

National Transportation Safety Board

Office of Highway Safety

Washington, DC 20594



HWY23MH015

VEHICLE FACTORS

Group Chair's Factual Report

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A. CRASH

Location: Highland, Madison County, Illinois
Date: July 12, 2023
Time: 1:48 a.m. CDT

B. VEHICLE FACTORS GROUP

Group Chair Jason Zeitler
National Transportation Safety Board
Washington, DC

Group Member Jerome Cantrell
National Transportation Safety Board
Washington, DC

Group Member Special Agent Curtis Eggemeyer
Illinois State Police
Belleville, IL

C. 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 Vehicle Factors Group Chairman’s Factual Report is a collection of information regarding the vehicles involved in this collision. This report focuses on details obtained during the examinations of the 2014 Prevost motorcoach, 2019 Freightliner truck-tractor and semi-trailer combination, 2000 Kenworth truck-tractor and semi-trailer combination, and 2023 Mack truck-tractor and semi-trailer combination. The examinations were conducted between July 12 and 18, 2023.

The Illinois State Police (ISP) conducted preliminary inspections of the vehicles while on scene. The Prevost motorcoach, Freightliner combination vehicle, and Kenworth combination vehicle were subsequently secured at Petroff Towing, in Caseyville, Illinois, where the vehicles were examined by NTSB investigators. The Mack combination vehicle was released by ISP prior to the arrival of the NTSB and was not available to be examined.

During the examination of the Prevost motorcoach, all major mechanical systems were inspected, including steering, braking, electrical, and suspension systems. The overall collision damage was documented, as well as any damage or anomalies within the vehicle's major mechanical systems. Event data recorders and collision mitigation systems were also imaged and will be explored in this report. The overall collision damage was documented for the Freightliner combination vehicle, Kenworth combination vehicle, and the Mack combination vehicle.

For uniform description of the vehicles involved in this collision, unless otherwise noted, "left" will refer to the driver's side, and "right" will refer to the passenger's side of the vehicles.

1.0 2014 Prevost Motorcoach - Vehicle Examination



Figure 1: Motorcoach - Front-left Damage Overview

1.1 General Information

Make:	Prevost (Subsidiary of Volvo Group North America)
Model:	X3-45
Passenger Capacity:	50
VIN: ¹	2PCG33495EC735508
Model Year:	2014
Date of Manufacture:	July 2013

¹ Vehicle Identification Number.

Mileage:	1,220,554.2
GVWR ² :	53,000 lbs.
GAWR ³ (Axle 1):	16,500 lbs.
GAWR (Axle 2):	25,500 lbs.
GAWR (Axle 3):	14,000 lbs.
Curb weight ⁴ :	36,000 lbs.
Engine:	Volvo D13H diesel 435 horsepower- S/N: 89045760
Engine Build Date:	August 2022
Transmission:	Allison B500 6-Speed Automatic
Rear Axle Ratio:	3.58
Steering Gearbox:	Bosch (manufactured 3/23) - Model illegible
Brake Type:	Air operated disc brakes with antilock braking system (ABS) - 6S/5M ⁵

1.2 Vehicle Summary

The 2014 Prevost X3-45 (motorcoach) was a single-stage built motorcoach capable of transporting up to 50-passengers and providing long-distance transportation services. The motorcoach was equipped with a wheelchair lift and baggage holds that were accessible from the exterior of the vehicle, underneath the main floor. The motorcoach was equipped with an inboard and outboard facing video recording device, event data recorders (EDRs), and collision mitigation technologies that will be discussed further in Section 1.17 and 1.18.

1.3 Terrestrial Laser Scans

The NTSB captured and processed 3D terrestrial laser scans of the damaged motorcoach into a point cloud. The point cloud was comprised of millions of colored measurement points that could be used to preserve a scaled version of the damaged vehicle and could provide a basis with regards to deformation, impact configuration, speed analysis, and many other analytical computations.

1.3.1 Exemplar Motorcoach

A sampling of images of the resulting point cloud for the undamaged exemplar motorcoach can be observed below in Figure 2, Figure 3, and Figure 4.

² Gross Vehicle Weight Rating (GVWR) is the total maximum weight that a vehicle is designed to carry when loaded, including the weight of the vehicle itself, plus fuel, passengers, and cargo.

³ Gross Axle Weight Rating (GAWR) is the maximum distributed weight that a given axle is designed to support.

⁴ Curb weight is the weight of the vehicle including fluids and standard equipment. It does not include the weight of passengers or cargo.

⁵ Six sensors and five modulators.



Figure 2: Motorcoach - Exemplar Point Cloud - Front-Right

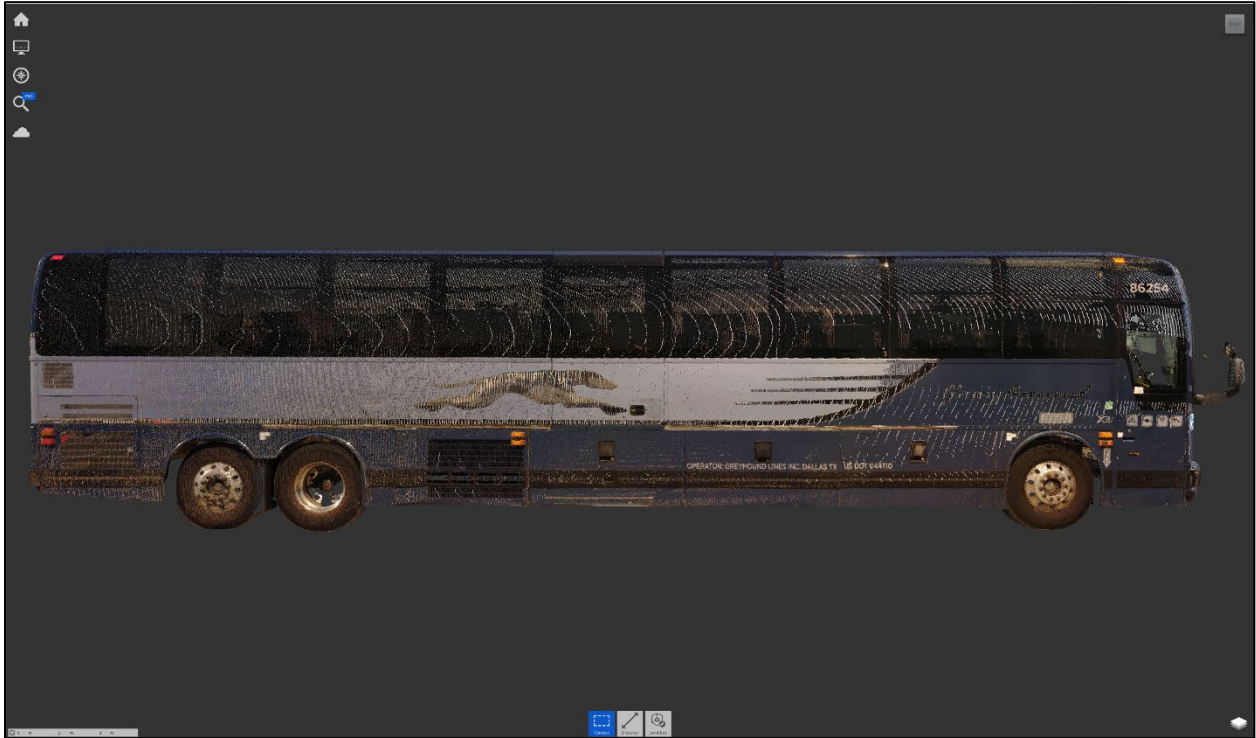


Figure 3: Motorcoach - Exemplar Point Cloud - Right-Side



Figure 4: Motorcoach - Exemplar Point Cloud - Rear-Right

1.3.2 Subject Motorcoach

A sampling of images of the resulting point cloud for the damaged subject motorcoach can be observed below in Figure 5, Figure 6, and Figure 7.



Figure 5: Motorcoach - Subject Point Cloud - Front-Right

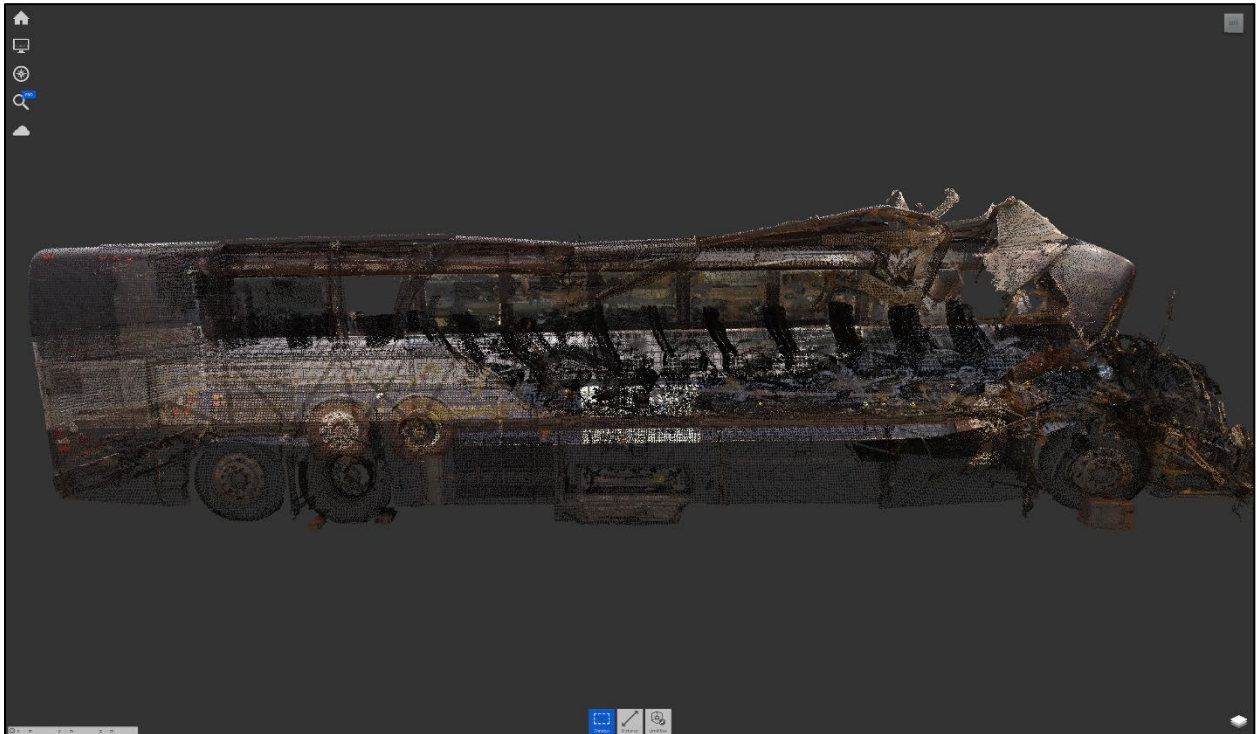


Figure 6: Motorcoach - Subject Point Cloud - Right-Side



Figure 7: Motorcoach - Subject Point Cloud - Rear-Right

1.4 Damage Description

For uniform description, “left” will refer to the driver’s side, and “right” will refer to the entrance-door side of the motorcoach. The motorcoach sustained crash damage to the front-right and right-side of the vehicle.

The top of the front bumper was rotated forward, and the right side was pushed rearward. The right headlight assembly was damaged. The entrance door was sheared off and missing. The front of the motorcoach’s right skirt rail was damaged and pushed rearward. The right side-rail was damaged and pushed rearward from the front of the motorcoach to Row 2. Damage to the side-rail continued rearward to approximately Row 9. The right waist⁶/window rail was missing from the front of the motorcoach to Row 9. The right A-pillar was detached from the base and was pushed rearward to row 5. There was induced damage to the left A-pillar, and it was bent rightward while still attached to the roof support. Right-side pillars B, C, D, E, and G were missing, pillars F and H were severed and pushed rearward, and pillars I, J, K, and L remained intact, as observed in Figure 8.

The right-front tire was torn and flat. The right-side of the motorcoach was compromised and the interior was exposed from the front of the motorcoach to Row

⁶ The waist-rail is the longitudinal structural part of the bodywork below the side windows.

9. The storage door covers between the curb rail and the side rail were pushed inward and contained dark colored transfer. The right-side paneling between the waist rail and the side rail were missing from the front of the motorcoach to Row 9 and the exterior skin was missing from Row 9 to the engine compartment area of the motorcoach. The wheelchair accessory door was damaged, stuck open, and hanging from the motorcoach.

The windshield was missing from the motorcoach. All right-side windows were broken and missing. The left-side windows one and two were broken and missing. The left-side window nine was broken. The right-side of the roof's leading edge was rotated downward and rightward. The roof was torn in the approximate area of Row 2. From Row 2 to Row 7, the roof sustained induced damage and was rotated clockwise and upward.

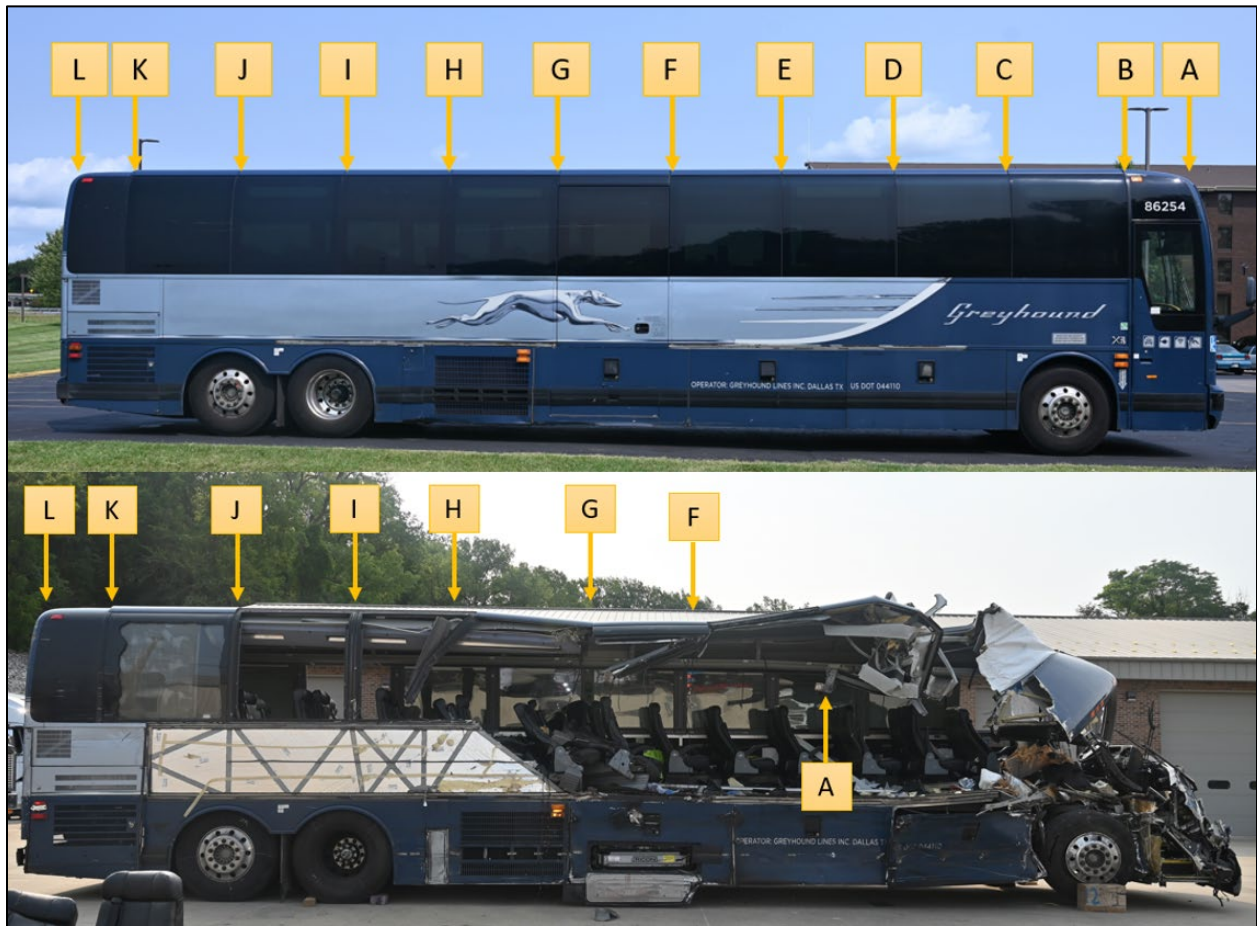


Figure 8: Motorcoach - Pillar Damage Comparison - Exemplar and Subject⁷

⁷ Lower image: "G" denotes the location that Pillar G previously resided.

1.5 Weights and Measurements

The undamaged exemplar motorcoach measurements can be observed in Table 1 and graphically in Figure 9. The motorcoach had a GVWR of 53,000 lbs. and a curb weight of 36,000 lbs.⁸

Table 1: Motorcoach - Undamaged 2014 Exemplar Measurements

Exemplar Motorcoach Measurements		
Overall Height	128.5	in
Overall Width ⁹	102.8	in
Overall Length	541.0	in
Wheelbase	358.5	in
Front Overhang	73.0	in
Rear Overhang	109.5	in
Front Track Width	87.7	in

Figure 9 shows the measurements taken from an undamaged exemplar motorcoach utilizing 3D terrestrial laser scans taken during the on-scene inspection.

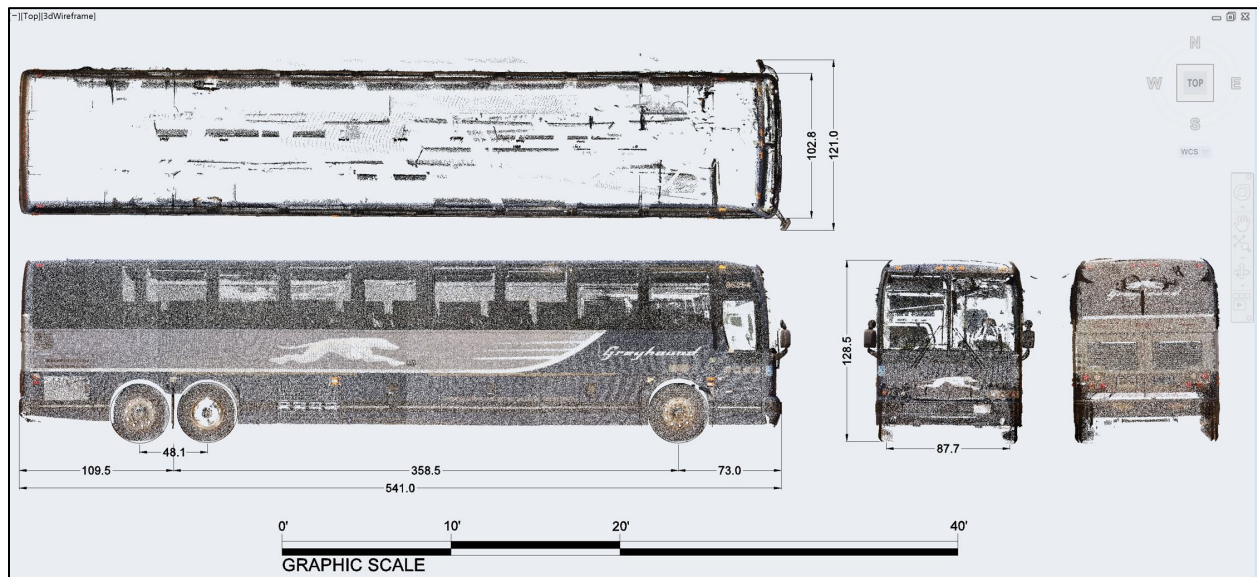


Figure 9: Motorcoach - Exemplar Dimensions¹⁰

⁸ Curb weight is typically defined as the total weight of the vehicle with standard equipment, all necessary consumables (e.g., motor oil, coolant, etc.), and a full tank of fuel, while not loaded with passengers or cargo.

⁹ Excluding side mirrors.

¹⁰ Measured in inches.

1.6 Driver Controls

All driver controls remained intact and appeared in functional condition. The motorcoach was electronically governed at 68 mph.¹¹ Below in Figure 10, Figure 11, and Figure 12, an overview of the available driver controls can be observed. The instrument cluster to the motorcoach was functional when power was supplied. Prior to supplying power, all gauges were recessed to their neutral zero position. The headlight switch was found in the "on" position at the time of the vehicle examination. The cruise control switch was in the "off" position. The driver's accelerator and brake control pedals were intact and in place.

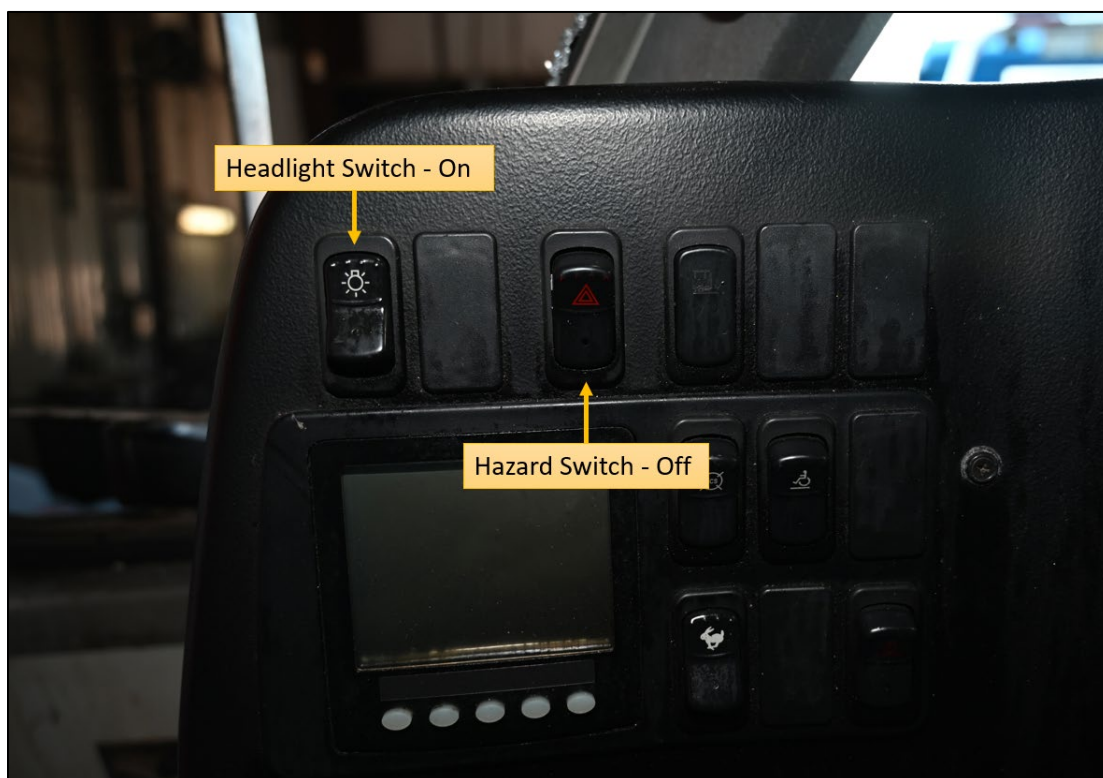


Figure 10: Motorcoach - Driver Controls - Headlight and Hazard Light Switches

¹¹ See **Vehicle Factors Attachment:** Prevost Order Specification Document.



Figure 11: Motorcoach - Driver Controls - Cruise Control

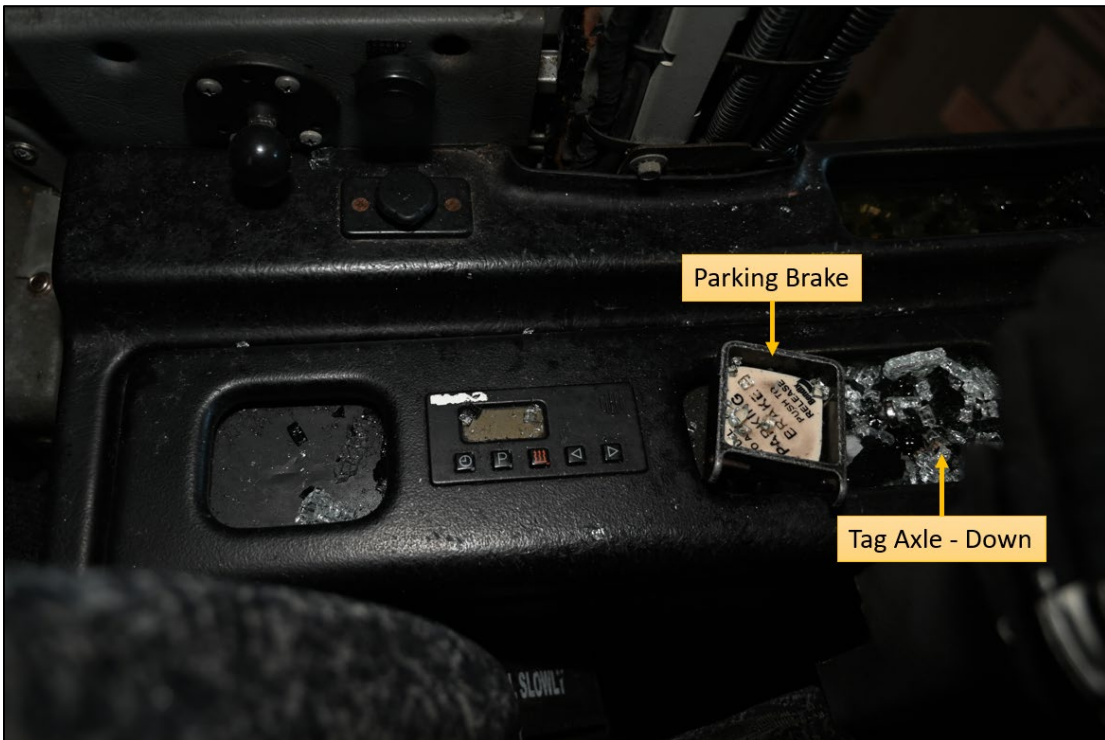


Figure 12: Motorcoach - Driver Controls - Tag Axle

1.7 Steering

The steering system was intact and functional. The steering gearbox, pitman arm, drag link, steering knuckles, and tie rod were examined (Figure 13). There was crash-related downward deformation observed at the center of the tie rod which caused the tie rod to be in contact with suspension components, as observed in Figure 14. All securement pinch bolts were examined and found to be tight. According to maintenance records obtained from Greyhound Lines, Inc., the steering gearbox, pitman arm, drag link, tie rod, and ball joint ends were replaced on June 29, 2023. The tie rod did not have any visible part number attached or stamped onto it but did have an affixed label that stated "Kit IS18091". The steering was checked for looseness at the sector shaft, pitman arm, drag link, and the ball joints. There was no looseness observed. The steering system was manually rotated from the left stop to the right stop and vice versa, via the steering wheel, with no other issues observed.

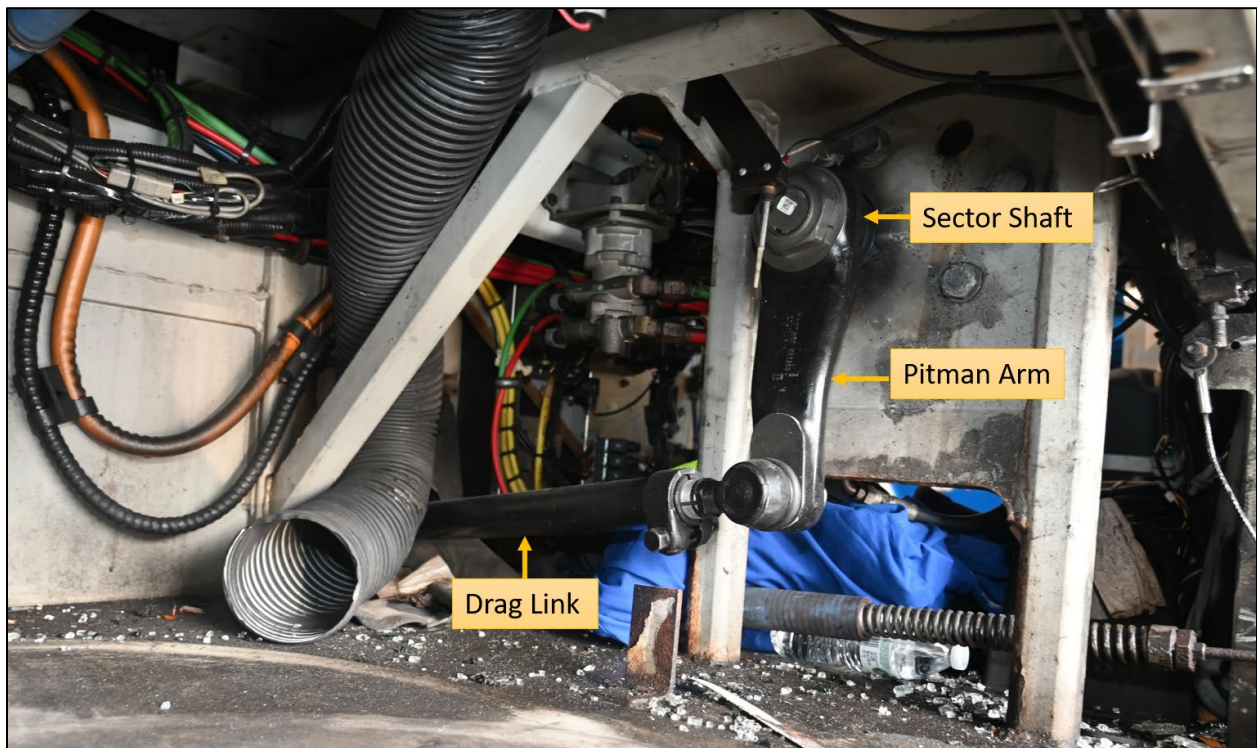


Figure 13: Motorcoach - Steering Components



Figure 14: Motorcoach - Deformed Tie Rod

A steering damper was mounted on the right side of the steering axle (axle 1). The piston rod separated from the damper pressure tube and was broken away from the steering knuckle connection and exited through a tear that was observed in the damper boot, as observed in Figure 15.

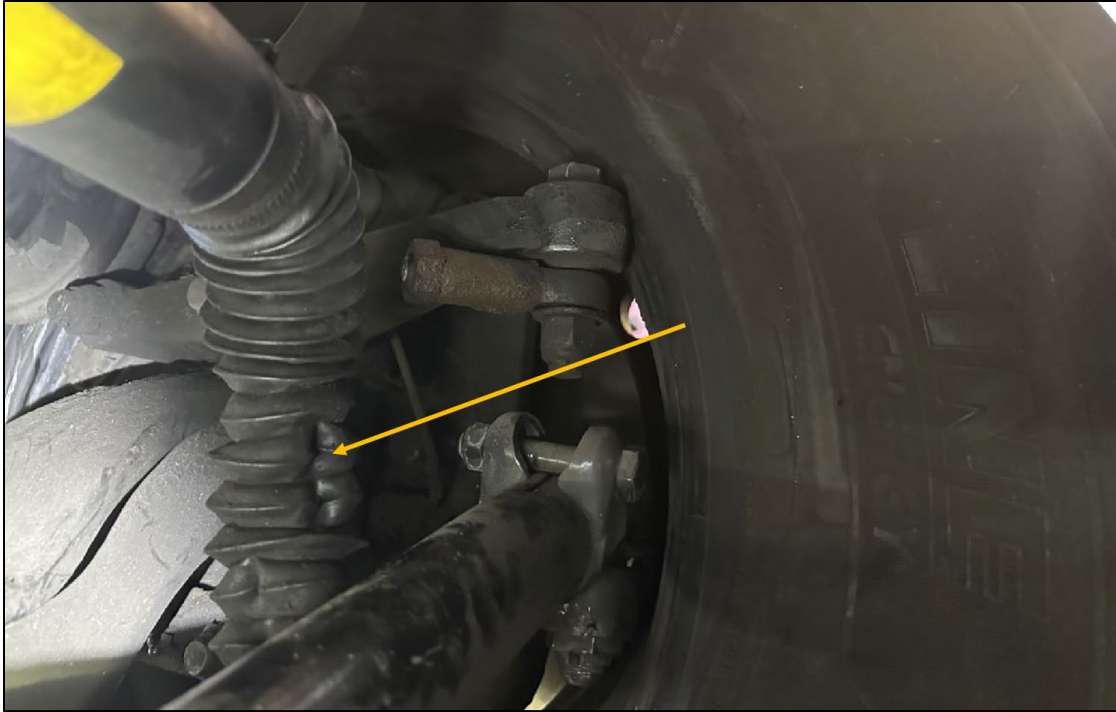


Figure 15: Motorcoach - Tear in Damper Boot and Missing Component

1.8 Suspension

The suspension on the steering axle (axle1) consisted of a solid axle with a stabilizer bar with connecting links, and torsion arms, shock absorbers, and air springs mounted to each axle end. The suspension on the drive axle (axle 2) consisted of a solid axle with a stabilizer bar and connection links, and torsion arms, air springs, and shock absorbers mounted at each axle end. Axle 3 consisted of a retractable tag axle. No defects were observed to the motorcoach's suspension system. The motorcoach was equipped with a quick front kneeling suspension that allowed the front of the motorcoach to lower to allow passengers to enter and exit the motorcoach more safely.

1.9 Tires and Wheels

The manufacturer's specification plate was attached to the inside lower-left area of the driver's seating compartment. Per the specification plate, the motorcoach was specified to be equipped with 315/80R22.5 tires, mounted on 22.5X9 rims. The tires were specified to be inflated to 130 pounds per square inch (psi) for axle one and 105 psi for axles' two and three.

General information about each of the tires on the motorcoach at the time of the inspection is documented in Table 2. All the wheels were inspected for cracks, welds, and elongated lug nut holes. The motorcoach's wheels were free from non-crash

related defects. Tire pressure measurements were taken using a commercial grade tire pressure gauge. The outboard side of axle-1-right's tire had an approximate 16-inch tear, an approximate five-inch tear, several small tears, and several gouges to the sidewall. The inboard portion of the tire had a dark transfer and abrasion that ran circular around 360 degrees of the tire and was located in the inside portion near the inboard portion of the wheel. The outboard side of the wheel contained multiple scrapes and black-colored transfer marks. The tread belonging to axle-2-left-inside's tire was melted and sticky to the touch, as observed in Figure 16.



Figure 16: Motorcoach - Tire - Axle-2-Left-Inside

Table 2: Motorcoach Tire Information

Axle #1	Left		Right	
Make	Michelin		Michelin	
Model	X Line		XZA2 ENERGY	
Size	315/80R22.5		315/80R22.5	
Pressure	116 psi		0 psi	
Tread Depth ¹²	14, 14, 14, 14		14, 14, 14, 15	
DOT #	HAD7039X 3422		HAD7039X 2922	
Retread #	-		-	
Load Rating	9090 lbs.		9090 lbs.	
Axle #2	Left		Right	
	Outside	Inside	Outside	Inside
Make	Michelin	Michelin	Michelin	Michelin
Model	X Line	X Line	X Line	X Line
Size	315/80R22.5	315/80R22.5	315/80R22.5	315/80R22.5
Pressure	116 psi	94 psi	96 psi	96 psi
Tread Depth	14, 10, 10, 13	10, 10, 9, 10	10, 9, 8, 9	11, 10, 10, 12
DOT #	HAD7039X 4821	FVD7039X 0921	B60735CX 3821	HAD7039X 0721
Retread #	-	RAFRC1A 1422	RAFRC1A 1422	RAFRC1A 1422
Load Rating	8270 lbs.	8270 lbs.	8270 lbs.	8270 lbs.
Axle #3	Left		Right	
Make	Michelin		Michelin	
Model	X Line		X Line	
Size	315/80R22.5		315/80R22.5	
Pressure	86 psi		92 psi	
Tread Depth	16, 16, 16, 16		10, 10, 10, 10	
DOT #	HAD7039X 4922		FVD7039X 4920	
Retread #	-		CIARDBP 0123	
Load Rating	9090 lbs.		9090 lbs.	

During the tire inspection, an unknown stamp was located on both steer axle tire sidewalls. Axle-1-left had a branded stamp located on the sidewall that stated "RLY15343J" (Figure 17) and axle-1-right was also branded with a sidewall stamp that stated "KLY12194J". The tire manufacturer, Michelin, was contacted by NTSB investigators. According to Michelin, the stamps were "matricule numbers". Typically, a Michelin tire that is produced in North America is labeled with a barcode sticker for tracking purposes. These two tires that displayed the unique stamp were produced at Michelin's Spain plant. Rather than a barcode, the Spain plant used the matricule numbers as an identification or serial number for internal tracking of the tire. Michelin

¹² Measured in 1/32" increments (outboard to inboard).

further stated that beyond the internal traceability in the plant, the matricule number served no other purpose.¹³



Figure 17: Motorcoach - Tire Stamp Located on Steer Axle Tire

1.10 Braking System

The motorcoach was equipped with air operated disc brakes. As a result, stroke length measurements typically measured with drum brakes were not applicable. During the imaging of the vehicle's modules, the motorcoach was pressurized and provided power. There were no air leaks discovered in the air system. The brake primary and secondary tank pressure were stable and recorded to be 116.0 and 113.1 psi, respectively, as observed in Figure 19.

Operation of the brake pedal and low air warning was accomplished by connecting an external air source directly to the air system of the motorcoach. Once the brake air pressure was approximately 120 psi, a full brake application was applied, and no air leaks were detected. The brake pedal was then pumped to exhaust the air pressure down, and the low air warning activated at approximately 60 psi.

¹³ See **Vehicle Factors Attachment:** Michelin Tire Correspondence

There was slight bluing¹⁴ observed to axle-2-left's rotor. Lips were observed on the rotors for axle 2-left and axle-2-right.¹⁵ The minimum rotor thickness for the subject rotors were 37mm (1.456 inches) and the thickness of brand-new rotors were 45mm (1.771 inches).¹⁶ An axle-1-right air brake hose was observed with chaffing present. The chaffing and wear extended through the braid reinforcement ply, as observed in Figure 18, in violation of 49 CFR 393.45(b)(2).¹⁷ Due to the wear extending through the reinforcement ply, an out-of-service criteria for the motorcoach was met. There were no other defects observed during the examination of the braking system.

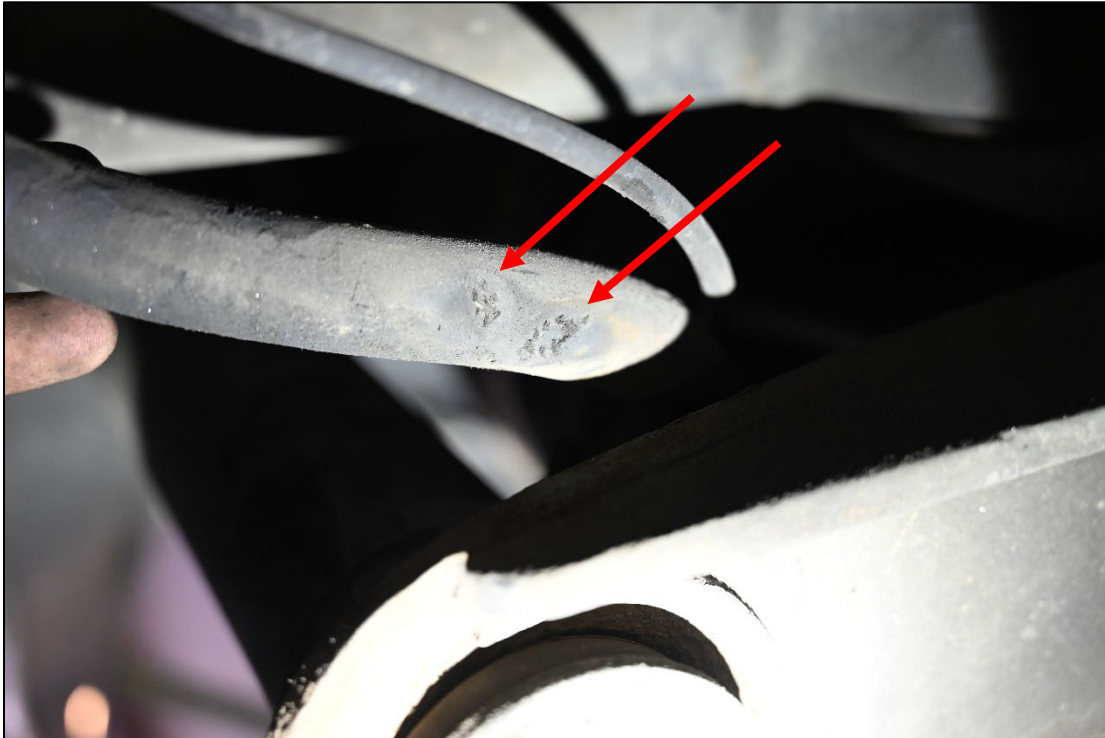


Figure 18: Motorcoach - Axle-1-Right Out-of-Service Air Brake Hose

¹⁴ Bluing to brake rotor is caused by excessive heat buildup between the brake rotor and brake pads during heavy or prolonged braking.

¹⁵ A lip is created as brake pads do not normally contact all the rotor surface.

¹⁶ Per Greyhound Lines, Inc.

¹⁷ [49 CFR 393.45 Brake tubing and hoses; hose assemblies and end fittings.](#)

Table 3: Brake Component Information

Position	Brake Type	Lining Thickness ¹⁸		Rotor Thickness	Brake Chamber	
		Inside	Outside			
Axle 1	Left	Disc	26	26	1.763"	24 Regular
Axle 1	Right	Disc	16	16	1.762"	24 Regular
Axle 2	Left	Disc	23	24	1.570"	24/24 Regular
Axle 2	Right	Disc	23	23	1.590"	24/24 Regular
Axle 3	Left	Disc	14	12	1.648"	16 Regular
Axle 3	Right	Disc	17	16	1.657"	16 Regular

1.10.1 Anti-Lock Braking System (ABS)

The motorcoach was equipped with a 6-sensor, 5-modulator (6S/5M) ABS. The ABS was controlled by a Bendix EC-60 electronic control unit (ECU), part number K038368, ABS software BB41062. There was an ABS sensor broken from impact located on axle-1-right. All other ABS sensors, wiring, and modulators remained intact and in place.

1.11 Electrical System

During the vehicle examination and the imaging of the motorcoach's EDR modules, the motorcoach was powered without issue. The electrical system to the motorcoach was functional, however, power was disconnected from the motorcoach post-collision on-scene. When powering the vehicle, Bendix ACom Diagnostics was utilized to evaluate various vehicle system statuses and to extract data from vehicle modules. During the imaging of the modules, the battery voltage and the ABS battery voltage was reported to be 25.1 volts and 12.1 volts, respectively, as observed in Figure 19.

The instrument cluster contained a backup battery that kept the ECM date and time current in the event of a power loss to the vehicle's electrical system. The instrument cluster was removed by NTSB investigators to determine if the backup battery was functional. The battery voltage was measured to be 3.195 volts. The instrument cluster was returned to the driver's floorboard area of the subject motorcoach.

¹⁸ Measured in 1/32 of an inch.



Figure 19: Motorcoach - Bendix ACom Overview

1.12 Lighting

The motorcoach's lighting was tested without issue. The left headlight assembly's low and high beams, hazards, turn-signals, taillights, and brake lights were all inspected and in working condition. The right headlight assembly was damaged from the collision and the low and high beam bulbs were not recovered. The left headlight assembly's low and high beam bulbs were removed from the vehicle by NTSB investigators, secured as evidence, and submitted to the NTSB Materials Laboratory, located in Washington, DC, for further advanced imaging of the bulb filaments to facilitate further analysis. The imagery of the left headlight assembly bulbs can be observed in Figure 20 and Figure 21.

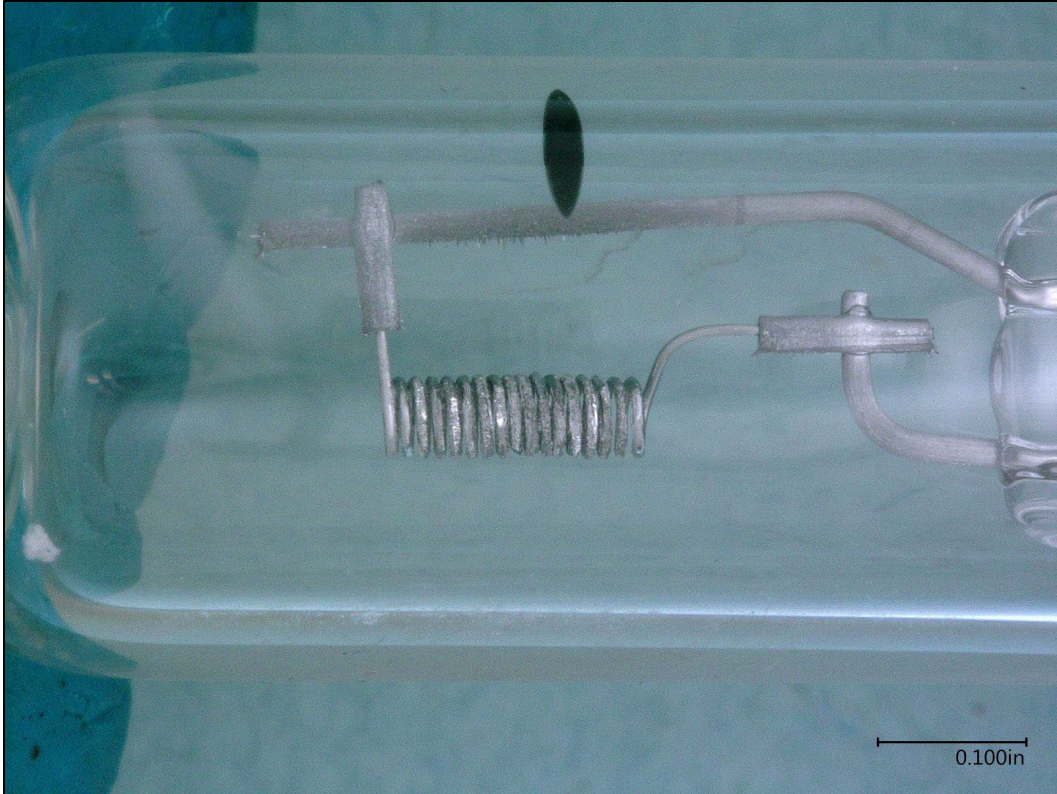


Figure 20: Motorcoach - Left Low-Beam Filament

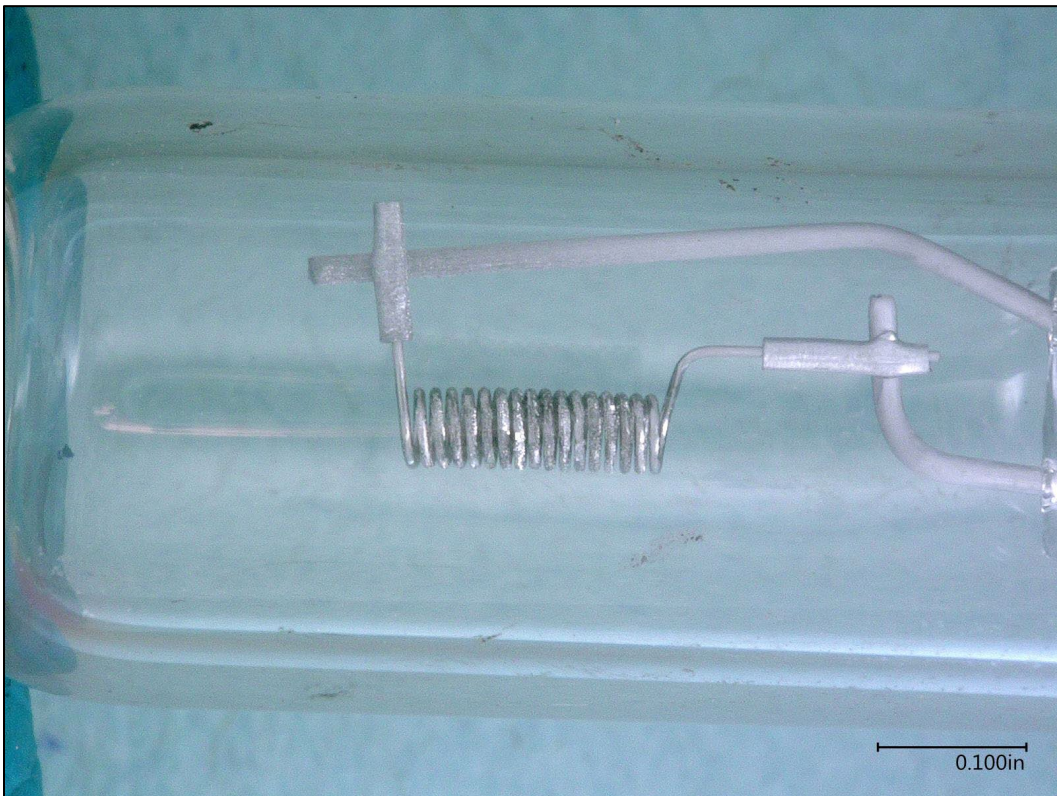


Figure 21: Motorcoach - Left High-Beam Filament

The rear of the motorcoach was captured by Freightliner's dash-cam during the collision sequence. The motorcoach's rear lights were illuminated during collision sequence, as observed in the screenshot of the video footage located in Figure 22.



Figure 22: Motorcoach - Rear Lighting During the Collision Sequence (Source: Freightliner's dash-cam)

1.13 Powertrain

The engine was mounted at the rear of the motorcoach. An inspection of the engine compartment, which included the accessory drive belts, operating fluids, and electrical, revealed no defects or malfunctions.

As with the engine, the transmission was mounted at the rear of the motorcoach. The transmission was still intact and securely mounted to the engine and frame of motorcoach. The output shaft of the transmission was connected to a short driveline via a yoke and universal joint assembly. The opposite end of the driveline was connected to the pinion gear shaft of the drive axle also via a yoke and universal joint assembly. A visual inspection of the transmission and driveline revealed no defects or malfunctions.

The drive axle housing was mounted to the motorcoach in the axle two location. Within the axle housing, the pinion gear transfers the rotational movement transmitted from the transmission, via the driveline, to the ring gear. The ring gear then transfers

rotational movement to the two axle shafts which are connected to tires and wheels at their respective outboard ends. An inspection of the drive axle housing revealed no defects or malfunctions.

1.14 Maintenance and Inspection History

The motorcoach's maintenance records, and inspection history were obtained from Greyhound Lines, Inc. and reviewed. According to maintenance records obtained from Greyhound, a routine inspection of the "adaptive cruise braking system" was completed during Work Order 1159906, which was completed on July 6, 2023, six days prior to the subject collision. During the routine inspection, the system was inspected for proper operation and a complete testing of the (software) suite.

According to Work Order 1153481, which was completed on June 29, 2023, the motorcoach's steering system was inspected and the drag link, tie rod assembly, pitman arm, steering gearbox, and the arm stabilizing bar were replaced after popping noises were heard while turning or driving over "bumps" and play was found in the steering gear.¹⁹

¹⁹ See **Vehicle Factors Attachment**: Maintenance Records.

1.15 Documented Recalls and Warranty Claims

Table 4: Completed Warranties, Bulletins, and Recalls²⁰

Date		Description
1/25/2014	Warranty	Replaced pendant
2/11/2014	Warranty	Wheelchair ramp safety switch repaired
2/26/2014	Warranty	FSS harness short repaired
8/29/2014	Warranty	Vehicle is overheating - removed and replaced bearings
8/30/2014	Warranty	AC not working - removed and replaced solenoid
9/16/2014	Warranty	Sunshade removed and replaced
9/19/2014	Warranty	Regular check of lights - LED removed and replaced
9/25/2014	Warranty	Engine compartment lamp replaced due to shorted out wires
10/31/2014	Warranty	Fan clutch replaced
11/13/2014	Warranty	AC repaired
12/20/2014	Warranty	AC repaired
1/21/2015	Warranty	Replaced light lens on rear of vehicle
1/21/2015	Warranty	Backup alarm replaced
1/21/2015	Warranty	LED lamp replaced
1/23/2015	Warranty	Webasto timer replaced
1/24/2015	Warranty	Brake light assembly replaced
1/27/2015	Warranty	Backup alarm replaced
6/2/2015	Warranty	Regular check of motorcoach - LED replaced
9/22/2015	Warranty	Lamps replaced
11/14/2015	Warranty	PA amp replaced
11/14/2015	Warranty	Turn signal LED replaced
11/14/2015	Warranty	Coolant cap replaced
11/14/2015	Warranty	Alternator replaced
11/30/2015	Warranty	AC repaired
12/2/2015	Warranty	Replaced turbo, oil pressure sensor, and hose
12/4/2015	Warranty	Diesel particulate filter clogged - disassembled and cleaned
5/24/2018	Recall	Emission campaign EC0017 - ECM software updated
5/24/2018	Recall	SR17-28 - Fuel tank cradle mounting bolts replaced
6/6/2018	Bulletin	WB17-16 Part A ²¹
10/23/2019	Warranty	Belt bearing replaced
9/17/2021	Warranty	Replaced hub fan assembly
9/17/2021	Warranty	Replaced belt tensioner
9/17/2021	Warranty	Replaced crowned pulley and belts
2/14/2023	Warranty	Replaced nitrogen oxide (NOx) sensor
4/18/2023	Warranty	Replaced pump 85013590

²⁰ See **Vehicle Factors Attachment:** Prevost Warranty Claims.

²¹ On the vehicles affected by this bulletin, remove selected wires from C15 and C58 of the HVAC system wiring, and place them in new connectors C15B and C58B. New connectors have a higher amp rating.

Table 5: Motorcoach - Completed and Open Recalls²²

Date	Safety Recall #	NHTSA #	Description	Completed
7/2017	EC0017	-	Emissions Recall	Yes
11/2014	SR14-02	13V-650	Lower windshield wiper motor	Yes
4/2016	SR16-18	16V-133	Transmission oil cooler - vent line removal	Yes
12/2017	SR17-28	17V-618	Fuel tank may separate from vehicle	Yes
5/2019	SR19-04	18V-928	Draglink replacement	No ²³
9/2022	SR22-05	22V-221	Alternator belt replacement	No ²⁴

1.16 Annual Inspections

The latest Federal Motor Carrier Safety Administration (FMCSA) Annual Vehicle Safety Inspection was completed on April 4, 2023.²⁵ The inspection was completed in Miami, Florida, and the subject motorcoach did not have any defects noted. The subject motorcoach also completed an FMCSA Vehicle Safety Inspection in Los Angeles, California, on February 14, 2022. During the 2022 annual safety inspection, no defects were noted.

1.17 Event Data Recorders

The motorcoach was equipped with several systems and modules that would have event data recorder (EDR) capabilities. The motorcoach's Volvo engine contained an engine/electronic control module (ECM) capable of recording diagnostic information and electronic data that may be associated with a hard braking event and last stop data information. The motorcoach's ABS controller was a Bendix EC-60 ECU that was capable of recording diagnostic information. Bendix EC-60 ABS ECUs possess the official capability of recording Bendix Data Recorder (BDR) information beginning revision number BB411X. Our subject EC-60 was BB410X, which was prior to the official recording capability. Bendix was contacted for assistance with the translation of the .html or .logx files extracted during the imaging. The motorcoach's transmission (Allison Transmission) possessed select recording capabilities. The motorcoach was equipped with a Bendix Wingman BX161502L forward-looking radar unit which also possessed recording capabilities via the EC-60 ECU. All of the aforementioned modules were imaged.

The motorcoach was also equipped with a Lytx SF300 inboard/outboard facing camera and telematics system that was capable of recording audio, video, and data

²² See **Vehicle Factors Attachment:** Completed and Open Recalls.

²³ Per Prevost, SR19-04 had not been completed. Steering components, including the drag link were replaced June 29, 2023, on the subject motorcoach.

²⁴ Per Prevost, SR22-05 had not been completed.

²⁵ See **Vehicle Factors Attachment:** Annual Inspections.

related to programmed triggers. The Lytx camera system was reportedly damaged and was sent to a Lytx forensic laboratory in San Diego, CA, for data recovery by Greyhound Lines, Inc, prior to NTSB's arrival on-scene. The results of the data extraction were negative for recovering any crash related video or audio files.

1.17.1 ECM Data

Electronic data was retrieved from the motorcoach's ECM. Various diagnostic information, fault codes, and DataMax Incident Log Information were evaluated.²⁶ Refer to Technical Reconstruction Group Chairman's Factual report for further information.

1.17.2 BDR Data

The pre-supported proprietary BDR translated data obtained from Bendix did not reveal any data related to subject crash.

1.18 Collision Mitigation Technologies

The motorcoach was equipped with a forward-looking Bendix Wingman radar unit, Prevost electronic stability program (ESP), and Prevost Aware adaptive cruise braking system.

The Prevost ESP was manufactured by Bendix and could provide full stability to help drivers mitigate rollover and loss-of-control situations on dry, wet, and ice-covered roadways.²⁷ The Prevost Aware system contained multiple mitigation functions including adaptive cruise braking that is capable of providing warnings and active interventions to reduce throttle, engaging the engine retarder, or applying the brakes to help maintain a safe following distance for the motorcoach if the cruise control was active and had a speed set.²⁷ It should be noted, the subject motorcoach did not have the cruise control active during the subject collision. If cruise control is not active, the Prevost Aware system can provide passive audible and visual alerts to the driver when the vehicle is approaching a significant roadway obstruction in their lane of travel up to three seconds prior to a potential impact.

1.18.1 Current Collision Mitigation Technologies

On February 4, 2020, Prevost announced the launching of a new optional safety suite known as Prevost Driver Assist.²⁸ The Prevost Driver Assist would be available for Prevost model years 2021 and later but could be retrofitted on motorcoaches with

²⁶ See **Vehicle Factors Attachment**: Prevost Data Imaging Report.

²⁷ [Prevost Launches Adaptive Cruise Braking by Bendix](#) - Accessed November 9, 2023.

²⁸ [Prevost Launches Driver Assist Electronics Suite](#) - Accessed November 9, 2023.

ABS8 back to model year 2018.²⁸ Prevest Driver Assist integrates a forward looking radar, camera, braking, and driver communication technologies to offer frontal collision mitigation, vehicle braking in response to stationary vehicles or large objects, lane departure warning, adaptive cruise control with braking, and following distance alerts, in addition to ABS and ESP.²⁸ Prevest Driver Assist safety suite was not available as a standard or optional feature on the subject 2014 Prevest motorcoach. The motorcoach was not equipped with an active or passive lane assist technologies.

2.0 2019 Freightliner Truck-Tractor and 2024 Vanguard Semitrailer

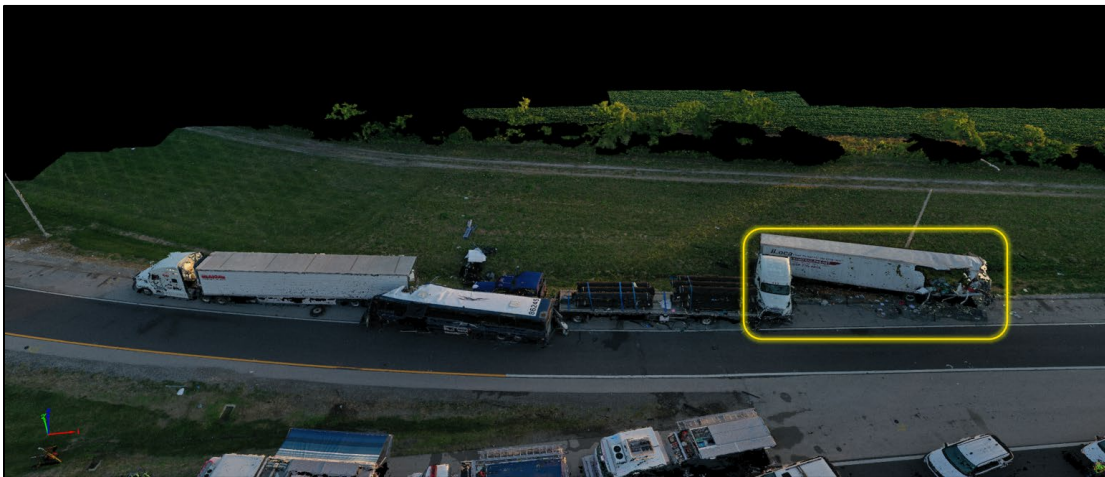


Figure 23: Tractor-Trailer 1 - Final Rest Position from Processed Point Cloud



Figure 24: Tractor-Trailer 1 - 2019 Freightliner Cascadia and Vanguard Trailer (Source: ISP)

2.1 General Information

Freightliner:

Make:	Freightliner
Model:	Cascadia (PT126064STSLP)
VIN:	3AKJHHDR9KSKP9922
Model Year:	2019
Vehicle #:	815027
Date of Manufacture:	August 2018
GVWR:	53,300 lbs.
GAWR (Axle 1):	13,300 lbs.
GAWR (Axle 2,3):	40,000 lbs.
Engine:	Detroit Diesel DD15

Trailer Information:

Make:	Vanguard National Trailer Corporation
Model:	REM VXP 53' Dry Van
Model Year:	2024
Manufactured:	January 2023
Axles:	2
GVWR:	68,000 lbs.

VIN: ²⁹	5V8VC5327RM406898
Trailer #:	534138
Conspicuity tape:	Yes

2.2 Damage Description

The Freightliner truck-tractor and Vanguard semitrailer (Tractor-Trailer 1) combination sustained damage to the front and front-right of the truck-tractor. The front bumper was pushed downward and was peeled away from the right bumper support. The right headlight assembly was damaged and separated from the vehicle. The left headlight assembly was cracked. The front grille was pushed rearward. The left-side fiberglass hood was cracked. The trailer received contact and induced damage to its rear left. The left-side of the trailer was damaged and there was an approximate 15-foot opening in the left-side of the trailer where several side skin panels were missing. The opening extended to the rear of the trailer. The rear portion of the trailer's cant rail and waist rail were damaged and displaced. There was a tear located on the left-side of the trailer's waist rail above axle-4. Several roof bows and floor rails were damaged. The left-rear of the trailer was displaced upward and rightward. The tire belonging to axle-5-left-outside was damaged and located inside of the trailer. The tire had an approximate four inch cut and several small cuts and abrasion marks located on the exterior of the sidewall. The wheel belonging to axle-5-left-outside was deformed inward and there was black-colored transfer observed on it.

2.3 Lighting

Body-cam video footage was obtained from an ISP first responder's vehicle. Tractor-Trailer 1's right taillight assembly, the rear clearance lights, and the rear identification lights were visible and illuminated in the body-cam video footage at the moment ISP arrived at the crash location shortly after the collision occurred. From the body-cam video footage, Tractor-Trailer 1 hazard lights were not activated. Tractor-Trailer 1 was the rearmost and first struck tractor-trailer combination in the collision sequence.

²⁹ Vehicle Identification Number.

3.0 2000 Kenworth Truck-Tractor and 2007 Benson Semitrailer



Figure 25: Tractor-Trailer 2 - Final Rest Position from Processed Point Cloud



Figure 26: Tractor-Trailer 2 - 2000 Kenworth W900 and Benson Trailer

3.1 General Information

Kenworth:

Make:	Kenworth Truck Company
Model:	W900
VIN:	1XKWD69X3YJ850703

Model Year: 2000
Vehicle #: 850703
Date of Manufacture: November 1999
GVWR: 52,350 lbs.
GAWR (front): 12,350 lbs.
GAWR (first inter): 20,000 lbs.
GAWR (rear): 20,000 lbs.
Engine: Cummins N14

Trailer Information:

Make: Benson International (Acquired by Wabash National Corporation)
Model: 524 (AF5244810250)
Model Year: 2007
Manufactured: August 10, 2006
Axles: 2
GVWR: Unknown
GAWR (front): 20,000 lbs.
GAWR (rear): 20,000 lbs.
VIN: 5DMFABTB07C000309
Trailer #: 14831
Conspicuity tape: Yes

3.2 Damage Description

The Kenworth truck-tractor and Benson flatbed trailer combination (Tractor-Trailer 2) sustained damage to the rear-left and left-side of the vehicle. Tractor-Trailer 2 combination was parked and was loaded with approximately 34,650 pounds of Tyton® X PE joint pipe cargo when it was impacted.³⁰

The rear-left of the trailer received contact damage to the left taillight assembly, the left mudflap (missing from trailer), and to the left-side stake pockets. Approximately four feet of left-side stake pockets were damaged and separated from the trailer. The truck-tractor received semi-horizontal scrape marks to the left-fender, damage to the driver's entry and exit steps, and inward denting and horizontal scraping to the left-side of the fuel tank. The fuel tank was punctured due to the crash and dripping onto the ground. The left-side exhaust stack was torn away from the cab.

³⁰ **Vehicle Factors Attachment:** Bill of Lading - Tyton Load

3.3 Lighting

To assess the rear lighting condition of Tractor-Trailer 2, Tractor-Trailer 1's dash-cam video footage was evaluated. Tractor-Trailer 1's video footage activated post-impact, after the combination unit jack-knifed, as observed in Figure 27. As a result, the rear of Tractor-Trailer 2 is not visible in the video footage. There are no other known video sources or witness testimony to confirm if Tractor-Trailer 2's rear lights or hazard lights were illuminated in the moments leading up to the subject collision. Tractor-Trailer 2 was the second struck combination vehicle in the collision sequence and was directly in front of Tractor-Trailer 1.

4.0 2023 Mack Truck-Tractor and 2019 Great Dane Semitrailer



Figure 27: Tractor-Trailer 3 - Final Rest Position from Processed Point Cloud

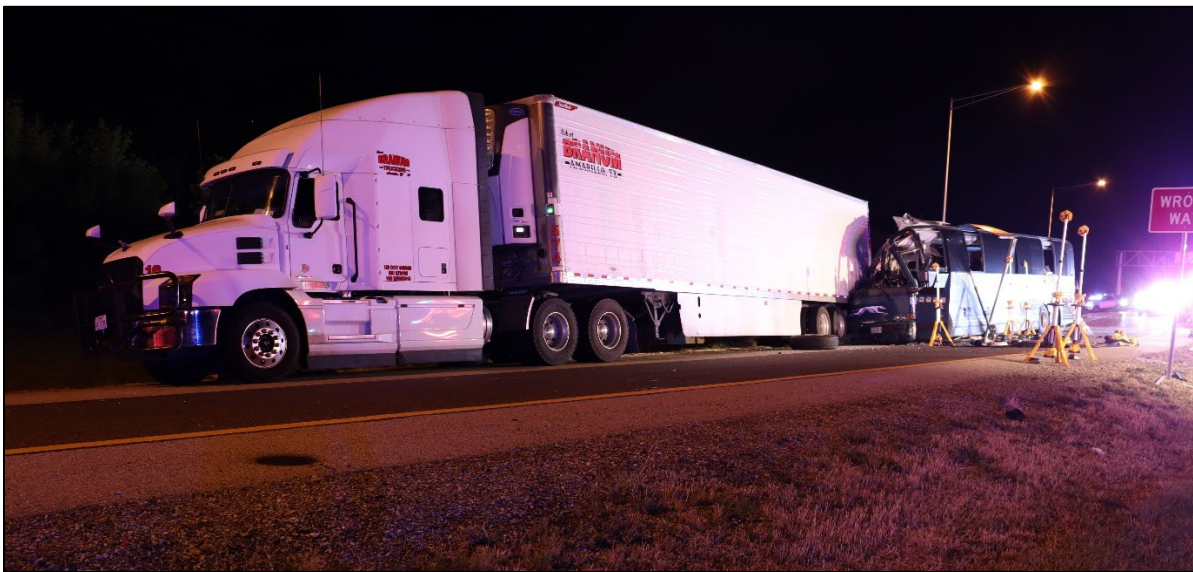


Figure 28: Tractor-Trailer 3 - 2023 Mack Truck-Tractor and Great Dane Semitrailer (Source: ISP)

4.1 General Information

Mack:

Make:	Mack Trucks, Inc.
Model:	Anthem (AN64T)
VIN:	1M1AN4GY6PM039915
Model Year:	2023
Date of Manufacture:	June 2022
GVWR:	53,200 lbs.
GAWR (Axle 1):	13,200 lbs.
GAWR (Axle 2):	20,000 lbs.

GAWR (Axle 3):	20,000 lbs.
Engine:	MP8
Factory Curb Weight:	18,820 lbs.
Curb Weight - Front	10,880 lbs.
Curb Weight - Rear	7,940 lbs.

Trailer Information:

Make:	Great Dane Trailers
Model:	ESS-1114-31053 (Everest Super Seal)
Model Year:	2019
Manufactured:	November 2017
Axles:	2
Height:	13 feet 6 inches
Length:	53 feet (Refrigerated van semitrailer)
GVWR:	68,000 lbs.
GAWR (All axles):	20,000 lbs.
VIN:	1GRAA062XKW100574
Trailer #:	574
Conspicuity tape:	Yes

4.2 Damage Description

The Mack truck-tractor and Great Dane semitrailer combination (Tractor-Trailer 3) were removed from the scene and released prior to NTSB's arrival at the crash location. A detailed examination of provided photographs were conducted to assess the damage to the Tractor-Trailer 3. The rear-left of the Great Dane trailer was impacted by the front-right of the motorcoach. At final rest, the motorcoach and the Great Dane trailer remained in contact, as observed in Figure 29. The damage to the Tractor-Trailer 3 was localized to the rear-left of the trailer. The left-side of the rear underride protection guard was bent and there was a horizontal tear in the rear-left portion of the trailer's body that was approximately two feet in length.



Figure 29: Tractor-Trailer 3 and Motorcoach at Final Rest (Source: ISP)

4.3 Lighting

Dash-cam video footage from Tractor-Trailer 2 was obtained. The video footage shows the rear of Tractor-Trailer 3 prior to the subject collision. Tractor-Trailer 3's rear-lights and hazard lights were not activated nor illuminated prior to the subject collision, as observed in Figure 30.



Figure 30: Tractor-Trailer 3 - Rear Lighting Condition Prior to Impact (Source: Tractor-Trailer 2 dash-cam)

E. DOCKET MATERIAL

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

LIST OF ATTACHMENTS:

Vehicle Factors Attachment: Prevost Order Specification Document.

Vehicle Factors Attachment: Michelin Tire Correspondence.

Vehicle Factors Attachment: Maintenance Records.

Vehicle Factors Attachment: Prevost Warranty Claims.

Vehicle Factors Attachment: Completed and Open Recalls.

Vehicle Factors Attachment: Annual Inspections.

Vehicle Factors Attachment: Prevost Data Imaging Report.

Vehicle Factors Attachment: Bill of Lading - Tyton Load.

Submitted by:

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