

# The Washington Metrorail Safety Commission

## Safety Audit

of the Washington Metropolitan Area Transit Authority



## Audit of Revenue Vehicle (Railcar) Programs

Final Report:  
September 14, 2021

---

Prepared under the authority of the Washington Metrorail Safety Commission

Commissioners: Christopher Hart (Chair), Greg Hull (Vice Chair), Debra Farrar-Dyke (Secretary-Treasurer)  
Robert Bobb, Michael Rush, Suhair Al Khatib  
Alternate: Robert Lauby

Report produced by WMSC staff led by CEO David L. Mayer, PhD

---

# Table of Contents

<b>Executive Summary</b> .....	2
<b>Background and Scope</b> .....	4
Open Corrective Action Plans .....	7
History.....	7
Prior Reviews and Audits .....	9
Current Structure .....	11
Audit Work.....	11
Personnel Interviewed.....	12
Documents Reviewed .....	13
<b>What the WMSC Found</b> .....	19
Positive Practices.....	20
Findings and Minimum Corrective Actions .....	21
Recommendations .....	36
Other Observations .....	39
<b>Next Steps</b> .....	41



# Executive Summary



The Washington Metrorail Safety Commission (WMSC) performed this audit of the Washington Metropolitan Area Transit Authority (WMATA) Metrorail's revenue vehicle (railcar) practices based on in-depth interviews and document and data reviews conducted in 2021. The scope of this audit included railcar inspection, maintenance, engineering and associated training in relation to rules, procedures, regulations and best practices, and the related aspects of Metrorail's safety plans, as well as the related management structures and staffing, planning and governance.

Broadly, this audit covered Metrorail's activities related to railcars, including regular maintenance and engineering as well as rehabilitation and overhauls.

The WMSC identified several positive practices and a number of areas that require improvement. As a result, the WMSC is issuing 12 findings requiring Metrorail to develop corrective action plans (CAPs) and three recommendations.

Among the findings, Metrorail did not follow its safety certification processes for the 6000-Series rehabilitation and overhaul project. In addition, Metrorail did not even follow the other steps, improperly created outside of its safety certification process, that it said were being used for this railcar rehabilitation work. Later, in fall 2020, two 6000 Series train pull-aparts occurred involving Red Line trains in revenue service. Safety certification is designed to ensure that hazards are addressed or mitigated prior to a safety event. Metrorail is also developing a similar rehabilitation project for the 7000 Series cars, but is doing so without full coordination with its Safety Department.

Among other findings in this audit, Metrorail is not requiring or receiving all necessary documentation, parts and tools from original equipment manufacturers (OEMs).

Metrorail does not have adequate document control practices for car maintenance job plans, does not clearly define the use of certain engineering documents, and does not have a systematic process to ensure that mechanics and engineers are trained for the specific tasks they are assigned to perform.

Metrorail also does not consistently follow a standard process to address wheels out-of-round, a situation that can be felt by operators and customers as significant vibrations or bouncing during their ride and that can contribute to infrastructure damage.

The responsibilities of the Chief Mechanical Officer, Rail's (CMOR) Incident Investigation Team and CMOR's separate unusual occurrence response personnel conflict and are not clearly defined, which impacts safety event investigations.

**Metrorail did not follow its safety certification processes for the 6000 Series rehabilitation and overhaul project.**

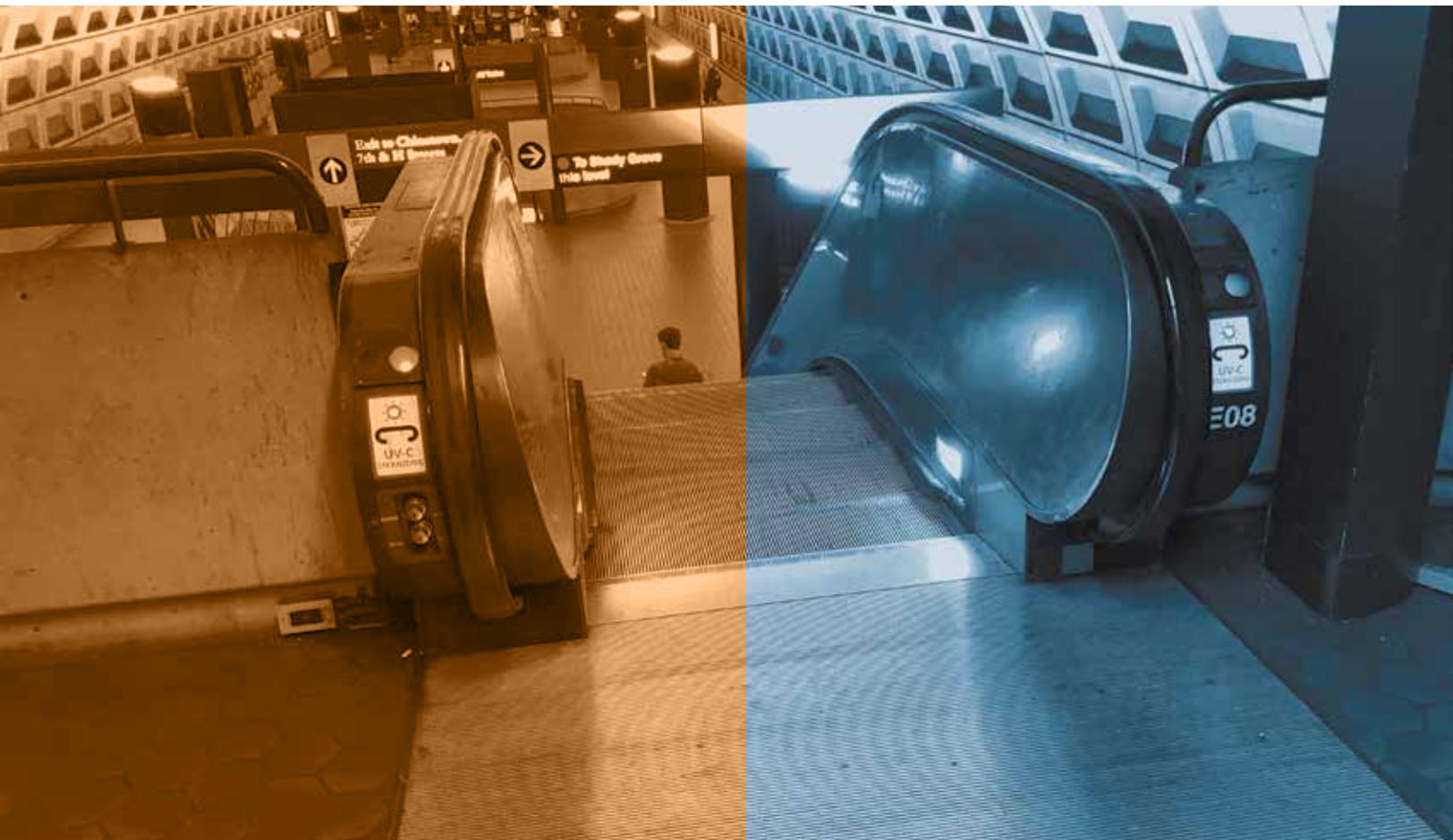


The three recommendations in this report include that Metrorail address the lack of inward- and outward-facing audio and image recorders in operating compartments that the National Transportation Safety Board (NTSB) has recommended transit agencies use to improve safety event investigations and to conduct regular hazard identification activities.

The WMSC appreciates the cooperation of the CMOR, Vehicle Engineering (CENV), and Car Maintenance (CMNT) departments during this audit process.

WMATA is required to propose a Corrective Action Plan (CAP) for each finding and to respond to each recommendation no later than 30 days after the issuance of this report.

**Two 6000 Series train  
pull-aparts occurred in  
fall 2020.**





## **Background** and Scope

# Background and Scope

The scope of this audit includes Metrorail's programs related to revenue vehicles – those vehicles that are or were originally designed to carry customers, which WMATA also refers to as Class 1 vehicles – and associated shop equipment such as railcar movers. This audit assesses and evaluates inspection, maintenance and associated training in relation to rules, procedures, regulations and best practices, and the related aspects of Metrorail's safety plans governing policy and procedure development, implementation and compliance, management structure, planning and governance, and associated training.

Among other areas, the audit focuses on elements of the System Safety Program Plan (SSPP) for the period through December 31, 2020, and, for more recent information, elements of WMATA's first Public Transportation Agency Safety Plan (PTASP), titled the WMATA Transit Agency Safety Plan, which replaced the SSPP on December 31, 2020. Due to the timing of the PTASP's approval and the required phased approach for effective implementation, aspects of the PTASP had not yet been implemented in this area at the time of this audit.

SSPP elements covered include:

- Implementation Activities and Responsibilities (Element 5)
- Hazard Management Process (Element 6)
- System Modification (Element 7)
- Safety Certification (Element 8)
- Safety Data Collection and analysis (Element 9)
- Accident Investigation (Element 10)
- Emergency Management Program (Element 11)
- Internal Safety Audits (Element 12)
- Rules Compliance (Element 13)
- Facilities and Equipment Inspections (Element 14)
- Maintenance Audits and Inspections (Element 15)
- Training and Certification for Employees and Contractors (Element 16)
- Configuration Management and control (Element 17)
- Compliance with Local, State and Federal Requirements (Element 18)
- Procurement Process (Element 19)

**This audit focuses on elements of the SSPP for the period through December 31, 2020 and, for more recent information, elements of WMATA's first PTASP, which replaced the SSPP on December 31, 2020.**



PTASP elements covered include:

### **1. Safety Management Policy**

- a. Safety performance targets
- b. Organizational SMS Accountabilities and Responsibilities
- c. Functional area common SMS responsibilities
- d. Functional area specific SMS responsibilities
- e. SMS documentation

### **2. Safety Risk Management**

- a. Risk Assessment Process
- b. Risk assessment methodology
- c. Hazard identification
- d. Hazard investigation
- e. Hazard analysis and evaluation of safety risk
- f. Hazard resolution (mitigation, elimination)
- g. Hazard tracking

### **3. Safety Assurance**

- a. Systematic, integrated data monitoring and recording of safety performance
- b. Real-time assessment with timely information as to safety management and performance
- c. Internal reviews, departmental controls, compliance and sufficiency monitoring
- d. Document assurance activities
- e. Preventive, Predictive, and Corrective Maintenance
- f. Event reporting/investigations
- g. Change management
- h. Safety and Security Certification
- i. Corrective action plans

**At the time of this audit, 6000 Series cars were being held out of service long-term due to safety issues.**



#### 4. Safety Promotion

- a. Training
- b. Contractor Safety
- c. Safety Communications
- d. Hazard and safety risk information
- e. Safety committees

This audit involved a broad review of railcar engineering, inspection and maintenance programs and associated procedures and training. Within that broad review, the audit also examined areas related to overhaul, modification and rehabilitation.

The WMSC completed a separate audit of WMATA's Roadway Maintenance Machine (RMM) Inspection, Maintenance and Training in March 2021 that addressed similar areas in relation to RMMs, which Metrorail also refers to as Class 2 vehicles.

#### Open Corrective Action Plans

As of the time of this audit, Metrorail has not completed improvements required under Corrective Action Plan (CAP) C0017. This CAP was developed in response to the WMSC's finding that Metrorail has not fully implemented sufficient protections against the unauthorized movement of trains with lost speed commands.

This WMSC finding and the CAP Metrorail was required to develop superseded a 2016 FTA finding and related CAP. Both the WMSC and FTA findings were that WMATA has not fully implemented sufficient protections against the unauthorized movement of trains with zero speed commands.

#### History

Metrorail refers to its railcars based on their model and time of delivery. Each series has different features and designs. The original railcars were the 1000 Series, and the newest railcars currently in service are the 7000 Series. Each railcar in a series is numbered based on its model and order of arrival. For example, the first 7000 Series car delivered is number 7000, the second is 7001, and the last, delivered to Metrorail in winter 2019, is 7747. The railcars operate in "married pairs" that are semi-permanently connected. Metrorail operates the 7000 Series in sets of four cars that are arranged into eight-car trains in revenue service. The four-car sets are broken up into pairs for maintenance work because WMATA's shops are designed to accommodate married pairs of cars.

**Metrorail has not fully implemented sufficient protections against the unauthorized movement of trains with lost speed commands.**



**Metrorail plans to retire 2000 and 3000 Series cars after 8000 Series cars enter revenue service.**

Fleet	Cars delivered	Current fleet size (in use or that may return to regular use)	In Service
1000 Series	300	0	1976-2017
2000 Series	76	76	1982-present
3000 Series	290	282	1987-present
4000 Series	100	0	1991-2017
5000 Series	192	0	2001-2018
6000 Series	184	184	2006-present
7000 Series	748	748	2015-present
8000 Series	(Planned) Min. 256, Max. 800	N/A	In design, expected around 2024

The 1000 Series, which began revenue operations when the system opened in 1976, were removed from revenue service in 2017. The 4000 Series, which entered revenue service in 1991 and the 5000 Series, which entered revenue service in 2001 were removed from service in 2017 and 2018, respectively.

Metrorail plans to retire 2000 Series and 3000 Series cars after 8000 Series cars enter revenue service. WMATA formally awarded the contract to Hitachi Rail Car for the 8000 Series final design and construction in early 2021.

At the time of this audit, 6000 Series cars were being held out of service long-term due to safety issues identified in Metrorail’s maintenance and rehabilitation process. These issues, described in more detail later in this report, were identified following train pull-aparts in fall 2020.

The National Transportation Safety Board (NTSB) raised concerns about the crashworthiness, emergency evacuation, event recorder, and other design features of particularly the 1000 Series cars for several decades following collisions or other safety events including the 1982 derailment in the Smithsonian interlocking, the 1996 fatal collision at Shady Grove station, a 2004 train rollback and collision at Woodley Park Station, and the 2009 fatal Red Line collision near Fort Totten Station.

Following the 1996 collision, the NTSB also recommended the use of vehicle monitoring systems.

After the 2009 fatal Red Line collision, the NTSB recommended removing all 1000 Series railcars from service and replacing them with cars that had at least the crashworthiness protections of the 6000 Series cars, recommended the use of event recorders, and recommended the maintenance of those event recorders.

Investigations into other safety events have also identified areas that require improvements.



For example, in 2018, prior to the WMSC's safety oversight of WMATA, a 6000 Series train pulled apart into two sections near McLean Station. This pull-apart occurred between two cars that were part of a married pair. The investigation identified that Metrorail used improper parts and did not have appropriate coupler procedures in place.

In fall 2020, two similar 6000 Series pull-aparts occurred on the Red Line on October 9, 2020 near Union Station and on November 24, 2020 near Glenmont Station. The investigations into these two events were continuing at the time interviews were conducted for this audit. Final investigation reports were adopted on May 18, 2021. These reports identified a series of corrective actions related to railcar maintenance, inspection and training, tools availability, engineering processes, emergency management and response, and rail operations.

Further information identified as part of this audit is described in the findings section of this report.

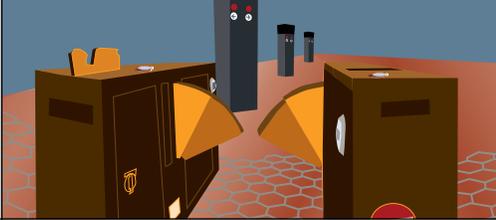
Other safety event investigations that have identified railcar-related corrective actions include investigation W-0017 of an event involving train movement with doors open on the Orange Line near Dunn Loring-Merrifield Station on May 21, 2019. The investigation led to an engineering modification to add a physical barrier to the master controller on 2000 Series and 3000 Series railcars.

## Prior Reviews and Audits

The Tri-State Oversight Committee (TOC) conducted several audits with findings and observations related to revenue vehicles.

The TOC's 2005 triennial audit report identified instances where employees were not using measurement gauges when required, that WMATA had not designated required training courses or training tracking systems for vehicle maintenance employees, and that there was an opportunity to increase trainees' specific car knowledge at the completion of the Technical Skills Program (TSP).

In 2007, the TOC identified a number of vehicle or vehicle maintenance findings including that maintenance work did not always follow written procedures, that documentation of preventive maintenance inspections was inconsistent, and that checklists were missing information related to the acceptable ranges for many readings required during preventive maintenance inspections. Those readings were also frequently not recorded, computer data entries were not made at the time car modifications were made, equipment calibration was inconsistent, and inspections were not always performed on schedule. The 2007 report also identified that WMATA did not have a current matrix showing all required technical training



**In fall 2020, two similar 6000 Series pull-aparts occurred on the Red Line on October 9, 2020 near Union Station and on November 24, 2020 near Glenmont Station.**



for railcar maintainers at each location, and did not have training in component repair procedures. For railcar materials, WMATA's procurement software did not reliably fax orders to suppliers, Metrorail did not have enough spares of some parts, parts were not always tracked, and there were parts availability issues for the 5000 Series and 6000 Series cars.

In 2010, the TOC observed railcar maintenance tools out of calibration and the use of improper tools for precision measurements.

In 2015, the Federal Transit Administration (FTA) conducted a broad Safety Management Inspection (SMI) of Metrorail. This included a review of areas related to vehicles. The SMI identified deficiencies in Roadway Worker Protection (RWP) training for maintenance and operations departments, that technical training for operations and maintenance departments was under-resourced and fractured, that documented maintenance procedures and standard operating procedures were not implemented as required, that out-of-stock parts had impacted maintenance and operations and was a serious concern in Car Maintenance, and that there was poor documentation of initial and refresher training, certifications, recertifications and licensing.

In 2016, the TOC published an audit of Metrorail's Railcar Maintenance programs based on work conducted both independently and in conjunction with the FTA's SMI of Metrorail. Among other areas, the TOC's report identified that Car Maintenance (CMNT) supervisors could not review or access training records and requirements of employees they supervised, and there were no notifications of training or retraining requirements. The WMSC identified similar concerns during this audit. The 2016 TOC Audit also identified concerns related to railcar CCTV systems, availability of qualified training instructors, lack of railcar maintenance plans, and





incomplete preventive maintenance inspection checklists and supervisor sign-off sheets.

Later in 2016, FTA conducted a Vehicle Securement Investigation at WMATA that resulted in six findings that were issued in Safety Directive 16-6. The investigation found that Metrorail was not properly securing unattended trains, which presented a significant safety risk.

The FTA “discovered a widespread lack of compliance with WMATA’s internal rules for both revenue passenger trains and maintenance machines and equipment located in rail yards.”

Since taking over direct safety oversight of WMATA in March 2019, the WMSC has continued oversight work related to vehicle securement, including inspections that identified required corrective actions in early 2021.

## Current Structure

Metrorail has assigned the Office of the Chief Mechanical Officer, Rail (CMOR), under the Chief Operating Officer (COO), as responsible for railcar maintenance and engineering.

Car Maintenance (CMNT) and Vehicle Program Services, also referred to as Vehicle Engineering or Chief Engineer for Vehicles (CENV), are the two departments that report to CMOR that carry out day-to-day engineering and maintenance work. Employees in these departments are supplemented by Metrorail contractors in some areas. Other parts of CMOR include Railcar Quality Assurance and Warranty Compliance (RQAW) and a project management group (PMO).

## Audit Work

The WMSC received initial documents related to this audit from WMATA in March 2021, conducted extensive interviews in April 2021, and received follow-up documents and conducted document reviews into May 2021.

An exit conference was held on April 23, 2021 with Metrorail staff to summarize the status of the audit to that point.

The WMSC later provided a draft of this report to WMATA for technical review and incorporated any technical corrections as appropriate.

This audit was already scheduled and communicated to Metrorail on the WMSC’s Triennial Audit Schedule prior to two train pull-aparts occurring in fall 2020.

**Car Maintenance (CMNT) and Vehicle Program Services (CENV) are the departments that carry out day-to-day railcar engineering and maintenance work.**



## Personnel Interviewed

### Chief Mechanical Officer, Rail (CMOR)

- Vice President & Chief Mechanical Officer

#### Office of Car Maintenance (CMNT)

- Acting General Superintendent
- Superintendent, Service and Inspection
- Superintendent, Service and Inspection
- Senior Program Manager
- Project Manager, Vehicles
- Mechanic AA Lead
- Mechanic AA
- Two Mechanic Bs
- Mechanic Helper

#### Vehicle Program Services (CENV)

- Deputy Chief Mechanical Officer New Car Program
- Deputy Chief Mechanical Officer Engineering Rail Vehicles
- Deputy Chief Vehicle Engineer
- Two Senior Vehicle Engineers
- Project Manager (8000-Series)

#### Railcar Quality Assurance and Warranty Compliance (RQAW)

- Manager of Compliance and Safety
- Senior Manager Quality Assurance and Warranty Compliance

### Reliability Centered Maintenance Planning (RCMP)

- Senior Reliability Engineer
- Maintenance Planner

### Department of System Safety and Environmental Management (SAFE)

- Deputy Chief, Safety Certification
- Contractor assigned to 6000 Series rehabilitation

### Operations Management Services (OPMS)

- Supervisor, Technical Skills Training



## Documents Reviewed

- WMATA's final System Safety Program Plan (SSPP), effective January 2019
- WMATA's current Public Transportation Agency Safety Plan (PTASP), effective December 31, 2020.
- Organizational charts (CENV, CMNT, CMOR, Reliability Engineering and Asset Management (REAM), Supply Chain Management (SCM))
- List of CMNT railcar personnel
- Railcar status list as of March 1, 2021
- Vehicle Track Interface (VTI) lateral acceleration data events for railcars 7000-7099 and 7600-7699 (August 2020 and January 2021)
- Wheel cut data for railcars 7000-7099 and 7600-7699
- 6000-Series Scheduled Maintenance Documents
  - Coupler Overhaul (Rev-01, 10/28/2020)
  - Propulsion Overhaul (Rev-02, 3/2/2021)
  - Friction Brake Overhaul (Rev-02, 10/28/2020)
  - HVAC System Overhaul (Rev-01, 10/28/2020)
  - Car body (Rev-02, 1/8/2021)
  - Door Limit Switch Overhaul (Rev-00, 3/20/2019)
  - Truck Overhaul (Rev-01, 1/19/2021)
  - Master Controller Overhaul (Rev-01, 2/18/2021)
  - 20% of completed SMP checklists
- List of railcar camera locations and specifications
- Policy/Instruction 11.6/0, Camera/Video Access, Distribution and Retention (Approved 5/26/2015)
- SOP 11, Rev. 1, Vehicle Program Services (CENV) Incident Investigation Procedure (Approved 10/28/2016)
- SIP (Special Instruction) 7K01, Rev. 0, CMOR IIT NVR Video Download Request Process & Procedures for 7K series Rail Vehicles (3/9/2021)
- Safety Certifications for all 7000-Series railcars
- 8000-Series technical specifications and program documents
- OAP 113-02, Rev. 1, TIES Rail Car Commissioning Policies (9/25/2014)
- SOP 113-03, Rev. 0, TIES Rail Car Commissioning Procedures (9/29/2016)
- SOP 113-04, Rev. 0, TIES Surveillance Inspection Report Procedure (10/1/2016)
- SOP, 113-05, Rev. 0, 7000 Series Feedback Procedure (10/1/2014)
- Safety Certification Certifiable Items List (CIL) Master Checklist for railcars 7010, 7350, 7650
- Conditional Acceptance certificate for railcars 7008-11, 7348-51, 7648-51
- 7000-Series current open items list (OIL) (as of February 5, 2021)
- List of railcar equipment used for inspection and maintenance
- Consolidated PI Tool List
- List of railcar special tools
- List of railcar movers
- JP0038 (Shop Equipment Preventive Maintenance Job Plan), Maxi Rail Vehicle Mover LPG Engine: Railquip (last revised 8/13/2015)
- Inventory of 7000-Series spare parts on hand
- Walk Around Daily Inspection Manual (all railcar series), Rev. 5.0 (last revised 12/10/2020)

## Documents Reviewed

- OAP 201-05, Policies for Controlling the Assignment and Utilization of WIBU Keys (6/26/2020)
- OAP 606-01, New Vendor Qualifications for existing or new Railcar Parts to be inducted within the Vendor Qualification List (1/9/2019)
- Periodic Inspection Manuals
  - **2000/3000 Series**
    - A-Inspection Manual, Rev-8 (11/30/2020)
    - B-Inspection Manual, Rev-8 (11/30/2020)
    - C-Inspection Manual, Rev-8 (11/30/2020)
    - Y-Inspection Manual, Rev-3 (11/30/2020)
    - All inspection checklists (10/6/2020)
  - **6000 Series**
    - A-Inspection Manual, Rev-8 (11/30/2020)
    - B-Inspection Manual, Rev-8 (11/30/2020)
    - C-Inspection Manual, Rev-8 (11/30/2020)
    - Y-Inspection Manual, Rev-4 (11/30/2020)
    - All inspection checklists (10/6/2020)
  - **7000 Series**
    - A-Inspection Manual, Rev-8 (10/30/2020)
    - B-Inspection Manual, Rev-8 (10/30/2020)
    - C-Inspection Manual, Rev-8 (10/30/2020)
    - Y-Inspection Manual, Rev-4 (11/30/2020)
    - All inspection checklists (10/6/2020)
- Portable Test Unit (PTU) Manuals
  - **2000/3000 Series**
    - Carborne ATC System Bench Test Unit Manual (June 2003)
    - Carborne ATC System Maintenance Manual (November 2013)
    - Carborne ATC System Schematics Manual (July 2013)
    - Carborne ATC System Parts Catalog (November 2013)
    - Carborne ATC System Portable Test Device Operator Instruction Manual (March 2003)
    - DCU Semi-Automatic Tester Operations Manual (Rev. 4)
  - **6000 Series**
    - Carborne ATC System Maintenance Manual (2013)
    - Carborne Illustrated Parts Catalog (August 2004)
    - DCU Semi-Automatic Tester Operations Manual (Rev. 4)
    - Carborne ATC System Portable Test Device Manual (April 2008)
    - Portable Test Equipment and Bench Test Devices Operation and Maintenance Manual (February 2008)
  - **7000 Series**
    - Portable Test Unit and Bench Test Equipment Operation and Maintenance Manual (July 2020)
    - Portable Test Unit and Bench Test Equipment Parts Catalog (July 2020)
- Running Maintenance and Service Manuals
  - 2000 & 3000 Series Rapid Transit Cars Heavy Repair Maintenance Manual, Rev. 2 (June 2011)

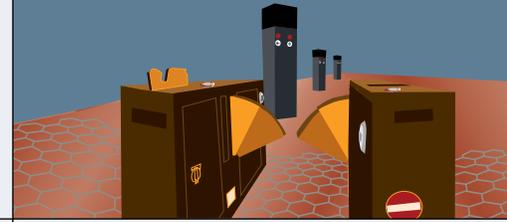


## Documents Reviewed

- Transit Car 6000 Series Heavy Repair Maintenance Manual, Rev. 1.4 (April 2010)
- Transit Car 7000 Series Heavy Repair Maintenance Manual, Rev. 0 (July 2020)
- WMATA Series 2000 & 3000 Rapid Transit Cars Illustrated Parts Catalog, Rev. 2 (June 2011)
- Transit Car 6000 Series Illustrated Parts Catalog, Rev. 1.0 (February 2008)
- Transit Car 7000 Series Illustrated Parts Catalog, Rev. 0 (July 2020)
- WMATA Series 2000 & 3000 AC Rapid Transit Cars Running Maintenance and Servicing Manual, Rev. 2 (June 2011)
- Transit Car 6000 Series Running Maintenance and Servicing Manual, Rev. 1.0 (February 2008)
- Transit Car 7000 Series Running Maintenance and Servicing Manual, Rev. 0 (July 2020)
- SOP 11, Vehicle Program Services (CENV) Incident Investigation Procedure, Rev. 1.0 (Approved 10/28/2016)
- SOP 12, Thermal Imagery Track Testing, Rev. 01 (Approved 2/6/2017)
- SOP 13, Management Methodologies, Rev. 1.0 (Approved 3/7/2017)
- SOP 15, Procedures for Rail Vehicle Retirement and Disposition, Rev. 0 (Approved 1/25/2017)
- SOP 16, Vehicle Program Services (CENV) Equipment Configuration Change (ECC), Rev. 0 (Approved 12/7/2017)
- SOP 17, Railcar Parts, Assemblies and Processes Standard Specifications, Rev. 01 (Approved 1/30/2017)
- SOP 18, Greenbelt Commissioning Facility Building H, Safety and Emergency Procedures, Rev. 0 (Approved 9/16/2015)
- SOP 19, Data Collection, Measurements and Validation, Rev. 2.0 (Approved 4/23/2019)
- SOP 2, Engineering Request, Rev. 5.0 (Approved 4/12/2019)
- SOP 202.10, Daily Inspection of 2000/3000, 6000, and 7000 Series Railcars, Rev. 0 (Approved 2/2/2021)
- SOP 202-01, Preparing, Processing and Approvals of Engineering Modification Instructions, Rev. 0 (Approved 9/25/2020)
- SOP 202-03, Preparing, Processing and Approvals of Engineering Test Plan (ETP) & Engineering Test Report (ETR), Rev. 0 (Approved 1/29/2021)
- SOP 202-08, Preparing, Processing and Approvals of Engineering Change Notice, Rev. 0 (Approved 9/25/2020)
- SOP 202-14, Maintaining, Revising and Updating Periodic Inspection Procedures for Class 1 Rail Vehicles & Preventive Maintenance for Class 2 Rail Vehicles, Rev. 0 (Approved 12/9/2020)
- SOP 202-31, Mandatory Safety Training Compliance of CENV Personnel, Rev. 0 (Approved 9/29/2020)
- SOP 205-01, Normal Operation of the Test Track Procedure, Rev. 0 (Approved 4/20/2016)
- SOP 21, MSRP Rule Compliance, Rev.0 (Approved 11/14/2019)
- SOP 22, CENV Computer Software Installation, Rev. 0 (Approved 10/25/2016)
- SOP 23, Capital Improvement Projects (CIP), Rev. 0 (Approved 5/1/2018)
- SOP 25, Parts Qualification Process, Rev. 0 (Approved 1/15/2019)

## Documents Reviewed

- SOP 27, Configuration Management, Rev. 0 (Approved 5/8/2019)
- SOP 4, Maintenance Service Instructions (MSI), Rev. 8 (Approved 8/21/2019)
- SOP 5, Engineering Service Bulletin (SB), Rev. 6 (Approved 3/10/2020)
- SOP 6, Rail Drawing Guidelines and Procedures, Rev. 3.0 (Approved 10/5/2016)
- SOP 7, Parts Action Form (PAF), Rev. 1.0 (Approved 7/10/2019)
- SOP 9, Inspection and Calibration for Precision Measuring Devices, Shop Equipment and Special Tools under Engineering Authority, Rev. 2 (Approved 3/7/2017)
- Vehicle Schematics and Point-to-Point Wiring Diagrams, Car level, Rev. 0 (July 2020)
- List of PMIs conducted on four married pairs from each railcar series for each shop (October 1, 2020 to January 1, 2021)
- List of all overdue PMIs for revenue vehicles as of February 1, 2021
- List of all equipment modification instructions (EMIs), Maintenance Service Instructions (MSIs), Service Bulletins (SBs), and Engineering Test Plans (ETPs) developed, approved, or implemented, and any EMIs that are not fully complete (January 1, 2019, to January 1, 2021)
- Samples of Engineering Change Notices (ECNs) and Engineering Modification Instructions (EMIs)
  - **ECN 000010**
  - **MSI 000001**
  - **2000/3000 Series**
    - Component and Overhaul Service (COS) Documents: 180008, Door Operator and Component Overhaul
- ECNs 180011, 180013, 180014, 180015, 180016, 180017, 180018, 180019, 180020, 180021, 180024, 180025, 180026, 180027
- EMIs 180494, 180496, 180501
- Engineering Test Plans (ETPs)  
Engineering Test Reports (ETRs):  
180370, Traction power thermal imagery, 180441, Line inductor qualification test, 180467, DNSS SV Phase II map and destination code update
- Maintenance Service Instruction (MSI), 180203, Breda AC traction motor, 180315, Door control PTU Diag Download Procedure, 180320, ATP coil frequency response tester
  - ◆ Service Bulletin (SB) 599, 604, 606, 608, 609, 610, 611, 612, 614, 615, 616, 617, 618, 621, 622, 623, 624, 625, 626, 627, 629, 630
- SMD 180004
- **6000 Series**
  - Component and Overhaul Service (COS) Documents: 150006, Door operator and component overhaul
  - ECNs 150001, 150003, 150020, 150028
  - EMIs 150078, 150180, 150189
  - ETP ETR 150120, 150142, 150143
  - MSI 150037, 150118, 150121
  - SB 62, 96, 98, 105, 107, 112, 113, 114, 115, 116, 118, 119, 120, 121, 122, 123, 124, 125, 127, 128, 130, 131, 132, 133, 134, 136
  - SMD 150001



## Documents Reviewed

- **7000 Series**
  - ECN 140010, 140011, 140012, 140013
  - EMI 140094, 140403, 140408
  - ETR ETP 140069, 140070, 140093
  - MSI 140017, 140018, 140020
  - SB 50, 64, 65, 70, 72, 74, 75, 77, 79, 80, 83, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, and 105
  - Front end inter-car barrier specifications
- Engineering Request 1901003, 1902004, 1902005, 1903006, 1904007, 1905008, 1905009, 1906010, 1906011, 1906012, 1906013, 1907013, 1907015, 1908017, 1908018, 1908019, 1908020, 1909021, 1909022, 1909023, 1909024, 1910025, 1911026, 1912027, 1912028, 1912029, 2001003, 2001004, 2001005, 2001006, 2001007, 2002009, 2004013, 2005014, 2006018, 2006019, 2007022, 2009025, 2009028, 2101001
- Monthly Railcar Reliability Data
  - 2000 Series Monthly Railcar Performance reports (July 2018 through December 2020)
  - 3000 Series Monthly Railcar Performance reports (July 2018 through January 2021)
  - 6000 Series Monthly Railcar Performance reports (July 2018 through November 2020)
  - 7000 Series Monthly Railcar Performance reports (January 2018 through January 2021)
  - ATC System Performance, all fleets (October 2018 through January 2021)
  - Brake System Performance, all fleets (July 2018 through January 2021)
  - Door Control System Performance, all fleets (July 2018 through January 2021)
- Pneumatic System Performance, all fleets (July 2018 through January 2021)
- Propulsion System Performance, all fleets (July 2018 through January 2021)
- Railcar Fleet Performance Report, all fleets (January 2018 through January 2021)
- List of all safety events involving railcars (January 2018 through January 2021)
- CMNT Daily Shop Safety Inspection & Housekeeping Checklist (January 2021)
- List of Maximo work orders generated from the CMNT Daily Shop Safety Inspection & Housekeeping Checklist, all shops (December 2020 through February 2021)
- List of Maximo work orders generated from the CMNT Daily Shop Safety Inspection & Housekeeping Checklist, New Carrollton S&I (January 2020 through February 2021)
- Car shop local safety committee meeting minutes (August through December 2020)
- 6000 Series Electrical Friction Brake System Instructor Guide (March 30, 2020)
- 6000 Series Electrical Friction Brake System Student Guide (March 30, 2020)
- 6000 Series Rail Cars Electrical Training, Friction Brakes and Pneumatics Presentation (Rev. 3/30/2020)
- 6000 Series Friction Brake Mechanical Training presentation (March 2020)
- 6K Friction Brake Systems (MT) Module Student Guide (Rev. 1.0, 3/2020)
- 7000 Series Electro-Mechanical Technician (ET) Maintenance Training for Introduction and Overview (3/30/2020)

## Documents Reviewed

- 7000 Series Railcar Familiarization Introduction and Overview presentation (3/30/2020)
- 7000 Series Introduction and Overview (3/30/2020)
- 7000 Series Subsystem Electrical Block 1 Instructor and Student Guide
- 7000 Series Subsystem Electrical Block 2 Instructor and Student Guide
- 7000 Series Subsystem Mechanical Instructor and Student Guide
- 7000 Series Subsystem Truck and Suspension Instructor and Student Guide
- Car Maintenance Training Report, 2021
- Car Maintenance Training Calendars, November 2020 to March 2021
- HVAC Instructor and Student Guide
- PI Electrical Instructor and Student Guide
- PI Mechanical Instructor and Student Guide
- SOP 12 and 19 Instructor and Student Guide
- VMS Instructor and Student Guide
- 32 Job descriptions
- CMNT Training Report, 2021
- Spreadsheets of active 7000-series contractors
- Scope of Work, Railcar SMS Inspection (5/31/2019)
- Memorandum, Revenue Vehicles and Related Maintenance Equipment Audit Requested Document #37 (3/21/2021)
  - 6000 Series SMP Verified Items List
  - Business Process Improvements/Mapping (January 2021)
  - CMOR RQAW Organization Chart (April 2021)
- Monthly Railcar Performance Reports (November 2020 and March 2021)
- Weekly REPA Reports (March 31, April 7, and April 14, 2021)
- Engineering Request 1906012 (6/11/2019)
- West Falls Church Daily Work Assignments for April 1, 2021
- OAP 102.04, Establish Quality Assurance and Warranty Compliance Branch (1/11/2021)
- CENV and CMNT Job Plan Data (spreadsheet)
- CMNT, 6K, 8YR, M18-36-7001 Drawbar PM Overhaul Tracker
- 7K Semi-Permanent Drawbar (spreadsheet)
- MRO Documentation Support – Priority List (04/26/2021)
- LPSU Failures July 2018 – March 2020
- Service Bulletin E-134, 6K Dellner Coupler Disposition (12/23/2020)
- CENV Offloads Tracker
- 8K Specification Changes Based on 7K Lessons Learned (5/6/2018)
- Maximo extract of 7K wheel cuts
- 8K Stakeholders Meeting agendas and sign-in sheets, 2020
- Safety and Security Certification Training 2021 (slides)
- 8K Safety and Security Certification Training attendees (spreadsheet)
- Safety Briefing Forms related to Safety Bulletin SB #21-04 – “Rail Safety Event Reporting Requirements for All Personnel” (April 2021)



What the **WMSC** Found

# What the **WMSC** Found

**Metrorail's Safety and Security Certification Program Plan (SSCPP) requires safety certification for rolling stock rehabilitation.**

## Positive Practices

The WMSC identified a number of positive practices related to Metrorail's railcar programs while conducting this audit including:

- Metrorail is effectively utilizing its engineering request process for improvements to maintenance practices, procedures, and facilities.
- Mentor and Technical Skills programs (TSP) provide important benefits and opportunities for those that have the opportunity to participate.
- Recently improved collaboration between engineers and mechanics, including in relation to some troubleshooting events and data downloads.
- Early stages of 8000 Series development have included cross-departmental cooperation and coordination.
- SAFE provided a safety certification briefing to WMATA program offices including the 8000 Series program in April 2021.
- More than 600 lessons learned from the 7000 Series are being incorporated into the 8000 Series project, including to make the 8000 Series lighter to reduce infrastructure wear and tear, to improve inter-car barrier safety measures, and to add a side-view cab camera.
- 8000 Series designs are planned to include the ability to incorporate future WMATA ATC and signaling upgrades.
- New software was installed on the wheel lathe equipment at the Greenbelt Rail Yard to study the progression of wheels out-of-round from the time a wheel is cut to the time the wheel reaches the out-of-round threshold. This software logs a picture of the wheel out-of-round condition for detailed analysis to determine the root cause of the problem.
- Job plans are being created to document and share good preventive and troubleshooting measures within Service & Inspection shops.
- REAM is now tracking reliability of railcars by their assigned S&I Shop. Railcars are assigned to S&I shops, where they are maintained and repaired. Deficiencies can be isolated by comparing reliability numbers of different S&I Shops. This process is expected to benefit S&I Shops with low railcar reliability numbers.
- CENV has had discussions with RTRA about rotating railcars in and out of operation as lead cars on trains. The reliability of railcars is reduced when the same railcar is constantly used on the lead (i.e. components such as master controller, push buttons, cab equipment, etc. receive higher use when the railcar is on the lead).





1

- Recently created procedure for camera downloads
- Local Safety Committee meeting minutes are documented and complete.
- CENV developed several test equipment devices (e.g. master controller tester, Silver Line safe braking system tester, propulsion speed sensor tester).
- Employees interviewed for this audit understood the importance of considering safety in their day-to-day work.
- Creation of new RQAW group in winter 2021 in wake of pull-aparts
- Employees are generally able to access manuals and procedures for their work.
- Creation of parts qualification group, although this process has not yet been fully utilized.
- Facilities are inspected using checklists.
- Metrorail produces and distributes regular railcar reliability reports.

## Findings and Minimum Corrective Actions

**Metrorail's 6000-Series rehabilitation program, including coupler overhaul work, was implemented by CMOR, CENV and CMNT without safety certification and approvals required by WMATA's SSCPP.**

Metrorail's Safety and Security Certification Program Plan (SSCPP) requires safety certification for rolling stock rehabilitation for all systems and operational elements affected by the rehabilitation or modification. The SSCPP lists Rail Car Vehicles as requiring Category 1 certification, the highest level, which includes review, approval and verification of, as applicable for the project, designs, construction, testing, training and manual, procedures or drawing updates related to the project.

CMOR, CENV and CMNT created and implemented the 6000-Series rehabilitation program to overhaul a number of subsystems, which they later internally titled the Scheduled Maintenance Program (SMP), without coordination with SAFE and without following the safety certification process. SAFE, when it became aware of the program well after it had been implemented on dozens of cars, asked CMOR to follow safety certification processes, but Metrorail still did not follow its safety certification requirements.

**Safety certification cannot be compromised.**

In response to the draft of this audit report, Metrorail confirmed that no project assessment was performed until May 2021. This was after the on-site portion of this audit was completed and after the WMSC had raised these concerns during the audit process. Despite various other statements described below that were made during audit interviews, and the approval of a related document in 2020 by the Safety Certification Review Committee (SCRC), Metrorail stated in response to the draft report that the safety certification process did not begin until that project assessment was completed.

Although some aspects of work included in the SMP had been carried out separately before, there was no examination of the risks that could be posed by conducting the work in this fashion, such as unintended impacts on other systems. WMATA put these extensive changes into a single effort without considering the impacts, something that would have been avoided by following the required safety certification practices for rehabilitations and overhauls of multiple mechanical systems and vehicle interiors.

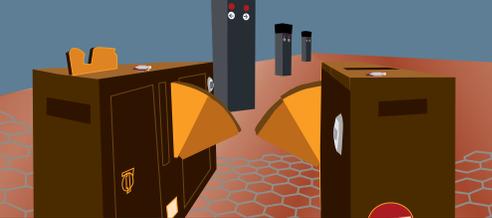
According to interviews, SAFE had not been involved in review or approval of key aspects of even specific parts of the SMP program, such as the coupler overhaul process, until after revenue train pull-aparts in fall 2020, despite a similar pull-apart that occurred in 2018.

SAFE stated that they raised the need for safety certification on this railcar rehabilitation and overhaul project to CMOR in mid-to-late 2019, but SAFE stated that CMOR refused to follow the safety certification process.

Later, after 6000-Series SMP work had already been ongoing for more than a year, WMATA's Safety and Security Certification Review Committee (SCRC) considered and approved a "Verified Items List" (VIL) for the 6000-Series SMP program in May 2020. There is no reference to or specifications for such a document in the SSCPP, so a VIL is not an approved process for safety certification and there is no standard governing the process, and, according to interviews for this audit, no hazard analysis was conducted. There was no documentation to indicate a VIL had been used on any other projects. The worksheet tab name in the approved document even reads "CIL". CIL stands for Certifiable Items List, which is a defined part of WMATA's safety certification process. SAFE stated that the dispute with CMOR over safety certification led to the use of a list with a different name as part of a compromise. Safety certification cannot be compromised. The SSCPP defines this as a rehabilitation, which means it requires safety certification under WMATA's own written policies.

During this audit, SAFE said the VIL approved in May 2020 was the CIL and there was no difference in their opinion. However, in fall 2020, SAFE told the WMSC that "The 6K SMP has not been certified by SAFE."





**A VIL is not an approved process for safety certification.**

At that time, more than 100 6000-Series cars had gone through the SMP and had been made available for service.

“[T]he 6K SMP was underway when we discovered that it was occurring and pursued certification,” SAFE told the WMSC in fall 2020.

At the time, the 6000 Series SMP was scheduled to be complete in June 2021, with the 7000 Series SMP due to start in July 2021. WMATA’s SSCPP specifies that SAFE has the authority and obligation to require other departments to complete the safety certification process.

Regardless, the “VIL” approved by the SCRC in May 2020 does not match the “VIL” documents that were provided for railcars that have been through the SMP process (see finding 2).

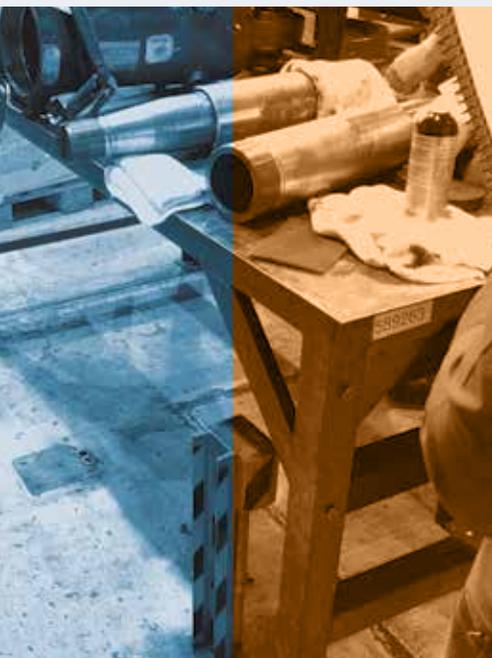
The “VIL” that was used in practice appears to be a reformatted portion of a document the vehicle engineering and maintenance groups refer to as a “traveler” that amounted to a list of which SMP work had been conducted on a car. That traveler document was also created without SAFE involvement and did not include steps to ensure those completing the tasks were properly trained before doing the work.

During interviews for this audit, WMATA personnel stated that the 6000-Series work was rushed to begin in spring 2019 without proper planning due to WMATA’s plans at the time to contract-out operations and maintenance related to Silver Line Phase 2. That plan would have included providing the contractor with responsibility for approximately 120 6000-Series cars, but that required having this rehabilitation program completed prior to the then-projected opening date of the Dulles Rail Yard.

This lack of planning and safety approvals contributed to challenges related to parts, materials, staffing, efficiency, and modifications that were initiated despite requiring significant additional revisions or updates.

Metrorail’s plans to replace multiple systems in this type of rehabilitation on a planned, regular interval of approximately every six years to complete recurring work on a vehicle in one fell swoop can provide benefits to car availability, but it must be done only with required reviews and approvals. The current 6000 Series SMP did not include clear bills of material, well-defined SMD documents or refined processes when the work began.

For example, a comprehensive review of the coupler overhaul process that was only initiated following two train pull-aparts in fall 2020 has identified parts and tools that the coupler manufacturer defines as necessary that WMATA had not obtained in the past. Metrorail stated that those tools were not listed in their manuals that were provided to them by the manufacturer. Reviews of the coupler overhaul process also



identified safety gaps related to parts identification and unapproved deviation from parts specified by the original equipment manufacturer, and a lack of quality assurance or quality control for those parts used in this overhaul process.

Metrorail has not conducted similar comprehensive reviews of the other SMP procedures to determine whether similar gaps exist in those. During this audit, Metrorail indicated that it is planning to review at least some other major repair and overhaul documents, but that lengthy work on the first several dozen procedures was only just getting underway.

A similar SMP program planned for the 7000 Series cars (see Finding 6) is also in development, with planning having begun before specific shortfalls were identified in the 6000 Series program.

**Minimum Corrective Action:** Metrorail must complete the safety certification process for all 6000 Series railcars. To accomplish this, Metrorail must review all of the 6000 Series SMP procedures to confirm proper documentation, training, and parts or tools availability, and make all required corrections to each car for any areas where the procedures were deficient. Metrorail must also ensure that safety certification processes are followed for all current and future railcar projects, initiatives or similar efforts, including by ensuring procedures and training are in place for all relevant personnel.

**SAFE approved SMP documentation that was incomplete and that did not match approved forms, and Metrorail did not comply with safety certification requirements defined in the SSCPP.**

A Verified Items List (VIL) does not exist in WMATA's safety certification program, yet SAFE and the SCRC approved the use of a VIL for the 6000 Series SMP program.

Even after that approval, the "VIL" documents for each car provided to the WMSC as approved by SAFE do not match the "VIL" approved by the SCRC in May 2020. Many of these documents were approved by SAFE in February and March 2021 for work conducted in 2019 and 2020 even after known issues were identified with the coupler replacement and overhaul process.

Some of these VILs were also approved by SAFE despite portions, such as the coupler overhaul process, not being completed, and no documentation demonstrating an alternative means of addressing the safety risks. SAFE stated that the couplers were no longer part of the SMP for cars that were continuing in the process after November 2020, but this was not documented and has not been considered by the SCRC (see Finding 4).





**A Verified Items List (VIL) does not exist in WMATA's safety certification program, yet SAFE and the SCRC approved the use of a VIL for the 6000 Series SMP program.**

3

The SAFE contractor approving these VILs in winter 2021 had not seen the “official” VIL that was approved by the SCRC in May 2020.

As noted above, the SSCPP designates SAFE as responsible for safety certification, but safety certification was not carried out on this SMP program.

Metrorail did not carry out a hazard analysis of the SMP program even after SAFE identified that the program required safety certification. During this audit, SAFE stated that it was determined that an operational hazard analysis (OHA) would not be practical based on when SAFE became engaged in the project, and that the VIL functions as an OHA, if only for select vehicle subsystems.

SAFE review of these VILs consisted of reviewing Maximo work order entries to confirm that Maximo showed the procedures and items listed for that car.

These gaps in the safety certification process mean that there is no documentation that all hazards or risks have been appropriately assessed and mitigated to ensure that the Metrorail system – in this case the railcars – are operating as safely as reasonably practicable.

In response to the draft of this audit report, Metrorail stated that it had not even conducted a project assessment that is required at the start of the project development and safety certification process until May 2021, after the WMSC had identified and communicated these issues. CMOR also suggested that they were not aware that Metrorail's SSCPP requires the safety certification process to be completed (or a temporary use notice issued) before a railcar undergoing this type of work may be put back into service.

**Minimum Corrective Action:** SAFE must establish a process to ensure that the SSCPP is being followed, including ensuring that any CIL matches the version approved by the SCRC prior to approval, and that each CIL is complete prior to approval. WMATA must demonstrate that this process is being followed.

**6000 Series cars that underwent rehabilitation were put into service without SAFE approval.**

SAFE began signing off on VILs in February and March 2021 around the time that the WMSC sent the formal notification letter for this audit, however 6000 Series cars had gone through the SMP process starting in 2019 and had been returned to revenue service without SAFE approval through November 2020.

Even after the SCRC approved a VIL in May 2020, 6000 Series cars that had gone through the SMP process but that did not have SAFE approval were returned to and continued operating in revenue service.

4

**WMATA did not follow even the alternate action it created that, in any case, did not meet its own documented safety certification requirements.**

5

Metrorail created a document outside of the safety certification process, and then did not even follow it.

At the time SAFE signed off on numerous VILs to approve them in winter 2021, the 6000 Series fleet remained out of service as a safety precaution due primarily to the ongoing risk of additional train pull-aparts due to Metrorail's failure to follow its own safety certification requirements.

**Minimum Corrective Action:** Metrorail must demonstrate that SAFE has approved the complete documentation specified in the SMP, including SAFE certification of coupler work, prior to each railcar returning to revenue service.

**Metrorail removed the coupler overhaul from the 6000 Series SMP process without documenting that change or completing a review of that change by the SCRC.**

The coupler overhaul and rehabilitation process was originally included in the SMP program and in the "VIL" approved in May 2020, however SAFE and CMOR are approving VILs as complete without the coupler overhaul and replacement completed. WMATA did not provide any documentation showing that the coupler was removed from the process or that the SCRC had approved its removal.

As noted above, the VILs being approved by SAFE do not match the VIL approved in May 2020, and revisions had not gone through safety approvals.

In practice, this demonstrates that WMATA did not follow even the alternate action it created that, in any case, did not meet its own documented safety certification requirements.

**Minimum Corrective Action:** Metrorail must ensure that safety-critical equipment and related procedures undergo all required safety reviews and approvals. Metrorail must document this for the process as a whole and for each railcar to show which couplers have been correctly handled under the latest procedures.

**Metrorail does not require or receive all necessary OEM documentation, parts or tools.**

Multiple managers interviewed for this audit indicated that documentation, parts or tools received from original equipment manufacturers as part of procurements are frequently insufficient for Metrorail's needs or do not include detail regarding the required number of each type of tool (including special tools) to complete each type of work.

For example, documents may cover only overhaul or other major work with no information related to normal periodic inspections, drawings may not include criteria



6

for reinspection, or the contracts may not require the manufacturer to provide an adequate supply of special tools for maintenance personnel to carry out their duties.

Special tools are generally those tools with one specific purpose, such as a go/no-go gauge. Typically, these tools are supplied or specified by original equipment manufacturers.

The WMSC identified related concerns during the recent Automatic Train Control and Signaling Audit related to a lack of clear processes to ensure that appropriate personnel at Metrorail get all necessary updates, notices and bulletins from manufacturers.

The review of the 6000 Series coupler overhaul and shop tool lists demonstrated that these issues also lead to insufficient parts and tools.

Metrorail does not have all required special tools for railcar maintenance and inspections, including for 7000 Series maintenance.

A list provided for this audit demonstrates that there are missing tools in multiple shops. Some shops have one of an item when they require six, while others have none at all. Metrorail is also still working on delivery of bench test equipment for the 7000 Series cars.

Some tool challenges relate to fabrication, while others require additional procurement actions.

This has led to personnel in some shops being directed to use what they see as equivalent tools for certain tasks rather than the tools that are intended for the job.

Metrorail appears to be making some progress in this area in recent months, but must complete this process.

**Minimum Corrective Action:** Metrorail must establish procedures to ensure that WMATA contracts or otherwise works with the original equipment manufacturer as part of the development of purchase, rebuild, rehabilitation or overhaul programs to identify and supply any necessary special tools and parts.

**The 7000 Series rehabilitation and subsystems overhaul program is being developed without full SAFE coordination, involvement or approval.**

Although several people interviewed for this audit suggested that the 7000 Series SMP program development had at least some Safety Department involvement, the WMSC identified that CMOR, CENV and CMNT are not including SAFE in all necessary activities, review and planning.

**The investigation into the March 26, 2021 runaway train event at Rhode Island Ave Station also demonstrated that CMOR investigations may not always be complete.**



For example, a 7000 Series tear down and dry run of the initial documents in April 2021 was scheduled without SAFE or the WMSC's knowledge.

Information from these types of critical steps or related meetings is crucial to developing accurate hazard analyses and the final Certifiable Items List (CIL). In response to the draft of this audit report, Metrorail confirmed that this tear down and dry run was intended to validate the procedures and documentation which are critical aspects of the safety certification process.

After the WMSC identified this safety deficiency and provided a draft of this audit report demonstrating that corrective action is required, CMOR stated they would plan to reach out to SAFE to begin discussions about the required safety certification process. However, CMOR had already begun significant work on the project.

In a separate response to the draft of this audit report, SAFE stated that a CIL would be used for the 7000 series program as required by the SSCPP. Metrorail did not provide a project assessment form.

The 7000 Series program had originally been scheduled to start by early 2021, but was delayed following the problems identified in the 6000 Series couplers. At the time of this audit, the full-scale work on the 7000 Series cars was expected to start in 2022, but specific dates had not yet been finalized.

Metrorail stated that this process will include a comprehensive project management plan, including risk mitigation and well-defined documents, which has not existed for the 6000 Series SMP.

CENV is generally modifying information in manufacturer maintenance manuals to develop the SMD documents, but those interviewed for this audit said there were no plans to have the manufacturer review the documentation, provide additional training, or participate in on-site demonstrations.

This process is beginning now as part of plans to conduct this work on a six-year cycle, given that the first 7000 Series cars are now approximately six years old.

Metrorail plans to complete 4 to 8 cars per month in the first months of the program, increasing to 12 cars per month by 2023.

**Minimum Corrective Action:** CMOR must coordinate with stakeholders including SAFE and follow the safety certification and approval process for the 7000 Series rehabilitation program.



7



**The responsibilities of CMOR's Incident Investigation Team and CMOR's separate unusual occurrence response personnel conflict and are not clearly defined.**

As of early 2021, CMOR now has two groups involved in responding to or assessing safety events or other potential emergencies: the Incident Investigation Team (IIT) and the individuals assigned to handle unusual occurrences such as train malfunctions. However, there is no documentation delineating their responsibilities, and those interviewed for this audit confirmed that the dividing line between the two is not clear. This creates procedural openings for information to not be fully considered, documented or shared as part of investigations, and for lessons learned from these reviews to not be fully incorporated into Metrorail practices.

For example, some of these reviews have resulted in memoranda about events. These do not incorporate the same long-term systemic fixes that a revised work instruction or SOP would.

The investigation into the March 26, 2021 runaway train event at Rhode Island Ave Station also demonstrated that CMOR investigations may not always be complete. In that event, the data reviewed focused specifically on the time that the event began, and did not take a comprehensive approach to ensure that all relevant data is considered, reviewed and shared.

Similarly, an improper door operation on June 11, 2021 was not properly identified and investigated. The WMSC notified WMATA of this event, which otherwise would not have been reported. Even then, CMOR's IIT only initially downloaded very limited information from the consist and removed one pair of cars from the consist prior to gathering all relevant and required information. The WMSC identified this deficiency and ensured WMATA downloaded and evaluated all relevant information from the railcars, to include video footage.

CMOR was also responsible for keeping elements of couplers involved in an October 2020 pull-apart secure for investigation, however those couplers were manipulated outside of the safety event investigation process. This led to a WMSC finding that required Metrorail develop and implement a corrective action plan to ensure the integrity of safety event investigations.

Clearly defining roles, responsibilities and coordination would also help ensure that information from these reviews reaches SAFE investigators and others at Metrorail who need the information in a timely fashion. Currently, SAFE only receives reports on request.

CMOR also does not always review final investigation reports from SAFE that incorporate their information and specify corrective actions. These processes are important not only to determine whether a vehicle functioned as designed, but also to determine whether those designs must be revised or adjusted. The WMSC has worked with SAFE under a separate process to ensure that each of the corrective actions in safety event investigation reports required by the WMSC is tracked to completion.

**Minimum Corrective Action:** Metrorail must define, document and clearly delineate the roles, responsibilities and procedures related to the Incident Investigation Team and any other CMOR individuals or teams such as unusual occurrence response personnel. These policies and procedures must include the coordination processes and requirements between the IIT, any other CENV groups, and SAFE.

### **Metrorail does not have adequate document control practices for car maintenance job plans.**

There is no standardized method to vet, enter and review job plans in Maximo.

Job plans specify the steps to take to perform a specific type of work, but not all plans in Maximo have gone through full reviews. Some may have been entered by a single shop supervisor without communication with other shops or engineering, while others were developed through the engineering review process. In other cases, such as the inspection of gas-powered railcar movers, there is no job plan at all.

Job plans in Maximo are also not named in any consistent, standardized fashion that would allow for the identification of their purpose or what process led to their creation.

CMOR recently began efforts to improve this system, and to ensure that job plans are available for all required tasks such as maintenance and troubleshooting, however there is significant work required to identify which of several job plans governing a specific action should be used (or whether some combination is required). Initial reviews identified some areas where there were conflicting job plans across different shops.

Metrorail does not have an organized process to ensure that all shops are working from the same job plan or to ensure that a job plan is reviewed before it is entered into or allowed to remain in Maximo.

This also creates a gap in the use of job plans or other useful information since different shops are aware of different job plans and other documents.





9

For example, even though Metrorail has improved steps to create engineering troubleshooting procedures, these procedures have not been made available or provided to all service and inspection shops to achieve their full benefit.

Troubleshooting procedures and case studies are provided to individuals or specific shops, but are not shared widely across CMNT or CENV.

Some of these processes, such as those addressing propulsion systems, have proven beneficial to ensuring that problems are properly identified and addressed, but not all shops or employees are benefiting from these improvements.

Engineers who solve an issue generally speak to the CMNT supervisor and may speak to a specific mechanic. CMNT shops also do not regularly share information they may identify with other shops unless it rises to the level of requiring additional assistance, so instances that might occur on multiple cars but in different shops may not be identified as connected or may lead to work being repeated. That work could be simplified and the identification of safety issues could be improved by better communication.

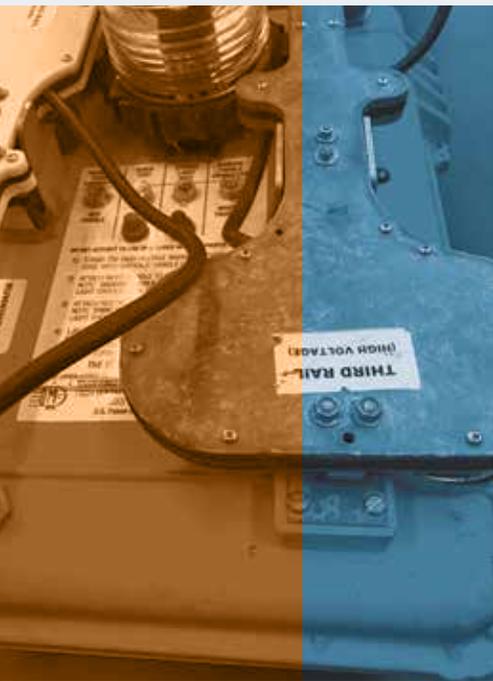
Metrorail would benefit if that information was actively passed along to others rather than relying on some of that information being available to just those individuals that access a shared drive and know what they are looking for.

**Minimum Corrective Action:** Metrorail must establish and implement document control, communication and distribution processes for job plans and engineering case studies including procedures and processes to ensure that there are no conflicting or duplicated documents, that there are defined processes for development and approval of job plans created by employees at any level, and that there are standardized file names and file formats. Metrorail must review existing job plans in Maximo to ensure they are current, have required approvals, and meet the defined naming and format standards.

**Metrorail does not have a systematic process to ensure that mechanics and engineers are trained for the specific tasks they are assigned to perform.**

On-the-job training (OJT) sheets for mechanics are sent to the training department, but are not tracked in any way, so supervisors have no way to identify who has completed OJT that is required to perform specific work.

Mechanics generally are not required to have certifications to complete specific tasks (other than general lift training and roadway worker protection qualification), and there are no recertification requirements for specific work.



Mechanics are also not required to get refresher training on tasks even if they have not worked in that role or on that series of vehicle in years. Some mechanics expressed concerns that they were not able to take additional training classes. This is of particular concern given the lengthy gap of several years where Metrorail did not provide its Technical Skills Program or full introductory testing and training for entry level mechanics.

Interviews for this audit established that supervisors do not know the training that an individual has completed unless they request documentation from the training department for each individual. This does not happen frequently, and is unlikely to occur in any case under the current process during job assignment picks such as the one effective in February 2021 that include large numbers of employees changing assignments. These large changes are expected on a somewhat frequent basis going forward as work is adjusted to account for shifting rail line shutdowns for construction work. For example, many mechanics moved to the major repair and overhaul roles in February 2021 as those positions expanded at Greenbelt Yard, but no special training was yet available at the time of this audit.

Some engineers are still waiting to get 7000 Series training in areas such as troubleshooting, even though the railcars entered revenue service in 2015 – six years ago.

Existing 7000 Series troubleshooting material from the OEM did not contain the in-depth information required, and improvements have been identified by CMOR.

**Minimum Corrective Action:** Metrorail must establish the minimum training requirements to conduct each specific type of work on each specific railcar series. Metrorail must then develop and implement a process requiring regular supervisory checks of those certifications, which may include checks during the pick process and automatic notifications of expiring certifications. Metrorail must review the training required for mechanics, determine if refreshers or recurring training are necessary for each type, and define what requires a refresher.

10

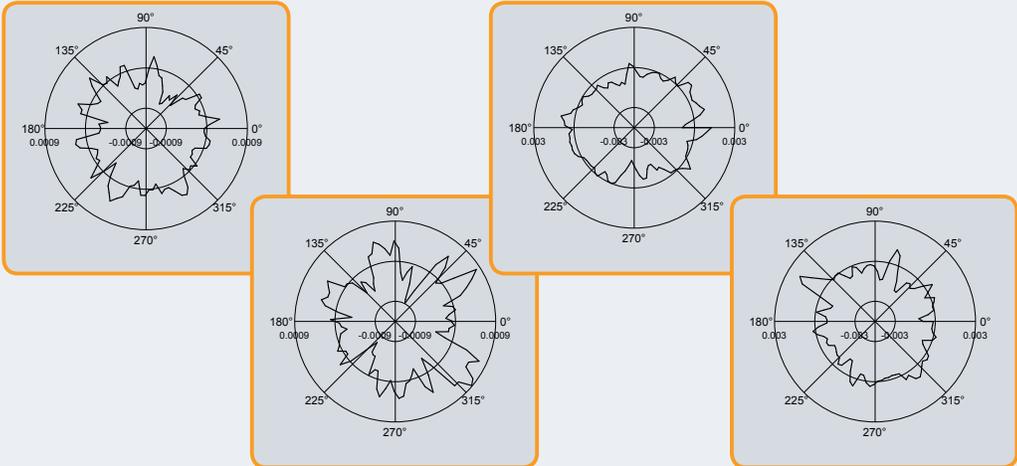
**Metrorail does not consistently follow a standard process to address wheels out-of-round, to prevent cars with wheels out-of-round from operating, and to identify and address the root causes of wheels out-of-round.**

Metrorail does not follow written criteria related to wheels out-of-round, a situation that can be felt by operators and customers as significant vibrations or bouncing during their ride. Wheels out of round can lead to infrastructure damage, railcar damage, customers falling, and other consequences. These are different from wheel flats, which are in only a specific part of the wheel.



Those interviewed for this audit stated that Metrorail defines an out-of-round wheel as a wheel with a difference greater than 0.015" between the highest and lowest radius measured on a wheel. Once a wheel is out-of-round, it can be cut to return it to the proper shape. However, there was mixed understanding during interviews of this standard and whether that meant that Car Maintenance personnel were not permitted to cut the wheels before the wheels reach that threshold. It was noted in interviews that an out-of-round wheel can be identified and addressed at lower thresholds, but that some managers are limiting cuts to occurring only at 0.015" while others are allowing cuts earlier when the issue is detected and reported with the wheel out-of-round 0.008" or 0.009".

**Measurements used to determine the degree to which wheels are out of round.**



Even using the 0.015" threshold, different shops and wheel lathe operators are cutting the wheels differently because there is no documented standard on how best to address this issue. More experienced operators appear to be cutting the wheels more deeply to ensure that defects are fully removed, but that guidance is not documented and communicated to others.

This difference was reported as "common knowledge" that is not documented, which is one reason that there is no consistent process.

The out-of-round issues are particularly pronounced at this time on the 7000 Series fleet; however, Metrorail has not yet identified the root cause(s), despite first identifying the issue in 2016. This has limited corrective actions or mitigations. WMATA's railcar reliability reports demonstrate that the 7000 Series wheels out-of-round issues have been prevalent since soon after the cars went into service.

A WMSC review of 2020 data demonstrates there were at least 88 instances where 7000 Series car wheels were out-of-round at least 0.015". At least 34 of those instances involved wheels out-of-round 0.030" or more, and 12 of those instances involved wheels 0.040" or more out-of-round.

	Active Fleet Size	WOR in 2020 as proportion of fleet	Flats as proportion of fleet	WOR in 2020 > 0.015"	WOR in 2020 > 0.030"	WOR in 2020 > 0.040"	Flats in 2020
2000 Series	76	0%	3.4%	0	0	0	3
3000 Series	282	6.0%	14.9%	17	8	2	42
6000 Series	184	4.9 %	11.9%	9	1	0	22
7000 Series	748	14.7%	11.8%	88	34	12	89

Note: Columns are cumulative (i.e., > 0.015" total includes >0.030" and >0.040")

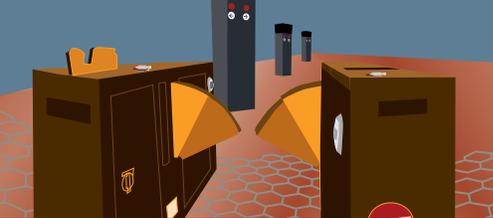
The number of wheels out-of-round that exceeded 0.030" also suggests that Metrorail is not reporting or addressing these issues in a timely fashion. This is significant beyond safety for standing customers and train operators because using railcars with wheels out-of-round increases vibration and accelerates damage to tracks, elevated structures and other infrastructure.

Metrorail is continuing to investigate the root cause of the wheels out-of-round issue (vibrations/harmonics/frequency between cars and track and structures infrastructure, wheel features, car features, track features, differences in braking technology compared to legacy cars, interaction with track infrastructure, etc.), which has not yet been identified. As part of exploring this issue, Metrorail has installed new measurement technology on some wheel lathes and has increased documentation.

So far, it appears that the wheels are less likely to become out-of-round after they are cut down to 27.5" in diameter. New wheels are delivered and put into service at 28.0" in diameter. Periodic Inspection Procedures Task 20.2 states the condemning limit is 25.0". During interviews, several individuals stated that the limit was 26.0", which would be more typical of other agencies.

Separately from this audit, the WMSC remains focused on ensuring coordination across Metrorail departments on the investigation into the root cause of this and other issues to ensure that it is addressed in a systemic way, including the incorporation of any lessons learned into the 8000 Series cars. Due to the design timeline, there is a pressing need for controlled engineering tests to ensure that any lessons learned are incorporated into the new vehicles.

**Metrorail does not follow written criteria related to wheels out-of-round, a situation that can be felt by operators and customers as significant vibrations or bouncing during their ride. Wheels out of round can lead to infrastructure damage, railcar damage, customers falling, and other consequences.**



**Minimum Corrective Action:** Metrorail must implement a consistent procedure for reporting and addressing wheels out-of-round, including processes to identify and mitigate root causes and to prevent cars with wheels out-of-round from operating, and must train personnel appropriately, including any relevant guidance for wheel lathe operators and their supervisors on the depth of cuts.

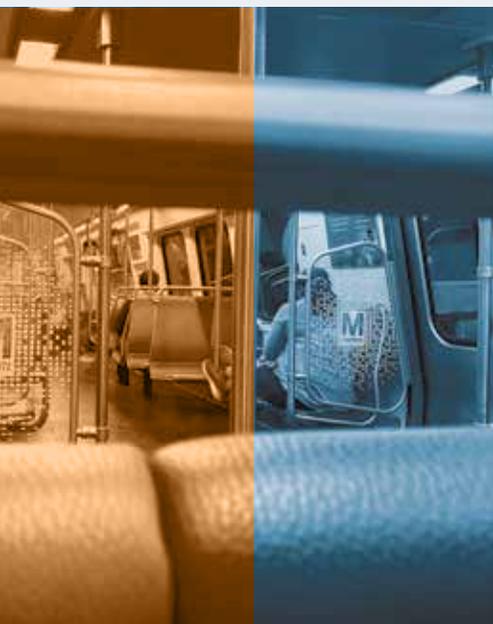
**Metrorail does not clearly define the proper use of engineering modification instructions (EMIs), service bulletins (SBs), and other railcar engineering change documents.**

Although other departments such as Automatic Train Control (ATC) Engineering have specific requirements for how to use EMIs and bulletins (e.g., ATC-4000 Systems Configuration Management Plan Instructions and Procedures Manual, section 4004.2), vehicle engineering does not clearly define which documents and processes are used for which changes. CENV SOPs define what occurs after the decision to use an EMI or SB is made, but do not define how to make that decision, which contributes to the inconsistent use of these documents and allows for documents to be issued that do not trigger associated changes that would be needed to ensure changes are lasting and systemic.

EMIs are required to include detailed information that helps ensure the proper use of parts, that all associated procedures are changed, and that the changes are implemented in a systemic fashion. Service bulletins are less detailed and are generally not sufficient to make changes to railcars. Service bulletins do not lead to all required associated documentation updates, and do not get the same comprehensive safety and operational reviews prior to issuance. Service bulletins are only intended to provide awareness of an EMI or to highlight or direct action based on existing procedures or special tasks such as checking torque stripes on bolts that is already spelled out in an existing approved document.

However, examples such as SBB-609, SBB-610, SBB-612, SBB-614, and SBB-617 demonstrate that Metrorail is using these service bulletins to make changes to railcars, procedures, or manuals without ensuring that associated required documentation is updated.

SBB-609 modifies the side door threshold plate, SBB-610 changes the part number of the go-no-go gauge, SBB-612 uses paint to mark the railcar number on the current collectors, SBB-614 adds a procedure for installing tie wraps in the side door electrical wiring, and SBB-617 replaces an old style electromechanical coil with a new style coil.



**Minimum Corrective Action:** Metrorail must clearly define the proper use of engineering modification instructions, service bulletins and other engineering change documents. Metrorail must implement a document review and approval process to ensure that these changes are properly documented, including being instituted only through approved forms and procedures.

**Metrorail utilizes multiple versions of the same inspection form that do not all include the same pass/fail criteria.**

Metrorail does not include the levelling height pass/fail requirements on hard copy inspection forms that are then required to be reviewed and approved by supervisors. The paper checklist includes a requirement for measuring the railcar height, but it does not state what the height should be. The forms do include other ranges of acceptable values such as brake rate pressure. Metrorail's completed electronic forms for this work do include the levelling pass/fail criteria.

Issues with the levelling valve on the 7000 Series cars have made the levelling height a more common area of concern. Proper height aligns the car with the platform edge, so it is critical to avoiding tripping hazards for customers, to ensuring accessibility, and to ensuring smooth travel.

**Minimum Corrective Action:** Metrorail must review and update each railcar PI checklist to ensure consistency across all versions of the forms that are in use. The WMSC recommends these revisions include easily accessible pass/fail criteria for each item that has such a requirement, including railcar height.

## RECOMMENDATIONS

**1 Metrorail railcars do not include inward- and outward-facing audio and image recorders in all operating compartments.**

Following a National Transportation Safety Board (NTSB) investigation of a February 21, 2017 Southeastern Pennsylvania Transportation Authority (SEPTA) Market-Frankford Line collision, the NTSB issued safety recommendation R-17-013, which recommended that all transit operating compartments include crash- and fire-protected inward- and outward-facing audio and image recorders capable of providing recordings to verify train crew actions and train operating conditions both for the investigation of accidents and as a tool to improve operational safety. The FTA issued a safety bulletin on December 30, 2020 highlighting the benefits of such recorders for reducing the risk of repeat accidents, operator rule violations, and unidentified hazards. The FTA noted that installing such recorders could help address hazard identification and safety performance monitoring and measurement because the



**Installing such recorders could help address hazard identification and safety performance monitoring and measurement because the cameras can also be used to conduct efficiency testing or other checks of procedural compliance and signs of fatigue.**

cameras can also be used to conduct efficiency testing or other checks of procedural compliance and signs of fatigue. That relates to the NTSB's emphasis that audio and image recorders provide benefits not only in investigations, but also in prevention of safety events by helping management identify safety issues and develop training tools to address them. Following the 2008 fatal train collision in Chatsworth, California, the NTSB recommended that the Federal Railroad Administration require operators under its oversight use recorders, in part to verify actions and to ensure operating conditions align with safety by using the recordings for efficiency testing and systemwide performance monitoring programs.

The NTSB currently classifies R-17-013 as open, acceptable response based on the FTA's prior communications regarding ongoing research to support its development of performance-based standards.

Metrorail would benefit from including audio recordings as recommended by the NTSB for a number of reasons, including to monitor the implementation of planned "point and call" signal programs, identification of distractions, and documentation of public address announcements or other communications with passengers that are currently not recorded to assist with continuous safety improvement. Video and audio filtering technology can also be used to review recordings to determine the conditions present in cars or the conditions of certain subsystems.

Outside of this audit, the WMSC has identified issues requiring improved training at WMATA even using the limited in-cab video recordings currently available only on 7000 Series trains. For example, when reviewing video to confirm compliance with electronic device policies as part of a corrective action plan closure request verification, the WMSC identified other areas of concern such as an operator wearing sunglasses in a tunnel, and operators drinking beverages while operating trains, both of which are prohibited by Metrorail rules. The WMSC raised these issues to Metrorail operations and training departments for resolution to improve safety, demonstrating the proactive value of these systems.

The FTA safety bulletin also referenced American Public Transportation Association (APTA) Recommended Practice RT-OP-RP-024-19 on Crash and Fire Protected Inward and Outward Facing Audio and Image Recorders in Rail Transit Operating Compartments. The recommended practice published in April 2019 in response to NTSB recommendation R-17-13 and related NTSB reports strengthened recommended specifications for crash and fire protected audio and image recording systems.

Metrorail's 7000 Series trains include inward- and outward- facing cameras, but they are not used to record audio. They were developed prior to the 2017 SEPTA crash, related NTSB reports and the APTA recommended practice. Metrorail did not test the

**Audio and image recorders provide benefits not only in investigations, but also in prevention of safety events by helping management identify safety issues and develop training tools to address them.**

crashworthiness of 7000 Series recording devices, but did analyze flammability, smoke emission and toxicity tests for other materials used in the 7000 Series cars.

Metrorail does not have inward- or outward- facing recorders on its older railcar fleets. At the time of this audit, Metrorail was pursuing plans to add cameras to the 6000 Series cars. After the WMSC emphasized the information in the FTA safety bulletin to WMATA in January 2021, CMOR stated that the contract was being revised.

Metrorail stated that the plans for the 8000 Series cars include additional inward-facing cameras and include audio recording capabilities. The 8000 Series is planned to include a crash hardened memory module for event recorder data, and may include video recording in solid state memory, which could provide improved chances of recovery following a crash.

**Possible Corrective Action:** Metrorail could install cameras and audio recording devices on its legacy fleets that will remain in service to meet the APTA recommended practice, and could consider improving the recording devices on the 7000 Series including the use of audio recording features to improve practices such as supervisory oversight, efficiency testing and safety event investigations.

## **② Part numbers are not being consistently entered in Maximo Work Orders for 7000 Series railcars.**

7000 Series work orders, particularly those related to warranty work, frequently do not include parts information. This information is entered in work orders for cars in other fleets.

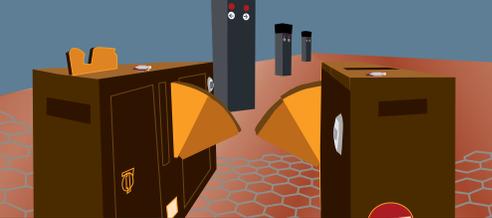
Without the part number, Metrorail cannot determine and document which specific type of part failed on a railcar, creating difficulties in analyzing 7000 Series failures.

A lack of failed parts data in work orders prevents Metrorail from determining the cause of failure and implementing corrective actions to improve the reliability of railcars.

**Possible Corrective Action:** Metrorail may develop or update and implement procedures to ensure that part numbers are consistently documented in each Maximo work order, and must demonstrate that this process is being carried out.

## **③ Some WMATA job descriptions have not been reviewed in more than 20 years.**

Although most job descriptions reviewed for this audit appeared complete, three had not been reviewed since the 1990s despite significant changes to the Metrorail system (and general workplace technology such as computers) in that time.



**Outdated job descriptions create a risk that employees will not have the knowledge, technological background, or familiarity with specific tools and software required to complete their work in the safest possible manner.**

**After the WMSC raised this issue, WMATA developed a procedure that set inspection and maintenance requirements for cars in longer-term storage.**

The job description for Mechanic: Machinist Rail (L689) has not been reviewed since November 1999, the job description for Shop Supervisor CTEM was last reviewed in March 1999, and the job description for Superintendent, Major Repair and Overhaul was last reviewed in July 1994.

Significant changes such as Metrorail fleets, yards and staffing have occurred in this time, and the job descriptions do not match today's technology. The job descriptions noted above also predate system safety requirements and the defined need for interdepartmental cooperation to achieve a positive safety culture.

These outdated descriptions create a risk that employees will not have or be provided with the knowledge, technological background, or familiarity with specific tools and software required to complete their work in the safest possible manner.

The lack of review suggests a deficiency in configuration management that could contribute to improper training or qualifications for positions critical to safety.

**Possible Corrective Action:** Metrorail could develop and implement a procedure to ensure that job descriptions and responsibilities are reviewed on a specified regular basis to reflect current operating realities.

## Other Observations

This audit was conducted during the ongoing, long-term COVID-19 public health emergency.

Early in the public health emergency, the WMSC had identified and communicated concerns regarding a lack of WMATA processes and procedures for handling railcars that were removed from service for an extended period. After the WMSC raised this issue, WMATA developed a procedure that set inspection and maintenance requirements for cars in longer-term storage.

WMSC inspections later identified deficiencies in WMATA's vehicle storage and securement in multiple yards, including vehicles that did not have wheels properly chocked and were not identified with blue flags to prevent unintended movement.

In winter 2021, WMSC inspections identified that 6000 Series cars that were indefinitely out of service had not been properly chocked and blue flagged, and did not all have handbrakes properly applied at Greenbelt and New Carrollton yards. In April 2021, a WMSC inspection identified other railcars not properly stored at the Alexandria Yard. These issues were addressed through the WMSC inspection process.

Initially, the public health emergency and associated shipping delays also exacerbated some parts challenges and extended some parts lead times, but personnel interviewed for this audit stated that things have improved in recent months.

Still, there are some areas such as air filters on 7000 Series cars in which an improved quality filter approved prior to the public health emergency has not yet been implemented due to procurement processes.

Metrorail is continuing to work on a number of outstanding issues including 6000 Series HVAC and master controllers, overall documentation revisions, and 7000 Series center pin liners. The center pin liner issue can create noisy rides for customers, but inspecting the pins is challenging due to their location in the middle of the truck. The 7000 Series center pin design is different from the legacy railcars and involves different materials.

Some aspects of 7000 Series maintenance are still being conducted under warranty by the manufacturer, Kawasaki. Generally, each car remains under warranty for two years, but the warranties for some specific subsystems have been extended.

Metrorail has an extensive reliability reporting system completed by Reliability Engineering and Performance Analysis (REPA) on a regular basis that provides important benefits. The WMSC observes that these reports are not consistent in terms of the time period covered due to the policies that lead to the reports being produced on specific days of the week and only capturing that month to date, rather than the reports actually being produced each week or each month.

The reports also identify the most failed component in the last 30 days in each fleet, but do not account for other opportunities to identify broader trends such as identifying component failures relative to installation, activation or age of the car.

Relatedly, CMOR only treats a car as a “repeater” if it returns with an issue with the same subsystem. Problems are not treated as “repeaters” if multiple cars experience similar issues in different shops and those problems are not documented in a REPA report.

Looking forward, as Metrorail prepares to open Silver Line Phase 2 and the associated Dulles Rail Yard, CMOR stated that the railcar fleet would be redistributed based on the needs of the Office of Rail Transportation (RTRA).





WMATA plans to add approximately 64 vehicle maintenance positions for the additional work required with the additional service. The exact number and type of individuals stationed at the Dulles Yard itself will be based on the work that is assigned there. At the time of this audit, Metrorail was preparing under the assumption Metrorail's work in the yard would begin around September 2021.

Metrorail has instituted information technology retention and storage policies that limit, for example, how long an email is saved in an employee's inbox. However, employees who had been relying on their email system to store important information relevant to future process reviews, approvals or explanations are not all familiar with how to store that information in other locations such as shared drives or other cloud storage. This has led to the loss of historical information, documents and communications that provide value and lessons learned for future actions or investigations.

## Next Steps

WMATA is required to propose CAPs for each finding and to respond to each recommendation no later than 30 days after the issuance of this report. Each proposed CAP must include specific and achievable planned actions to remediate the deficiency, the person responsible for implementation, and the estimated date of completion. Each proposed CAP must be approved by the WMSC prior to WMATA implementation.





750 First St. NE • Ste. 900 • Washington, D.C. 20002 • 202-384-1520

[www.wmsc.gov](http://www.wmsc.gov)