

NATIONAL TRANSPORTATION SAFETY BOARD

**Office of Railroad, Pipeline and Hazardous Materials Investigations
Washington, DC**

**TRACK & ENGINEERING /
SIGNAL & TRAIN CONTROL
FACTUAL REPORT**

RRD22LR001

**Washington Metropolitan Transit Authority Passenger Train
Derailment**

**Arlington, VA
October 12, 2021**

Accident

NTSB Accident Number: RRD22LR001
Date of Accident: October 12, 2021
Time of Accident: 4:59 p.m. eastern daylight time (EDT)
Railroad Owner: WMATA
Passenger Train ID: 407
Location of Accident: Arlington, VA

Track Group

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Preliminary Information

On October 12, 2021, about 4:59 p.m. eastern daylight time (EDT), 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 it derailed, the train traveled about 1,800 feet before stopping in the tunnel. All railcars remained upright and inline. Initially unaware of car 7200's wheelset derailment, the train operator reported to the rail operations control center that he believed there was a stuck brake on car 7200. The rail controller instructed the train operator to try to move the train. The attempt was unsuccessful, and when a WMATA supervisor arrived on-scene, they determined that the lead axle on car 7200 derailed. Power to the

third rail (an additional rail supplying electric current) was disconnected at 5:03 p.m.

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 59 mph. A preliminary review of data from an onboard event recorder revealed the train speed was about 37 mph prior to the derailment.

Based on physical evidence and station video review, between the Arlington Cemetery and Rosslyn stations, one of car 7200's wheelsets 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 accident occurred. Broken sections of brake discs were recovered at the crossover location north of the Arlington Cemetery station and at the turnout near the Largo Town Center station.

Parties to the Investigation

- Federal Transit Administration
- Washington Metrorail Safety Commission
- Washington Metropolitan Area Transit Authority
- Amalgamated Transit Union
- Kawasaki Rail Car, Inc. (rail car manufacturer)
- ORX (wheel press subcontractor)

NTSB Safety Alert

On December 1, 2021, NTSB issued safety alert 083 titled Passenger Railcar Wheelset Alert. The alert was aimed at informing other passenger rail operators of wheel migration identified on the accident train and subsequently on other cars in WMATA's fleet. The NTSB examined car 7200 of the accident train and found that both wheels had moved outboard from their seats, increasing the gage 2-inches, which exceeded the design specifications.

Based on the track and accident wheelset examinations, WMATA began a fleet inspection of its 7000-series cars on October 15, 2021. The inspections focused on the wheel and axle assembly to identify other cars with wheelsets similar to car 7200 that did not meet specifications. On October 26, 2021, WMATA reported to NTSB that inspection of all 748 cars was complete. WMATA

identified an additional 20 wheel and axle assemblies that are out of specification and exhibited outward movement of the wheel on the axle.

Track Description

WMATA's Blue line train travels from stations, Largo Town Center and ends at station, Franconia-Springfield. The Blue Line travels on portions and the entirety of four operational lines and consists of 59.7 track miles (29.9 route miles) of main track between Franconia-Springfield (J Line Chain-Marker 881+34) and Largo Town Center (G Line Chain-Marker 629+60). Much of this route operates on direct fixation track, and the remainder is on ballasted track with wood cross ties. AREMA 115 RE rail is standard across the WMATA rail system.

The trackage of the G-Line is 6.6 route miles and is shared with the Silver service line, which includes 5 stations, 3 crossovers and 2 single turnouts. This line has 29 curves with a curve radii¹ ranging from 755 to 16,000 feet and is almost exclusively direct fixated track with about 500 route feet of ballasted track. On average there are 210 trains that operate daily over the G-Line.

¹ Curve radii refers to the degree or sharpness of the curve. The lower the curve radius the sharper the curve.

The trackage on the portion of the D-Line and C-Line is 8 route miles and is shared with the Orange and Silver service lines between the D&G Junction and Rosslyn stations includes 13 stations, 5 crossovers and 5 single turnouts. This portion of the line has 48 curves with a radii ranging from 700 to 44,617 feet and is almost exclusively direct fixated track with about 300 route feet of ballasted track. On average there are 304 trains that operate daily these portions of the C and D-Line.

The trackage on the portion of the C-Line which, is exclusive to the Blue Line is between the Rosslyn and Pentagon stations. This portion is 2.3 route miles and includes one station, 1 crossover, and 4 single turnouts. This portion has 10 curves with radii ranging from 755 feet to 7000 feet. Approximately half of the line is direct fixated, and the other half is ballasted. On average there are 102 trains that operate over this portion daily.

The trackage on the portion of the C-Line which is shared with the Yellow service line is between Pentagon and King Street stations. This line is 5.8 route miles, includes 6 stations, 2 crossovers and 4 single turnouts. This portion of the line has 26 curves with a radii ranging from 770 to 7,163 feet. Just over half of the line is ballasted track and the remainder is direct

fixated. On average there are 202 trains that operate over this portion daily.

The trackage on the portion of the J-Line which is exclusive to the Blue Line between King Street and Franconia Springfield Stations is 7.2 route miles and includes 2 stations, 2 crossovers and 8 single turnouts. This line has 31 curve radii ranging from 2,465 to 46,355 feet. Most of this line is ballasted, with approximately 3/4 mile of route miles of direct fixated track. On average there are 110 trains that operate over this portion daily.

Documentation of Derailment Locations

On October 13, 2021, investigators identified the final point of derailment in the frog of the turnout at chain-marker 146 + 70, about 166 feet south of the Rosslyn station. The team identified flange marks in the turnout at the frog of the switch in the C05 switch. Corresponding flanges marks from departing wheels were found on track components in the area. The frog in the C05 switch had distinguished wear on the tread portion of the insert. Investigators measured 7/16" tread wear on the point portion of the frog at about 11" back from the point.

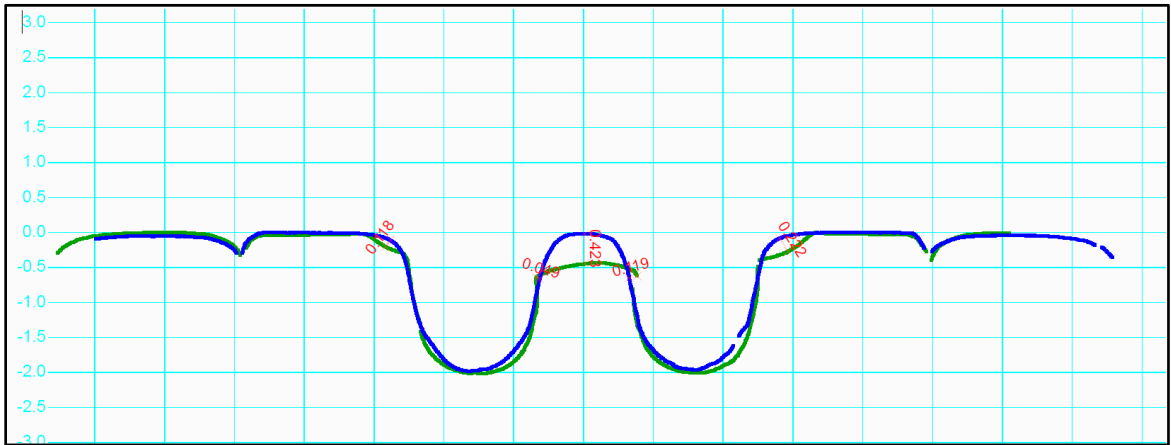


Figure 1. Laser scan representation from the C05 turnout frog. Image shows worn profile in green with the new frog profile in blue.



Figure 3. Wheel flange marks noted on the tread portion of the frog point at the C05 switch.



Figure 2. Corresponding wheel flange marks noted south of the frog on the concrete invert/tunnel floor near the C05 switch.

WMATA employees discovered evidence of a prior derailment on track No.1 in the crossover north of the AC station. This damage was noted the 1A and 3A switches. Investigators noted evidence derailed wheels striking two heel blocks, breaking bolts, scaring ties, and damaging Automatic Train Control (ATC) equipment as they were ground running. Broken sections of brake discs were

identified in this area. Station video of the accident train passing northbound through the AC station confirmed that train 407 had derailed and railed while traversing the turnout at about 3:20 pm.



Figure 3. Wheel flange mark seen coming across the switch point near the heel of the switch in the 1A switch in the Arlington Cemetery station area.



Figure 4. Corresponding wheel flange departure marks near the heel of the switch in the 1A switch in the Arlington Cemetery station area.

On October 14th, investigators traveled to Largo Town Center (LTC), here investigators confirmed that the train had previously derailed and railed at the LTC station; the LTC station and AC station locations are about 15 track miles apart. In G05, Largo, there was evidence of derailling/rerailing over switch 1B and 3B. Wheel marks on the ground seemed to indicate a bouncing of the wheel set. Grout pads were broken in large chunks, ATC equipment was also damaged

at this location. A review of station platform video revealed that the LTC station derailment took place at about 4:10 pm.

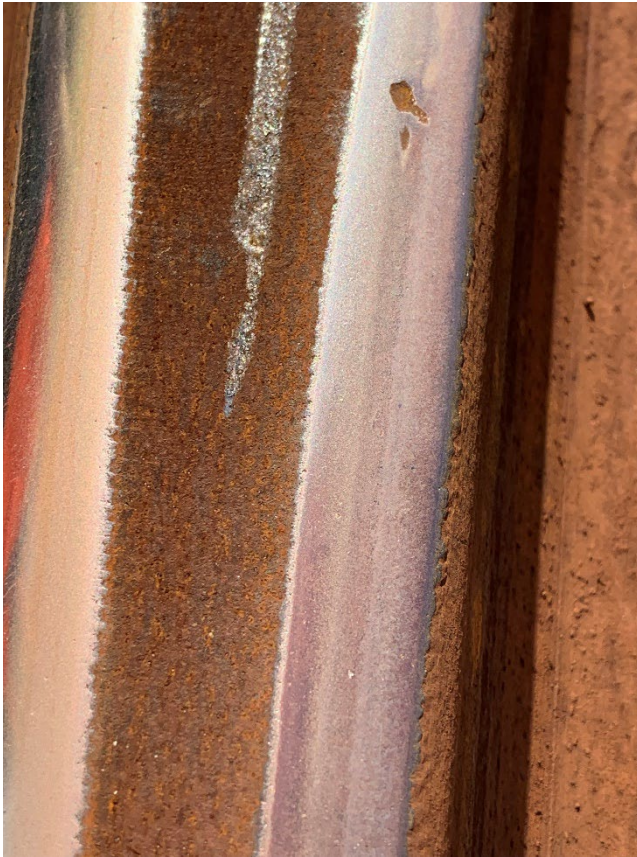


Figure 5. Wheel flange marks noted on the tread portion of the frog point at the G05 switch.



Figure 6. Corresponding wheel flange marks noted on the rail base in the G05 turnout.

In addition to these locations, WMATA reported that their inspectors found several new frog point conditions found during the special inspections that were not noted during the previous months' inspections. At D02, Smithsonian, there was a new minor chip in the frog point. At C02, E Square, a major chip was discovered that required replacement that night. WMATA reported that damage found at Largo track 2 and Arlington track 1 was repaired.

Restraining Rails

WMATA's TRST-1000 Vol.3 Manual discusses the proper installation and maintenance of restraining rails throughout the system. According to section 5.4.25 Guarded Curves and Restraining Rails:

It is customary in transit rail track design to provide a continuous guard rail or restraining rail through sharp radius curves. The restraining rail provides additional steering action using the flange of the wheel that is riding on the inside rail of the curve. By doing so, the Lateral over Vertical (L/V) ratio at the outer wheel can be reduced, which will both reduce wheel and rail wear and deter possible derailment.

Further section 5.4.25.7 states:

As a guideline, it is recommended that the inside restraining rail flangeway width be set to provide dual wheel contact so that the inside back face of wheel makes contact with the restraining rail face while the outside wheel is simultaneously contacting the gauge corner of the outside rail. This will divide the lateral steering force between both restraining rail and running rail (40% and 60% is recommended). In practice, this condition may not be immediately obtained, however, rail wear at either the outside running rail or inside restraining rail will eventually balance the curving action.

To better understand wheel migration that had been identified in the WMATA legacy fleet, WMATA contracted with LTK Engineering Services to complete a WMATA loose wheel investigation. LTK completed report LTK-041 dated September 2015. The executive summary from the report follows:

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.

No evidence was found that restraining rail of #8 turnouts has significant effect on increased Back-to-Back wheelset dimension.

Additional Track Inspection

To understand track configurations that result in outward forces on the wheels, on December 7th, investigators returned to WMATA to conduct walking track inspections and observations of various types of special track work and guarded curves within the system. A walking inspection was conducted from U Street station on track No. 2 from chain maker 84+39 feet to chain marker 143+30 feet. This area was selected because of high radii guarded curves of up to 755 feet with vertical restraining rail. On December 8th, investigators conducted a walking inspection in WMATA's West Falls Church yard. During this activity, the team looked at guarded curves of up to 250-foot radii as well as fully

guarded No.8 and No. 6 turnouts. The team walked Yard Lead Track 1 (Western loop leading to the Orange Line) with a radius from 250 feet initially, expanding to 316 feet for most of the curve. This curve was equipped with a horizontal restraining rail. The next curve that was inspected was Track 20 (eastern loop track in the box) has a 305-foot radius. This curve was equipped with a vertical restraining rail. The last curve inspected was Yard Lead Track 3 (direct fixated single track reverse curve) with a 300-foot radius and is partially on a 4% grade. This curve was also equipped with a vertical restraining rail.

During these inspections, the team noted a mostly robust track construction.

Some areas that were noted were as follows:

- Chain marker 139+00 improper joint bar/insecure rail joint on both ends of a replacement rail in a curve.
- Various locations of flangeway width outside of the measurements set forth in WMATA's maintenance standard. The narrowest flangeway noted was 1-1/2 inches. The widest flangeway noted was 2-3/4 inches.

Post-Accident Action

According to WMATA, after initial inspection of the derailment site a special frog inspection was ordered for the entire system. This was due to the battered

condition of the frog at the derailment site. Track and Structures (TRST) initiated a special inspection of all frogs throughout the system- this inspection began in the early hours of December 13th. Priority was given to the accident train route.

Analysis of VTI Data

Washington Metropolitan Area Transit Authority (WMATA) requested MxV Rail (MxV), also known as Transportation Technology Center, Inc., to conduct an independent investigation in coordination with the NTSB 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 world-class transportation research, testing and consulting organization, providing technology solutions for the transit and railway industry throughout North America and the world.

The following are excerpts from a WMATA memorandum dated January 12, 2022:

As a result of the derailment of the 7000 Series railcar at Arlington Cemetery on October 12, 2021, WMATA hired Transportation Technology Center Inc. (TTCI) to conduct an independent root cause investigation into the derailment. In the course of the investigation, TTCI

has reviewed Vehicle Track Interaction (VTI) data recorded from 7000 Series railcar. TTCl identified 27 mainline track locations where inefficient dynamic vehicle behavior is present.

TTCl reviewed the data to determine if there were locations that provided an impact great enough to likely cause lateral movement of a wheel relative to the wheel seat. As a result of the analysis, TTCl determined that it is unlikely there is a location on the mainline that is providing significant enough impact to the wheelsets that causes it to move without other contributing factors. Additionally, TTCl is using the VTI analysis to better understand where track instrumentation should occur for dynamic vehicle testing.

TTCl reviewed the exceptions reported through VTI and the findings from the inspections of the 27 locations. At this time, TTCl does not believe that any of these locations produced a severe enough impact to move the wheel and be called the sole root cause.

Vehicle Track Interaction Data Review

MOWE-TE2 led the evaluation of the existing track conditions that appear to match the locations of the VTI exceptions. Track conditions were identified to explain 23 of the 27 exceptions. Conditions identified with frequency are summarized as:

- 1) Eight - open/battered joints
- 2) Four - cross level conditions to include warps and twists
- 3) Five - gauge transitions
- 4) Five - battered frog
- 5) One - pumping track

The conditions identified by MOWE-TE are mostly minor to moderate (yellow condition). Six locations have been identified as major (red conditions) as defined within the TRST 1000 Volume 1 Track Inspection and Safety standards. The red conditions comprise of three gauge transition conditions, two warps conditions, and one track profile condition. The location and work plan are described below:

Three Gauge Transition:

- Eastern Market (D06) - D1 142+00, which was traced to a battered frog. This work is scheduled to take place 6-7 FEB 2022
- D&G Junction (D98) - D1 283+00, caused by track alignment irregularities. This work is scheduled to take place 14-17 FEB 2022.
- Federal Center SW (D04) - D2 87+00, possibly caused by a battered frog. The work is scheduled for 2-3 FEB 2022

Two Warps Conditions:

- Addison Rd (G03) - G1 489+00, caused by a cross level condition possibly due to track settlement at the transition of an arial structure with ballasted track. This work is scheduled for 14-17 FEB 2022
- Mainline Track adjacent to Brentwood Yard (B99) - B2 141+15, caused by pumping track at the interface of the arial structure and ballasted track. This work is scheduled for 22-24 FEB 2022

One Track Profile Condition:

- Deanwood (D10) - D1 392+00, cause by an open track joint on ballasted track. This work was completed on 28 DEC 2021.

The red conditions are scheduled for repair. Repairs that require tamping and concrete work will be completed during warm weather months. Additionally, temporary shimming repairs put in place for deferred concrete work (grout pads) until the permanent solution is implemented.

TRST twice weekly routine track inspections and MOWE-TE TGV data provide continual monitoring of Yellow and Red Conditions via until the repairs are made to that area.

Signal and Train Control

On October 13th and 14th, investigators went to the Arlington Cemetery, Largo Town Center, and Rosslyn Station accident locations for observations including any signal involvement or damage to signal equipment. There were no abnormalities noted and no damages to the signal equipment because of this accident. After determining that one of the derailments occurred near a crossover switch point at Arlington Cemetery Station on #1 track. Investigators

observed WMATA employees perform an obstruction and point detection test to switch in question. No defects or issues were noted during this testing procedure.

Damages Estimates

WMATA reported track structure and signal and train control component damages as \$161,750, as a result of the derailments covered in this report.

Track Inspection Records

Track and turnout inspection requirements are set forth in the TRST-1000 manual. NTSB reviewed track and turnout inspection records from WMATA for the identified derailment locations. No exceptions were taken to the records provided.

Geometry Tests

WMATA provided previous geometry car survey reports for the accident route. The most recent surveys were conducted in between mid and late September 2021. The G Line was tested on the night of September 23, 2021, the D Line was tested on the night of September 22, 2021, the C Line was tested on the night of September 19, 2021, and the J Line was tested on the night of

September 13, 2021. Geometry testing within the vicinity the 3 derailment locations of showed no out- of- tolerance track conditions.

External Oversight

The Washington Metrorail Safety Commission (WMSC) is the independent State Safety Oversight Agency (SSOA) for the Washington Metropolitan Area Transit Authority (WMATA) 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 (FTA) 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, 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.

End of Report