VEHICLE FACTORS
GROUP CHAIRMAN'S FACTUAL REPORT

Multiple Fatality Motorcoach Collision
With Vertical Poles Supporting an Overhead Bridge Sign
New York, NY; 03/12/2011

HWY-11-MH-005
(12 Pages)

NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF HIGHWAY SAFETY
WASHINGTON, D.C. 20594

VEHICLE FACTORS
GROUP CHAIRMAN'S FACTUAL REPORT

A. ACCIDENT

LOCATION:	Interstate 95 (I-95) New England Thruway, at Mile Marker 3.2, in New York, Bronx County, New York
VEHICLE 1:	1999 Prevost H3-45 56-Passenger Motorcoach
OPERATOR:	World Wide Travel of Greater New York, Ltd.
DATE:	March 12, 2011
TIME:	Approximately 5:37 a.m. EST

NTSB #: HWY-11-MH-005

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C. DETAILS OF INVESTIGATION

This report is a collection of factual information obtained during the detailed inspection of the accident bus and subsequent review of records. The 1999 Prevost motorcoach (the bus) was inspected at New York State Police Troop K headquarters in Salt Point, NY, between March 13th and 19th, 2011.

All major mechanical systems were examined, including the steering, braking, and suspension systems. Overall accident damage, along with any damage or anomalies within major vehicle mechanical systems was documented. Supporting photographs, vehicle specifications, maintenance records, and prior New York state inspections have been collected. Information was downloaded from the bus engine, which was equipped with a Detroit Diesel Electronic Control (DDEC) module, as well as the MeritorWABCO anti-lock brake system (ABS) module.

The inspection was conducted in conjunction with the New York State Police (NYSP) and the New York State Department of Transportation (NYSDOT), who is tasked with the inspection of all buses in the State of New York.

D. VEHICLE INSPECTION

1. VEHICLE #1: 1999 PREVOST H3-45, 56-PASSENGER MOTORCOACH

1.1 GENERAL INFORMATION

VIN: 2PCH33491X1xxxxxx
Model: H3-45, 56-passenger
Ordered by: World Wide Travel, Ltd. in March 1999
Manufactured: October 1999
Mileage: 857,238[1]

Curb Weight:	36,860 lbs
GVWR:	52,060 lbs
GAWR Front (Steer Axle):	16,500 lbs
GAWR Intermediate (Drive Axle):	22,500 lbs
GAWR Rear (Tag Axle)	14,000 lbs

Engine: Detroit Diesel Series 60, 6067MK28, serial number – 06R0508542
Transmission: Allison Automatic B500, serial number – 6610044402
Steering Gear: TRW model TAS 85097
Brake Type: Knorr-Bremse 6-wheel type SN7 air disc brakes, with 4-wheel ABS

[1]This mileage is an addition of two sources; the original engine ECM had a mileage of 763,160 miles when it was replaced on 12/1/2009. The mileage according to the new DDEC was 94,078 miles at the time of the accident.

1.2 DAMAGE DESCRIPTION

For uniform description, "left" will refer to the driver's side, and "right" will refer to the boarding door side of the accident bus.

The bus was damaged over the entire extent of its right side.[2] All passenger windows with the exception of the rearmost window on the right side, and two rearmost windows on the left side, were broken out. No damage was noted below the window line on the left side of the bus.[3] The front of the bus sustained significant damage that broke out the left and right upper, and right lower windshield panels, and pushed the front portion of the roof rearward, creating a large opening at the front of the bus.[4] The right front side of the bus, where the boarding had been located, was also pushed rearward, reducing the width of the entrance stairwell. Just forward of where the boarding door had been located, at the far right front lower edge of the bus, a metal corner of the unitized body was exposed and clean metal scrapes were observed at its underside.[5]

Linear scrapes were observed running from the front of the bus to the back of the bus along the length of the right side. The scrape marks were located below the window frames and on the luggage bay doors. In line with the scrapes, there were indentations where the scrapes passed over the vertical right side structural support columns. A debris pile, located along side the accident bus at the inspection site, was sorted and several fractured sections of the body panels and luggage bay doors were located. Many of the right side body panels and luggage bay doors found in the debris pile also had linear scrapes, going from front to rear. The debris pile also contained the front upper header section of the bus, as well as several of the upper window mounts, and fractured sections of the boarding door. These sections were laid out alongside the accident bus, near their estimated original positions, and photographed.[6]

At the rear of the bus, where the engine was located, several of the engines exhaust system components that were mounted to the right side of the engine compartment were pushed inward, and a mounting for the engine's turbo booster was fractured. The battery and electrical circuit compartment, just forward of the engine compartment on the right side of the bus, was damaged.[7] The damage caused the positive battery charge post to come into contact with adjacent metal. This caused a short to ground in the electrical system and resulted in distortion to the insulation on the positive battery charge post and cable. For the safety of personnel that would be coming into contact with the bus during the inspection, the positive battery power was disconnected from the cables leading to the charge posts for the remainder of the inspection.

1.3 WEIGHT AND MEASUREMENTS

The accident bus was weighed by the New York State Police using certified portable scales on March 17th, 2011. The measured axle weights are shown in **Table 1**. Due to the post crash condition of the bus, axle weights may not be distributed as they were at the time of the

[2] See Vehicle Photo 1 – Post crash view of the accident bus, right side
[3] See Vehicle Photos 2 and 3 – Post crash view of the accident bus, left side and left front corner
[4] See Vehicle Photo 4 – Post crash view of the accident bus, right front corner
[5] See Vehicle Photo 5 – Right front lower edge of the bus body, showing scrape marks
[6] See Vehicle Photo 6 – Post crash view of the accident bus, with panel sections laid out
[7] See Vehicle Photo 7 – Right rear of the accident bus, showing damage to engine and electrical components

accident. Additionally, the weights shown do not include the weight of the passengers and their belongings that were onboard the bus at the time of the accident.

Table 1: Accident Bus Axle Weights

Position	Weight (lbs)	
	Left	Right
Steer Axle	4,100	4,650
2nd Axle	6,300	7,550
3rd Axle	6,100	4,200
Total	32,900	

According to the manufacturer, Prevost, a H3-45 model motorcoach has a dry weight (without fuel and oil) of approximately 33,800 lbs at the time it was built.[8] Pre-crash dimensional specifications according to the manufacturer are listed in **Table 2**, along with hand measurements taken of the accident bus at the time of inspection.

Table 2: Pre and Post Crash Measurements of Accident Bus

Dimension	Pre-Crash (inches)	Post-Crash (inches)
Overall Length	548	Left - 546 Right - 547
Overall Width	101	Front - 101 Rear - 101
Wheelbase (Axles 1-2)	316.25	Left - 315.5 Right - 316
Axle Spacing (Axles 2-3)	47.5	Left - 47.5 Right - 48
Track Width (Steer)	84.4	86
Track Width (Axle 2)	76.7	75
Track Width (Axle 3)	83.6	83.5
Front Overhang	76	Left - 74 Right - 74
Rear Overhang	108.25	Left - 108 Right - 108

In addition to the hand measurements, the accident bus was photographed using photogrammetric markers that allow the images of the bus to be referenced to one another, and can be used to create a three dimensional model, from which any scaled measurement can then be taken, a process known as photogrammetry. iWitnessPRO software was used to correlate the photographs and generate the three dimensional model. Photogrammetry was completed on the accident bus on March 17th, 2011 with the roof still attached, and collapsed downward, as found upon initial inspection. The roof of the accident bus was then cut off on March 18th, and photogrammetry was again done with the roof off on March 19th, 2011. In addition, photogrammetry was completed on an exemplar motorcoach owned by World Wide Travel (a

[8] See Vehicle Attachment 1 – Final Record and Technical Specifications for the Accident Bus.

2001 model year Prevost H3-45) on March 18th, 2011. Images of the three-dimensional models can be found in the docket for this investigation.[9]

Prevost conducted calculations for the estimated center of gravity of the accident bus and determined the center of gravity to be located at approximately 238.50 inches rear of the front axle, and approximately 53.08 inches above ground height. Rollover stiffness and rollover threshold calculations were also performed and can be found in the docket for this investigation.[10]

1.4 DRIVER CONTROLS

The driver's seat was intact and in place in the bus. To the left of the driver's seat was a long narrow panel, which was found disconnected at the rear and loose, and included switches for the air operated tag axle (to lower or raise the axle), as well the push/pull button for the air parking brakes, side mirror adjustment, driver's window, cruise control, and transmission selector.[11]

The dash in front of the driver's seat was not damaged on the side that faced the driver. However, the backing to the dash (the side closer to the windshield) was broken off and found in the debris pile. On the left side of the dash there was a panel that included switches for the exterior lighting, high idle, engine brake, and windshield wipers. In the center of the dash, in front of the steering wheel, there were 10 gauges for coolant temperature, coolant pressure, oil pressure, engine rpm (revolutions per minute), vehicle speed, battery power, fuel level, air compressor pressure, front brake system air pressure, and rear brake system air pressure. All gauge needles were found at their '0' (or start point) at the time of inspection. On the right side of the dash, there were additional buttons and switches for interior lighting, boarding door operation, and front kneeling for the bus. The right side of the dash also included controls for the audio visual passenger entertainment system that was on the bus, as well as the heating and air conditioning controls.[12]

The accident bus was also equipped with a "Scenic View" camera system, manufactured by Radio Engineering Industries, Inc. The camera was mounted in the lower right corner of the upper left windshield panel facing forward, out of the front of the bus. This system is designed to allow the view to the front of the bus to be shown, via closed circuit broadcast, to the video monitors in the passenger area of the motorcoach, and is not designed to record or store any information, including video files. According to the manufacturer, a separate video surveillance system option would have to have been installed, including a video switcher and either a digital video recorder or a VCR, in order to provide recording capability through this system. During an examination of the accident bus and the associated wreckage, no such recording equipment was located.

1.5 STEERING AND SUSPENSION

The steering wheel was found to be concentric and was not deformed. With the front axle tires lifted off the ground, full rotation of the steering wheel from far left to far right was

[9] See Vehicle Attachment 2 – Images of the Three-dimensional Models of the Accident and Exemplar Motorcoaches
[10] See Vehicle Attachment 3 – Center of Gravity and Roll Stiffness Calculations for the Accident Bus
[11] See Vehicle Photo 8 – Driver control panel to the left of the driver's seat
[12] See Vehicle Photo 9 – Driver control area forward of the driver's seat

possible without restriction or binding being felt at the wheel. With movement of the steering wheel, the front axle tires and wheels were observed to move outward and inward, from axle stop to axle stop, corresponding with the rotation of the steering wheel.

The steering column transcended through the floorboard of the accident bus and into a TRW hydraulically assisted steering gear box via a universal joint. The output shaft from the steering gear was then connected to the pitman arm and drag link. The drag link was connected to the left side of the front axle (referred to as the steer axle), and the cross member was connected from left to right across the rear of the steer axle, with tie rod end connections into either side of the axle. A steering dampener was located on the right side of the steer axle. No damage was noted to any of the steering system components. All connections were solid and free of wear or excess play.

The accident bus was equipped with both pneumatic (air) and conventional suspension system components. The steer axle was equipped with left and right side air suspension cushions, as well as fore and aft bilateral shock absorbers. Torsion bar and stabilizer links were present. All steer axle suspension components were found to be undamaged.

The drive and tag axle suspension included six air suspension cushions, as well as six shock absorbers. Torsion bars and stabilizer links were present and undamaged. The tag axle was equipped with a pneumatically-operated assembly to raise and lower the axle, which was found undamaged and functional. The top mounting of the left tag axle air suspension cushion had become detached, and the outer bolt subsequently damaged when it was bent over onto the top of the air cushion. The air line supplying the left tag axle air suspension cushion was pulled apart at the inside edge, creating a hole in the line and a subsequent air leak. On the opposite side of the bus, there was a tag axle tire contact mark with the right side tag axle shock absorber, as well as a drive axle tire contact mark with the adjacent section of the unitized bus body.[13]

1.6 TIRES AND WHEELS

According to the placard mounted behind the driver's seat, the bus was to be equipped with 315/80R22.5 load range J tires mounted on 22.5X9 rims for all axles. Recommended tire pressure was listed as 120 pounds per square inch (psi) for the steer axle tires, 90 psi for the drive axle tires, and 100 psi for the tag axle tires. The bus was found to be equipped with all Michelin brand, type XZA tires. According to Michelin's tire load and pressure ratings for these types of tires, the tires have an operating range from 85 psi to 130 psi, depending on the load. At 100 psi, the tires have a maximum load limit of 14,380 lbs per axle in a single wheel application, and 26,180 lbs per axle in a dual wheel application.[14]

Table 3 includes information on the condition of the bus tires as they were examined at the time of inspection. The tires were all of the same size, which was the size specified by the manufacturer. All tires were load range L, which have equivalent or higher load ratings as the specified load range J tires.

Tire tread depth measurements were taken in tread grooves of each tire; the lowest number found is displayed in **Table 3**, and represents a minimum tread depth. The minimum

[13] See Vehicle Photo 10 – Rear suspension damage and tire contact marks
[14] See Vehicle Attachment 3 – Michelin XZA Tire Specifications

tread depth regulation for commercial vehicle tires is 4/32 of an inch for the steer axle and 2/32 of an inch for all other axles.[15] All tread depths were found to be in excess of the minimum tread depth requirements.

Table 3: Accident Bus Tire Information

Steer Axle	Left	Right
Make	Michelin	Michelin
Model	XZA2 Energy	XZA2 Energy
Size	315/80R22.5	315/80R22.5
Load Rating	L	L
Pressure	100 psi	102 psi
Tread Depth	15/32 inch	16/32 inch

2nd Axle	Left		Right	
	Outside	Inside	Inside	Outside
Make	Michelin	Michelin	Michelin	Michelin
Model	Pilote XZA	Pilote XZA	Pilote XZA	Pilote XZA
Size	315/80R22.5	315/80R22.5	315/80R22.5	315/80R22.5
Load Rating	L	L	L	L
Pressure	88 psi	92 psi	98 psi	88 psi
Tread Depth	8/32 inch	8/32 inch	7/32 inch	9/32 inch

3rd Axle	Left	Right
Make	Michelin	Michelin
Model	Pilote XZA	Pilote XZA
Size	315/80R22.5	315/80R22.5
Load Rating	L	L
Pressure	104 psi	89 psi
Tread Depth	8/32 inch	7/32 inch

During the tire examination, several areas of right side tire and wheel rim damage were noted. The lug nuts on the right side of the steer axle wheel had visible scrapes at the edges. The outer tire on the right side of drive axle had a large gouge, scrapes, and numerous cuts to the tire. There were several indentations to the right side drive axle wheel rim and damage to the wheel seal, such that gear oil was present on the inboard side of the wheel and adjacent brake components. The right side tag axle center hub and wheel seal were broken open, causing gear oil to be present in the surrounding area. No centrifugal spread pattern of the gear oil was observed at the right side drive or tag axle.

1.7 BRAKING

The accident bus was equipped with Knorr-Bremse (Bendix) type SN7 air disc brakes on all three axles. The brakes consisted of dual piston brake calipers on all axles. In the case of an air disc brake, there are no brake stroke measurements that can be taken to provide an assessment

[15] Measured in two adjacent tread grooves at any location on the tire, according to the Federal Motor Carrier Safety Regulations, Title 49 of the US Code of Federal Regulations, Part 393.75(Tires)

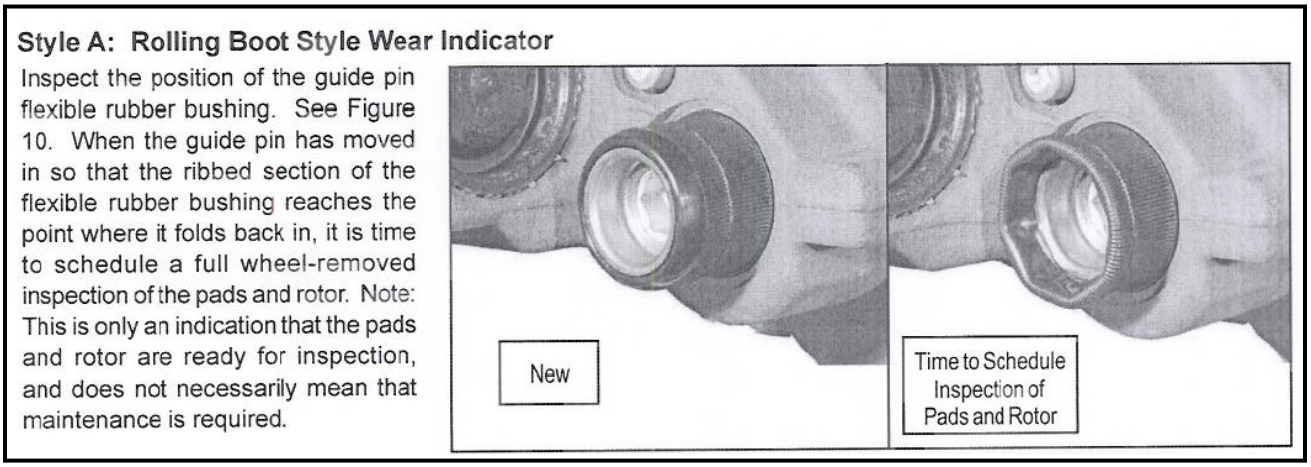
of braking efficiency; however, the air system was examined, and brake system component wear was inspected.

Auxiliary air pressure was supplied from a tow truck and plumbed into the service port at the right rear of the accident bus. The system was able to build pressure once a leak at the left tag axle suspension line was isolated. Tests were conducted for the one-way check valves, two-way check valves, protection valve, inversion valve, and low air warning system. All valves functioned as designed. When a leak was introduced, the low air warning system initiated at 60 psi and the emergency brakes automatically applied at approximately 30 psi. Brake lights came on at the rear of the bus when the emergency or service brakes were applied.

There was a small air leak found at the line coming from push-pull parking brake valve. The line appeared to have been pulled slightly away from the parking brake valve, creating the leak, near the damaged control panel to the left of the driver's seat, where the push-pull parking brake valve was located. This air leak was only present when the push-pull parking brake valve was actuated. The only affect this leak would have is to cause a loss of pressure, causing the parking brake to remain on until the system's air pressure was built up to adequate levels for the parking brake to be released. The leak was slight enough that the compressor system of the bus would have kept up, or outpaced, the leakage.

According to the Service Data Sheet for type SN7 air disc brakes, there are one of three different types of wear indicators available as a visual indicator of brake pad and rotor wear; rolling boot, solid rubber, and caliper notch style wear indicators. The accident bus was equipped with "Style A: Rolling Boot Style Wear Indicators" on all axles. The Service Data Sheet does not provide a measurement of the boot or guide pin to determine if the brake rotors or pads are worn, however it does provide an image of what "new" and "time to schedule an inspection" wear indicators look like, shown in **Figure 1**. [16]

Figure 1: Disc Brake Wear Indicator Image from Bendix Service Data Sheet



On the accident bus, the guide pin had pulled away from the rolling boot as it had begun to recess into the caliper housing on all but the right side tag axle wear indicator. The right side tag axle wear indicator appeared be look more like the "new" image above than the "time to schedule an inspection" image above.[17] The guide pin on the remainder of the calipers could be

[16] See Vehicle Attachment 4 – Bendix SN7 Air Disc Brake Service Data, noted image is shown on page 2
[17] See Vehicle Photo 11 – Right tag axle disc brake wear indicator

seen when looking into the boot, but they were no longer attached at the face of the pin.[18] This detachment prevented the boot from rolling in with the guide pin, making all but one of the wear indicators on the accident bus ineffective in assessing the level of wear.

During the air system testing, brake applications were made, and the calipers could be seen actuating the brake pads and gripping the rotors. Although precise measurements were not possible due to the tight configuration of the disc brakes, outside brake pad material that could be seen during the inspection appeared to be in excess of the 1/8 inch requirement.[19] Rotor thickness was measured using a vernier caliper; measurements found for each wheel location are listed in **Table 4**, along with the brake chamber type for each axle. Minimum rotor thickness is specified as 36.00 millimeters (or 1.417 inches) by the brake manufacturer. However, a minimum of 37 millimeters (or 1.456 inches) is noted in the maintenance documentation from World Wide Travel. All rotors were observed to have a thickness in excess of either minimum.

Table 4: Accident Bus Brake Measurements

Position	Disc Brake Chamber Type	Rotor Thickness (inches)
L Steer Axle	24	1.7188
R Steer Axle	24	1.7188
L 2nd Axle	30/36	1.6563
R 2nd Axle	30/36	1.6250
L 3rd Axle	16/16	1.7188
R 3rd Axle	16/16	1.7188

1.7.1. Anti-lock Braking System (ABS)

The accident bus was equipped with a Meritor WABCO anti-lock braking system, which was also examined. ABS sensors were observed to be connected and in place on the steer axle and the drive axle. The tag axle was not equipped with ABS. During the air brake testing, the ABS system cycled as necessary, however it was noted that the ABS warning light was illuminated in the dash.

Diagnostic information within the ABS module was downloaded and also indicated that the ABS warning light status was "ON".[20] Further information contained within the ABS module download indicated that he warning light was on as a result of an active fault code in reference to a burnt out blink-code light, which was located next to the ABS module in one of the forward luggage bays, and is used for maintenance and the determination of fault codes. Four inactive fault codes were also present.

[18] See Vehicle Photo 12 – Disc brake wear indicator, showing face of pin detached from rolling boot.
[19] According to section 393.47 (d) of the Federal Motor Carrier Safety Regulations, and Part II (section 1.a.6.c) of the CVSA Out-of-Service Criteria
[20] See Vehicle Attachment 5 – Meritor WABCO ABS Code Report and Code Descriptions, ABS light status shown in screen print included as page 7.

1.8 MAINTENANCE HISTORY

Maintenance records were obtained from the motor carrier, World Wide Travel of Brooklyn, NY. Records include approximately one month of daily vehicle inspection reports (DVIRs) from drivers of the accident bus, as well as the prior three years, from March 2008 to March 2011, of maintenance and inspections preformed on the accident bus.

No defects with the major mechanical systems of the accident bus were noted in the DVIRs provided. The maintenance records were reviewed in detail, and contained a variety of regularly scheduled maintenance and as-needed repairs made to the accident bus. Noted in the maintenance records was the replacement of the Detroit Diesel engine control module (ECM) on December 1, 2009 at a vehicle mileage of 763,160 miles. Also noted was that on October 23, 2009 the drive axle differential carrier was rebuilt and changed from a 4.30:1 to 4.56:1 drive axle ratio.

NTSB staff visited the World Wide Travel maintenance facility, where four large bays and commercial grade lifts were found to be present for servicing their fleet of approximately 35 motorcoaches. Also present were available stocks of new tires, brake components, and other parts, as well as an organized set of motorcoach service manuals.

Inspections of the accident bus were conducted bi-annually by the NYSDOT. The NYSDOT, Motor Carrier Safety Bureau, is tasked with performing safety inspections on all buses, including motorcoaches and school buses, in the State of New York. The accident bus was last inspected, and passed the inspection, on January 13, 2011. This was a re-inspection from a previous inspection January 11, 2011 when the accident bus failed inspection due to the left tag axle wheel not being able to freely rotate with the brakes released. Repairs were made on January 12, 2011, by removing the wheel and adjusting the brakes. The bus was then re-inspected, and passed, on January 13, 2011.[21]

Prior to the January 11-13 inspections of the accident bus, the bus was inspected by the NYSDOT in July 2010, March 2010, September 2009, April 2009, October 2008, and May 2008 (the 6 prior state inspections) without any mechanical defects noted or vehicle repairs needed.[22] After the accident, the New York State Department of Transportation also generated a post-crash inspection report for the accident bus.[23]

1.9 EVENT DATA

The Detroit Diesel engine of the accident bus was controlled by a Detroit Diesel Electronic Control module, series IV (DDEC). The purpose of the DDEC is to control engine timing and fuel injection based on various engine and sensor inputs. The DDEC is also capable of diagnostics and storing engine and sensor fault codes. At times, the DDEC can also record information about the last events of the vehicle, to include vehicle parameters of engine rpm, vehicle speed, throttle percentage, brake ON/OFF status, and cruise control ON/OFF status. Recordings are for up to 2 minutes surrounding the last time the engine was stopped, and 1

[21] See Vehicle Attachment 6 – January 2011 Inspection of the Accident Bus
[22] See Vehicle Attachment 7 – Prior State Inspections of the Accident Bus
[23] See Vehicle Attachment 8 – New York State Department of Transportation Post Crash Inspection Report for the Accident Bus.

minute and 15 seconds surrounding hard braking events defined by a deceleration of the bus in excess of 7 mph/sec.

The DDEC was downloaded on March 18th, 2011 at NTSB headquarters in Washington, DC. A last stop record and two hard braking events were captured. The DDEC configuration settings were downloaded April 13th, 2011 at NYSP Troop K headquarters in Salt Point, NY. The DDEC was set to a 4.56:1 rear axle ratio, which was the correct rear axle ratio for the accident bus according to the maintenance records. Settings also included a tire size of 490 revolutions per mile, a 16-tooth vehicle speed sensor, a minimum cruise control speed of 20 mph, a maximum cruise control speed of 78 mph, and a governed speed limit of 78 mph, and engine mileage of 94,077.9 miles.

The last stop record indicated that there were no diagnostic codes active prior to the last stop being set (time 0.00) and that the cruise control was not being used in the previous 1 minute and 45 seconds. Further information regarding the DDEC, and events captured, are detailed in the *Vehicle Recorders - Electronic Control Module - Specialist's Factual Report*, which can be found in the docket for this investigation.

LIST OF ATTACHMENTS

Vehicle Attachment 1 – Final Record and Technical Specifications for the Accident Bus
Vehicle Attachment 2 – Images of the Three-dimensional Models of the Accident and Exemplar Motorcoaches
Vehicle Attachment 3 – Center of Gravity and Roll Stiffness Calculations for the Accident Bus
Vehicle Attachment 4 – Michelin XZA Tire Specifications
Vehicle Attachment 5 – Bendix SN7 Air Disc Brake Service Data
Vehicle Attachment 6 – Meritor WABCO ABS Code Report and Code Descriptions
Vehicle Attachment 7 – January 2011 Inspection of the Accident Bus
Vehicle Attachment 8 – Prior State Inspections of the Accident Bus
Vehicle Attachment 9 – New York State Department of Transportation Post Crash Inspection Report for the Accident Bus

LIST OF PHOTOGRAPHS

Vehicle Photo 1 – Post crash view of the accident bus, right side
Vehicle Photo 2 – Post crash view of the accident bus, left side
Vehicle Photo 3 – Post crash view of the accident bus, left front corner
Vehicle Photo 4 – Post crash view of the accident bus, right front corner
Vehicle Photo 5 – Right front lower edge of the bus body, showing scrape marks
Vehicle Photo 6 – Post crash view of the accident bus, with panel sections laid out
Vehicle Photo 7 – Right rear of the accident bus, showing damage to engine and electrical components
Vehicle Photo 8 – Driver control panel to the left of the driver's seat
Vehicle Photo 9 – Driver control area forward of the driver's seat
Vehicle Photo 10 – Rear suspension damage and tire contact marks
Vehicle Photo 11 – Right tag axle disc brake wear indicator
Vehicle Photo 12 – Disc brake wear indicator, showing face of pin detached from rolling boot

END OF REPORT