National Transportation Safety Board

Office of Railroad, Pipeline and Hazardous Materials Investigations

Washington, D.C. 20594

Derailment of WMATA Passenger Train 407

Arlington, VA

October 12, 2021

Mechanical Group Factual Report

Accident

NTSB Accident Number:	RRD21LR001
Date of Accident:	October 12, 2021
Time of Accident:	4:50 p.m. (EST)
Type of Train:	Passenger
Railroad Owner:	WMATA
Train Operator:	WMATA
Fatalities:	0
Injuries	1
Location of Accident:	Arlington Cemetery, VA

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SYNOPSIS

On October 12, 2021, about 4:49 p.m. local time, WMATA train 407, consisting of eight 7000-series railcars, was traveling southbound on track 2 of the blue line between the Rosslyn and Arlington National Cemetery stations in Arlington, Virginia, when one wheelset on railcar 7200 derailed. Of the 187 passengers onboard, 1 passenger was transported to the hospital for treatment; no other injuries were reported. The evacuation, coordinated by WMATA and the Arlington County Fire Department, began about 6:20 p.m. and concluded about 7:16 p.m. Passengers were safely evacuated onto the track bed through the end railcar door and escorted south to the Arlington Cemetery station.

The train had departed the Rosslyn station when one wheelset on the fourth car of the train, car 7200, derailed. After the derailment, the train moved approximately 600 ft to a stop. The Operator could not take a point of power because the vehicle detected a stuck brake. ROCC instructed the Operator to engage the power knockout bypass, the Operator was able to move the train approximately 1200 ft.

The National Transportation Safety Board (NTSB) identified that the point of derailment was in the frog of a turnout about 166 feet south of the Rosslyn station. The maximum authorized speed through the area is 44 mph. Although the train momentarily achieved a speed of 40 mph, a preliminary review of data from an onboard event recorder revealed the train speed was about 37 mph at the time of the derailment.

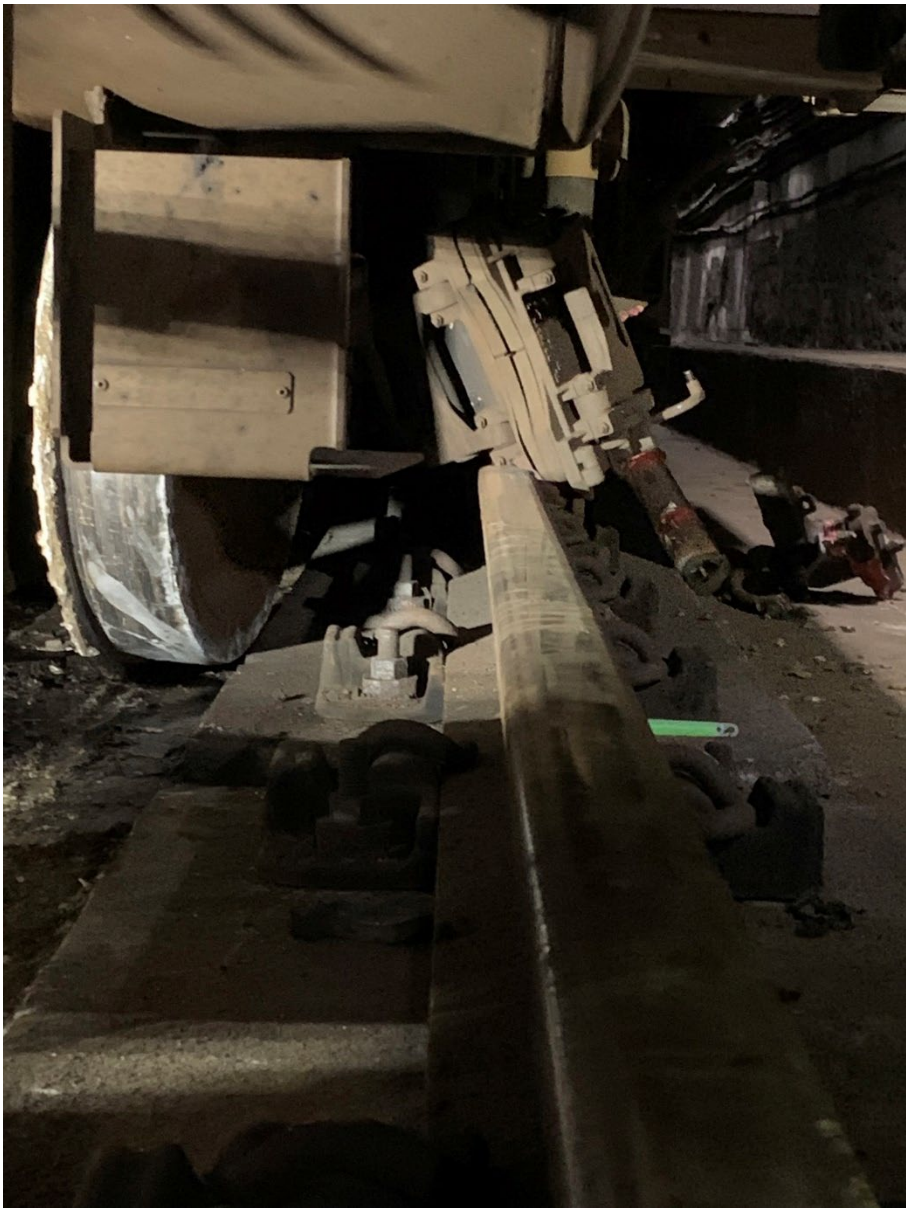

Figure 1 Lead axle at final derailment site.

Based on physical evidence and station video review, between the Arlington Cemetery and Rosslyn stations, one of car 7200's wheelsets (Axle 4) derailed and rerailed while moving through a pair of switches, and the train continued traveling toward the Largo Town Center station. As the train departed the Largo Town Center station on track 2, the same wheelset on car 7200 derailed and rerailed again while moving through a pair of switches, and the train continued inbound through Washington, DC, toward Arlington, Virginia, where the final derailment occurred. Broken sections of brake discs were recovered at the crossover location north of the Arlington Cemetery station and at the crossover near the Largo Town Center station.

Parties to the investigation include the Federal Transit Administration, Washington Metrorail Safety Commission, Washington Metropolitan Transit Authority, the Amalgamated Transit Union, Kawasaki Rail car, Inc., and ORX.

MECHANICAL INVESTIGATIVE SUMMARY

Investigators examined the running gear of car 7200 (derailed) for defective conditions that may have caused or contributed to the derailment. The wheels on the lead axle of car 7200 exhibited a majority of the damage. The distance between the wheels exceeded the maximum allowed specifications. These wheels are cold pressed onto the axle during the assembly process. The wheels had migrated on the machined seat and were found moving outboard.

Normally, at WMATA, the distance between the two wheels on the axle are measured every 90 days during periodic inspections and recorded in maintenance records. The last time car 7200 received a 90-day periodic inspection was in July of 2021 and was about 2 weeks out from its next periodic inspection where this condition could have been detected and repaired.

As of November 2022, 80 wheelsets have been identified out of 2,992 (748 7000-series cars) that exhibit movement of the wheel relative to the machined axle seat surface by measuring the back-to-back distance on the individual wheel sets. This is an indication of unwanted wheel movement on the axle. This condition, if undetected, could result in a derailment.

WMATA

WMATA operates a multi-modal transit system that provides service to a population of approximately four million people across the National Capital Region (NCR), covering 1,500 square miles in Maryland, Virginia, and the District of Columbia. Prior to the pandemic, average weekday passenger trips combined on all three modes totaled approximately one million. In terms of trip volume, Metro operates the third largest heavy rail transit service (Metrorail), the sixth largest bus network (Metrobus) and the sixth largest paratransit service (MetroAccess) in the United States:

- Metrorail operates more than 1,200 heavy rail cars over 118 miles of track serving six rail lines and 91 rail stations.
- Metrobus operates approximately 1,600 buses, on over 240 bus routes serving more than 11,500 bus stops throughout the NCR.
- MetroAccess operates over 700 paratransit vehicles, providing door-to-door trips for customers with disabilities who are unable to use Metrorail, Metrobus, and other local bus service for some or all their trips.

KAWASAKI RAIL CAR

Kawasaki's technological capabilities, over a history that exceeds a century, send products into wide-ranging fields that go beyond land, sea, and air. The aerospace division is active in products ranging from aircraft to satellites; the rolling stock division delivers high speed trains and subway cars for metropolises around the world; the ship and offshore structure division's products range from gas carriers and large tankers to submarines; and the energy solutions division covers the spectrum from development and manufacture of energy equipment to management systems. In the field of rolling stock, as Japan's leading manufacturer of rail cars, Kawasaki provides a wide range of products, including Shinkansen, electric cars, passenger coaches, freight cars, locomotives, diesel locomotives, and new transit systems. In addition to the company's main Kobe Head Office in Japan, there are also two manufacturing facilities in Yonkers, New York and Lincoln, Nebraska.

ORX Inc.

ORX is a wheel, axle, and truck shop for passenger car and locomotive rolling stock components. Located in Tipton, Pennsylvania, the company manufactures, maintains, and overhauls wheels, axles, wheel set assemblies, trucks, and their related components. ORX was founded in 1979 and has been in continuous operation under the same ownership since that time. They have extensive experience in light and heavy rail passenger equipment and have provided products and services to rail transit authorities throughout the United States and Canada, including for Amtrak's Acela High Speed train. ORX has been an active contributor to the American Public Transit Association's (APTA's) creation of industry standards. Specifically, they have been instrumental in APTA's development of three standards for passenger rail vehicle components --- wheels, axles, and the assembly of wheel sets.

KAWASAKI 7000 SERIES FLEET (WMATA)

There are a total of 748 7000 series cars, procured under the base order (64) and five contract options. Each married pair consists of an A-Car (Cab) and B-Car (Hostler Panel Only) connected via a semi-permanent coupler.

The contract for the 7000 Series program was awarded to Kawasaki Railcar in July 2010. The design was completed in 2013, and qualification tests were performed between December 2013 and February 2015. Revenue service began in April 2015.

The car body is made of stainless steel. The truck and bolster are constructed from carbon steel. The truck uses a chevron primary suspension with airbag secondary suspension. The wheels and brake calipers are mounted outboard of the truck frame. Each wheelset is powered by a traction motor that is powered by the propulsion inverter. The traction motor is connected to the gearbox via a flexible high-speed coupling.

Figure 2 Photo of the exterior of an exemplar 7000 series car (Photo provided by Kawasaki Rail Car Inc.)

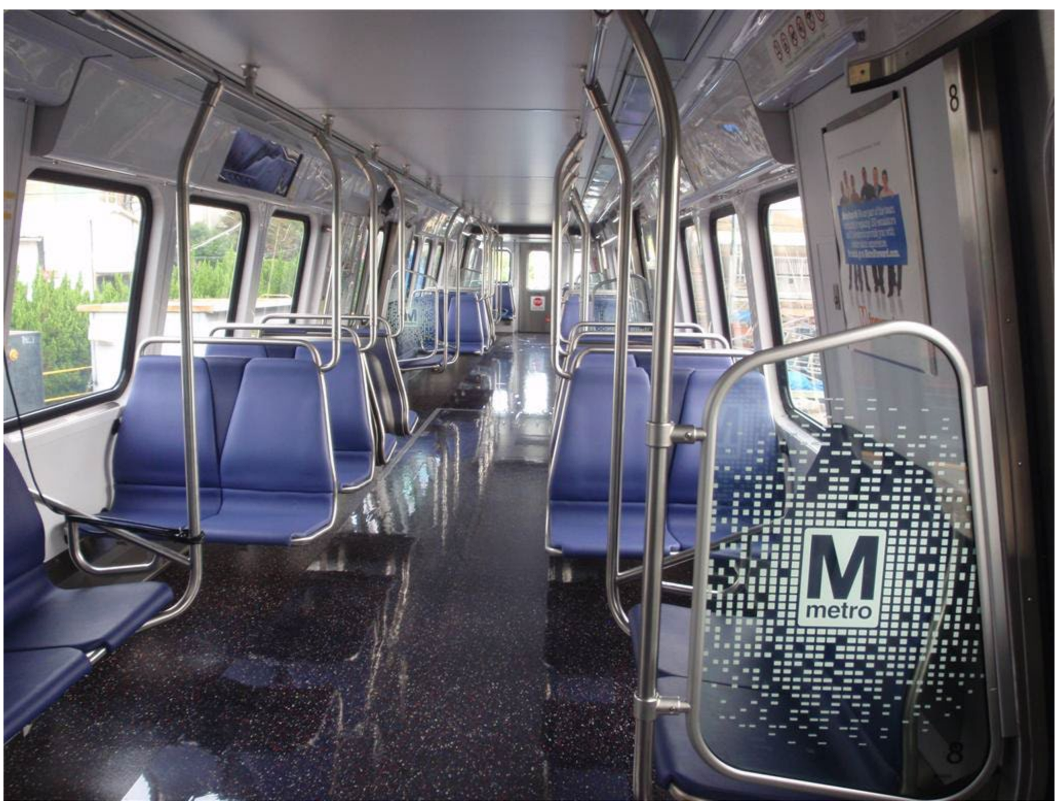

Figure 3 Photo of the interior of an exemplar 7000 series car (Photo provided by Kawasaki Rail Car Inc.)

WMATA FLEET SPECIFICATIONS

Rail Car Series	2000 /3000 Alstom Rehab	6000 Alstom Car	7000 Kawasaki Car
GENERAL			
Manufacture	Alstom	Alstom	Kawasaki
Quantity	364	184	748
Yr. Delivered (last)	2010	2008	2015-present
Body Type/Underbody	Al/Al	Al/steel	Stainless/LAHT Steel
Empty Weight	78,600	82,000	84,106
Seats	68	64	62 (A-car)/68 (B-car)
Minimum Radius	250'	250'	225'
Voltage (input/Output)	700 VDC/37.5	700 VDC/37.5	700 VDC/37.5
Maximum Speed (Balance, mph)	75	75	75
Full Acceleration (mphps)	2.8	2.8	2.8
Deceleration, Service (mphps)	2.2	2.2	2.2
E/H Accessibility	-3.2	-3.2	-3.2
Car Configuration	MP	MP	MP
Noise Level at 35 Mph	72@35	72@35	71 dB (at 70 mph)
CAR BODY			
Material Buff loads (lbs)	200,000	200,000	200,000
Length	75'	75'	75'
width	10' 1 3/4"	10' 1 3/4"	120"
Height	10'	10'	10' 9"
Ceiling Height	6' 9 1/2"	6' 8"	6' 9 1/2"
Floor Height (TOR)	3' 4"	3' 4"	3' 4"
Floor Construction	3/4" plymetal	composite phenolic	Phenol Composite
Seat Type	steel frame with full cushon	steel frame with full cushon	steel frame with full cushon
Window Type	Safety Glass	Safety Glass	Safety Glass
TRUCKS AND SUSPENSION			
Manufacturer	Breda/ TTA Remanufactured	Atchison (Bradken)	Kawasaki
Primary Suspension	Chevron	Journal Rubber Sleeve	Chevron
Secondary Suspension	2 air spring/truck	2 air spring/truck	2 air spring/truck
Wheel Base (Ft-In)	7' 6 1/2"	7' 3"	7' 4"
Wheel Manufacturer	Various	Various	Sumitomo Metals
Wheel Type	Forged Class C	Forged Class C	Forged Class C
Wheel Size (inches)/worn	28" / 25"	28" / 25"	28" / 25"
Truck Centers	52'	52'	52'
Frame Location	Internal	Internal	Internal
Wheel Profile	1:20	1:20	1:20

Figure 4 (Note: 1. Specifications in this figure are original. Actual specifications vary during and after manufacture. 2. Wheel manufacturer for the 7000 series Kawasaki car is Nippon Steel, formerly Sumitomo Metal)

TRAIN 407 CONSIST (At final derailment point)

- 7360 Lead Car
- 7361
- 7201
- 7200 Derailed Car (lead axle #4 R-end)
- 7746
- 7747
- 7086
- 7087 Rear Car

EQUIPMENT DAMAGE

Investigators performed initial inspection on the train consist:

1) 7447 #2 collector shoe missing.

2) 7746 #1 collector shoe missing.

3) 7201 #1 axle ground brush housing broken.

4) 7200 (derailed car) #3&4 collector shoe assemblies broken off. #8 brake caliper broken off. #8-wheel hub moved approx. ½" past end of axle. #7-wheel moved to end(flush) of axle. -see photos. Wheels 7&8 both have thin flanges and signs of ground running. Dragging damage to underframe of truck. Chevron spring displaced on axle #4. Damaged electrical connectors on truck.

5) There was $528,000 damage to the cars.

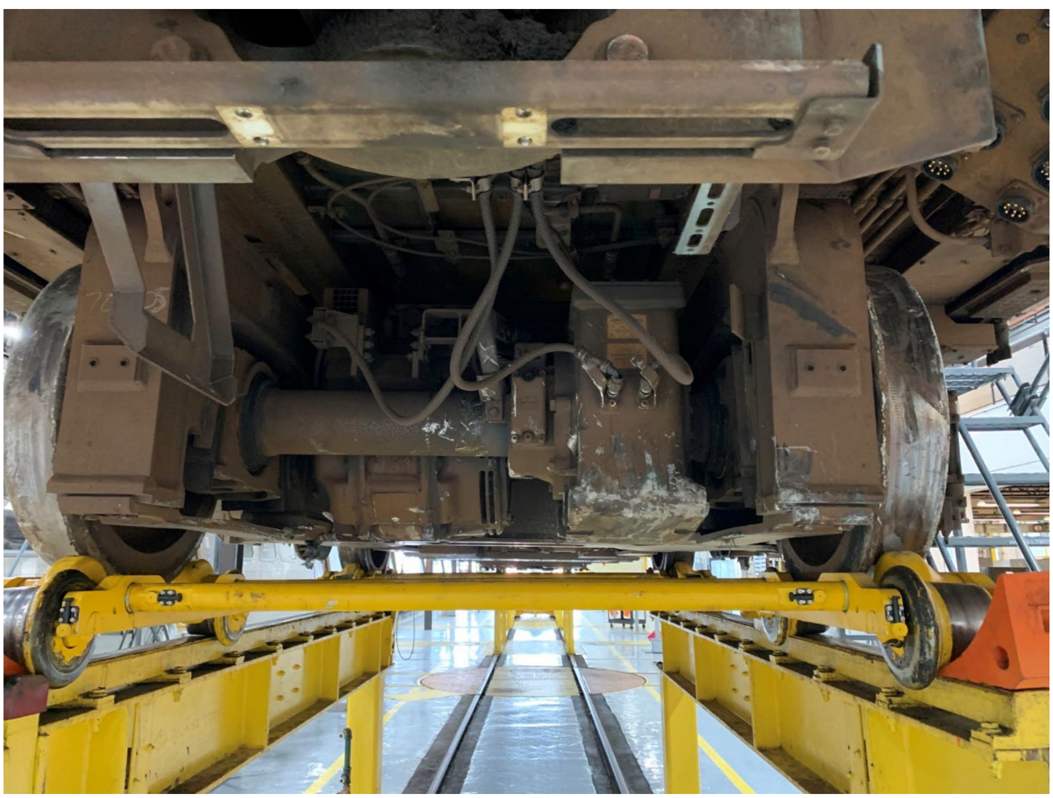

Figure 5 Leading truck and axle of car 7200.

TRAIN DAILY INSPECTIONS

The purpose of the Daily Inspection

WMATA Procedure 2-3000/6000/7000 Series CENV WI DI0001 – Daily Inspection 5.0 – 12/10/2020 is to identify defective conditions that cannot wait until the next inspection, as well as problems that may impact passenger safety and comfort. Throughout the entire inspection, the inspector looks for irregularities or excessive damage on all equipment, excessive trash or debris build up, leaking oil, grease, and fluid, wheel defects, tightness, and security of mounting hardware for critical components. This inspection is performed by WMATA qualified personnel only. (See Appendix A) Part 2.3.1 of the Daily Inspection procedure states to inspect for wheel defects in the visible portions of the wheel: unusual wear patterns, cracks, flats, spalling, and/or other damage. All instances of wheel defects should be reported.

EQUIPMENT POST-ACCIDENT INSPECTIONS

October 15 – WMATA personnel performed back-to-back axle measurements on cars 7200. WMSC performed initial inspection of cars 7746-47 & 7086-87 located at Branch Ave yard.

October 16 – Assembled Mechanical Group and performed a modified "C" truck inspection on the leading truck on car 7200. Except for the leading axle, all components and measurements were with in specifications. (See Appendix B)

October 18 – The lead truck of car 7200 was removed and transported to the Greenbelt mechanical facility for examination.

October 19 – Investigators assembled at the Greenbelt truck shop to perform the derailment inspection. All undamaged components were measured and tested per derailment inspection criteria with no exceptions. (See Appendix C) The wheel sets were removed for disassembly.

October 20 – Observed the pressing off of the two lead wheels sets (#4 and #3) at the Greenbelt machine shop. WMATA and ORX performed axle diameter measurements as well as wheel bore measurements. These measurements were within specifications.

MxV's final report to contain all data collected and analyzed (Currently ongoing).

See **Appendix D** for wheel profile measurements of preliminary failed wheelsets taken by ORX personnel.

NTSB PRELIMINARY METALLURGY FINDINGS

See NTSB Materials Laboratory Factual Report data gathered regarding the disassembled wheelsets, brake rotor remnants, restraining rail, and gearbox.

FEDERAL OVERSIGHT (FTA)

In October 2015, the U.S. Secretary of Transportation directed the Federal Transit Administration (FTA) to assume temporary and direct safety oversight of the Washington Metropolitan Area Transit Authority Metrorail system. FTA was performing this safety oversight responsibility in place of the current and ineffective Tri-State Oversight Committee (TOC) until March of 2019 when the Washington Metrorail Safety Commission (WMSC) took over oversight responsibilities.

The responsibility for improving the safe operation of the Metrorail system, including the performance of daily inspections and preventative maintenance, sat squarely on WMATA. The FTA WMATA Safety Oversight Team's role was to verify WMATA's progress on implementing safety-related Corrective Action Plans and remedial actions, and to ensure that WMATA was effectively carrying out its own critical maintenance, operations, and training programs.

This enhanced safety oversight added to other activities previously undertaken by FTA including initiating a comprehensive Safety Management Inspection of WMATA in February 2015 and subsequently issuing Safety Directive 15-1 in June 2015.

FTA's Corrective Action Plan tracking table provided a searchable table of findings and the status of each action WMATA was required to implement. FTA was also conducting on-the-ground inspections, lead accident investigation, and performed audits and safety blitzes, which may have resulted in additional required actions. FTA was also exercising its authority to direct the use of federal funding received by WMATA to ensure that federal dollars were improving Metrorail safety.

FTA's role was temporary and continued until the District of Columbia, Maryland and Virginia replaced the TOC with a new State Safety Oversight Agency that complied with federal law and is capable of performing its WMATA Metrorail safety oversight responsibilities.

On March 18, 2019, FTA certified the State Safety Oversight Program of the Washington Metrorail Safety Commission (WMSC). Direct safety oversight of WMATA Metrorail transferred from FTA to the WMSC at the close of WMATA's regular service hours on March 18.

STATE SAFETY OVERSIGHT (WMSC)

The Washington Metrorail Safety Commission is the independent State Safety Oversight Agency (SSOA) for the Washington Metropolitan Area Transit Authority Metrorail system. The WMSC derives its authority from the WMSC Compact among the District of Columbia, State of Maryland and Commonwealth of Virginia that was approved by Congress in 2017 as Public Law 115-54. The WMSC assumed direct safety oversight of Metrorail from the Federal Transit Administration in March 2019 when the FTA certified the WMSC's safety oversight program, as required by federal law and FTA regulations. The WMSC has exclusive safety oversight authority and responsibility over the WMATA Rail System including, without limitation, the power to restrict, suspend, or prohibit rail service on all or part of the WMATA Rail System, and the power to require, review, approve, oversee and enforce corrective action plans developed by WMATA. The WMSC Compact requires Metrorail to provide the WMSC with access to its electronic information and databases.

As part of the WMSC's safety oversight program, the WMSC team includes subject matter experts in technical areas such as rail vehicles, track, power, operations, signals, and emergency management. The WMSC staff also includes an investigations team with expertise in additional systems and the functions of the Rail Operations Control Center (ROCC). The WMSC staff carry out the safety oversight program, including conducting or causing to be conducted inspections, investigations, examinations and testing of WMATA personnel and contractors, property, equipment, facilities, rolling stock and operations. The WMSC staff also conduct audits of Metrorail's compliance with WMATA's Public Transportation Agency Safety Plan on an ongoing basis over a three-year period and monitor WMATA's implementation of corrective action plans developed by Metrorail.

MxV (Also known as TTCI)

Washington Metropolitan Area Transit Authority has requested MxV Rail (MxV), also known as Transportation Technology Center, Inc. (TTCI), to conduct an independent investigation to determine the root cause of out of tolerance back-to-back (B-t-B) measurements on the 7000-Series fleet and specify recommended corrective actions.

MxV, a wholly owned subsidiary of the Association of American Railroads (AAR), is a transportation research, testing and consulting organization, providing technology solutions for the transit and railway industry throughout North America and the world, headquartered in Pueblo, CO.

Notably, MxV is responsible for the AAR's North American Railroad Strategic Research Initiatives, performing fundamental and implementation stage research for the North American railway (freight and passenger) industry. Infrastructure research includes multiple year efforts extend the life of rail, special track work, crossties, substructure, and bridges. MxV also conducts fundamental railway research for the FRA including research in the areas of railway infrastructure, track, and vehicles. MxV has been an active participant in the Federal Transit Administration's safety standards research program. Under this program recommendations and findings have been developed in the areas of tracks, tunnels, crash energy management of rolling stock, communication, and train control. In addition, MxV has been supporting the Transit Cooperative Research Program (TCRP), completing numerous projects in the areas of track and vehicle/track interaction with regards to design, maintenance, failure analyses, and technology implementation.

MxV staff have been providing a broad range of consulting and testing services to the transit industry, including WMATA, for more than 40 years. Work has been conducted in the areas of track infrastructure, rolling stock, communication, and train control, for both capital and maintenance/operation programs, at various stages from planning, design, procurement, construction, start-up and commissioning tests, operation, maintenance, to derailment or failure analysis. Support has been provided for many transit agencies and their suppliers (heavy rail, light rail including street running operations, and commuter rail.

MxV engineering staff provide ongoing support to the Association of American Railroads committees that develop and maintain AAR standards and recommended practices for rail vehicles. MxV staff also provide support to the American Railway Engineering Maintenance of way Association (AREMA) and APTA committees that develop and maintain AREMA and APTA recommended practices for railway infrastructure and rail passenger transit systems.

MxV develops and owns the NUCARS® Multi-body Vehicle/Track Dynamic Interaction Simulation and TOES™ train operation simulator tools and has extensive experience in modeling and analysis of vehicle-track interaction, and derailment.

WMATA WAYSIDE DETECTOR SYSTEMS

Although WMATA had 3 wayside detectors installed at the time of this incident that may have detected wheel/truck discrepancies, they were out of service for various reasons. See **Appendix E** for details.

FRA'S MOTIVE POWER AND EQUIPMENT COMPLIANCE MANUAL CHAPTER 16 WAYSIDE DETECTOR/TRAIN INSPECTION GUIDANCE

Although WMATA does not fall under the regulations of the FRA or the recommendations of the AAR, the FRA has published industry guidance on the use of wayside detector technology.

AAR and Class I Railroad Initiatives

> *To reduce or mitigate the adverse effects of heavy axle loads on track infrastructure, degradation of freight car components and as tools for enhanced train inspections, the railroads have started leveraging the emerging wayside detection technology. Besides addressing the higher or distressed-and-unsafe "stress state" of equipment and track, the railroads intend to achieve, at a minimum, an equivalent or enhanced level of railroad safety by using the wayside detection technology. To achieve this goal, the Advanced Technology Safety*

Initiative (ATSI) was implemented on October 1, 2004, by the Association of American Railroad's (AAR's) Technical Services Working Committee.

ATSI is a predictive and proactive maintenance system that uses the best available technology to detect and report potential safety problems and poorly performing equipment before they result in accidents or undue rail damage. The overall objectives of the railroads are to enhance the quality, efficiency and safety of the train inspection processes through this technology including any assessment of the underlying causal issues. It is believed that a mature wayside detector system can provide remote intervention capabilities by combining facets of this technology that relate to the prevention of incidents, detection of incidents, notification of incidents and recovery from incidents.

For FRA's Motive Power and Equipment Manual Chapter 16 See **Appendix F**

PREVIOUS WHEEL ISSUES/FAILURES (WMATA)

Previous to the commissioning of the newer 7K (Kawasaki) fleet, all but one series of rail car in WMATA's legacy (older) fleet encountered at least one similar instance of failing the back-to-back wheelset measurements. WMATA contracted LTK Engineering Services in 2014 to study and conduct a failure analysis with conclusions and recommendations regarding these failures. In September of 2015, LTK presented their final report to WMATA (See **Appendix G** for full report). The Executive Summary from LTK's "WMATA Loose Wheel Investigation Report" is below:

In spring 2014 multiple rail cars were flagged by the WMATA installed Truck Performance Detector (TPD) for exceeding the alert criteria. Further inspections revealed the back-to-back (B-t-B) dimensions were out of tolerance. Fleet wide inspection of all rail cars found more than 30 cars with B-t-B dimension exceeding tolerance. The majority of wheel sets with B-t-B being out of tolerance were assembled in the Greenbelt shop; however, a certain number were assembled in the Brentwood facility.

WMATA has traditionally used wheel bore to axle wheel seat interference fit of 0.0045-0.0055" with a resulting mounting force of 55 to 80 tons. These WMATA shop practices do not follow exactly the AAR Wheel and Axle Manual and Recommended Practices guidelines on wheel bore to axle wheel seat interference fit. The recommendation is to increase the interference fit and raise allowable mounting force range to comply with the AAR guidelines.

Hence, the recommended interference fit range should be increased to 0.00475 - 0.00550-inch, with a deduction of 0.0005 inch for Grade H axles and an increase of 0.0005 inch for axles less than HRc 19.

Better finished wheel bores (cylindricity and taper), with increased interference fits will increase wheel pressing forces to the anticipated AAR guideline range of 65 to 95 tons. These improvements are expected to greatly reduce the chance occurrence of B-t-B dimension changes as found by the TPD detector. Also note, new equipment was obtained by Greenbelt shop to improve consistency of wheel bore finish.

WMATA adopted LTK's new specifications for the legacy fleet and required Kawasaki to use LTK's new specifications in 2017 midway through production and acceptance of the new 7K fleet.

Fleet	Car Qty	Axle Qty	B2B
1K	284	1136	1
2K3K	352	1408	7
4K	100	400	0
5K	192	768	15
6K	184	736	3
7K	748	2992	80

Figure 6 WMATA's back-to-back axle set failure totals.

For WMATA's detailed wheel set failures by fleet See **Appendix H**

WMATA'S CONFORMED TECHNICAL SPECIFICATION DOCUMENT

The NTSB requested and reviewed the Conformed Technical Specification (CTS) document from WMATA. The NTSB sent 16 questions to WMATA to help define and explain the adoption and implementation of these requirements therein. (See **Appendix I**) The first 2 questions are regarding the purpose and usage of the CTS, see below:

1. Describe the purpose of the WMATA Conformed Technical Specification (CTS) (Volume II) document dated August 16, 2010.

The Conformed Technical Specification sets forth requirements for the complete design, manufacture, delivery, testing, and acceptance of 7000 Series railcars for *use on the Washington Metropolitan Area Transit Authority system. The Specification also addresses requirements for spare parts, materials & workmanship, quality standards, training, special tools & test equipment, and execution of the reliability demonstration program.*

2. How did the CTS serve as a tool to ensure products, materials, and designs are safe and meet expectations?

The Conformed Technical Specification defines the safety, performance, qualification, reliability, and workmanship requirements for the railcar. The vehicle design is captured in the plans, analyses, drawings, and other documents specified in the CDRL list. Resolution and definition of all issues and requirements are derived from the Conformed Technical Specification.

The Technical Specification requires that Kawasaki and the sub-system OEM's perform hazard analyses to demonstrate that no unmitigated hazards exist in the design of the vehicle. In addition, The Technical Specification requires the component materials of the railcar to be analyzed to ensure that they comply with the Flame Smoke, and Toxicity (FST) requirements.

For WMATA's CTS Document (In Part) See **Appendix J**

End of Report-