VEHICLE FACTORS GROUP CHAIRMAN'S FACTUAL REPORT

Baltimore, MD

HWY17MH007

(21 pages)

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

VEHICLE FACTORS GROUP CHAIRMAN'S FACTUAL REPORT

A. CRASH INFORMATION

Location:	Eastbound Frederick Avenue between South Monastery Avenue and South Morley Street, Baltimore, Baltimore County, Maryland
Vehicle 1:	2015 IC 64-Passenger School Bus
Operator 1:	AAAfordable Transportation, LLC
Vehicle 2:	2012 Ford Mustang
Operator 2:	Private Operator
Vehicle 3:	2005 New Flyer Transit Bus
Operator 3:	Maryland Transit Administration
Date:	Tuesday, November 1, 2016
Time:	Approximately 6:30 a.m. eastern daylight time
NTSB #:	**HWY17MH007**

B. VEHICLE FACTORS GROUP

David Pereira, Vehicle Factors Investigator, Group Chairman
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C. CRASH SUMMARY

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

D. DETAILS OF THE VEHICLE FACTORS INVESTIGATION

The Vehicle Factors Group Chairman's Factual Report is a collection of factual information regarding involved vehicles.

The detailed postcrash inspections of the 2015 IC school bus and of the 2005 New Flyer transit bus were conducted at Maryland Transit Administration's Bush Division Facility at 1515 Washington Boulevard in Baltimore Maryland, between November 1 and 7, 2016. The 2012 Ford Mustang was inspected at the Baltimore City Tow Yard on November 4, 2016 at 6700 Pulaski Highway, Baltimore, Maryland.

All major mechanical systems were examined, including the steering, braking, and suspension systems. Overall collision damage, along with any damage or anomalies within major vehicle mechanical systems were documented. Supporting photographs, vehicle specifications, maintenance records, and prior annual inspection reports were collected and reviewed. The inspection of the Ford Mustang was limited to the documentation of damage, supporting photographs and vehicle specifications.

1. Vehicle 1: 2015 IC School Bus

1.1. General Information

VIN[1]:	4DRBUAAP9FB029679
Model:	PB10500
Series:	CE S
Serial Number:	029679
Build Date:	12/04/2013
Company Unit#:	1876
Capacity:	64 passengers
Wheelbase:	254.0 inch
Mileage:[2]	34,224.9
Engine Hours:[3]	3,173.7 hr.

[1] Vehicle Identification Number (VIN).
[2] This mileage reading was obtained from the bus's Engine Control Module (ECM)
[3] This hour reading was obtained from the bus's Engine Control Module (ECM)

GVWR:[4]	28,500 lbs.
GAWR Front:[5]	10,000 lbs.
GAWR Rear:	18,500 lbs.
Engine:	International MaxxForce DT, Serial Number 466HM2Y3518196
Engine Specs:	Diesel 4-cycle inline 6-cylinder engine, rated at 215 hp.
Transmission:	Allison MD, Automatic
Brake Type:	WABCO full power hydraulic 4-wheel disc brakes with ABS

1.2. Damage Description

The IC school bus (school bus) sustained severe collision damage to the front end, affecting all major mechanical systems. Damage specific to many of the vehicle components will be described in greater detail later in the appropriate sections of this report.

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

The school bus sustained two impacts. The first impact was to the bus's front from impacting the 2012 Mustang. The second impact was also to the front when it impacted the transit bus, causing significant damage to the front end and extended down the left side as shown in **Figure 1.**

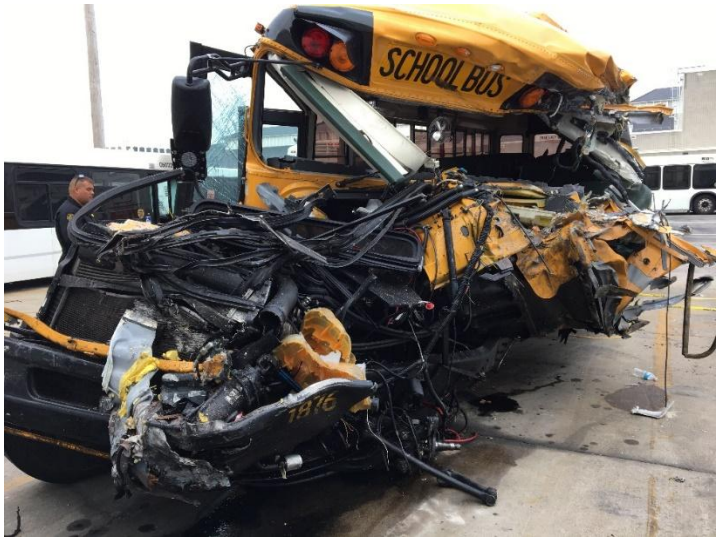

Figure 1 – Front view of the 2015 IC School Bus

The deformation to the bus's front with the rear of the Mustang could not be measured because the secondary impact with the transit bus masked it. The overall impact resulted in the left

[4] 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.
[5] Gross Axle Weight Rating (GAWR) is the maximum distributed weight that a given axle is designed to support.

frame rail being bent to the right approximately 27 inches as measured at the upper front shock absorber mount, with an upward deflection.[6]

The impact resulted in buckling of the roof that extended to the mid-point of the bus.

The rear bumper was slightly gapped away from the bus body due to the frame shift. The loading stairwell was also deformed and shifted upwards as a result of the crash.

The left side outside rearview mirror was broken off. The pop-out stop sign on the left exterior adjacent to the driver's seat was also torn off.

Both windshield panes of the bus were broken out. The bus was equipped with eleven windows on each side plus the driver's slider window. The driver's slider window and the first two side window on the left were broken out. The bi-fold loading doors each had upper and lower windows. The forward bi-fold door windows were both cracked. The first two windows behind the loading door were also cracked. The rear emergency exit door was operational.

1.3. Weight and Measurements

The school bus was weighed by the Maryland Transportation Authority (MDTA) Police using certified portable scales on November 2, 2106. The measured axle weights for the vehicle are shown in **Table 1**. Due to the damage and weight shift as a result of the crash, these measurements will not represent the exact axle weights at the time of the collision. An exemplar school bus VIN: 4DRBUAAP6FB029672 was also weighed by MDTA Police and the measured axle weights for the vehicle are shown in **Table 2.**

Table 1: Axle Weights of Crash Involved School Bus

Position	Weight (lbs.)		Axle
	Left	Right	Total
Axle 1	3800	3300	7100
Axle 2	5900	4500	10400
Total			17,500 lbs.

Table 2: Axle Weights of Exemplar School Bus

Position	Weight (lbs.)		Axle
	Left	Right	Total
Axle 1	4300	4400	8700
Axle 2	5600	5450	11050
Total			19,750 lbs.

Due to the extensive collision damage, hand measurements of the school bus were not obtained. The MDTA Police mapped the crash involved and the exemplar school bus using a

[6] See Vehicle Photo 1 – Left frame rail of 2015 IC school bus

FARO laser scanner, which generated a 3-dimensional model of the buses, from which scaled measurements were taken.

1.4. Driver Controls

Due to the collision damage to the school bus, investigators were unable to document the driver controls. The driver's compartment and seat were displaced aft and to the right side of the bus. The brake and accelerator pedals were crushed upward into the firewall separating the engine and passenger compartment.[7]

1.5. Steering

The 17-inch steering wheel was removed from the upper steering shaft by emergency response personnel at the scene of the collision, to assist in extracting the driver. It was found deformed with the center horn pad missing. Due to the significant damage sustained by the vehicle, a functional check of the steering system was not performed.

The steering column was displaced aft and to the right side of the school bus and was not connected to the steering shaft. The intermediate steering shaft was connected to the input shaft of a steering gear box through a universal joint. The sector shaft from the steering gear was broken and not connected to the pitman arm. The pitman arm was connected by means of a ball joint to the drag link. The drag link was connected to the left side of the steer axle through a steering arm using a ball joint connection. The left side of the steer axle was connected to the right side of the steer axle by means of a tie rod that had significant inward bending, with ball joint connections on each end.[8]

The power steering gear box was removed from the school bus. The intermediate shaft remained connected to the input shaft. The sector shaft was broken off from the pitman arm. The input and sector shaft were not turned or examined for internal movement. An external examination of the steering gear revealed obvious contact damage to the housing.[9]

On Friday December 9, 2016, a detailed external and internal examination and component teardown of the steering gear was conducted at RH Sheppard Facilities in Hanover, Pennsylvania as shown in **Figure 2**.

These examinations were conducted by RH Sheppard staff under the direction and in the presence of NTSB and Baltimore Police Department investigators. The exam found the steering gear to be mechanically functional, with no worn or defective components.[10]

Examination concluded that the steering gear did receive an impact load, significant enough to cause indentations from recirculating ball bearings on the internal helical worm gear.[11] From the location of the recirculating ball bearing impacts, the steering wheel angle at collision

[7] See Vehicle Photograph 2 - Driver controls of the 2015 IC school bus
[8] See Vehicle Photograph 3 - Steering components of the 2015 IC school bus
[9] See Vehicle Photograph 4 - Steering gearbox of the 2015 IC school bus
[10] See Vehicle Attachment 1 - 2015 IC school bus RH Sheppard steering gear examination report
[11] See Vehicle Photograph 5 - Internal helical worm gear from the steering gearbox of the 2015 IC school bus

was determined to be 187 degrees of steering wheel rotation to the left, corresponded to the front wheels being at about 10 degrees to the left, at the time the steering gear was subjected to the impact load.

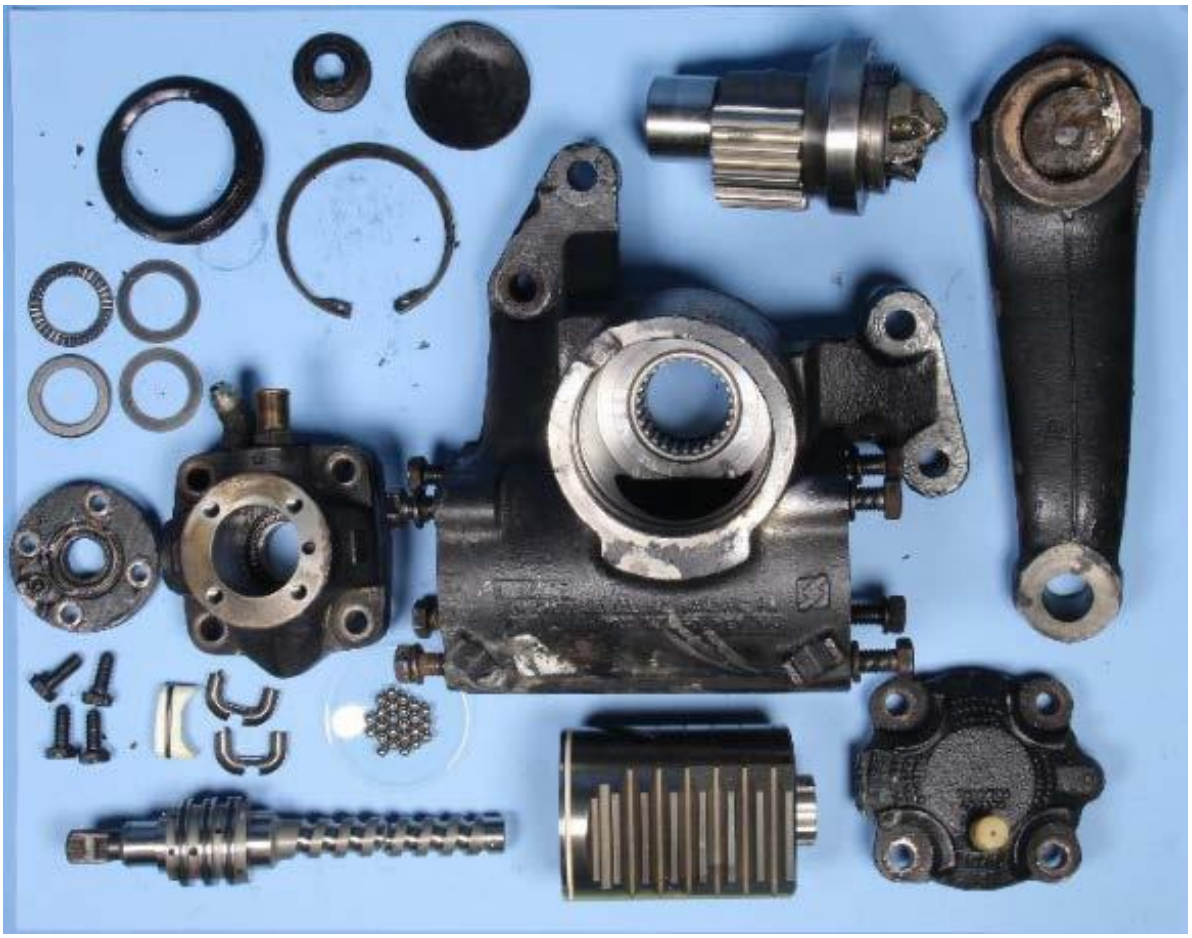

Figure 2 - Disassembled Steering Gearbox of the 2015 IC School Bus

1.6. Suspension

The bus's steer axle (axle 1) suspension consisted of two leaf spring packs mounted to the solid steer axle, and shock absorbers. The left side of the steer axle was significantly displaced back, shifting the left leaf spring pack and tearing the U-bolts securing the axle to the leaf springs. The leaf spring pack was secured to the front and rear hanger brackets that were connected to the frame rail. The left side shock absorber was broken in half with the upper section still mounted to the upper mount. The left front tire assembly was torn off the axle during the collision sequence.

The right side left spring pack was displaced forward braking one of two U-bolts that secured the axle to the leaf spring pack. The leaf spring pack was secured to the front and rear hanger brackets that were connected to the frame rail. The right-side shock absorber was secured to the upper and lower mounts.

The school bus's drive axle (axle 2) suspension consisted of two leaf spring packs mounted to the solid drive axle and shock absorbers. All the leaf springs were free of any visible cracks, or apparent pre-collision defects. The left side helper leaf spring was distorted from the axle having shifted during the collision sequence.

1.7. Tires

According to the placard mounted on the front interior header, the school bus was to be equipped with 11R/22.5 tires mounted on 22.5X7.50 rims for all axles. Recommended tire pressure was listed as 110 psi for the steer axle tires, 100 psi for the drive axle tires. **Table 3** below includes information on the condition of the school bus tires as they were examined at the time of inspection.

Tire tread depth measurements were taken in the major tread grooves of each tire. The smallest depth measured is displayed in the table, and represents a minimum tread depth value for that tire. The minimum tread depth regulation for commercial motor vehicle tires is $^{4}/_{32}$ of an inch on the steer axle, and $^{2}/_{32}$ of an inch for all other axles.[12] The four tires on the rear axle were re-treaded tires.[13] All of the rims were inspected for cracks, welds, and elongated lug nut holes. No non-collision related defects were found on any of the rims.

The only tire damage observed during the examination was that the left front tire assembly was detached from the vehicle during the collision sequence. As shown in **Figure 3.**

The tire and rim damage are referenced to a clock position with the valve stem being at 12:00.

- At 1:00 there was a 4-inch tear to the outer sidewall.
- At 9:00 extending to 12:00 there was a jagged 20-inch tear along the outer sidewall.
- At 6:00 there was a 3-inch gouge to the outer sidewall.

The left front rim had two impacts to the inboard flange displacing the flange inward.

[12] According to the Federal Motor Carrier Safety Regulations (FMCSRs), Title 49 Code of Federal Regulations, Part 393.75

[13] According to the Federal Motor Carrier Safety Regulations (FMCSRs), Title 49 Code of Federal Regulations, Part 393.75 prohibits the use of re-grooved, recapped, or retreaded tires only on the steer axle wheels of busses. The use of re-grooved, recapped, or retreaded tires on any other axle of a bus, and any axle of a truck, is not prohibited by the FMCSRs.

Figure 3 – Left front tire assembly of the 2015 IC school bus

Table 3 - School Bus Tire Information

Steer Axle	Left	Right
Make	Goodyear	Goodyear
Model	G662 RSA	G662 RSA
Size	11R/22.5	11R/22.5
Load Rating	G	G
Pressure	0	91psi
Tread Depth	9/32nd	9/32nd
DOT Number	MC3TMKBW4313	MC3TMKBW4313

Drive Axle	Left		Right	
	Outside	Inside	Inside	Outside
Make	Bridgestone	Bridgestone	Goodyear	Michelin
Model	Retread	Retread	Retread	Retread
Size	11R/22.5	11R/22.5	11R/22.5	11R/22.5
Re-Tread Make	Bandag	Bandag	Bandag	Bandag
Pressure	91psi	89psi	86psi	85psi
Tread Depth	10/32nd	10/32nd	10/32nd	9/32nd
Re-Tread Number	RAAR 3212	RARR 2512	RARR 2813/3704	RARR 3313

1.8. Brakes

Due to the significant collision deformation sustained by the vehicle, direct functional checks of the braking systems were not performed.

The school bus was equipped with a Meritor WABCO Hydraulic Power Brake Unit (HPB) with disc brakes on all four wheels.[14] All the visible brake components appeared to be in nearly

[14] Meritor WABCO's Hydraulic Brake (HPB) is a braking and vehicle control system for business class trucks, classes 4 through 7, and buses that are equipped with hydraulic brakes. The HRB provides the following functions, Full power brake performance, brake control functions including Anti-lock braking system (ABS), Automatic Traction Control (ATC), Electronic Brake force Distribution (EBD) and optional parking brake control.

new condition. The master cylinder was damaged during the collision. No visible leaks were found in any of the brake system components beyond the damaged master cylinder. Anti-lock braking system (ABS) sensors were in place on all four of the wheels. The left steer axle wheel was detached from the vehicle with the brake rotor and partial brake caliber still attached to the broken wheel hub assembly. The brake pads for the wheel were located at the collision scene and were examined and measured.

The remaining wheels were removed from each axle end, and the disc brake components were examined and measured. Measurements of the rotors and pads can be found in **Table 4**. All the brake pads were found to be in excess of the $^{1}/_{8}$-inch minimum thickness requirement for disc type brakes.[15] The rotors were found to be smooth to the touch, and did not show any signs of grooves or major cracks.

On Tuesday January 3, 2017, the HPB unit was imaged to determine if any crash related data was available in its electronic control module. This examination was conducted at the Maryland Transit Administration's Bush Division Facility by Meritor WABCO representatives under the direction and in the presence of NTSB and Baltimore Police Department investigators. See the Recorder Group Chairman Factual Report, which can be found in the docket for this investigation, for the data obtained from the HPB unit.

Table 4- School Bus Brake Measurements

Location	Rotor Thickness[16] (inches)	Brake Pad Thickness Inner (inches)	Brake Pad Thickness Outer (inches)
Left Steer	1.19/32nd	16/32nd	16/32nd
Right Steer	1.19/32nd	16/32nd	16/32nd
Left 2nd Axle	1.37/64th	13/32nd	14/32nd
Right 2nd Axle	1.37/64th	11/32nd	12/32nd

1.9. Lighting and Electrical

The battery box and the vehicle's electrical system were damaged from the collision sequence. The headlight assemblies were destroyed from the collision sequence. It was not possible to check the function or integrity of the electrical system.

1.10. Event Data

The International MaxxForce engine on the school bus was controlled by an Engine Control Modules (ECM). The purpose of the ECM is to control engine timing and fuel injection

[15] According to the Federal Motor Carrier Safety Regulations (FMCSRs), Title 49 Code of Federal Regulations, Part 49 CFR 393.47(d)(1).
[16] Meritor WABCO recommends that: The rotors should be replaced if the rotor thickness is less than 1.574-inches (40mm). TP-02173

based on various engine and sensor inputs. The ECM is also capable of diagnostics associated with engine and/or sensor faults, which may then illuminate warnings on the dash.

The ECM was removed from the school bus and placed in an exemplar school bus and examined by an NTSB recorder specialist. See the Recorder Group Chairman's Factual Report for additional information.

1.11. Maintenance and Inspection Records

Maintenance and inspection records were obtained by the Motor Carrier Group Chairman from AAAffordable, LLC. Records included:

- Two State of Maryland Motor Vehicle Administration (MVA) School Vehicle Inspection Certification – Type A (Form EP-213) dated 8/15/15 and 7/18/16.[17]
- Three Baltimore City Public Schools, School Vehicle Inspections dated 3/30/15, 12/1/15 and 8/18/16.[18]
- Eight AAAfordable maintenance work orders, dated from 3/12/15 thru 9/11/16.[19]
- 10 outside vendor maintenance invoices dated from 8/18/14 thru 8/3/16.[20]
- 24 Driver Vehicle Inspection Reports (DVIRs) dated 5/4/16 thru 9/30/16.[21]

According to the Federal Motor Carrier Safety Regulations (FMCSRs), commercial vehicles must be inspected at a minimum of every 12 months to ensure compliance with the requirements set forth in the regulations.[22] The bus traveled interstate, and the state of Maryland had a mandatory inspection program that met or exceeded the requirements under 396.17(c).

The bus involved in this collision was inspected 2 times between August 15, 2015, and July 18, 2016, with each of these inspections meeting the requirements of an annual inspection under the FMCSRs. Under the FMCSRs, another inspection of the bus would not have been required until July 2017.

The maintenance records were reviewed in detail, and contained a variety of regularly scheduled preventative maintenance and as needed repairs made to the vehicle. When needed repairs were documented during the inspections, repairs were documented as having been completed on the same day as the inspection or sent to an outside vendor for repair.

1.12. Documented Recall and Warranty Claims

[17] See Vehicle Attachment 2 - MVA, School Vehicle Inspection Certification
[18] See Vehicle Attachment 3 - Baltimore City Public Schools, School Vehicle Inspection Forms
[19] See Vehicle Attachment 4 - AAAfordable Transportation LLC, Maintenance Work Orders
[20] See Vehicle Attachment 5 - Outside Vendor Maintenance Invoices
[21] See Vehicle Attachment 6 - Driver Vehicle Inspection Reports (DVIRs)
[22] According to the Federal Motor Carrier Safety Regulations (FMCSRs), Title 49 Code of Federal Regulations, Part 49 CFR 396.17(c)

A search of the safety recall database maintained by the National Highway Traffic Safety Administration (NHTSA) uncovered no recalls pertaining with the school bus. [23] Additionally, records kept by Navistar, Inc.,[24] did not indicate there were any active or pending safety related recalls pertaining to the school bus.

2. Vehicle 2: 2012 Ford Mustang

2.1. General Information

VIN:	1ZVBP8AM4C5[redacted]
Model:	V-6 Premium
Mileage:	Unknown
Curb Weight:[25]	3401 lbs.
Engine:	3.7L, 4V, PFI, V6, Petrol fuel
Transmission:	6 Speed Automatic Trans (6R80)
Horsepower:	305 hp.
Horsepower rpm:	6,500
Torque:	280lb-ft.
Torque rpm:	4,250
Drive type:	Rear-wheel
Turning radius:	16.7
Brake Type:	4-wheel disc brakes

2.2. Damage Description

The Mustang sustained three impacts with the initial impact from the bus being the most significant. The initial impact and most severe was to the rear, shown in **Figure 4**. The rear impact resulted in the driver's door being jammed closed. The right door was operational. The second impact was with a curb, resulting in damage to the left front wheel assembly. The third impact was to the front bumper and edge of the hood from colliding a brick wall and fence simultaneously.

[23] The safety recall database was accessed via the NHTSA safety recall website https://www.nhtsa.gov/recalls#vehicles

[24] Navistar International Corporation is the parent company, that owns the manufacturer of International brand commercial trucks, IC school and commercial buses

[25] Curb weight means the actual or the manufacturer's estimated weight of the vehicle in operational status with all standard equipment, and weight of fuel at nominal tank capacity.

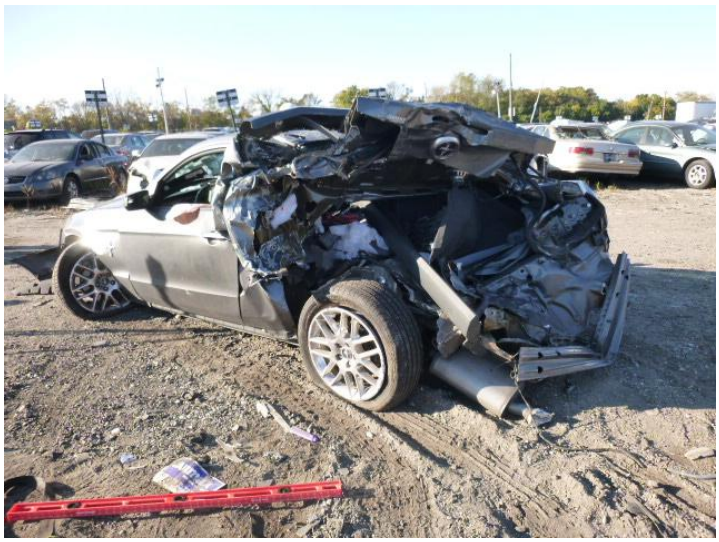

Figure 4 – Rear damage of the 2012 Ford Mustang

The direct damage width to the front bumper was approximately 35 inches. The left front wheel assembly sustained significant damage from the curb impact as shown in **Figure 5.**

Figure 5 - Front end damage of the 2012 Ford Mustang

The rear window was completely broken out as was the left rear side window. The windshield was cracked and the crack radiated across the entire surface. The driver's window was rolled down and remained intact.

2.3. Weight and Measurements

The Mustang was weighed by the MDTA police using certified portable scales on November 4, 2016. The measured axle weights for the vehicle are shown in **Table 5**. Due to the damage and weight shift resulting from the crash, these measurements do not represent the exact axle weights at the time of the collision.

Table 5: Axle Weights of Mustang

Position	Weight (lbs.)		Axle
	Left	Right	Total
Axle 1	950	850	1800
Axle 2	500	800	1300
Total			3,100 lbs.

Due to the extensive collision damage, hand measurements of the Mustang were not obtained. The MDTA Police mapped the involved vehicle using a FARO laser scanner, which generated a 3-dimensional model of the Mustang, from which scaled measurements were taken.

2.4. Event Data

The Baltimore Police Department utilized the Crash Data Retrieval (CDR) System software to image pre-and post-crash data from the vehicle's airbag control module (ACM). The software generated a 24-page report that was analyzed by the NTSB Recorders Specialist. See Recorder Group Chairman Factual Report.

2.5. Documented Recall and Warranty Clams

A search of the safety recall database maintained by the National Highway Traffic Safety Administration (NHTSA) indicated there were two voluntary safety recall campaigns which would have affected the vehicle involved in the collision.[26] The first recall pertained to a potential issue causing driver airbag inflator housing rupture if the vehicle is involved in a crash, causing a risk of metal fragments striking and injuring vehicle occupants. The second recall pertained to a potential issue where some vehicles may experience an intermittent loss of the transmission output speed sensor signal to the powertrain control module, potentially resulting in a temporary, unintended downshift into first gear. Though there were two open recalls for this vehicle they were not causal to this crash.

3. Vehicle 3: 2005 New Flyer Transit Bus

3.1. General Information

VIN:	5FYD4FS185B028137
Model:	D40LF
Bus Type:	Diesel Transit
Build Date:	September 2005
Company Unit Number:	05090
Seating Capacity:	39 seats / 15 standees
Wheelbase:	24ft 5 inches
Mileage:[27]	499988.25

[26] The safety recall database was accessed via the NHTSA safety recall website: https://www.nhtsa.gov/recalls
[27] This mileage reading was obtained from the transit bus's Engine Electronic Control Unit (EECU)

Engine Hours:[28]	41338:51:07
GVWR:	42,640 lbs.
GAWR Front:	14,780 lbs.
GAWR Rear:	27,760 lbs.
Engine:	Cummins ISM, Serial Number: 35129486
Engine Specs:	In-line 6-cylinder Diesel, rated 280 hp.
Engine Serial #:	35129486
Transmission:	Voith D864,3E, Automatic
Brake Type:	MGM 4-wheel air operated drum brakes

Additional equipment and specifications are included in the MTA Bus Technical Summary.[29]

3.2. Damage Description

The transit bus sustained extensive damage as a result of the impact with the school bus, affecting major mechanical systems with extensive intrusion into the passenger compartment. Damage specific to many of the vehicle components will be described in greater detail later in the appropriate sections of this report.

The impact started at the front left bumper corner and extended vertically to the windshield header. The damage extended down the left side, tearing away the windows, sheet metal, and fiberglass resulting in an approximate 6-foot-tallopening as shown in **Figure 7.**

Figure 7 - Left side view of the 2005 New Flyer Transit Bus

3.3. Weight and Measurements

[28] This hour reading was obtained from the transit bus's Engine Electronic Control Unit (EECU)
[29] See Vehicle Attachment 7 - New Flyer Transit Bus Vehicle Specifications

The transit bus was weighed by the MDTA Police using certified portable scales on November 2, 2016. The measured axle weights for the vehicle are shown in **Table 6**. Due to the damage and weight shift as a result of the crash, these measurements do not represent the exact axle weights at the time of the collision. An exemplar transit bus, VIN: 5FYD4F5175B02B100, was also weighed by MDTA Police and the measured axle weights for the vehicle are shown in **Table 7.**

Table 6: Axle Weights of Crash Involved Transit Bus

Position	Weight (lbs.)		Axle
	Left	Right	Total
Axle 1	3600	3200	6800
Axle 2	8150	9750	17900
Total			24,700 lbs.

Table 7: Axle Weights of Exemplar Transit Bus

Position	Weight (lbs.)		Axle
	Left	Right	Total
Axle 1	4100	4600	8700
Axle 2	11200	9900	21000
Total			29,800 lbs.

Due to the extensive collision damage, hand measurements of the transit bus were not obtained. The MDTA Police mapped the transit bus and the exemplar transit bus using a FARO laser scanner, which generated a 3-dimensional model of the bus, from which scaled measurements were taken.

3.4. Driver Controls

Driver controls and the instrument panel settings could not be documented due to the collision damage to the bus. The driver's seat was located in the driver's area of the wreckage, and found attached to the driver's floor board area that was displaced aft and to the right side of the bus. The driver's seat back was broken from the left backrest and pushed downward and to the right.[30]

The brake and accelerator control pedals were located on the floor to the right of the steering column. The brake pedal was 3-inches wide and 11-inches long. The accelerator pedal was 3 inches wide and 10-inches long. The pedals were separated by 3-inches. There was no noticeable damage to either brake or accelerator pedals.[31]

3.5. Steering

[30] See Vehicle Photograph 6 - Driver controls of the 2005 New Flyer transit bus
[31] See Vehicle Photograph 7 - Brake and accelerator control pedals of the 2005 New Flyer transit bus

The deformed 20-inch steering wheel was attached to the upper steering shaft. The steering wheel was displaced forward exceeding the upper limits of the tilt steering system. Due to the significant damage sustained by the vehicle, a functional check of the steering system was not able to be performed.[32]

The steering column transcended through the firewall and was disconnected from the steering shaft. The steering shaft connected to the input shaft of a steering gear box through a universal joint. The output shaft from the steering gear was then connected to the pitman arm.

The pitman arm was connected by means of a ball joint to the drag link. The drag link was connected to the left side of the steer axle through a steering arm using a ball joint connection.

The left side of the steer axle was connected to the right side of the steer axle by means of a tie rod with ball joint connections on each end. All lower connection and linkage appeared to be free of play or excessive wear.

3.6. Suspension

The transit bus was equipped with an air suspension system. The steer axle was equipped with left and right conventional shock absorbers and air suspension cushions. The steering axle, torsion bars, links, and related components were free of any visible cracks, damage, or apparent defects.

The drive axle suspension included air suspension cushions, as well as conventional shock absorbers, which were free of any visible cracks, damage, or apparent defects.

3.7. Tires

According to the placard mounted in the transit bus, it was to be equipped with 305/70R22.5 tires mounted on 22.5X8.25 rims for all axles. Recommended tire pressure was listed as 115 psi for the steer and drive axle tires.

Table 8 below includes information on the condition of the transit bus tires at the time of inspection. Tire tread depth measurements were taken in the major tread grooves of each tire. The smallest depth measured is displayed in the table, and represents a minimum tread depth value for that tire. The minimum tread depth regulation for commercial motor vehicle tires is 4/32nd of an inch on the steer axle, and 2/32nd of an inch for all other axles. Maryland Transit Administration leases the Goodyear tires used on their fleet of transit buses and are branded with a unique control number.

During the tire examination, one area of damage was noted. The tire and rim damage is referenced to a clock position with the valve stem being at 12:00. The only tire damaged was located on the outside left of axle 2.

- At 6:00 were several 6 to 8-inch cuts to the outside sidewall.

[32] See Vehicle Photograph 8 - Steering wheel and column of the 2005 New Flyer transit bus

Table 8 - Transit Bus Tire Information

Steer Axle	Left	Right
Make	Goodyear	Goodyear
Model	Metro Miller	Metro Miller
Size	B305/70R225	B305/70R225
Load Rating	L	L
Pressure	112psi	110psi
Tread Depth	13/32nd	15/32nd
DOT Number	MC9BD7EW3815	MC9BD7EW3815

Axle #2	Left		Right	
	Outside	Inside	Inside	Outside
Make	Goodyear	Goodyear	Goodyear	Goodyear
Model	Metro Miller	Metro Miller	Metro Miller	Metro Miller
Size	B305/70R225	B305/70R225	B305/70R225	B305/70R225
Load Rating	L	L	L	L
Pressure	110psi	111psi	105psi	105psi
Tread Depth	8/32nd	7/32nd	8/32nd	10/32nd
DOT Number	MC9BD7EW3815	MC9BD7EW3815	MC9BD7EW3215	MC9BD7EW3815

3.8. Brakes

Due to the significant collision damage sustained by the vehicle, direct functional checks of the air and braking systems were not able to be performed. The bus was equipped with MGM air operated drum brakes on all wheels. All brake pads exceeded the minimum pad thickness or worn behind the wear indicator. [33] Push rod stroke measurements were obtained for all of the brakes, as seen in **Table 9**. In order to obtain the push rod stroke measurements, air regulated to 90-105 psi was applied directly to each of the brake chambers from an auxiliary air supply.

[33] According to the Federal Motor Carrier Safety Regulations (FMCSR), Title 49 Code of Federal Regulation, Part 393.47(d)

Table 9- Bus Brake Measurements

Position	Side	Brake Chamber Type	Brake Pad Thickness (inches) Upper/Lower	Push Rod Stoke (inches)	Adjustment Limit [34] (inches)
Steer Axle	Left	20L	11/64 – 11/64	1-5/8	2
Steer Axle	Right	20L	5/16 - 19/64	1-1/4	2
Drive Axle	Left	30L	31/64 – 15/32	1-3/8	2-1/2
Drive Axle	Right	30L	25/64 – 25/64	1-3/8	2-1/2

3.9. Lighting and Electrical

The vehicle's electrical system was damaged from the collision sequence. It was not possible to check the function or integrity of the electrical system. The headlight assemblies were destroyed from the collision sequence.

3.10. Event Data

The Cummins ISM engine of the transit bus was controlled by an Engine Control Module (ECM). The purpose of the ECM was to control engine timing and fuel injection based on various engine and sensor inputs. The ECM was also capable of diagnostics associated with engine and/or sensor faults, which may then illuminate warnings on the dash.

The ECM was removed from the transit bus and placed in an exemplar transit bus and examined by an NTSB recorder specialist. See Recorder Group Chairman Factual Report.

3.11. Maintenance and Inspection Records

Maintenance and inspection records were obtained by the Motor Carrier Group Chairman from MTA. Records included:

- Four MTA preventive maintenance work orders[35]

MTA maintained an ongoing preventative maintenance program including records of all maintenance performed and copies of daily vehicle inspection reports. The maintenance records were reviewed in detail, and contained a variety of regularly scheduled preventative maintenance and as needed repairs made to the vehicles. When needed repairs were documented during the inspections, repairs were documented as having been completed on the same day as the inspection.

[34] According to the Federal Motor Carrier Safety Regulations (FMCSRs), Title 49 Code of Federal Regulations, Part 393.47(e).
[35] See Vehicle Attachment 8 - MTA Preventive Maintenance Work Orders

3.12. Documented Recall and Warranty Claims

A search of the safety recall database maintained by the National Highway Traffic Safety Administration (NHTSA) uncovered no defects pertaining to this vehicle.[36] Additionally, records kept by New Flyer, did not indicate there were any active or pending safety related recalls pertaining to the transit bus.

E. DOCKET MATERIAL

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

LIST OF ATTACHMENTS

Vehicle Attachment 1 -	2015 IC School Bus RH Sheppard Steering Gear Examination Report
Vehicle Attachment 2 -	MVA, School Vehicle Inspection Certification
Vehicle Attachment 3 -	Baltimore City Public Schools, School Vehicle Inspection Forms
Vehicle Attachment 4 -	AAAfordable Transportation LLC, Maintenance Work Orders
Vehicle Attachment 5 -	Outside Vendor Maintenance Invoices
Vehicle Attachment 6 -	Driver Vehicle Inspection Reports (DVIRs)
Vehicle Attachment 7 -	New Flyer Transit Bus Vehicle Specifications
Vehicle Attachment 8 -	MTA Preventive Maintenance Work Orders

LIST OF PHOTOGRAPHS

Vehicle Photograph 1 -	Left frame rail of 2015 IC school bus
Vehicle Photograph 2 -	Driver controls of the 2015 IC school bus
Vehicle Photograph 3 -	Steering components of the 2015 IC school bus

[36] The safety recall database was accessed via the NHTSA safety recall website: https://www.nhtsa.gov/recalls#vehicles

Vehicle Photograph 4 -	Steering gearbox from the 2015 IC school bus
Vehicle Photograph 5 -	Internal helical worm gear from the steering gearbox of the 2015 IC school bus
Vehicle Photograph 6 -	Driver controls of the 2005 New Flyer transit bus
Vehicle Photograph 7 -	Brake and accelerator control pedals of the 2005 New Flyer transit bus
Vehicle Photograph 8 -	Steering wheel and column of the 2005 New Flyer transit bus

END OF INFORMATION

David Pereira
Vehicle Factors Investigator