measured to the front of the truck tractor, the Freightliner combination came to rest about 413 feet southeast of the initial area of impact. The vehicle had departed the roadway pavement and entered the median about 129 feet before coming to a stop. At final rest, the combination vehicle was essentially parallel to the highway with the truck tractor angled such that the left front wheel occupied the westbound roadway left shoulder. The trailer remained off the pavement but had rolled partially toward the left (driver's) side. The front of the truck was entangled with both shoulder guardrails from the east- and westbound roadways. Although partially displaced from several vertical support posts, the westbound roadway shoulder guardrail remained anchored and exhibited evidence of having restrained the truck from additional forward travel. **Figure 6** is a screen capture of the orthomosaic map depicting the positions of rest for both vehicles.

Figure 6: Screen capture depicting a cropped portion of the photogrammetry project orthomosaic image highlighting the vehicle positions of rest.

During the collision event, the three fatally injured occupants of the Eldorado bus were ejected and came to rest on the surface of the eastbound roadway. Those locations were identified by roadway evidence and are depicted by red circles in **Figure 7**.

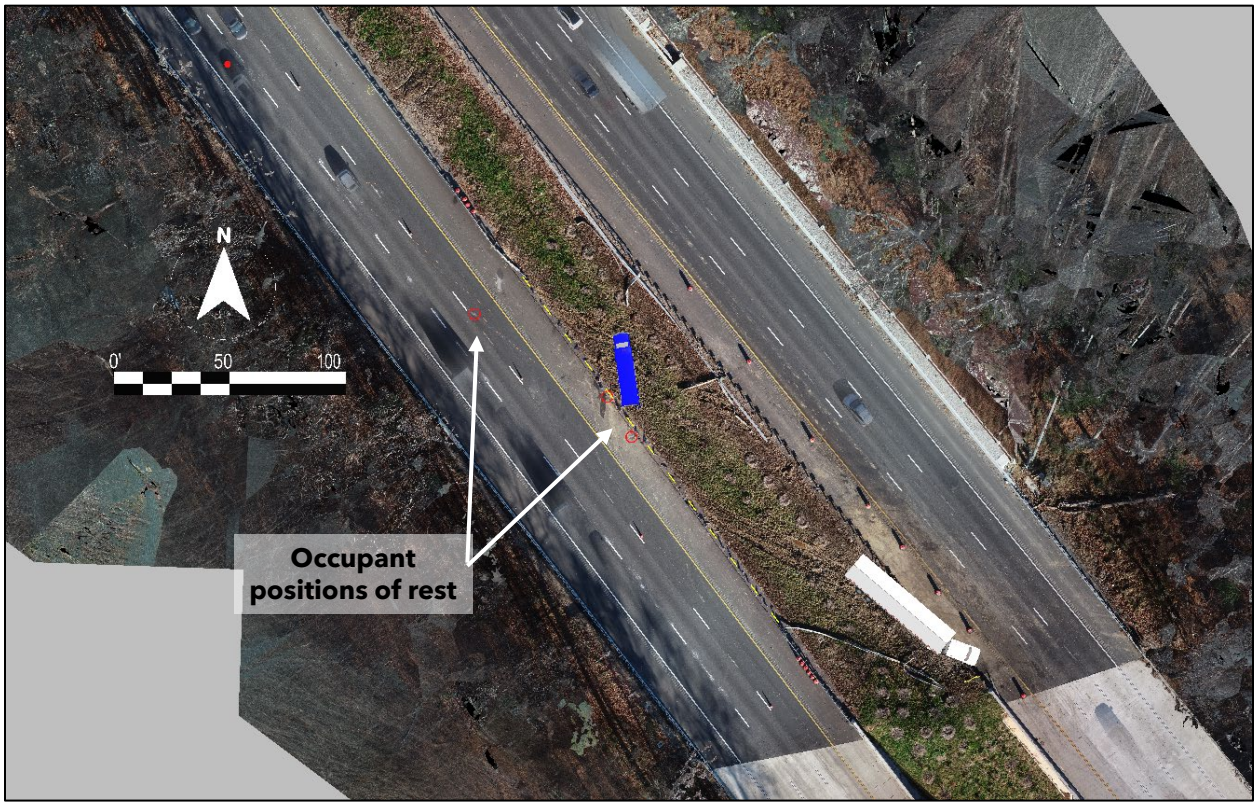

Figure 7: Screen capture depicting a cropped portion of the photogrammetry project ortho image highlighting the vehicle and ejected occupant positions of rest.

Evidence for the western-most occupant was located in the left travel lane about 25 feet from the pavement edge and eight feet southward from the guardrail impact evidence. The second and third occupants were located on the left shoulder near the pavement edge about 71 and 91 feet southeastward from the guardrail impact evidence.

2.0 Vehicles

2.1 Freightliner Combination Vehicle

The truck tractor exhibited evidence of contact damage along both sides of the cab consistent with fixed object impacts and at the front consistent with a vehicular impact. Frontal impact damage exhibited more substantial component displacement at the left (driver's) side, consistent with an offset impact. Post-collision scene

photographs depicted considerable interaction between the vehicle and left shoulder guardrails for both the east- and westbound roadways. Black colored material transfer was also discernible along the driver's side A-pillar.

As observed at the storage facility, the van body semitrailer had separated at the trailing end of the king pin plate. The king pin plate and portions of the trailer lower sidewall frame remained coupled to the truck tractor. While the original length of the semitrailer was 53 feet, post-recovery the trailer measured no more than 36 feet in length. In addition, deposits of material consistent with biological material were observed on the left side of the semitrailer at the aft corner sidewall vertical support.

At the time of the collision the combination vehicle was transporting cargo. Based on bill of lading documents and vehicle manufacturer data, the total weight of the unit is estimated at 76,000-79,000 pounds.

The Freightliner truck tractor and Great Dane semitrailer were scanned from which a 3D point cloud was rendered. **Figures 8** and **9** are screen capture images depicting images of the rendered point clouds.

Figure 8: Screen capture depicting an oblique view of the Freightliner truck tractor 3D point cloud.

Figure 9: Screen capture depicting a left side view of the Great Dane semitrailer 3D point cloud.

Refer to the factual reports prepared by the NTSB *Survival Factors Group* and *Vehicle Factors Group* for additional information concerning the combination vehicle.

2.2 Eldorado Bus

Prior to examination and 3D scanning, the bus chassis, an International 3400, had been cleared of most loose debris and the interior seating repositioned by NTSB investigators for inspection. The bus body (sidewalls and roof), identified as having been manufactured by ElDorado (formerly ElDorado National Co.), had separated completely from the chassis, and was essentially destroyed. The bus exhibited areas of contact damage at the front, consistent with a fixed object impact and at the rear consistent with a vehicular impact. Impact damage at the rear exhibited more substantial component displacement at the right (passenger's) side, consistent with an offset impact. A portion of the bus body rear vertical wall that included the rear identification lamps and right-side rear clearance lamp near the roof line exhibited evidence of vertical scrapes and paint scuffing.

Figure 10 is a screen capture depicting an oblique image of the 3D point cloud.

Figure 10: Screen capture depicting an oblique view of the Eldorado bus 3D point cloud

2.3 Point cloud orientation

Alignment of the Freightliner and Eldorado bus point clouds corroborated an offset impact orientation as depicted in **Figure 11**.

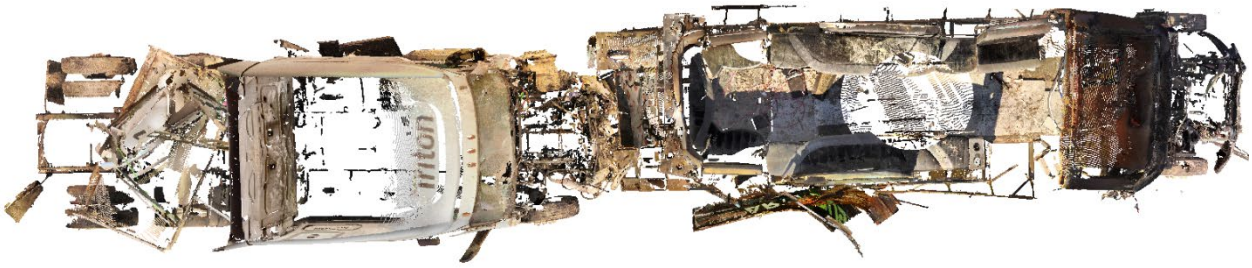

Figure 11: Screen capture of the alignment of areas of contact for the Freightliner and Eldorado bus.

3.0 Electronic Data

3.1 Freightliner truck tractor electronic control module data

As referenced in the NTSB Vehicle Factors Group Chair factual report, the Freightliner was powered by a Detroit Diesel Corporation DD-15 diesel engine that is electronically managed by multiple electronic control modules (ECMs). Peripheral to engine management and operation, these various electronic control modules

communicate certain data related to engine usage, fault codes and event data that may be stored and later retrieved. On January 13, 2023, the requisite combination of ECMs were transported by NTSB investigators to Detroit Diesel Corporation (DDC) to facilitate imaging of any stored data. Using standard, commercially available DDC software (DDEC Reports and Diagnostic Link) the stored data was imaged and supplied to investigators as native data files and preformatted (PDF) reports.

The Diagnostic Link software provided certain data related to engine ECM configuration and programming while the DDEC Reports software provided data related to certain engine and transmission usage and events related to a last stop record, hard brake record, and diagnostic or fault code records.[4] The event records are reported as time-series data and can include up to two hard brake events, one last stop event, and three most-recent diagnostic trouble code (DTC) conditions or events. Engine use data can include certain daily engine use activity, histograms related to engine load, engine speed, idle time, speed range, etc., a three-month engine use summary, certain configuration and life-to-date data. The Diagnostic Link software will access data that includes ECM calibration, audit trail, ECM and engine configuration, and additional fault code information.

Recovered event data related to the crash included the last stop record (LSR). The two hard brake records preceded the crash by two days and more than 935 miles, while the two diagnostic fault records were identified as invalid or triggered after the system was repowered following the crash. While certain engine and transmission usage data exhibited incomplete entries, this data is disassociated from the last stop event and was otherwise consistent with known reporting issues.

Last stop events are reported as time-series data that is typically triggered when the vehicle speed decreases from a speed above 1 km/hour (0.62 mph) to less than or equal to 1 km/hour. The record contains 104 seconds of data that preceded the LSR trigger to which 15 seconds of post-trigger data is added, resulting in a total of 120 seconds of data reported at one-second intervals. The second possible situation to trigger a last stop is if the vehicle speed is greater than 1 km/h and the ignition on status becomes no longer true. In this case, the LSR incident record is saved with no 15-second post trigger buffer. This is likely what occurred in the accident involving the Freightliner as the vehicle speed does not decrease to 1 km/hour or less in the LSR. In this case the data recording continues, utilizing what would typically be the 15-second post trigger buffer. This resulted in 120 seconds of recorded data that ceased when the ECM memory was full.

During examination of the truck, NTSB investigators observed a separation of the main battery cable that fed the Battery Cable Access (BCA) box (a power

[4] The threshold for a *Hard Brake* event trigger was set for a minimum braking deceleration rate of 7 mph/sec or about .32g.

distribution/fuse box) located on the passenger side firewall. The cable exhibited additional areas of damage – cuts and abrasions – to the sleeving and insulation. Although the cable was completely severed upon examination, the tow operator recalled observing electrical arcing in this area as recovery operations were commencing. Police scene photographs depict the guardrail that was carried by the Freightliner as having wrapped across the front of the tractor, displacing the hood, and overlaying the engine. Toward the passenger side of the tractor the guardrail made contact with the lower portion of the firewall and passed between the cab and upper surface of the fuel tank. The main battery cable and BCA are located in this area of the firewall and appear to have been compromised by the guard rail, likely leading to a power interruption that was interpreted by the engine ECM as a change in "ignition on" status thus triggering the LSR[5]. **Figure 12** depicts the Freightliner at its position of final rest with the guard rail wrapped across the engine.

[5] The firewall in the area of the damaged battery cable also exhibited deformation consistent with the edges of the guard rail.

Figure 12: Photograph provided by VSP investigators depicting the Freightliner truck tractor at its position of rest at the crash scene depicting the W-beam guard rail uprooted from the eastbound roadway draped across the engine compartment. Circle "A" indicates the position of the Battery Cable Access (BCA) box while circle "B" highlights a portion of the battery cable that ascends the firewall to the BCA.

Data reported with the last stop event included vehicle speed (mph), engine speed (revolutions per minute-RPM), brake (signal lamp switch activation), clutch (pedal switch activation), percent engine load, percent throttle, cruise control ("on"/"off") and fault code (present "yes"/"no"), reported at one second intervals. Generally, what the recorded data indicated during the 120 seconds (2 minutes) was that the Freightliner was traveling at a relative constant speed, averaging about 68 miles per hour (ranging between 65 and 70 mph) with the cruise control active. Engine load, engine RPM and speed fluctuation appeared consistent with vertical changes in grade (e.g., engine load and RPM decrease while descending a grade as speed increases). Further corroborating cruise control activation was a constant zero percent throttle pedal application. Braking is not indicated until the final data sample, which when aligned with data acquired from the Samsara camera system appears at about or immediately following impact with the Eldorado bus. No DTCs were reported in the LSR.

Figure 13 graphically depicts the DDEC Report data table – note that brake status was assigned an arbitrary value on the secondary vertical axis to be depicted as "on" or "off" ("off"=1, "on"=0); the cruise control status is similarly depicted on the secondary axis where "on" equals 0. An image of the data table is presented in an appendix to this report.

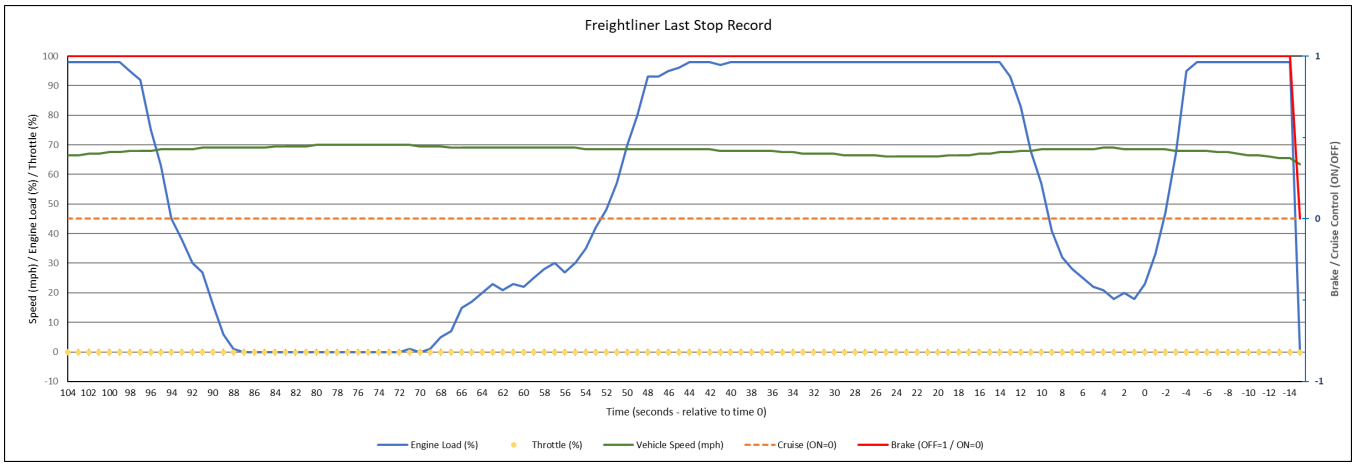

Figure 13: Graphical depiction of Freightliner *Last Stop Record* data.

Figure 14 depicts a similar graphical depiction of certain DDEC LSR data overlaid atop the highway vertical profile (solid black line) as depicted in plans provided by VDOT.

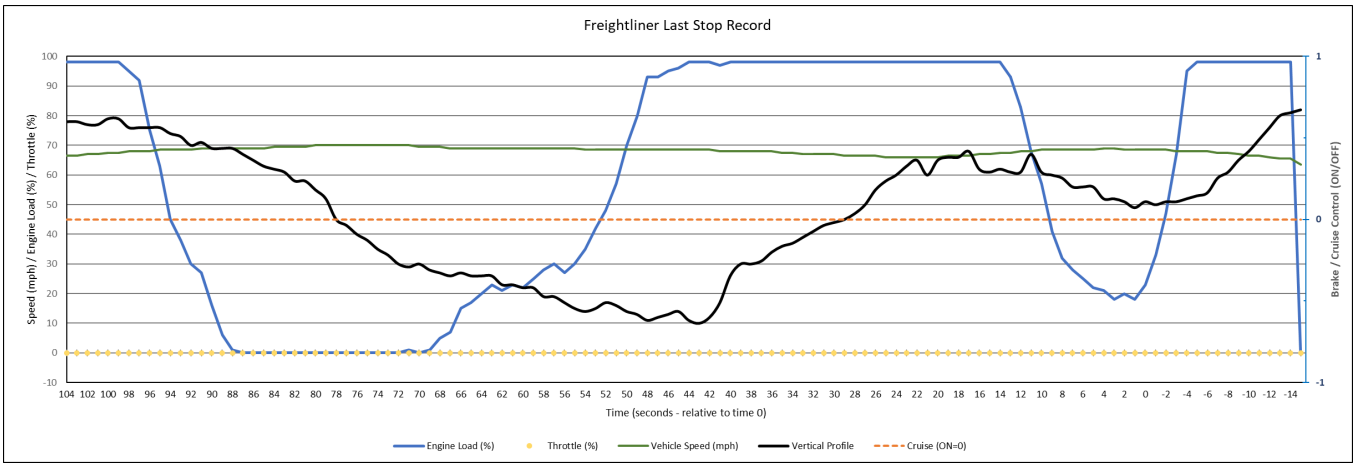

Figure 14: Graphical depiction of certain Freightliner *Last Stop Record* data overlaid atop the highway vertical profile (solid black line).

Some inconsistent data separate from the LSR appeared in other sections of DDEC report. Certain issues of missing or repeated data were observed under sections such as Daily Engine Use and Monthly Activity, although such occurrences were

acknowledged by DDC as recurrent issues that did not otherwise affect the validity of the LSR or other reported data. The two DTC records indicated in the DDEC report were identified as unassociated with the operation of the vehicle. One occurred during the post-collision imaging of the modules while the other was an invalid code.[6]

3.2 Freightliner truck tractor Samsara telematic fleet management system

At the onset of the investigation, NTSB investigators learned that the Freightliner truck tractor was outfitted with components of a fleet management system manufactured by Samsara, Inc., that included a Samsara CM31 forward-facing high-definition camera connected to a gateway module. The gateway module provided telematics cellular communication, included a GNSS receiver, and could be configured to interface with other vehicle systems via SAE J1939 communications protocol. As part of a subscription service, Samsara provided an internet-based dashboard through which the carrier could access data transmitted from the vehicle – including certain data when programmed "event" thresholds were met.

While system configuration information was unavailable from the motor carrier, Samsara had previously described event triggers in terms of acceleration that could include braking, turns, throttle acceleration and "crash". While braking, turns and throttle acceleration are defined as user defined, the "crash" event trigger threshold was defined as preset and proprietary to Samsara. When a triggered event threshold is met, the configured data is sent via wireless communication through the customer portal where it is reported as time series.

The carrier conveyed the receipt of certain data – a time series event record labeled as an incident report - following the crash, although the triggering event was not defined. That record was provided to NTSB investigators as a .csv file that included:

- Date and time (CST zone)
- General location description
- Latitude and longitude
- Heading
- GPS speed
- ECU speed
- Cruise control
- Brake
- Accelerator pedal input percent

Although communicated asynchronously, the event data was reported at distinct one-second intervals, although data for the last three parameters – cruise

[6] Data reported through the Diagnostic Link software indicated the presence of some DTCs that preceded the crash and occurred at imaging, but none were associated with the crash

control, brake, and accelerator pedal percentage – were reported as "N/A". As system configuration information was unavailable, it is unknown whether these parameters were programmed or if a fault occurred. The geographic positions (latitude and longitude) were updated every 5-6 seconds. **Table 1** depicts the reported event data in tabular format.

Table 1: Samsara event record data depicted in tabular format.

Time (CST)	Location	Latitude	Longitude	Heading (deg)	GPS Speed (mph)	ECU Speed (mph)	Cruise Control	Brake	Accelerator Pedal %
0:35:53	I 64, Parkway Estates, VA, 23187-1776	37.28223566	-76.66760768	144	67.9	68.4	N/A	N/A	N/A
0:35:54	I 64, Parkway Estates, VA, 23187-1776	37.28223566	-76.66760768	144	68	68.4	N/A	N/A	N/A
0:35:55	I 64, Parkway Estates, VA, 23187-1776	37.28092775	-76.66637721	140.8	67.4	68.4	N/A	N/A	N/A
0:35:56	I 64, Parkway Estates, VA, 23187-1776	37.28092775	-76.66637721	140.8	67.5	68.4	N/A	N/A	N/A
0:35:57	I 64, Parkway Estates, VA, 23187-1776	37.28092775	-76.66637721	140.8	67.5	68.4	N/A	N/A	N/A
0:35:58	I 64, Parkway Estates, VA, 23187-1776	37.28092775	-76.66637721	140.8	67.2	67.7	N/A	N/A	N/A
0:35:59	I 64, Parkway Estates, VA, 23187-1776	37.28092775	-76.66637721	140.8	67	67.7	N/A	N/A	N/A
0:36:00	I 64, Parkway Estates, VA, 23187-1776	37.28092775	-76.66637721	140.8	66.5	67.1	N/A	N/A	N/A
0:36:01	I 64, Parkway Estates, VA, 23187-1776	37.27971456	-76.66508787	139.4	66	67.1	N/A	N/A	N/A
0:36:02	I 64, Parkway Estates, VA, 23187-1776	37.27971456	-76.66508787	139.4	65.9	66.5	N/A	N/A	N/A
0:36:03	I 64, Parkway Estates, VA, 23187-1776	37.27971456	-76.66508787	139.4	65.7	65.9	N/A	N/A	N/A
0:36:04	I 64, Parkway Estates, VA, 23187-1776	37.27971456	-76.66508787	139.4	65.2	65.9	N/A	N/A	N/A
0:36:05	I 64, Parkway Estates, VA, 23187-1776	37.27971456	-76.66508787	139.4	64.6	65.9	N/A	N/A	N/A
0:36:06	I 64, Parkway Estates, VA, 23187-1776	37.27877143	-76.66404113	135.2	63.8	64.6	N/A	N/A	N/A
0:36:07	I 64, Parkway Estates, VA, 23187-1776	37.27877143	-76.66404113	135.2	63	55.3	N/A	N/A	N/A
0:36:08	I 64, Parkway Estates, VA, 23187-1776	37.27877143	-76.66404113	135.2	60.4	52.2	N/A	N/A	N/A
0:36:09	I 64, Parkway Estates, VA, 23187-1776	37.27877143	-76.66404113	135.2	50.7	51	N/A	N/A	N/A
0:36:10	I 64, Parkway Estates, VA, 23187-1776	37.27877143	-76.66404113	135.2	48.5	51	N/A	N/A	N/A
0:36:11	I 64, Springfield Terrace, VA, 23187	37.27848916	-76.66328045	121.4	34.1	51	N/A	N/A	N/A
0:36:12	I 64, Springfield Terrace, VA, 23187	37.27848916	-76.66328045	121.4	31.5	51	N/A	N/A	N/A
0:36:13	I 64, Springfield Terrace, VA, 23187	37.27848916	-76.66328045	121.4	28	51	N/A	N/A	N/A
0:36:14	I 64, Springfield Terrace, VA, 23187	37.27848916	-76.66328045	121.4	20.2	20.2	N/A	N/A	N/A
0:36:15	I 64, Springfield Terrace, VA, 23187	37.27848916	-76.66328045	121.4	5.3	5.3	N/A	N/A	N/A
0:36:16	I 64, Springfield Terrace, VA, 23187	37.27848916	-76.66328045	121.4	0.7	0.7	N/A	N/A	N/A
0:36:17	I 64, Parkway Estates, VA, 23187-1776	37.27852920	-76.66337628	0	0	0	N/A	N/A	N/A
0:36:18	I 64, Parkway Estates, VA, 23187-1776	37.27852920	-76.66337628	0	0	0	N/A	N/A	N/A

The motor carrier informed NTSB investigators that while the event data had been received from the truck, the video segment that should have accompanied that data had apparently not been transmitted. Investigators facilitated the upload of the video after repowering the camera and gateway and were subsequently provided with a copy of that video file, which ran 59 seconds in length. Additional information regarding the video file is available in the NTSB *Video Study* report.

The video display included a date and time counter (hh:mm:ss in EST), vehicle speed and representative roadway speed limit. Previous information conveyed to NTSB investigators by Samsara 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 data depicted the impact with Eldorado bus as occurring between 01:36:05 and 01:36:06 hours, about 5.5 seconds after the start of the video.

From the start of the video segment (display time 01:36:00) the truck, the hood of which appears in the imagery, is established in the right lane. Portions of the two headlamp beam patterns can be visibly seen reflecting from the road surface ahead of the truck. Roadway lane lines, roadside reflectors and right roadside barriers all reflect

sufficient light to be clearly seen and identified. Similarly, aspects of the Eldorado bus, which was also fully established in the right lane can be seen ahead of the truck. The most salient features of the bus included rearward lighting and the reflectorized surface of the registration plate. The rearward lighting included two outboard tail lamps mounted near mid vertical height, two outboard clearance lamps mounted near the roof line and three identification lamps mounted near the roof line and mid width of the vehicle. As the truck closed on the Eldorado, other vertical surfaces at the rear of the bus increasingly reflected light from the truck's headlamps.

While the video segment times out at a displayed time of 01:36:59, nothing is visually discernible after the initial contact with the Eldorado as the camera appears to have been displaced.

3.3 Eldorado bus electronic engine control module

Following completion of the vehicle inspection, the electronic engine control module was removed and taken by NTSB investigators to a local International service center for data imaging. The imaging returned only configuration data. While some configuration parameters could be corroborated through the inspection process, one element appeared inconsistent. Configuration settings indicated a tire revolutions per mile count of 625, the tire manufacturer reported a figure of 611. When used to provide an input for the speedometer, this could result in an underreporting of speed by about 2% or between one and 1.5 miles per hour at 60 mph.

E. REFERENCES

- NTSB Highway Factors Group Chair factual report
- NTSB Vehicle Factors Group Chair factual report
- NTSB Survival Factors Group Chair factual report
- VDOT highway plans

F. DOCKET MATERIALS

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

- None (reference sources processed by other NTSB investigative groups)

Submitted by:

Robert Squire
Highway Crash Investigator

APPENDIX A DDEC LAST STOP DATA TABLE

Time	Vehicle Speed (mph)	Engine Speed (rpm)	Brake	Clutch	Engine Load (%)	Throttle (%)	Cruise	Diagnostic Code
104	66.5	1268	No	No	98	0	Yes	No
103	66.5	1271	No	No	98	0	Yes	No
102	67	1272	No	No	98	0	Yes	No
101	67	1275	No	No	98	0	Yes	No
100	67.5	1281	No	No	98	0	Yes	No
99	67.5	1284	No	No	98	0	Yes	No
98	68	1291	No	No	95	0	Yes	No
97	68	1295	No	No	92	0	Yes	No
96	68	1296	No	No	75	0	Yes	No
95	68.5	1299	No	No	63	0	Yes	No
94	68.5	1308	No	No	45	0	Yes	No
93	68.5	1305	No	No	38	0	Yes	No
92	68.5	1306	No	No	30	0	Yes	No
91	69	1307	No	No	27	0	Yes	No
90	69	1309	No	No	16	0	Yes	No
89	69	1299	No	No	6	0	Yes	No
88	69	1312	No	No	1	0	Yes	No
87	69	1317	No	No	0	0	Yes	No
86	69	1314	No	No	0	0	Yes	No
85	69	1319	No	No	0	0	Yes	No
84	69.5	1318	No	No	0	0	Yes	No
83	69.5	1322	No	No	0	0	Yes	No
82	69.5	1325	No	No	0	0	Yes	No
81	69.5	1327	No	No	0	0	Yes	No
80	70	1329	No	No	0	0	Yes	No
79	70	1331	No	No	0	0	Yes	No
78	70	1329	No	No	0	0	Yes	No
77	70	1335	No	No	0	0	Yes	No
76	70	1335	No	No	0	0	Yes	No
75	70	1334	No	No	0	0	Yes	No
74	70	1334	No	No	0	0	Yes	No
73	70	1336	No	No	0	0	Yes	No
72	70	1331	No	No	0	0	Yes	No
71	70	1329	No	No	1	0	Yes	No
70	69.5	1328	No	No	0	0	Yes	No
69	69.5	1324	No	No	1	0	Yes	No
68	69.5	1322	No	No	5	0	Yes	No
67	69	1318	No	No	7	0	Yes	No

Time	Vehicle Speed (mph)	Engine Speed (rpm)	Brake	Clutch	Engine Load (%)	Throttle (%)	Cruise	Diagnostic Code
66	69	1313	No	No	15	0	Yes	No
65	69	1312	No	No	17	0	Yes	No
64	69	1315	No	No	20	0	Yes	No
63	69	1310	No	No	23	0	Yes	No
62	69	1309	No	No	21	0	Yes	No
61	69	1306	No	No	23	0	Yes	No
60	69	1308	No	No	22	0	Yes	No
59	69	1309	No	No	25	0	Yes	No
58	69	1308	No	No	28	0	Yes	No
57	69	1309	No	No	30	0	Yes	No
56	69	1311	No	No	27	0	Yes	No
55	69	1310	No	No	30	0	Yes	No
54	68.5	1308	No	No	35	0	Yes	No
53	68.5	1307	No	No	42	0	Yes	No
52	68.5	1304	No	No	48	0	Yes	No
51	68.5	1305	No	No	57	0	Yes	No
50	68.5	1298	No	No	70	0	Yes	No
49	68.5	1302	No	No	80	0	Yes	No
48	68.5	1305	No	No	93	0	Yes	No
47	68.5	1304	No	No	93	0	Yes	No
46	68.5	1291	No	No	95	0	Yes	No
45	68.5	1305	No	No	96	0	Yes	No
44	68.5	1299	No	No	98	0	Yes	No
43	68.5	1305	No	No	98	0	Yes	No
42	68.5	1300	No	No	98	0	Yes	No
41	68	1298	No	No	97	0	Yes	No
40	68	1297	No	No	98	0	Yes	No
39	68	1294	No	No	98	0	Yes	No
38	68	1293	No	No	98	0	Yes	No
37	68	1291	No	No	98	0	Yes	No
36	68	1288	No	No	98	0	Yes	No
35	67.5	1281	No	No	98	0	Yes	No
34	67.5	1282	No	No	98	0	Yes	No
33	67	1277	No	No	98	0	Yes	No
32	67	1276	No	No	98	0	Yes	No
31	67	1275	No	No	98	0	Yes	No
30	67	1272	No	No	98	0	Yes	No
29	66.5	1270	No	No	98	0	Yes	No
28	66.5	1267	No	No	98	0	Yes	No

Time	Vehicle Speed (mph)	Engine Speed (rpm)	Brake	Clutch	Engine Load (%)	Throttle (%)	Cruise	Diagnostic Code
27	66.5	1264	No	No	98	0	Yes	No
26	66.5	1263	No	No	98	0	Yes	No
25	66	1258	No	No	98	0	Yes	No
24	66	1259	No	No	98	0	Yes	No
23	66	1257	No	No	98	0	Yes	No
22	66	1256	No	No	98	0	Yes	No
21	66	1259	No	No	98	0	Yes	No
20	66	1256	No	No	98	0	Yes	No
19	66.5	1260	No	No	98	0	Yes	No
18	66.5	1262	No	No	98	0	Yes	No
17	66.5	1267	No	No	98	0	Yes	No
16	67	1269	No	No	98	0	Yes	No
15	67	1275	No	No	98	0	Yes	No
14	67.5	1280	No	No	98	0	Yes	No
13	67.5	1286	No	No	93	0	Yes	No
12	68	1296	No	No	83	0	Yes	No
11	68	1297	No	No	68	0	Yes	No
10	68.5	1300	No	No	57	0	Yes	No
9	68.5	1300	No	No	41	0	Yes	No
8	68.5	1305	No	No	32	0	Yes	No
7	68.5	1307	No	No	28	0	Yes	No
6	68.5	1307	No	No	25	0	Yes	No
5	68.5	1306	No	No	22	0	Yes	No
4	69	1307	No	No	21	0	Yes	No
3	69	1308	No	No	18	0	Yes	No
2	68.5	1307	No	No	20	0	Yes	No
1	68.5	1307	No	No	18	0	Yes	No
0	68.5	1306	No	No	23	0	Yes	No
-1	68.5	1304	No	No	33	0	Yes	No
-2	68.5	1303	No	No	47	0	Yes	No
-3	68	1298	No	No	67	0	Yes	No
-4	68	1299	No	No	95	0	Yes	No
-5	68	1296	No	No	98	0	Yes	No
-6	68	1293	No	No	98	0	Yes	No
-7	67.5	1287	No	No	98	0	Yes	No
-8	67.5	1281	No	No	98	0	Yes	No
-9	67	1272	No	No	98	0	Yes	No
-10	66.5	1266	No	No	98	0	Yes	No
-11	66.5	1261	No	No	98	0	Yes	No

Time	Vehicle Speed (mph)	Engine Speed (rpm)	Brake	Clutch	Engine Load (%)	Throttle (%)	Cruise	Diagnostic Code
-12	66	1255	No	No	98	0	Yes	No
-13	65.5	1247	No	No	98	0	Yes	No
-14	65.5	1243	No	No	98	0	Yes	No
-15	63.5	843	Yes	Yes	0	0	Yes	No

Appendix B VDOT Skid Resistance Testing Results

As provided in the NTSB *Highway Factors Group* factual report, VDOT conducted as series of skid resistance tests along a portion of eastbound I-64 that encompassed the crash location. While the results are cited in that NTSB report, a graphical representation of the acquired data relative to the area of impact is provided below. Refer to the NTSB *Highway Factors Group* factual report for the data table.