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

VEHICLE FACTORS GROUP CHAIRMAN'S FACTUAL REPORT

A. CRASH INFORMATION

Location:	Intersection of Northern Boulevard and Main Street, Flushing, NY
Vehicle #1:	2015 Motor Coach Industries Motorcoach
Operator #1:	Dahlia Group Inc., of Flushing, NY
Vehicle #2:	2015 New Flyer Transit Bus
Operator #2:	New York City Transit
Vehicle #3:	2009 Honda Odyssey
Operator #3:	Parked at curb, not running, unoccupied
Vehicle #4:	2002 Toyota Sequoia
Operator #4:	Parked at curb, not running, occupied by two passengers (one in the driver's seat, and one in the right-front passenger seat)
Date:	Monday, September 18, 2017
Time:	6:16 a.m. Eastern Daylight Time (EDT)
NTSB #:	**HWY17MH015**

B. VEHICLE FACTORS GROUP

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C. CRASH SUMMARY

For a summary of the crash, refer to the *Crash Summary Report* in the docket for this investigation.

D. DETAILS OF THE VEHICLE FACTORS INVESTIGATION

This document is a collection of factual information obtained during the inspections of the Motor Coach Industries (MCI) motorcoach hereinafter referred to as the motorcoach, the New Flyer transit bus hereinafter referred to as the transit bus, and the subsequent review of their respective maintenance records. A detailed inspection of the 2015 MCI was conducted at the College Point Auto Pound, in Flushing, NY, between September 19, and 23, 2017. A post-crash inspection of the motorcoach had been completed by the New York State Department of Transportation (NYSDOT) on September 18, 2017.[1] Between September 23, 2017 and March 12, 2018, the motorcoach had been relocated to a NYPD storage yard in Brooklyn, NY. On March

[1] See Vehicle Attachment – MCI New York State DOT Post-Crash Vehicle Inspection

14, 2018, NTSB investigators met with the Allison Transmission engineer at the storage lot in Brooklyn, NY, to retrieve data from the MCI.

All major vehicle mechanical and operational systems were examined, including the steering, braking, suspension, powertrain, and electrical systems. Overall vehicle crash damage, along with any damage or anomalies discovered within the major vehicle and operational systems were documented. Supporting photographs, vehicle specifications, maintenance records, and prior state inspections were collected and reviewed. The Detroit Diesel Electronic Control (DDEC) module, the Bendix EC60 Antilock Braking System (ABS) and Electronic Stability Control (ESC) module, and the Aftertreatment Control Module (ACM) were removed from the MCI and forwarded to the NTSB recorders laboratory for further examination and analysis. The Allison Transmission Control Module (TCM) was downloaded while the module was attached to the motorcoach.

On March 12, 2018, NTSB investigators returned to Flushing, NY, to collect additional information about the motorcoach. On March 13, 2018, NTSB investigators were provided an exemplar motorcoach. The exemplar motorcoach tests included engine operation, lighting, braking, and road tests. On March 14, 2018, a download of the TCM and removal of the Aftertreatment Control Module (ACM) were completed on the crashed motorcoach.

An inspection of the 2015 transit bus was conducted at the New York City Transit terminal, in Bronx, NY, on September 20, 2017. The inspection was limited in scope to the overall accident damage and photographic documentation of the vehicle. A mechanical inspection was not performed.

E. VEHICLE INSPECTIONS

1. Vehicle 1 – 2015 Motor Coach Industries Motorcoach (MCI)

1.1. General Information: [2]

VIN:[3]	2MG3JM8A0FW[redacted]
Make:	Motor Coach Industries
Model:	J4500, 56-passenger
Model Year:	2015
Date of Manufacture:	October 2014
Placed into Service:	November 26, 2014
Mileage:[4]	184,889
Company Unit #:	1573
GVWR:[5]:	54,000 lbs
GAWR[6] (Axle 1):	16,500 lbs

[2] See Vehicle Attachment – 2015 MCI Vehicle Specifications
[3] Vehicle Identification Number (VIN)
[4] Taken from the downloaded information from the Detroit Diesel Electronic Control module
[5] 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
[6] Gross Axle Weight Rating (GAWR) is the maximum distributed weight that a given axle is designed to support

GAWR (Axle 2):	23,000 lbs
GAWR (Axle 3):	16,500 lbs
Engine:	Detroit Electronically Controlled Diesel, DD13, Six-Cylinder, 410 hp, SN:471934S0279824
Transmission:	Allison, Electronically Controlled, B500 Automatic, Gen IV, SN:6610405
Steering Gear:	ZF, SN:000006
Brake Type:	Bendix, 6-wheel air-operated antilock disc brakes

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 motorcoach.

There was severe crash damage sustained across the front of the motorcoach. The forward, motorcoach tubular frame body, was displaced rearward and to the left, more so on the right than the left. The right front upper corner of the motorcoach was broken, and a portion of the fiberglass shell was missing. The entrance door and frame assembly were crushed rearward, preventing the use of the step well to enter or exit the motorcoach. The front damage extended from the front bumper, up to the roof structure, and from the right "A" pillar to the left "A" Pillar. The right and left windshield glass panes were broken and were not with the motorcoach at the time of this inspection. The front bumper cover was found detached from the MCI but was later located in the debris pile. The middle of the bumper had a prominent crease which extended the full width of the bumper. The distortion of the bumper prevented the removal of the spare tire which was in a compartment behind the bumper. All lighting assemblies, headlamps and turn signals, except for the right-side driving lamp, were found either broken or completely missing. Numerous electrical wires, fuses, and switches were found dislodged from the front of the motorcoach.[7]

On the left side of the motorcoach, the driver's side window and window frame were missing. The left passenger side windows 1,2,3, and 7 were damaged.[8] On the right side, passenger side windows 1 and 7 were damaged.

The front structural frame of the motorcoach was displaced and had intruded into the driver's compartment, buckling the floorboard area around the accelerator and brake pedal assemblies. The dash and instrument panels, along with the associated switches and gauges, were damaged and/or missing. The driver's seat was distorted and separated from the mounting pedestal.[9]

1.3. Measurements:

[7] See Vehicle Photograph 1– Overall Damage Facing Right Front Corner, and Vehicle Photograph 2 - Overall Damage Facing Left Front Corner

[8] Counted from the front of the motorcoach to the rear

[9] Additional exterior and interior damage description is available in the Survival Group Chairman's Factual Report

The motorcoach axle weights were not obtained.

The motorcoach was scanned using a 3-deminsional (3D) laser scanner. The 3-D laser scanner was also used to scan an exemplar MCI.[10]

1.4. Driver Controls:

The driver's seat was deformed due to the buckling of the floorboard and the rearward intrusion of the motorcoach. The back of the seat was in a reclined position which displaced the vanity panel directly behind the driver. The driver's seat was equipped with a lap/shoulder belt which was unlatched. The seat was also separated from the seat pedestal at the seat travel rail.

Due to the extensive damage sustained to driver's compartment of the MCI, a very limited number of switches were available to be inspected. The switches, that were available, had been displaced from their respective switch panels and were found protruding from the front of the motorcoach. The instrument panel, which contained the speedometer, tachometer, indicator lights, and a 4-in-1 gauge that displayed the oil pressure, water temperature, and brake air pressures was missing. The switch panels to the left and right of the instrument panel, along with the automatic transmission shift selector, were missing.[11]

The steering wheel column was found to have been displaced rearward and the steering wheel ring was distorted. The steering wheel had various operational controls built into it such as, cruise control, engine brake, and a courtesy light switch which momentarily flashes the marker lights. The steering wheel assembly had been cut from the steering wheel mounting stem by rescue personnel. Attached to the left side of the steering wheel column was the tilt/telescoping control lever and the turn signal control lever. The turn signal lever (multi-function switch) contained controls for the air horn, headlamp dimmer, and windshield wipers and washers. Both control levers were damaged in the crash.[12]

The driver's foot pedals were distorted and trapped in the buckled floorboard. The brake pedal remained attached to the floor plate, but the accelerator pedal was broken near the mounting pin and was found on the floorboard. Both pedal assemblies were removed from the floorboard and transported to the NTSB headquarters for further analysis and testing. The accelerator pedal testing will be described in the following paragraphs. The brake pedal testing will be described later in the *Air and Braking Systems* section of this document.

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[10] See the Technical Reconstruction Chairman's Factual report for more detailed information
[11] See Vehicle Photograph 3 – A View Looking at the Instrument Panel to the Left of the Driver's Seat
[12] See Vehicle Photograph 4 – A View of the Tilt/Telescoping Control Lever and the Turn Signal Lever

1.4.1. Accelerator Pedal:

The accelerator pedal was not connected to the engine by a direct mechanical means. A rotary position sensor was attached to the accelerator pedal. The sensor sends different levels of electrical current to the accelerator control depending on the position of the accelerator pedal. The more the pedal is depressed the more electrical current the sensor sends to the accelerator control. The less the accelerator is depressed, the sensor decreases the amount of electrical current to the accelerator control.

The electronic accelerator pedal assembly, which was manufactured by Williams Controls, consisted of a foot pedal with rubber tread, a spring-returned roller actuating mechanism, a contact rotary position sensor, and a floor plate. The testing included the operation of the spring-returned roller actuating mechanism for roughness, catching or sticking, and roller defects. The sensor testing consisted of testing for resistance (Ohms) at the wide-open throttle and closed throttle accelerator pedal positions. In **Table 1** the measured Ohms from the contact rotary position sensor are listed.

Table 1: Contact Rotary Position Sensor Test Results[13]

APS Function		Contact Rotary Position Sensor	Measured Value: KOhms	Manufacturer Specifications:
APSVCC	APSGND	Measured at Wide Open Throttle (R_{WOT}) & Closed Throttle (R_{CT})	2.6K	2.5K Ohm +/- 20%
APSOUT	APSGND	Measured at Closed Throttle	0.35K	N/A
Resistance Ratio		R_{CT}/R_{WOT}	13%	13% +/- 2% (Note 1)

Note 1: Resistance ratio was used as an estimate to indicate proper operation. Ratio will change slightly when the pedal assembly is connected and powered by the engine controller

APSVCC = Accelerator Position Sensor Supply Voltage

APSGND = Accelerator Position Sensor Ground Reference

APSOUT = Accelerator Position Sensor Signal Output

Rwot = Resistance at Wide Open Throttle

Rct = Resistance at Closed

[13] It should be noted that the contact rotary sensor test was completed without the engine control or external power

1.5. Steering:[14]

Due to the extensive crash damage sustained by the vehicle, a functional check of the complete steering system was not performed. The steering components from the steering wheel to the steering gear box sustained substantial damage. The steering wheel and column damage is described in the *Driver Controls* section of this document. The upper steering shaft was separated from the telescopic intermediate steering shaft at the slip joint. The intermediate shaft was still connected to the miter box assembly, but the lower steering shaft, which transferred the rotational movement between the miter box steering assembly to the steering gear box, was not. The miter box steering assembly housing and mounting bolt bolsters were broken, and it was displaced from its mounting location.[15] The lower steering shaft was separated from the universal joint which was still attached to the output shaft of the miter box. The lower steering shaft was bowed. The distorted body of the motorcoach was in contact with the lower steering shaft.

To check for the ability of the axle ends to move left-to-right, the lower steering arm was disconnected from the steering gear box. The steering gear remained attached to the steering knuckles via the pitman arm, tie rods, and ball joints. The steering knuckles were capable of being rotated from stop-to-stop by hand. The input shaft, sector shaft, and pitman arm, on the steering gear, moved in the corresponding directions as the steering knuckles were being operated back-and-forth. No binding or roughness was observed during the rotation of the steering knuckles and steering gear.

The remotely mounted power steering hydraulic reservoir was intact, and the fluid was at the “Max” level mark, as indicated by a label attached to the outside of the reservoir. The gear-driven hydraulic power steering pump was intact. No hydraulic fluid leaks were discovered.

1.6. Suspension:

The suspension on each side of the steer axle (axle 1) of the motorcoach consisted of an independent suspension with upper and lower control arms, an air spring, and stabilizer bar connecting links connected to the stabilizer bar.

The drive axle (axle 2) of the MCI was a non-independent, solid axle suspension. Each side of axle 2 consisted of a shock absorber, fore and aft air springs, and a non-adjustable torque arm. There was a transversal torque arm attached to the drive-gear housing of the drive axle.

The suspension on each side of the tag axle (axle 3) consisted of an independent suspension with upper and lower control arms, a shock absorber, an air spring, and a tie rod connecting the steering knuckle to the rack and pinion rear axle steering system.

[14] See Vehicle Attachment – MCI Motorcoach Steering Component Diagram
[15] See Vehicle Photograph 5 – A View of Miter Box Steering Assembly

The inspection of the suspension components on the motorcoach revealed no defects or malfunctions, either pre-existing or crash related.

1.7. Powertrain:

The powertrain of the motorcoach consisted of a six-cylinder diesel engine, a six-speed automatic transmission, a drive shaft, and a rear drive axle assembly (axle 2) with a 3.54:1 gearing ratio.

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. The engine compartment was covered with fire extinguishing agent from the automatic fire suppression system. The extinguishing agent was observed to be on top of the accessory drive belts and pulleys.

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 revealed no defects or malfunctions.

The drive axle housing was mounted to the motorcoach the axle 2 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.

1.8. Tires and Wheels:

The manufacturer's label for this motorcoach was located on the lower portion of the bulkhead to the left of the driver's seat. The manufacturer's label contained information specific to this vehicle, which included suggested tire and wheel information. The manufacturer's label specified that the motorcoach be equipped with 315/80R22.5 (J) tires, mounted on 22.5X9.0 rims,[16] for all axles. The tires were specified to be inflated to 120 psi for axle 1, 100 psi for axle 2, and 120 psi for axle 3.

General information about each of the tires on the motorcoach at the time of the inspection is included in **Table 2.** Tire tread measurements and tire air pressures were taken from the NYSDOT post-crash inspection of the motorcoach. All the wheels were inspected for cracks, welds, and elongated lug nut holes. No non-crash related defects were discovered on any of the wheels. While the rolling radius measurement for axle 1 was not obtained due to the damage sustained from the crash, an average rolling radius of 20 inches was measured for axles 2 and 3.

[16] Hereafter referenced as wheel

Table 2: Motorcoach Tire Information:

Axle 1	**Left**		**Right**	
Make/Model	FIRESTONE FS 400		FIRESTONE FS 400	
Tire Size	315/80R22.5 (LRL)		315/80R22.5 (LRL)	
Pressure [17]	Deflated		Deflated	
Tread Depth[18]	14/32 inch		16/32 inch	
DOT #	4D4D 35K 4116		4D4D 35K 4316	
MLR[19]	9,370 lbs @ 130 psi (single)		9,370 lbs @ 130 psi (single)	
Tire Plies	Tread 5-Steel Sidewall 1-Steel		Tread 5-Steel Sidewall 1-Steel	
Wheel Size & Type	22.5 X 9.0-Alloy		22.5 X 9.0-Alloy	
Axle 2	**Left**		**Right**	
	Outside	Inside	Inside	Outside
Make/Model	FIRESTONE FS 400	FIRESTONE FS 400	FIRESTONE FS 400	FIRESTONE FS 400
Tire Size	315/80R22.5 (L)	315/80R22.5 (L)	315/80R22.5 (L)	315/80R22.5 (L)
Pressure	110 psi	102 psi	105 psi	105 psi
Tread Depth	9/32 inch	11/32 inch	12/32 inch	11/32 inch
DOT #	4D4D 35K 3416	4D4D 35K 3416	4D4D 35K 1716	4D4D 35K 3616
MLR	8,820 lbs @ 130 psi (dual)	8,820 lbs @ 130 psi (dual)	8,820 lbs @ 130 psi (Dual)	8,820 lbs @ 130 psi (Dual)
Tire Plies	Tread 5-Steel Sidewall 1-Steel	Tread 5-Steel Sidewall 1-Steel	Tread 5-Steel Sidewall 1-Steel	Tread 5-Steel Sidewall 1-Steel
Wheel Size & Type	22.5 X 9.0-Alloy	22.5 X 9.0-Alloy	22.5 X 9.0-Alloy	22.5 X 9.0-Alloy
Axle 3	**Left**		**Right**	
Make/Model	FIRESTONE FS 400		FIRESTONE FS 400	
Tire Size	315/80R22.5 (L)		315/80R22.5 (L)	
Pressure	96 psi		90 psi	
Tread Depth	12/32 inch		12/32 inch	
DOT #	4D4D 35J 2015		4D4D 35J 3214	
MLR	9,370 lbs @ 130 psi (single)		9,370 lbs @ 130 psi (single)	
Tire Plies	Tread 5-steel Sidewall 1-Steel		Tread 5-Steel Sidewall 1-Steel	

[17] The tire air pressure was obtained from the NYSDOT on-scene vehicle inspection.
[18] The tire tread depth was obtained from the NYSDOT on-scene vehicle inspection.
[19] Maximum Load Rating – The maximum weight the tire has been manufactured to transport.

Wheel Size & Type	22.5 X 9.0-Alloy	22.5 X 9.0-Alloy

During the tire and wheel examination, several areas of crash damage were observed to the axle 1 tires. The tire damage is referenced to a clock position. The tire and wheel damage observed included the following:

Axle 1- Left-Side Tire [20] [21]

- The tire was found in a deflated and debeaded condition
- The outboard side of the tire sustained a 3 ¼ inches by 3 ½ inches "L" shaped puncture approximately at the 6:00 position
- The outboard edge of the tire tread sustained a 2 ¾ inches in length, oblique cut approximately at the 2:30 position

Axle 1 – Right-Side Tire [22] [23]

- The outboard sidewall was cut from the 12:00 to 1:30 positions, approximately 16 inches in cord length
- The outboard sidewall was punctured from the 1:30 to 3:00 positions, approximately 17 inches in chord length
- The outboard sidewall had a "triangle" shaped puncture approximately at the 5:45 position
- The outboard shoulder had large gouges from the 9:30 to 10:45 positions, approximately 15 inches in chord length
- The outboard sidewall was abraded from the 9:45 to 10:00 positions, approximately 8 inches in chord length
- The tread area had an oblique cut from the 3:00 to 4:30 positions, approximately 17 inches in chord length
- The tread blocks had severe abrasions and gouges from the 9:45 to 10:45 positions, approximately 18 inches long and 4 ½ inches wide

The inspection of the remaining tires and wheels mounted on the motorcoach revealed no defects.

1.9. Air and Braking Systems:

The motorcoach was equipped with a dual air Antilock Brake System (ABS) with disc brakes on all axles. The dual air brake system allows for separation between the front and rear brakes. Each brake system contains an air reservoir with a one-way check valve installed on the inlet side of the reservoir. The one-way check valves will open if the air pressure entering the reservoir is equal to or greater than the air pressure inside the reservoir. Once the air pressure inside the reservoir becomes greater than the air pressure being supplied, the check valve will close to prevent air loss from that side of the brake system. The dual air brake system was designed so

[20] The letter" D" in DOT was used as the 12:00 position for this tire
[21] See Vehicle Photograph 6 – View of Axle 1 Left-side Tire and Wheel
[22] The letter" F" in Firestone was used as the 12:00 position for this tire
[23] See Vehicle Photograph 7 – View of Axle 1 Right-side Tire and Wheel

that if one of the two brake systems were to fail, the motorcoach would still have one brake system available for braking. Testing of the one-way check valves was not performed due to the damage to the front of the motorcoach from the crash. The push-pull parking brake valve and the emergency parking brake release valve were both located outside of the motorcoach.

Due to the crash, low air pressure warning tests were not able to be performed. The air system at the front of the motorcoach was compromised and the instrument panel containing the air gauges was missing. The brake pedal and treadle valve assemblies, which were still in their original mounting positions, were found trapped within the buckled floorboard. The forward portion of the floorboard had been displaced upward and rearward. The brake pedal was distorted and multiple thermoplastic airlines and brass fittings, connected to the treadle valve, had been broken or damaged from the crash.[24] The brake pedal, along with the treadle valve, were extracted from the floorboard.

After the brake pedal and treadle valve were removed, the thermoplastic airlines and brass fittings, which had been broken or damaged during the crash, were repaired and re-attached to the treadle valve.[25] An air hose, from a service truck, was connected to the air supply fitting, located inside the side compartment below the driver's side window location. After the air reservoirs started to fill up, there were multiple air leaks around the left-front of the motorcoach. The air leaks were coming from severed or damaged airlines and once the air leaks at the front of the motorcoach were repaired, no other air leaks were identified. Brake applications were applied by hand to manipulate the brake pedal and treadle valve, the brake application was made to verify the functionality of the brake chambers and calipers. All brake components were functional, and no air loss was discovered while the brakes were applied.

The tires and wheels were removed from each axle end and a detailed examination of the brake system components was conducted. The brake chambers were bolted directly to the brake calipers, so there were no exposed pushrods to obtain a pushrod stroke measurement. The disc brake components were examined, and the brake linings and rotors were measured.[26] The brake component information along with the measurements taken of the rotors and brake linings can be found in **Table 3**.

[24] See Vehicle Photograph 8 – View of Brake Pedal and Vehicle Photograph 9 – View of Treadle Valve Before Repairs
[25] See Vehicle Photograph 10 – View of Brake Pedal and Treadle Valve After Repairs
[26] Title 49 CFR 393.47(d)(1)(2) 1/8-inch (0.125) minimum thickness allowed for air disc type brakes

Table 3. Motorcoach Brake Measurements (all measurements are in inches)

Brake Location	Axle 1		Axle 2		Axle 3	
	Left	Right	Left	Right	Left	Right
Brake Type	Bendix 20/Disc	Bendix 20/Disc	Bendix 20/24 Disc	Bendix 20/24 Disc	Bendix 16/Disc	Bendix 16/Disc
Pushrod Stroke	N/A	N/A	N/A	N/A	N/A	N/A
Measured Lining Thickness	Inboard: 0.682	Inboard: 0.673	Inboard: 0.646	Inboard: 0.691	Inboard: 0.729	Inboard: 0.693
	Outboard: 0.671	Outboard: 0.673	Outboard: 0.608	Outboard: 0.624	Outboard: 0.724	Outboard: 0.693
Measured Rotor Thickness	1.577	1.586	1.598	1.584	1.626	1.613
Manufacturer's Specification – Minimum Rotor Thickness	1.46	1.46	1.46	1.46	1.46	1.46

1.9.1. Anti-lock Braking Systems (ABS):

A Bendix 6S/6M ABS was installed on this motorcoach. The ABS sensors, modulators, and wiring were in place and intact at all wheel locations. The ABS light function could not be verified due to the crash damage sustained by the instrument panel and electrical wiring. The ABS light was contained in the same instrument panel as the air gauges, which was not located during the inspection. The Bendix EC60 ABS controller was removed by the NTSB Recorders Specialist for further evaluation.[27]

1.9.2. Exemplar motorcoach Brake Testing:

The exemplar motorcoach and driver, were provided by Dahlia Group Inc.[28] Dahlia had made a purchase of multiple motorcoaches from MCI, which included the crashed motorcoach, and all were manufactured to the same specifications. The exemplar motorcoach used was one VIN digit different than the motorcoach involved in the crash.

On March 13, 2018, under the direction of NTSB investigators, brake testing was conducted using an exemplar motorcoach.

- A test was conducted to see if a brake application would override the torque of the powertrain. The transmission was placed in drive while the driver depressed the

[27] See the Vehicle Data Recorders Specialist's Factual report for additional Information
[28] Hereafter referenced as Dahlia

brake pedal. As the driver was depressing the brake pedal, he attempted to move the exemplar motorcoach by depressing the accelerator to increase the torque output from the powertrain. There was no movement from the exemplar motorcoach.

- A test was conducted to see how long it would take to stop the exemplar motorcoach if the parking brake push-pull valve was activated while the exemplar was moving. This test was conducted as the exemplar motorcoach was traveling at 31 miles per hour. After the parking brake push-pull valve was activated, the exemplar motorcoach traveled approximately 158 feet before coming to a complete stop.

- Brake pedal angle was measured to see how many degrees the brake pedal must move before the brake lights illuminated. Less than 1-degree of pedal application was required for the brake lights to illuminate. However, the brake application gauge did not register any application with the 1-degree movement of the brake pedal.

1.10. Vehicle Recorded Event Data:

All electronic control modules with diagnostic and/or fault codes were downloaded and their data reviewed.

DDEC 10 Engine Control Module

The Detroit Diesel engine was controlled by a DDEC 10 Engine Control Module (ECM) system consisting of three separate units; a Motor Control Module (MCM), a Common Powertrain Controller (CPC), and an Aftertreatment Control Module (ACM). The primary function of the ECM is to control the engine's performance, fuel efficiency, and emissions based on various engine and sensor inputs. The ECM is also capable of recording diagnostics associated with engine and/or sensor faults, which may then activate warnings on the dash, as well as record vehicle speed, engine speed, and other parameters during triggered events. There is an internal clock and calendar, with an internal battery, which tracks time and stamps event-based occurrences such as hard braking incidents and last stop records. This module was removed from the engine compartment of the motorcoach and transferred to the NTSB Recorders Specialist.

NTSB investigators removed the ACM from the motorcoach on March 14, 2018. The ACM monitors the emission system. The ACM receives data from multiple sensors located throughout the exhaust system. Once certain parameters are met, the ACM will illuminate a light on the instrument panel indicating that a regeneration cycle is required.

The purpose of the regeneration cycle is to reduce NOx and capture and burn off (regenerate) the particulate matter (soot) in the engine's exhaust gas. It does this using a diesel oxidation catalyst (DOC) and a diesel particulate filter (DPF). By monitoring exhaust gas temperature and system back pressure, the DDEC® control module determines the most efficient way required to ensure complete regeneration of the soot captured in the DPF.

There are two types of regeneration cycles; stationary and active. Stationary regeneration cycles require the vehicle to be parked and take approximately 45 minutes to complete. Active regeneration cycles happen during the normal operations of the vehicle and take approximately 40 – 45 minutes to complete.

Since the motorcoach experienced sudden power shutdown, the DDEC 10 ECM was unable to capture or record any fault codes for the day of the crash. A decision was made to enlist the assistance of Detroit Diesel to evaluate the ECM further with their software and obtain additional data for the day of the crash.

On April 11, 2018, the DDEC 10 ECM and associated components were transported by NTSB investigators to the Detroit Diesel headquarters in Detroit, MI. Under the direction of NTSB investigators, the ECM, ACM, and CPC were connected to a bench test as though they were still attached to the motorcoach. The data was then downloaded and saved. Once the data had been saved, the ECM was placed in an electronic simulator to mimic or represent an actual engine operating at idle. There were no abnormal characteristics observed from the ECM as it was being operated by the simulator.

The data received from the DDEC 10 ECM, downloaded at Detroit Diesel, did not reveal any additional information and substantiated what the NTSB Recorders Specialist report contained.

Transmission Control Module

The Allison transmission was controlled by a Transmission Control Module (TCM). The TCM can record a limited number of diagnostic trouble codes (DTCs) along with taking a "snapshot" of the operating conditions at that time. On March 14, 2018, an engineer from Allison Transmission met with NTSB investigators at a NYPD storage yard in Brooklyn, NY to retrieve any data available from the TCM. The engineer retrieved the data from the TCM with the module mounted to the motorcoach. The data retrieved contained seven DTCs and they appeared to have all been set at the same time.[29]Although there were seven DTCs, only five DTCs had failure records available. There were no failure records for the "Gear Shift Direction Circuit" and "Engine Speed Sensor Circuit." The TCM does not "time stamp" the data records, but the engineer from Allison was able to extrapolate the Total Accumulated Miles (106,788.2) and Total accumulated Hours (5,499.9) since the TCM was originally programmed.

Although the motorcoach contained multiple control modules which were capable of recording diagnostics and fault codes associated vehicle operation, the downloads contained only limited, if any, data for the day of the crash. [30]

1.11. Electrical:

Due to the extent crash damage, the electrical system on the motorcoach was compromised. It was not possible to check the function or integrity of the electrical system.

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[29] See Vehicle Attachment – Motorcoach TCM Download

[30] Refer to the Vehicle Data Recorders - Specialist Report which is available in the Docket for this report

1.12. Maintenance History[31]

Maintenance and inspection records for the motorcoach were obtained from Dahlia Group Inc. by the NTSB Motor Carrier Factors Group Chairman and were reviewed along with the prior motorcoach inspections conducted by State and Federal agencies. The maintenance records received included an inspection, repair, and maintenance record, an emergency exits inspection record, preventative maintenance inspection records, and invoices for completed warranty work. The maintenance records were reviewed in detail and contained a variety of scheduled maintenance and as-needed repairs made to the motorcoach.[32] No structural or major deficiencies were noted.

There were six inspections conducted on the motorcoach by the NYSDOT between November 26, 2014 and August 31, 2017, there were no mechanical violations documented. The NYSDOT is tasked with inspecting all buses on a semi-annual basis. The inspection conducted on November 26, 2014, was the initial inspection for this motorcoach which was required before the motorcoach could be placed into service. On August 31, 2016, the New York State Police Commercial Vehicle Enforcement Unit conducted a CVSA level III inspection, no violations were documented. On April 4, 2017, the Federal Motor Carrier Safety Administration conducted a CVSA level I vehicle inspection on the motorcoach and documented one violation for a headlamp being inoperative.[33]

1.13. Documented Recalls and Warranty Claims:

A search of the safety recall database maintained by NHTSA indicated there were seven safety recall campaigns issued for this year, make, and model MCI. Of the seven campaigns listed, only four applied to the VIN assigned to this motorcoach.

- January 5, 2015, pertained to the brake hose routing on the front axle. The recall states that the brake hose may rub on the tires, resulting in a hole being worn into the hose. This condition would result in the loss of air pressure to the front brake chamber, reducing brake performance and increasing the risk of a crash.
    - MCI records indicated this recall repair had been completed on April 28, 2015.
- June 19, 2015, pertained to the drive axle hub carrier. The recall states that the cracks in the hub may result in a hub failure, which could cause a loss of vehicle control, increasing the risk of a crash.
    - MCI records indicated this recall repair was completed on November 3, 2015.

[31] See Vehicle Attachment – Motorcoach Maintenance Records and Inspection Reports

[33] Motorcoach Maintenance Records and Inspection Reports

- March 27, 2017, pertained to the front sway bar. The recall states that if the sway bar cracks, it could detach from the vehicle, affecting handling and increasing the risk of a crash.
    - MCI records indicated that the parts had been ordered to complete this recall repair on July 7, 2017, but there is no completed date. The record does show this recall as having been done.
- June 2, 2017, pertains to front axle brake hose and clamps. The recall states that if the front brake hoses leak, the distance needed to stop the motorcoach may be lengthened, increasing the risk of a crash.
    - MCI records indicated this recall repair had not been completed and was still open.

The search of the safety database maintained by NHTSA, also indicated there were no investigations or complaints, and there were 29 service bulletins for this make, model, and year MCI.

2. 2015 NEW FLYER TRANSIT BUS

2.1. General information:

Make/Model:	New Flyer, XD40 Transit Bus
VIN:	5FYD8FV01FB0[redacted]
Company Unit #:	7430
Date of Manufacture:	September 2015
Passenger Capacity:	38
GVWR:	42,540 lbs
GAWR (front axle):	14,780 lbs
GAWR (rear axle):	27,760 lbs
Engine:	Cummins, ISL, 9L, 280 hp, Diesel
Transmission:	Allison, B400R, 5th Generation, Automatic

Additional equipment and specifications are included in New Flyer General Information and Vehicle Specifications Attachment[34]

2.2. Damage Description:

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

[34] See vehicle attachment - New Flyer General Information and Vehicle Specifications Attachment

The transit bus was removed from the scene in the early afternoon on Monday, September 18, 2017, and transported to the East Chester Depot located in Bronx, NY for storage and inspection. The motorcoach was inspected at this location on September 20, 2017.

The front of the transit bus sustained little crash damage. The right-front windshield was broken with the major damage located at the top-right corner. At the top right of the windshield there were multiple cracks that extended downward and to the left. The cover for the front destination sign, located above the windshields, was missing.

On the left side of the transit bus there were six passenger side windows and a driver's side window. The driver's side window and the first three of the passenger side windows were all intact. The fourth passenger side window was shattered, but it was still mounted inside the window frame assembly. The fifth passenger side window was missing entirely with the frame located inside the transit bus. The sixth passenger upper glass was missing and the lower glass was shattered and was partially separated from the window frame assembly. Damage to the left side of the roof line started approximately two feet forward of axle 2 and continued rearward. The body panel above axle 2 was separated from the body and frame structure. The radiator access door was missing. The left rear of the transit bus sustained extreme contact damage which was displaced to the rear and to the right. The radiator and cooling fans were crushed and displaced to the right. The exhaust system, which was located at the left rear of the transit bus, was separated in multiple locations.

The left-rear corner body panel and lamp assembly were missing. The engine compartment access door was missing. The engine compartment was crushed, and the engine was found to be completely out of the engine compartment, but it was still attached to an upper engine mount. The front of the engine[35] was angled up and to the right.[36] A majority of the engine operating fluids had leaked out and most of the electrical wiring, hydraulic fluid lines, and air hoses had been severed. The transmission was found to have been completely separated from the transit bus and the engine. All wiring and hydraulic fluid lines for the transmission were severed and the transmission housing was broken.[37] The right-side rear-lamp assembly was broken, but the lamps were still intact.

The right side of the transit bus had five passenger side windows and two entrance/exit doors. The front entrance/exit door, located adjacent to the driver, also contained a wheelchair ramp. The second door, which was marked exit only, was located forward of axle 2. Neither door sustained crash damage. The last passenger side window (#5) was shattered but remained in the window frame assembly. The rear of the right-side of the transit bus sustained severe induced damage. The rear frame assembly, which helps support the engine and transmission, was broken and displaced rearward. The corner body panel displayed blue paint transfer. The side access door to the engine compartment, was distorted and displayed a large amount of red paint transfer towards the rear portion of the door. The battery compartment door was distorted. The side-body panel, rear of axle 2, was displaced to the right and contained multiple gouges and scrapes. The roof ridgeline and side-body panel were buckled above axle 2.

[35] The front of the engine is pointed towards the rear of the transit bus
[36] See Vehicle Photograph 11 – A View of the Rear of the Transit Bus and Engine
[37] See Vehicle Photograph 12 – A view of the transit bus transmission

The damage sustained by the transit bus was mostly contained to rear of the axle 2. [38] Damage specific to the vehicle components will be described in greater detail later in this document.

2.3. Steering and Suspension:

The front of the transit bus sustained no crash damage and as a result, the steering system was intact and functional. The functionality of the steering system was conducted by turning the steering wheel from the full-left stop to the full-right stop which rotated the steering knuckles from stop-to-stop. The inspection of the steering system and suspension system components did not reveal any pre-existing defects or malfunctions.

2.4. Tires and Wheels:

According to the VIN label located on the bulkhead behind the driver, the transit bus was specified to be equipped with 305/70R22.5 tires, mounted on 22.5X8.25 rims. The tires were specified to be inflated to 120 psi for the front (axle 1) and rear (axle 2) axles. All wheels on the transit bus were inspected for cracks, welds, and elongated lug nut holes. Apart from the inside tire and wheel on the right side of axle 2, no other crash or non-crash related defects were found on any of the remaining tires and wheels. The tires and wheels were removed to facilitate an inspection of the suspension and brake systems. Table 4 includes the tire and wheel information documented at the time of inspection.

Table 4. Transit Bus Tire Information:

Axle 1	**Left**		**Right**	
Make/Model	GOODYEAR METRO MILER		GOODYEAR METRO MILER	
Tire Size	B305/70R22.5 (H)		B305/70R22.5 (H)	
Pressure	105 psi		112 psi	
Tread Depth	24/32 inch		24/32 inch	
DOT #	MC9BFJBW1117		MC9BFJBW1217	
MLR	7,390 lbs @ 120 psi (single)		7,390 lbs @ 120 psi (single)	
Tire Plies	Tread 5-Steel Sidewall 1-Steel		Tread 5-Steel Sidewall 1-Steel	
Wheel Size & Type	22.5 X 8.25-Steel		22.5 X 8.25-Steel	
Axle 2	**Left**		**Right**	
	Outside	Inside	Inside	Outside
Tire Make	GOODYEAR REGIONAL RHDII	GOODYEAR REGIONAL RHDII	GOODYEAR ENDURANCE TSD	GOODYEAR ENDURANCE TSD
Tire Size	305/70R22.5 (L)	305/70R22.5 (L)	305/70R22.5 (L)	305/70R22.5 (L)

[38] See Vehicle Photograph 13 – A View of the Damage, Facing the Left-Rear of the Transit Bus, and Vehicle Photograph 14 – A View of the Damage, Facing the Right-Rear of the Transit Bus

Pressure	100 psi	100 psi	Deflated	118 psi
Tread Depth	11/32 inch	13/32 inch	21/32 inch	22/32 inch
DOT #	DN9BAA4W4415 (L)	DN9BAA4W4315 (L)	MC9BM3EW4416 (L)	MC9BM3EW5016 (L)
MLR	7,390 lbs @ 130 psi (dual)	7,390 lbs @ 130 psi (dual)	7,390 lbs @ 130 psi (dual)	7,390 lbs @ 130 psi (dual)
Tire Plies	Tread 5-Steel Sidewall 1-Steel	Tread 5-Steel Sidewall 1-Steel	Tread 5-Steel Sidewall 1-Steel	Tread 5-Steel Sidewall 1-Steel
Wheel Size & Type	22.5 X 8.25-Steel	22.5 X 8.25-Steel	22.5 X 8.25-Steel	22.5 X 8.25-Steel

2.4.1. Tire and Wheel Damage:

During the tire and wheel inspection, there was only one tire and wheel with any damage.

- Axle 2 right, inside tire was deflated due to a “L” shaped puncture located on the inboard tire sidewall.
- Axle 2 right inside wheel sustained a radial collapse, approximately 10 ½ inches in chord length. The radial collapse was approximately 1 ½ inches in depth.[39]

2.5. Braking:

The transit bus was equipped with a dual air Antilock Brake System (ABS) with disc brakes on all axles. The brake chambers bolted directly to the brake calipers which meant there were no exposed pushrods available to determine “Pushrod Stroke” measurement. A visual inspection of the brake linings and brake rotors was completed.

By disconnecting the air discharge hose from the transit bus’s air compressor and connecting the air discharge hose to an auxiliary air source, the air systems (brake, suspension, auxiliary) were filled. The air pressure gauges on the instrument panel were used to regulate the air pressure and the brake pedal was used to apply the brakes. The brake operational check was done by depressing the brake pedal once the air reservoirs reached 100 psi. No defects or abnormalities were discovered, and all brake linings and rotors were observed to be well within manufacturer specifications.

2.5.1. Anti-lock Braking Systems (ABS)

The transit bus was equipped with a Meritor Wabco ABS. A visual inspection confirmed all ABS wiring and sensors were intact and properly mounted.

2.6. Vehicle Recorded Event Data:

[39] See Vehicle Photograph 15 – A View of Axle 2, Right Inside Tire and Wheel

The transit bus was equipped with an electronically controlled Cummins engine. The electronic control module (ECM) on this year engine had the capability to capture or record events which often include vehicle speed, engine rpm, brake circuit status, throttle percentage, and other associated data in the event of a sudden decelerations or hard braking.

2.7. Maintenance History:

Maintenance and inspection records for the transit bus were obtained from New York City Transit by the NTSB Motor Carrier Factors Group Chairman.[40] The maintenance records were reviewed in detail and contained a variety of regularly scheduled maintenance and as-needed repairs made to the transit bus.

[40] Refer to the Motor Carrier Factors Group Chairman's report for this investigation

F. DOCKET MATERIAL

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

LIST OF ATTACHMENTS:

Vehicle Attachment -	MCI New York State DOT Post-Crash Vehicle Inspection
Vehicle Attachment -	2015 MCI Vehicle Specifications
Vehicle Attachment -	MCI Motorcoach Steering Component Diagram
Vehicle Attachment -	Motorcoach TCM Download
Vehicle Attachment -	Motorcoach Maintenance Records and Inspection Reports
Vehicle Attachment -	New Flyer General Information and Vehicle Specifications

LIST OF PHOTOGRAPHS:

Vehicle Photograph 1 –	Overall Damage Facing Right Front Corner
Vehicle Photograph 2 –	Overall Damage Facing Left Front Corner Vehicle Factors
Vehicle Photograph 3 –	A View Looking at the Instrument Panel to the Left of the Driver's Seat
Vehicle Photograph 4 –	A View of the Tilt/Telescoping Control Lever and the Turn Signal Control Lever
Vehicle Photograph 5 –	A View of Miter Box Steering Assembly
Vehicle Photograph 6 –	View of Axle 1 Left-side Tire and Wheel
Vehicle Photograph 7 –	View of Axle 1 Right-side Tire and Wheel
Vehicle Photograph 8 –	View of Brake Pedal
Vehicle Photograph 9 –	View of Treadle Valve Before Repairs
Vehicle Photograph 10 –	View of Brake Pedal and Treadle Valve After Repairs
Vehicle Photograph 11 –	A View of the Transit Bus Engine
Vehicle Photograph 12 –	A view of the Transit Bus transmission

Vehicle Photograph 13 – A View of the Damage, Facing the Left-Rear of the Transit Bus

Vehicle Photograph 14 – A View of the Damage, Facing the Rear of the Transit Bus

Vehicle Photograph 15 – A View of the Axle 2, Right Inside Tire and Wheel

END OF REPORT

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