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

HWY24MH005

TECHNICAL RECONSTRUCTION

Group Chair's Factual Report

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A. CRASH INFORMATION

Location: Rushville, Schuyler County, Illinois
Date: March 11, 2024
Time: 11:29 a.m. CDT

B. TECHNICAL RECONSTRUCTION GROUP

Group Chair	Eric Gregson National Transportation Safety Board
Group Member	Trooper Jacob Miller Illinois State Police

C. CRASH SUMMARY

For a summary of the crash, refer to the *Crash Information and Summary Report,* which can be found in the NTSB 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 Illinois State Police (ISP). 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 a 2020 Micro Bird MB-II school bus (bus) and a 2001 Mack truck tractor in combination with a 2001 Vantage dump trailer (combination). The bus had been traveling eastbound on U.S. Route 24 as the combination vehicle traveled westbound. The bus was in a rightward curve when it crossed the centerline of the roadway, into the westbound travel lane, colliding head-on with the combination vehicle.

E. FACTUAL INFORMATION

1.0 Crash Location

The crash event occurred on U.S. Route 24 in Rushville, Schuyler County, Illinois, at the Global Positioning System (GPS) coordinates of 40.115959° latitude and -

90.583929° longitude. U.S. Route 24 consisted of two travel lanes, one westbound and one eastbound with adjoining shoulders. Drainage channels paralleled both the east and west sides of the roadway. Figure 1 is an area map depicting the approximate location of the crash.

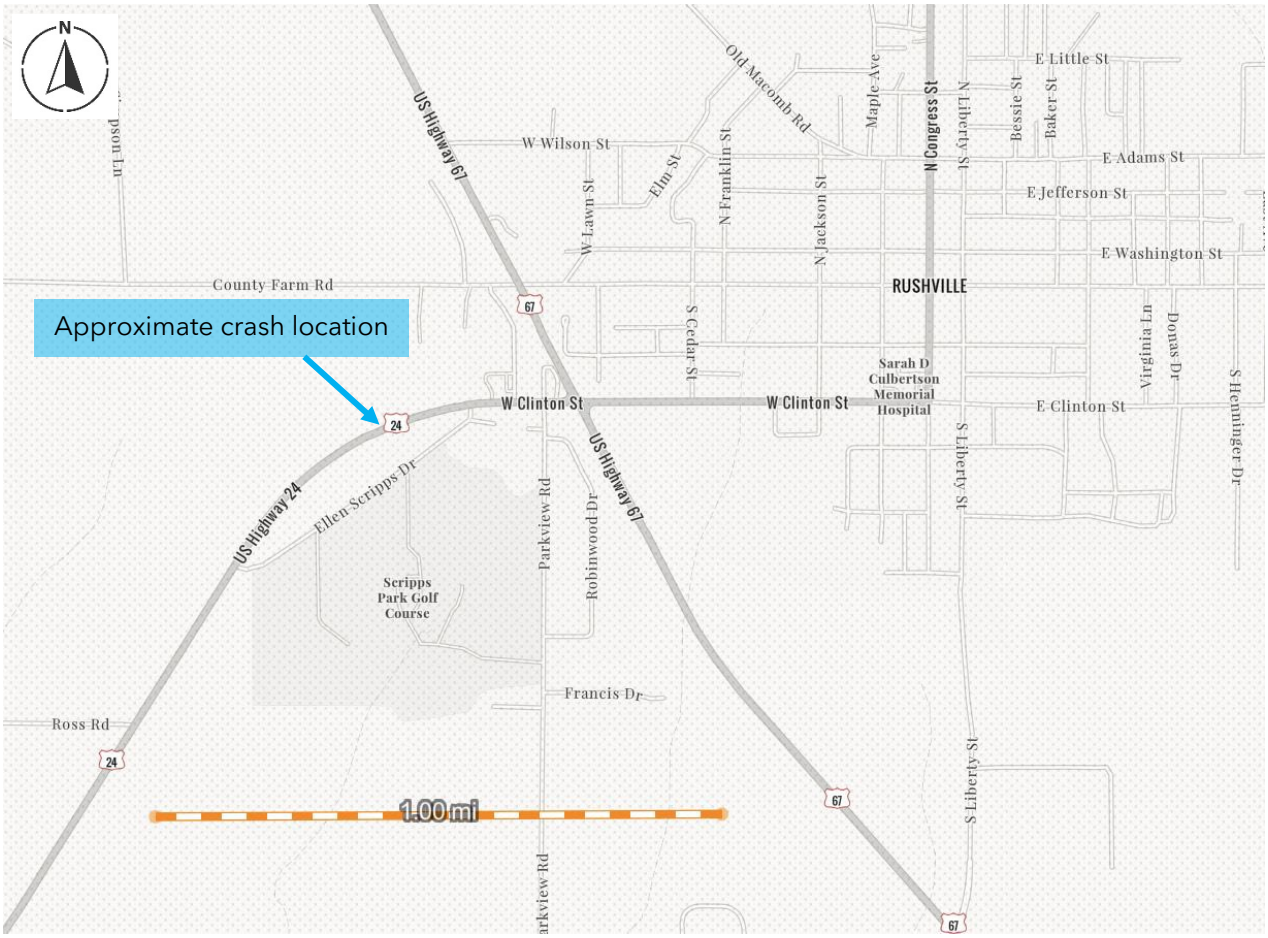

Figure 1. Area map of Rushville, Illinois, depicting the approximate crash location.

The eastbound and westbound approaches, along U.S. Route 24, were straight before transitioning into the sweeping curve. The curve was 2,863 feet long having an approximate radius of 2,865 feet.[1] The crash event occurred approximately 985 feet into the curve, when traveling east to west. Figure 2 below contains two images depicting the westbound (left) and eastbound (right) approach to the crash location. As can be seen there were no obstructions impeding the visual line of sight in either direction.

[1] See the NTSB Highway Factors Group Chair Report for additional details.

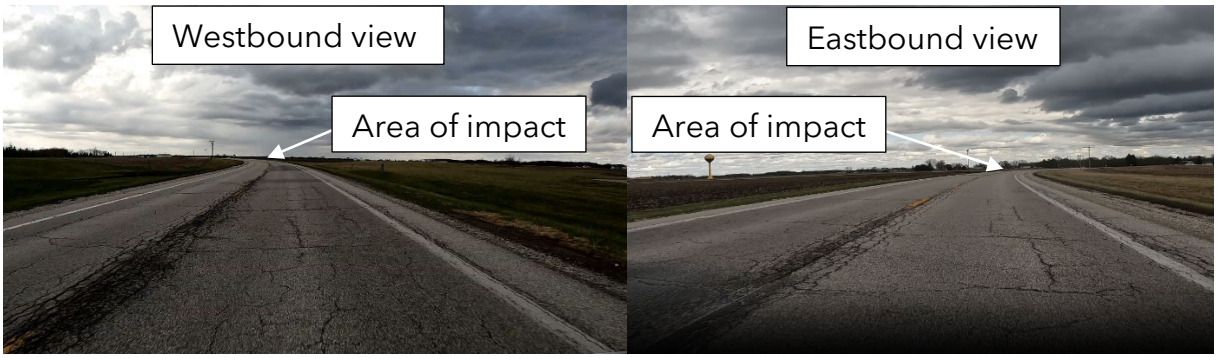

Figure 2. Two images depicting each approach to the crash location.

1.1 Post Collision Site Documentation and Roadway Evidence

The crash site was confined to the westbound travel lane and the north side drainage channel. The site was documented by ISP investigators using both terrestrial and aerial, small unmanned aerial system (sUAS). NTSB investigators employed similar documentation methodologies. ISP investigators had marked some roadway evidence with yellow and orange marking paint. ISP investigators further identified and marked six ground control points (GCPs) beginning east of crash site, progressing westward, and concluding west of the crash site.[2] The sUAS photographs were processed using Pix4DMapper photogrammetry software from which three-dimensional point clouds and two-dimensional orthomosaic images were rendered for analysis.[3] Additionally, NTSB investigators employed terrestrial three-dimensional scanning about the involved vehicles, exemplar vehicles, and an area of U.S. Route 24 east of the crash site which will be discussed later in the report.[4]

The area of impact (AOI) was established at a location where several scrape, gouge marks, and friction marks were identified along the westbound side of U.S. Route 24. The marks began with two parallel gouge marks (A) adjacent to the white edge line, within the westbound lane, measuring approximately one foot in length. The two gouge marks transitioned to five parallel gouge marks (B) that crossed the white edge line onto the shoulder. The five gouge marks were at an approximate angle of 35 degrees relative to the westbound lane and varied in lengths. Continuing west, there was a large gouge that measured about two feet in length and seven inches wide (C). The large gouge paralleled the white edge line and was also where the scorching of

[2] Ground control points – points on the surface that have known coordinates. The points are then utilized to geo-reference the points with the rendered three-dimensional point cloud.
[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.
[4] 3D scanning was completed using the FARO Focus Premium 350 laser scanner. Scans were rendered into three-dimensional (3D) point clouds using FARO Scene® software.

the asphalt began. The scorching ended at the edge of the asphalt. Figure 3 is a photograph depicting the scrape, gouge marks, and scorching described above.

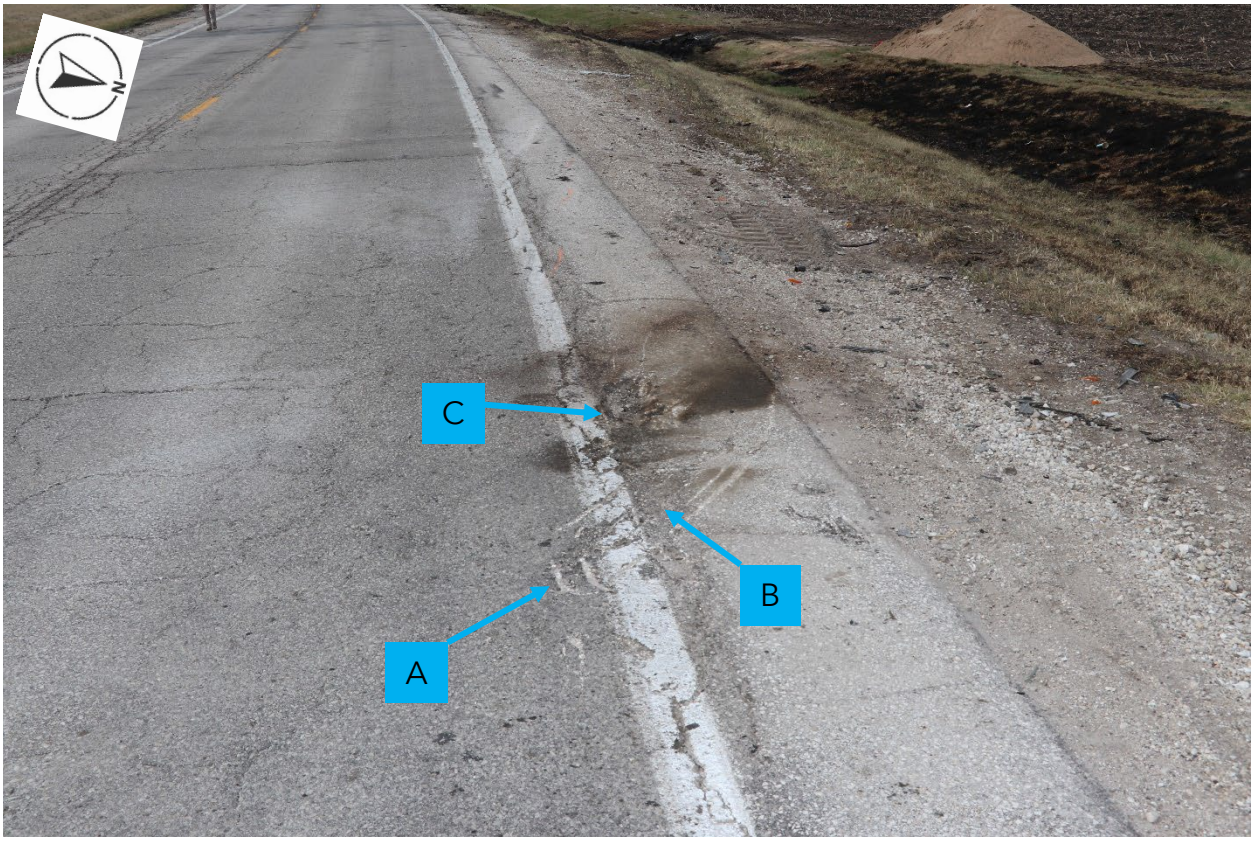

Figure 3. Photograph showing the scrape/gouge marks and scorching on the asphalt.

Figure 4 is an image obtained from the two-dimensional orthomosaic created from the three-dimensional point cloud with the marks labeled for reference. East of the area of impact, were two sets of dual linear tire friction marks that paralleled each other. Both sets began within the westbound lane, the northern set of friction marks (D) measured approximately 113 feet, crossed the white edge line, and terminated on the paved portion of the westbound shoulder. The southern set of friction marks (E) measured about 118 feet and terminated within the westbound lane. The two sets of tire friction marks traveled at an approximate 4-degree angle tangent to the curve. At their onset, the intensity of the friction marks was faint becoming darker approximately 85 feet west of the onset. Where the friction marks became darker each set transitioned from two friction marks to four friction marks in each set which continued to their termination. West of the set (D) friction marks were two additional tire friction marks on the paved shoulder. The first friction mark (F) measured approximately three feet in length. The second friction mark (G) measured about eight feet in length. Table 1 lists the labeled friction marks along with their measurements.

Table 1. List of friction marks.

Friction mark	Length (ft)	Offset from edge of pavement to center (ft)
A	1.0	N/A
B	various	N/A
C	2.0	N/A
D1	85	3
D2	28	9
E1	84	1
E2	34	8
F	3	1
G	8	0

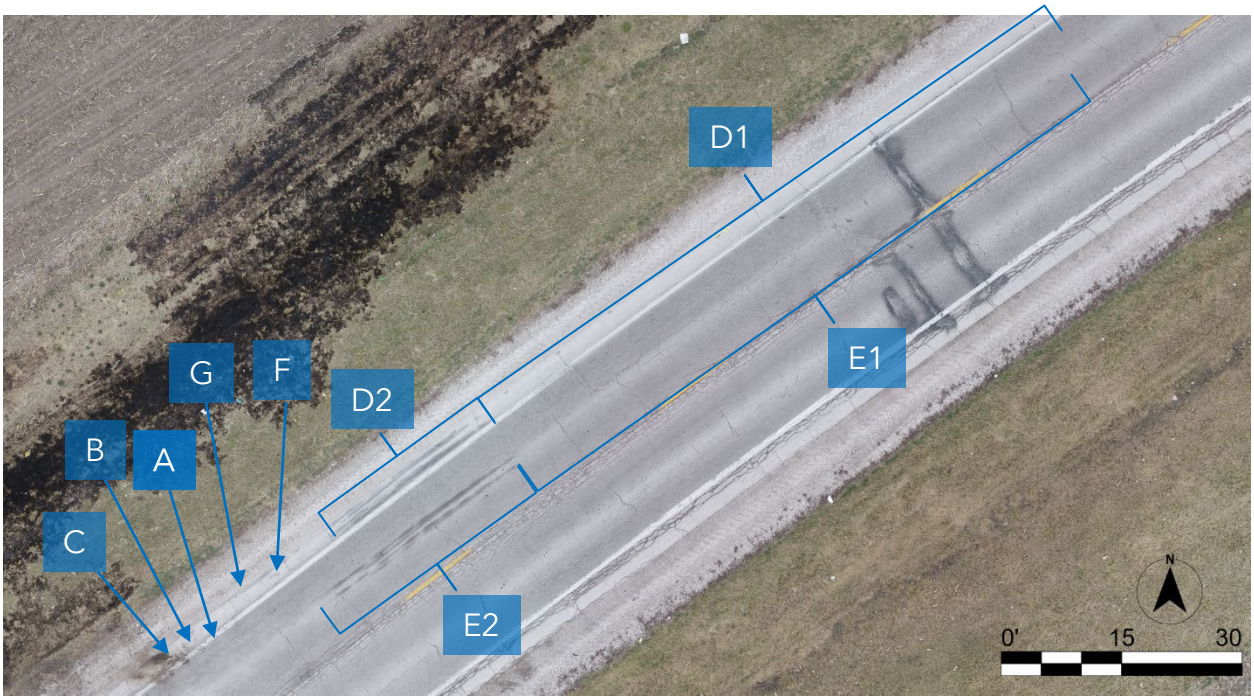

Figure 4. Selected image from the orthomosaic created from NTSB sUAS project.

West of the AOI were additional tire friction marks and furrows angled from the westbound travel lane toward the right roadside. ISP identified and marked, with orange spray paint, a set of tire friction marks that began around the scrape/gouge marks within the westbound travel lane. The intensity of the friction marks was light as they transitioned from the roadway over the concrete asphalt shoulder to the aggregate shoulder section at an approximate 8-degree angle relative to the roadway. Two additional parallel tire friction marks were identified approximately 50 feet west of the AOI, along the asphalt shoulder. The friction marks each measured about seven feet in length and were consistent with damaged tires.

Continuing westward, the friction marks transitioned to furrows in the grass lined drainage channel. There were four distinct areas of prominent furrows that continued at the approximate 8-degree angle relative to the roadway. Three of the furrows terminated at the combination's position of final rest with the fourth terminating at the bus. From north to south, the furrows measured approximately 75 feet, 98 feet, 73 feet and 42 feet. Figure 5 is a selected image of the orthomosaic obtained from the ISP sUAS project identifying friction marks and furrows west of the AOI.

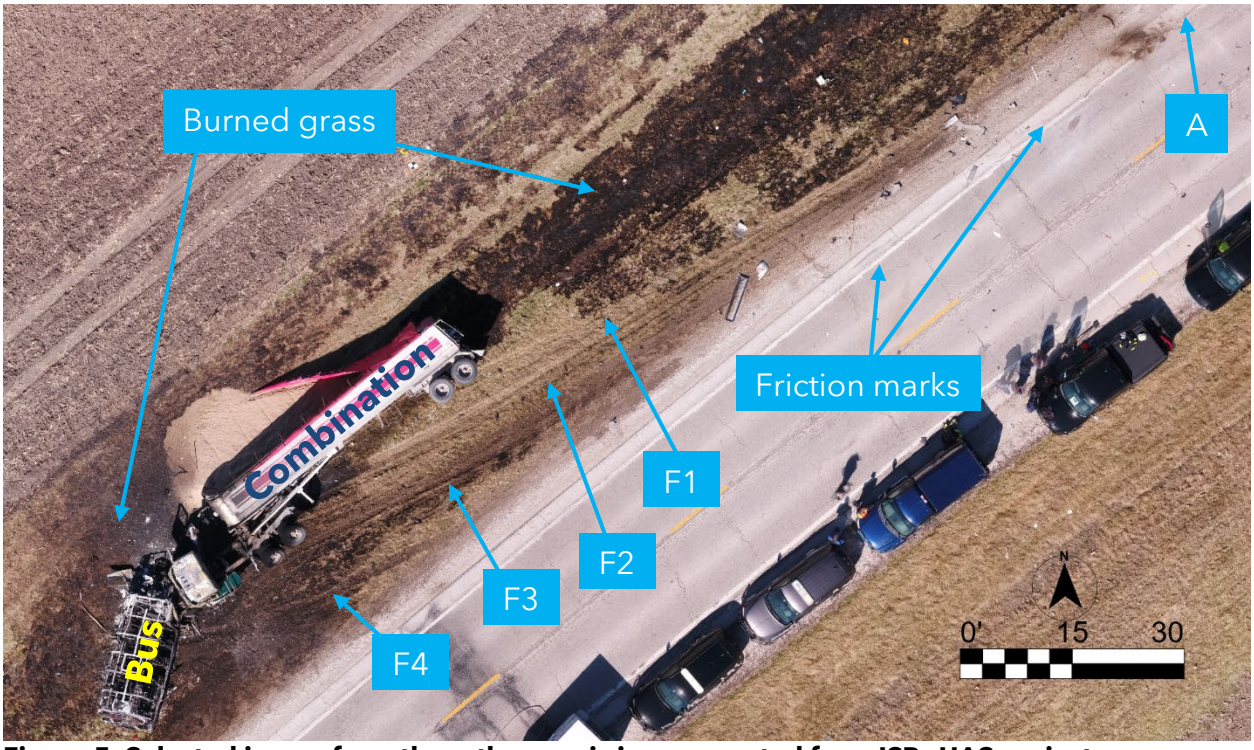

Figure 5. Selected image from the orthomosaic image created from ISP sUAS project.

Table 2. List of furrows.

Furrow	Furrow length (ft)
F1	75
F2	98
F3	73
F4	42

1.2 Roadway Friction Testing

On March 14, 2024, testing was conducted near the collision site to identify a potential sliding friction value (also referred to as drag factor) between a passenger vehicle tire and the road surface. Testing was conducted by equipping a Ford Edge with a GoPro Hero 11 and a Vbox Sport. The testing was conducted with the anti-lock braking system enabled. A total of three tests were conducted resulting in an average friction value of 0.91. The composition of commercial motor vehicle tires is harder than

that of the passenger vehicle tires and therefore can only achieve about 75% of the roadway friction of a passenger vehicle tire.[5][6]

2.0 Vehicles

Two commercial vehicles were involved in the collision. At their final rest positions, both vehicles were located off the westbound side of U.S. Route 24 in the drainage channel. Orientation of the vehicles at rest were documented by ISP investigators through sUAS imagery as shown in Figure 5 above.

2.1 2020 Micro Bird MB-II School Bus

As manufactured, the bus had a nominal length and width of approximately 22.8 and 7.1 feet, respectively, a wheelbase of about 13.0 feet, and had an unloaded weight of 7,178 pounds.[7]

The front of the bus sustained extensive direct contact damage across its full width. The engine and all components within the engine compartment were torn from the frame rails and displaced rearward. Both front wheels, suspension system, and steering components including control arms and sway bars were all displaced rearward. The left-front tire was displaced rearward under the driver's seat with the right-front tire displaced rearward under the loading/unloading steps. The firewall had been displaced rearward into the driver seat and loading/unloading area of the bus displacing both rearward. The bus sustained extensive thermal damage encompassing the entire vehicle.

Figure 6 is two photographs of the right side of the bus. An image of the crash involved bus has been overlaid atop the exemplar bus depicting extensive damage to the front of the bus.

[5] Frick, L.B., "Traffic Accident Reconstruction," Northwestern University Traffic Institute, Illinois, 1990.
[6] Bedsworth, K., Butler, R., Rogers, G., Breen, K., Fischer, W., "Commercial Vehicle Skid Distance Testing and Analysis," SAE Technical Paper 2013-01-0771, 2013.
[7] See the NTSB Vehicle Factors Group Chair Report for additional details.

Figure 6. Two photographs, one of the damaged and one of the undamaged bus.

Figure 7 below is a graphic of the damaged bus captured from the three-dimensional scan, overlayed with an outline of the undamaged exemplar bus. The graphic is depicting the approximate distance, five feet, the front of the engine was displaced rearward as measured from the front bumper.

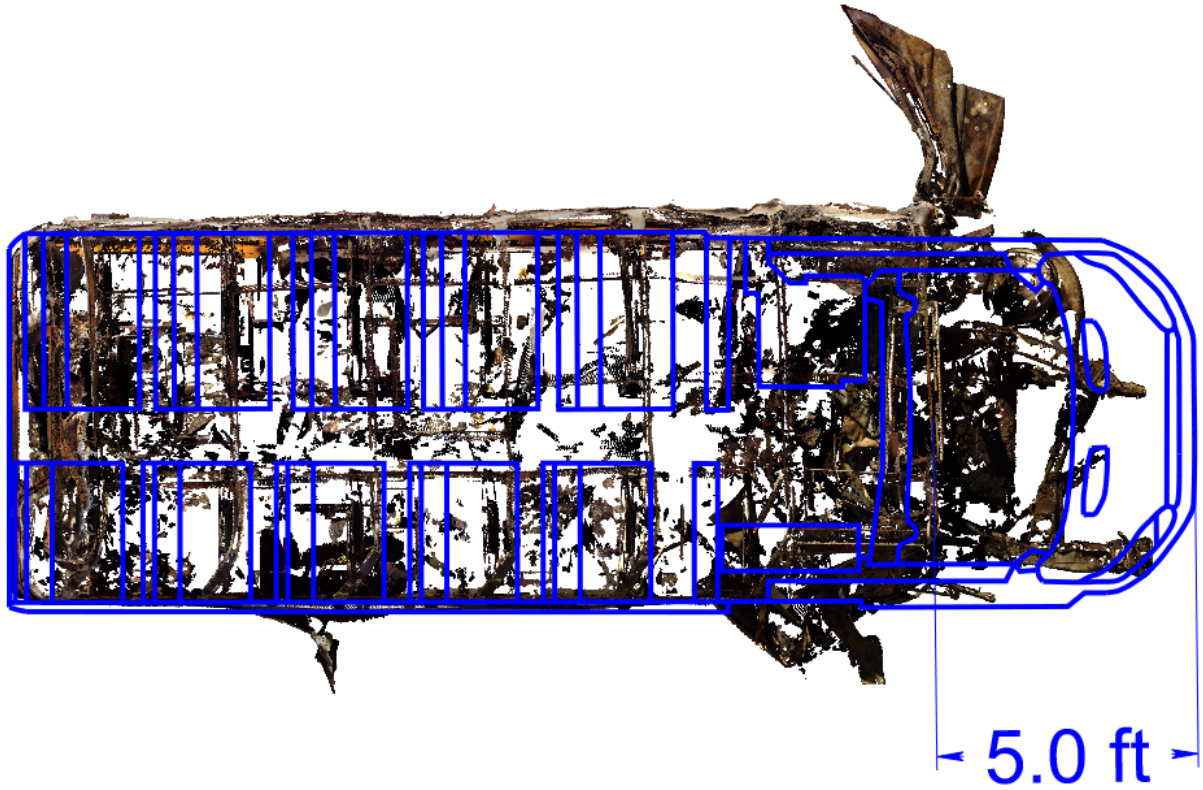

Figure 7. Graphic of the damaged bus overlayed with an outline of an undamaged bus.

At final rest, the bus was situated at an approximate 45-degree angle, facing northeast, within the drainage channel. The right rear tires were at the top of the fore slope while the left rear tires and right front were at the bottom of the fore slope. The left front of the bus was resting against the backslope. The front of the bus was still in contact with the front of the combination.

Reports prepared by NTSB Vehicle Factors and Survival Factors Groups should be referred to for additional vehicle information.

2.2 2001 Mack truck in combination with a 2001 Vantage dump trailer

Due to extensive thermal damage, the front of the Mack exhibited direct contact damage across the full width. The front bumper cover, hood, and fenders were all missing, exposing the engine, frame rails, steering, and suspension components. The bumper and radiator were displaced rearward. The bumper and lower portion of the radiator, between the frame rails, were curved inward. The frame was buckled causing the top of the cab to lean rearward. The left-front wheel was displaced rearward into the small storage box forward of the saddle, which was subsequently pushed rearward into the front of the saddle tank damaging it. Additionally, the saddle tank received thermal damage. The left side frame rail forward of the second axle and fifth wheel was bent downward. The trailer was still coupled to the tractor via the fifth wheel coupler

and evidence of thermal damage was noted to the front and along the right side. Figure 8 is a photograph showing the damage to the truck tractor and front of the dump trailer.

Figure 8. Photograph depicting damage to the truck tractor.

At final rest, the combination was in the drainage channel, approximately 25 feet north of the westbound lane, parallel with the roadway. The front of the combination was in contact with the front of the bus. The dump trailer had rolled over onto its right side resting along the backslope of the drainage channel. The combination and bus together were approximately 157 feet west of the AOI. The combination weighed approximately 79,680 pounds. Figure 9 is an image taken from the generated orthomosaic depicting the positions of final rest for the bus and combination vehicle.

Figure 9. Image from the two-dimensional orthomosaic depicting the vehicles final rest.

3.0 Point Cloud Orientation

Alignment of the combination and bus point clouds corroborated an approximate 3-degree angled impact orientation as can be seen in Figure 10.

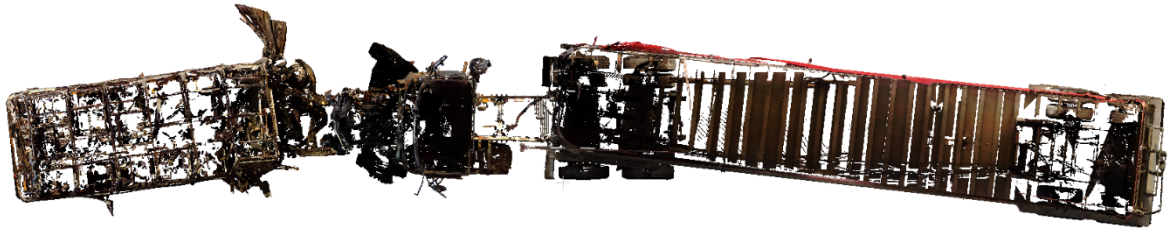

Figure 10. Screen capture of the vehicle's alignment at impact.

4.0 Electronic Data

4.1 2001 Mack truck tractor

The Mack truck tractor was powered by a diesel engine manufactured by Mack. The engine is controlled by several controllers which are generally referred to as electronic control modules (ECMs). The ECM may be capable of recording and storing engine data related to configuration, fault codes, and quick stop events.

Mack ECMs consists of two components, the engine electronic control unit (EECU) and the vehicle electronic control unit (VECU). For the involved truck tractor, the EECU was located on the left side of the engine and the VECU was located behind the kick panel on the right (passenger) side. Both modules are required to successfully complete data extraction.

During the examination of the Mack truck tractor NTSB investigators located the EECU at the bottom of the engine next to the left frame rail. The EECU had broken from the mounting screws and was hanging by its wiring harness. The EECU was recovered and disconnected from the wiring harness. Closer examination found thermal damage to the metal case, and pin connectors as well as contact damage to the outer casing causing a large indentation. Figure 11 is a photograph of the EECU depicting the damage sustained in the collision. NTSB investigators located the VECU behind the kick plate and observed that it received extensive thermal damage. Figure 12 is a photograph of the VECU depicting the damage observed by investigators.

Due to the damage sustained by both modules, data was not able to be extracted.

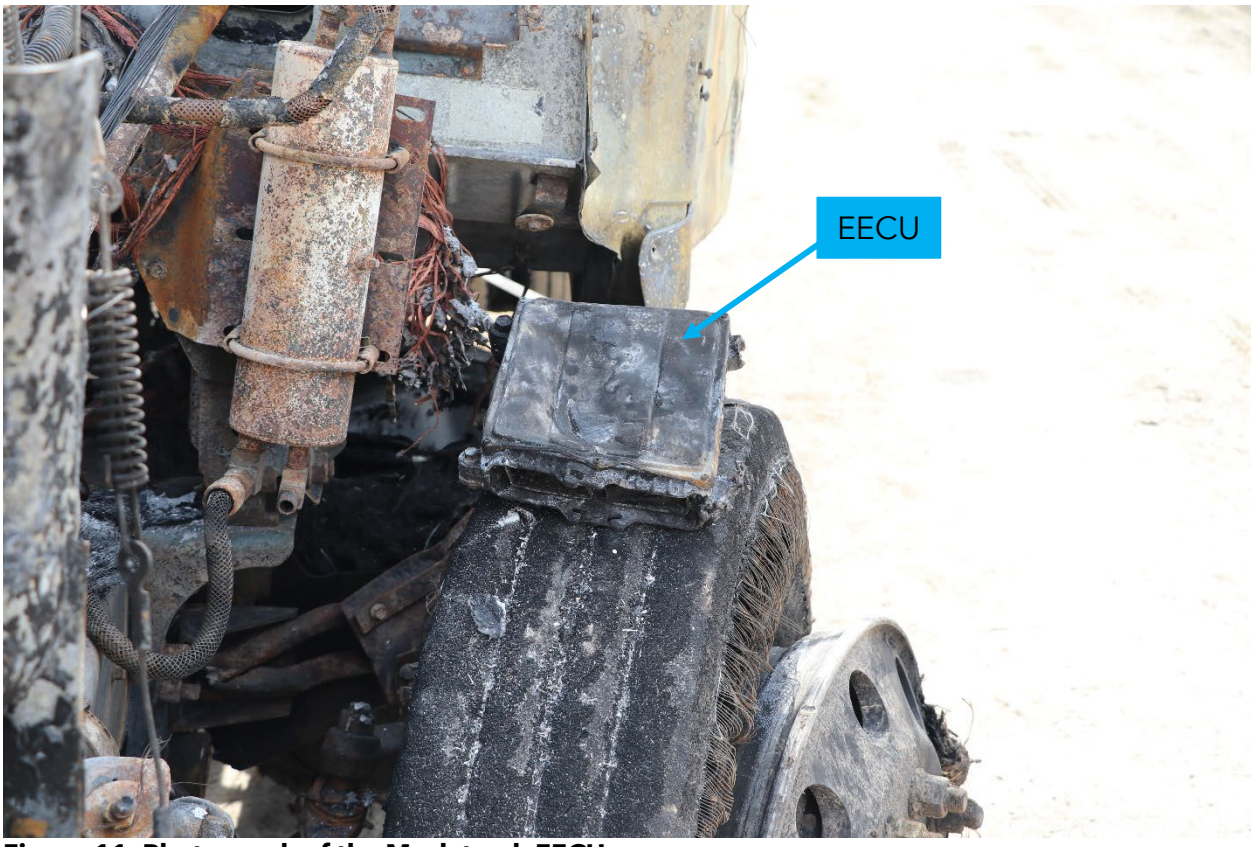

Figure 11. Photograph of the Mack truck EECU.

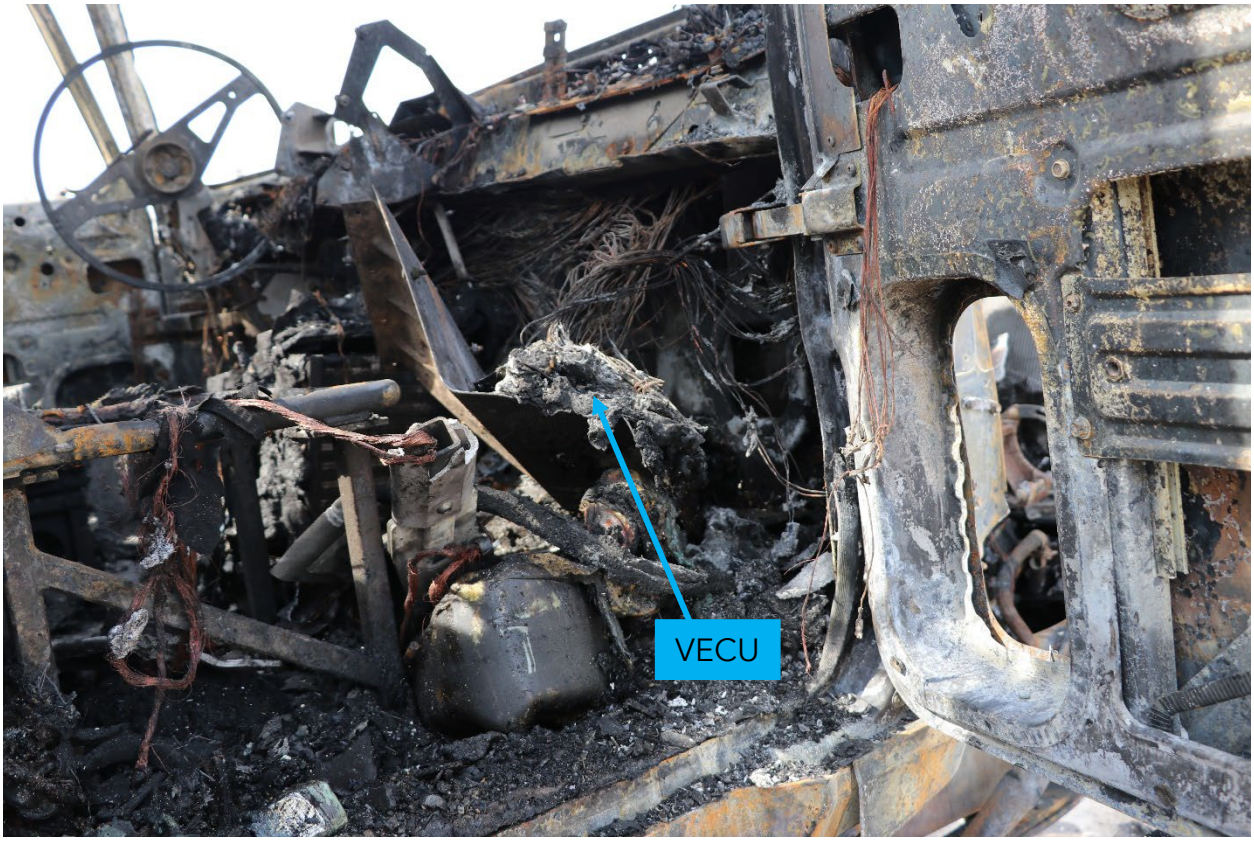

Figure 12. Photograph showing the VECU.

4.2 2020 Micro Bird MB-II School Bus

The bus body and seating were built atop the chassis of a 2020 Ford Transit 350 which was equipped with an airbag control module (ACM) with event data recorder (EDR) capability. During the examination of the bus, NTSB investigators were able to locate the ACM. The casing had broken apart revealing the circuit board inside. The circuit board and wiring harness were removed from the vehicle and photographed. Figure 13 shows the wiring connector and circuit board that was recovered from the bus. Along with the physical damage the components also sustained thermal damage. The circuit board was transported to NTSB headquarters by NTSB investigators.[8] NTSB investigators examined the components for damage and completed the chip-level forensic examination on August 14, 2024. Data was not able to be recovered from the EDR.[9]

[8] See Technical Reconstruction Attachment – National Transportation Safety Board Evidence Control Form.
[9] See the NTSB Group Chair Vehicle Recorders Report for further details.

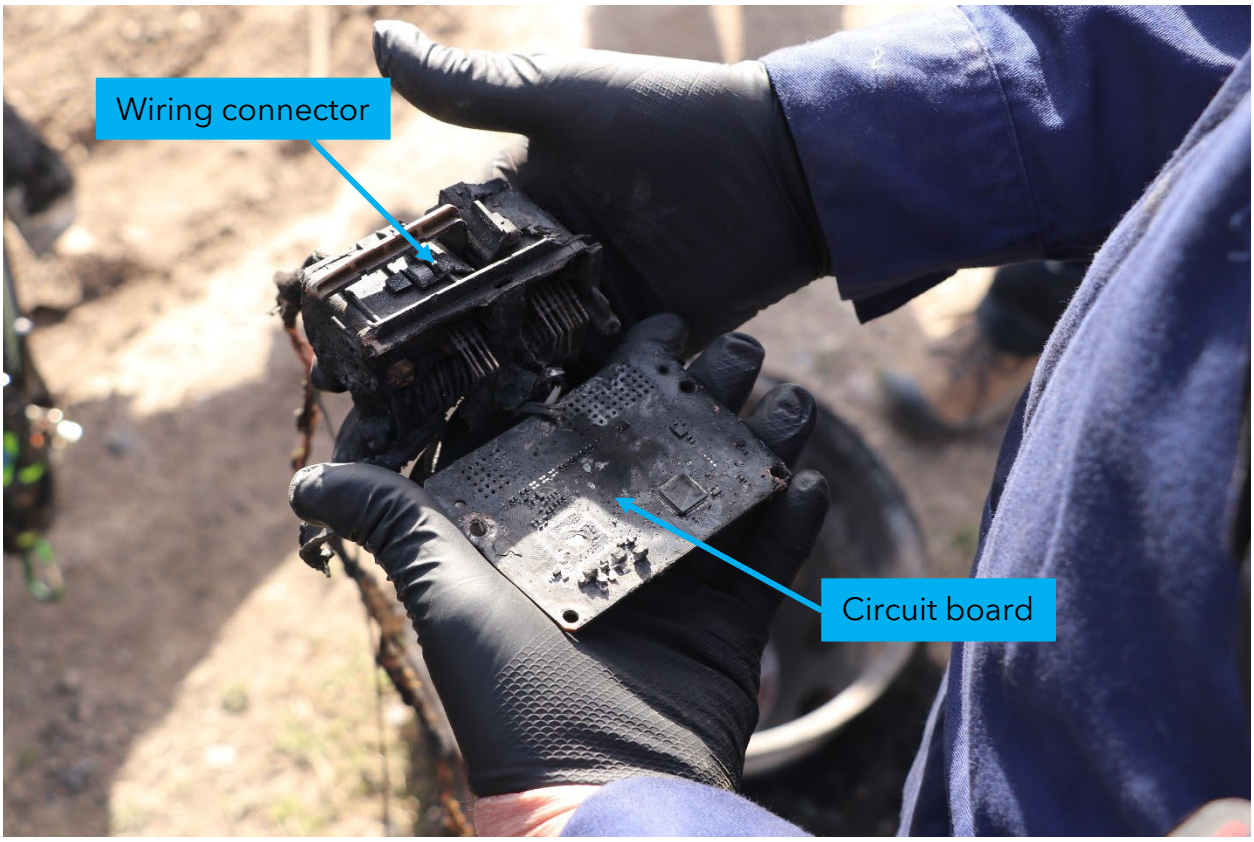

Figure 13. Photograph showing the wiring connector and circuit board.

5.0 Security Camera Recordings

ISP provided NTSB investigators with a video that was obtained from an Illinois Department of Justice Services located north of the collision location. During the on-scene investigation, NTSB investigators obtained two additional security camera videos from a convenience store/gas station located on the northwest corner of the intersection between U.S. Route 24 and Route 67.

5.1 Convenience Store/Gas Station

The videos were recorded by security cameras that were located on the south side, identified as CH14, and west side, identified as CH2, of the store. During the review of the recordings clock drift was observed between the time displayed on an attached monitor and the time displayed on a mobile phone. Utilizing the time on the mobile phone as the reference time the exported video was 3 minutes and 23 seconds faster. Both cameras captured the pre-impact travel of the combination, a witness, and first responders traveling to the collision. Figure 14 below shows the location of the two security cameras that recorded the videos.

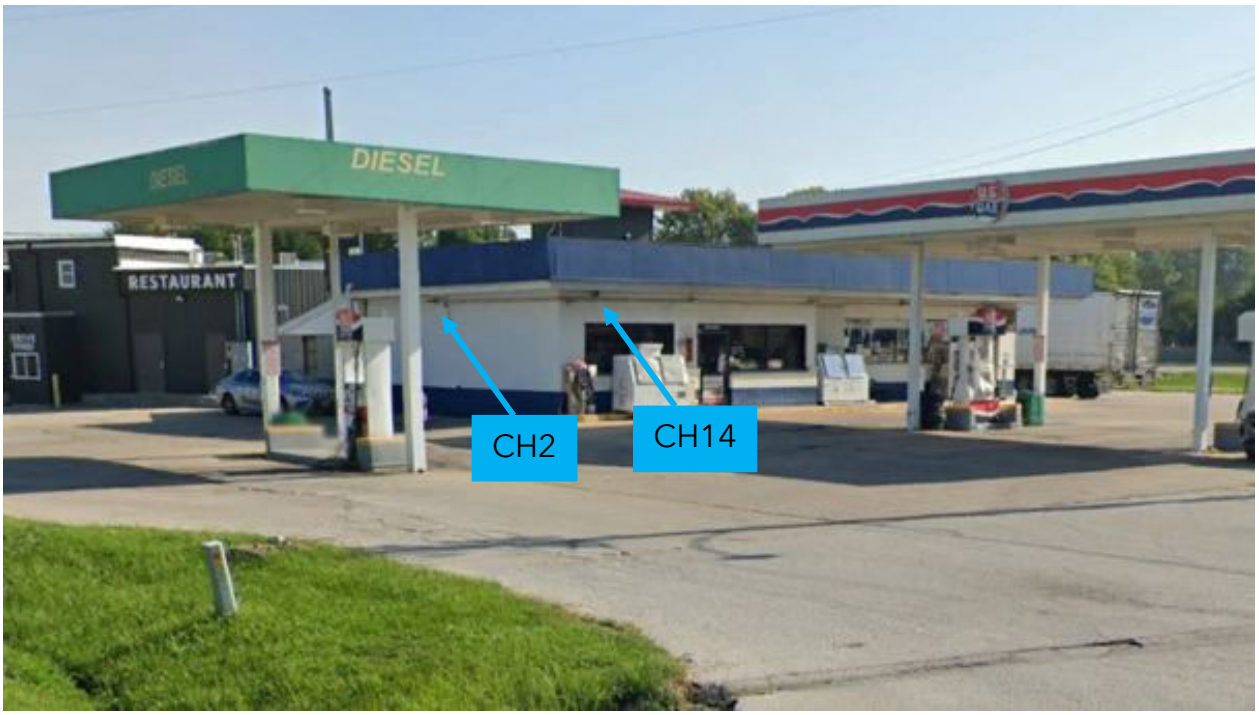

Figure 14. Location of security cameras. (Source: Google Earth revised by NTSB)

5.1.1 CH14 Timeline of Events

The camera was located on the south side of the of the building and showed the intersection of U.S. Route 24 and Route 67. The obtained video was 2560 x 1440 pixels and in color. The duration of the video was one hour at a frame rate of 25 frames per second (fps). The original video was obtained.

Figure 15 is a screen capture of the combination traveling west on U.S. Route 24. The combination traveled through the intersection at approximately 11:28:46 CDT. The headlights on the combination were illuminated. There was a white sport utility vehicle (SUV) traveling south on Route 67. After the combination passed through the intersection the SUV turned right onto westbound U.S. Route 24. At approximately 11:28:50 CDT the combination cleared the cameras field of view.

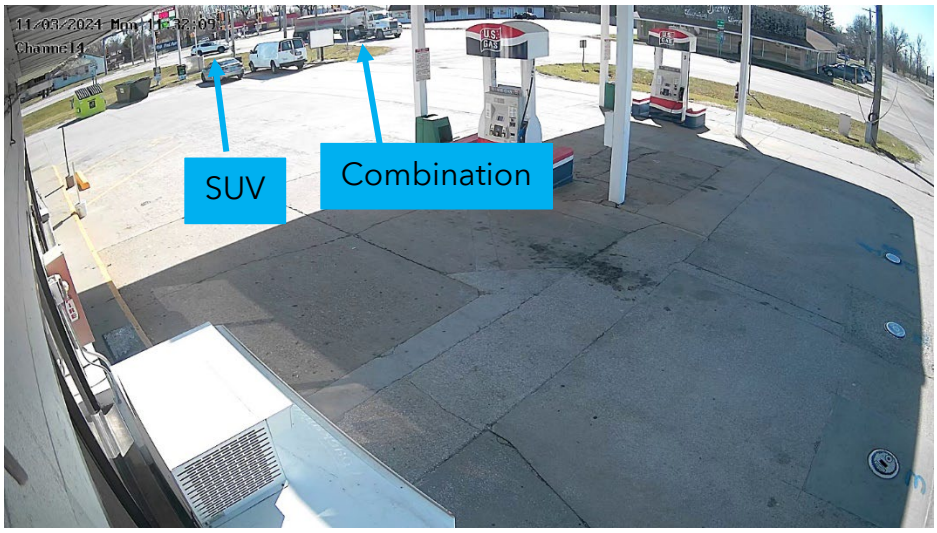

Figure 15. Screen capture from surveillance video showing combination traveling west on US 24.

Approximately 4 minutes later at 11:32:21 the first emergency responder vehicle, black pick-up truck, turned right from southbound Route 67 to westbound U.S. Route 27 (Figure 16).

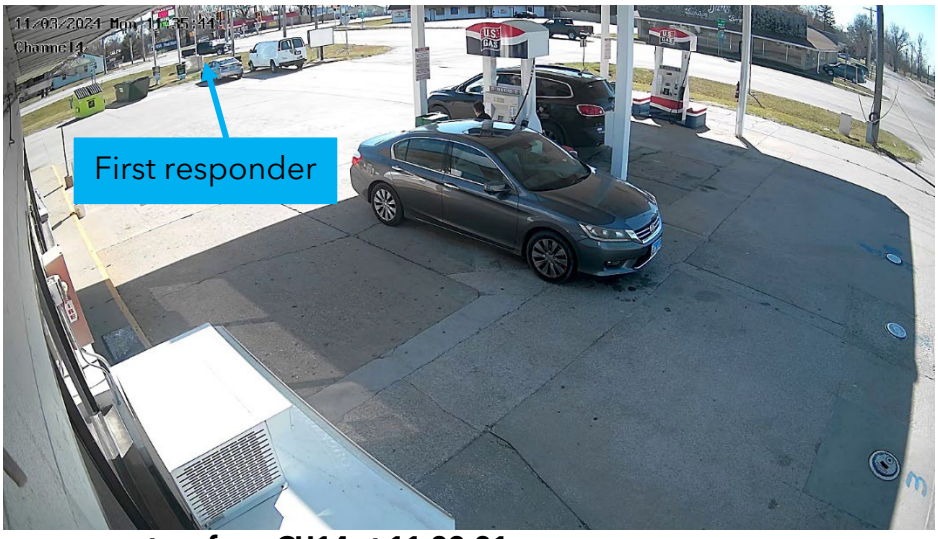

Figure 16. A screen capture from CH14 at 11:32:21.

5.1.2 CH2 Timeline of Events

The camera was located on the west side of the building and captured U.S. Route 27 west of the store. The obtained video was 2592 x 1944 pixels and in color. The duration of the video was one hour at a frame rate of 18 fps. The original video was obtained.

Figure 17 is a screen capture from CH2 when the combination was completely visible. The combination continued traveling west on U.S. Route 24.

Figure 17. A screen capture from CH2 at time 11:28:51.

Figure 18 shows the combination traveling west with the white SUV traveling behind it. The white SUV was identified as a witness and interviewed by NTSB investigators.[10] The combination negotiated the leftward curve leaving the camera view as it traveled behind a tree. At 11:29:33 smoke was visible rising from behind the tree and the white SUV was stopped in the westbound travel lane.

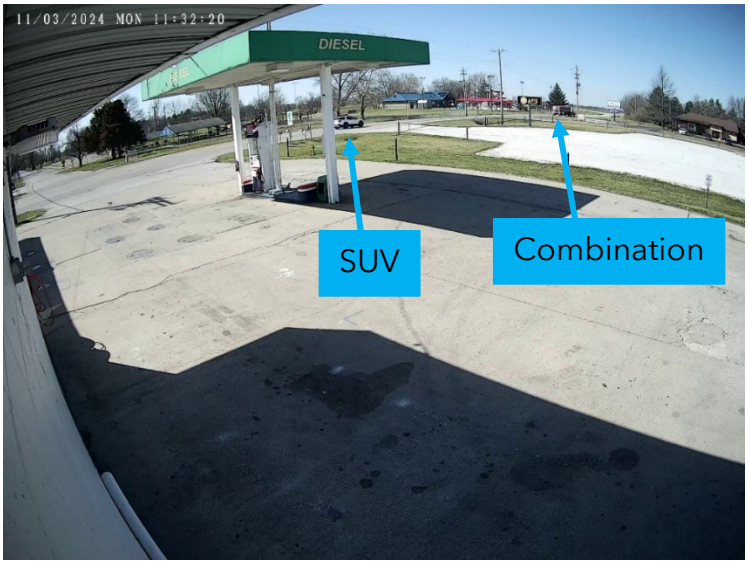

Figure 18. A screen capture from CH2 at time 11:28:57.

[10] See the NTSB Survival Factors Group Chair Report for additional details.

5.1.2.1 Gas Station Documentation

After reviewing the videos, NTSB investigators completed a three-dimensional scan of U.S. Route 24 that was within the field of view of the security camera. The three-dimensional point cloud in conjunction with other software was utilized to conduct a frame-by-frame analysis to determine the speed of the combination.

5.1.3 Department of Justice Services Video

The video that was provided by ISP investigators was not the original video. The length of the video was one hour. The video was recorded in a low resolution and in color. The video did not have a date or time stamp.

The combination appeared in the video traveling westbound. The bus was not visible in the video. The combination continued westbound until impact with the bus, white smoke and fire were all visible in the video. As the combination and bus moved west post-collision, the fire expanded westward. Figure 19 below shows the post-impact fire.

Figure 19. A screen capture from the Department of Justice Services video.

F. REFERENCES

NTSB Highway Factors Group Chair Factual Report
NTSB Survival Factors Group Chair Factual Report
NTSB Vehicle Factors Group Chair Factual Report
NTSB Vehicle Recorders Group Chair Factual Report

G. LIST OF ATTACHMENTS

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

Technical Reconstruction Attachment:	National Transportation Safety Board Evidence Control Form
Technical Reconstruction Attachment:	Convenience Store Surveillance Video

Submitted by:

Eric Gregson
Technical Reconstructionist