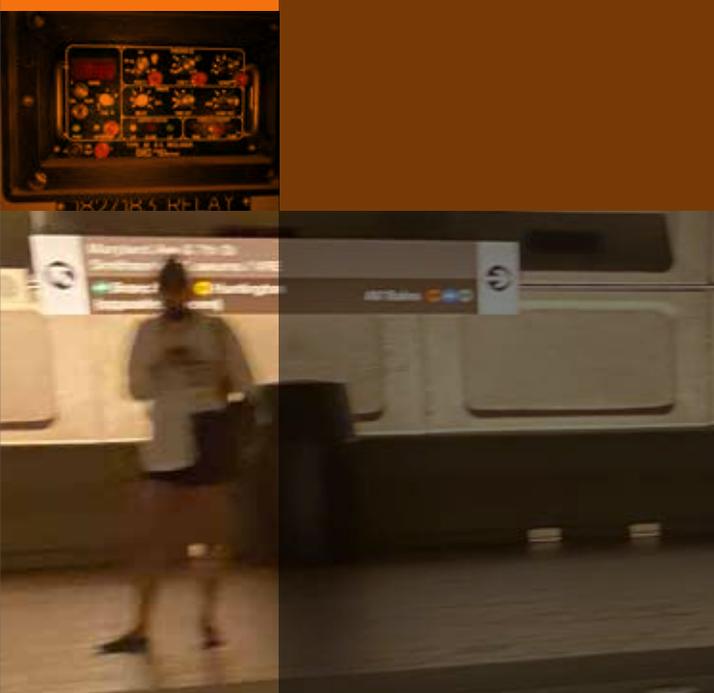


# The Washington Metrorail Safety Commission

## Safety Audit

of the Washington Metropolitan  
Area Transit Authority

Audit of High  
Voltage and  
Traction Power



Final Report:  
October 27, 2021

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Prepared under the authority of the Washington Metrorail Safety Commission

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# Executive Summary

**Safety certification is designed to ensure that hazards are proactively addressed or mitigated in order to avoid potential safety events.**

The Washington Metrorail Safety Commission (WMSC) performed this audit of the Washington Metropolitan Area Transit Authority (WMATA) Metrorail's high voltage and traction power practices through in-depth interviews and document and data reviews conducted in 2021. The scope of this audit included 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, staffing, planning and governance. The WMSC appreciates the cooperation of all departments associated with high voltage and traction power during this audit.

The audit demonstrates that Metrorail has made significant improvements in its traction power work and programs since 2016, but that there are additional areas where it is not meeting its own written requirements, does not have adequate procedures, processes or requirements, or does not have adequate training, coordination and supervision. As a result, the WMSC is issuing eight findings requiring Metrorail to develop corrective action plans (CAPs). The WMSC is also issuing four recommendations that Metrorail must address.

As described in the findings below, Metrorail did not follow safety certification and approval processes before installing and placing traction power systems into service. Safety certification is designed to ensure that hazards are proactively addressed or mitigated in order to avoid potential safety events.

Metrorail is also not documenting, tracking and conducting all preventive maintenance that is required by WMATA policy, manuals and instructions.

While Metrorail has made progress in some parts of the system, Metrorail is still relying on vital traction power equipment that is beyond its useful life, and has not fully followed through on implementation of prioritized renewal plans to ensure a state of good repair.

As it relates to training, there is no process in place to ensure personnel are trained on specific equipment prior to working on that equipment, and there is inadequate training, awareness, documentation, interdepartmental coordination and supervisory oversight to ensure knowledge of and compliance with documented procedures.

A review of documents provided for this audit identified forms such as daily inspection reports, supervisory field audit sheets, pre-job safety briefings, and TRPM Power AC Unit Substation/AC Room Facility Inspection Data Sheets that were not completed or were not completed with the required level of detail.





Metrorail is behind schedule on floating slab testing, does not have required as-built schematics in each facility, and is not fully identifying, tracking and mitigating hazards related to high voltage and traction power as required by WMATA's Public Transportation Agency Safety Plan (PTASP).

The recommendations in this audit relate to effective corrective maintenance prioritization, outdated job descriptions, equipment calibration, and equipment quality and availability risks due to materials tracking, storage, securement and procurement practices.

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.

**Metrorail is not documenting, tracking and conducting all preventive maintenance that is required by WMATA policy, manuals and instructions.**





## **Background** and Scope

# Background and Scope

The scope of this audit includes Metrorail's programs related to high voltage (480 volts alternating current (AC) or greater) and traction power systems. This audit involved a broad review of engineering, inspection and maintenance programs and associated procedures and training. Within that broad review, the audit also examined areas related to upgrades and rehabilitation.

Metrorail owns, operates, maintains and is responsible for the safety of power systems beginning where the local utility line from PEPCO or Dominion Energy ends in tie-breaker stations (TBS), traction power substations (TPSS) and other systems. The systems owned, operated and maintained by Metrorail include transformers and switchgear, cables and connections to the 750-volt third rail used to provide power to railcars, and the associated negative return systems that complete circuits.

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)
- Rules Compliance (Element 13)
- Facilities and Equipment Inspections (Element 14)

**The systems owned, operated and maintained by Metrorail include transformers and switchgear, cables and connections to the 750-volt third rail used to provide power to railcars, and the associated negative return systems that complete circuits.**





**This audit involved a broad review of engineering, inspection and maintenance programs and associated procedures and training.**

- 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 21)

PTASP elements covered include:

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

- Safety performance targets
- Organizational SMS Accountabilities and Responsibilities
- Functional area common SMS responsibilities
- Functional area specific SMS responsibilities
- SMS documentation

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

- Develop and implement a Safety Risk Management (SRM) process for all system elements
- Risk Assessment Process
- Risk assessment methodology
- Hazard identification
- Hazard investigation
- Hazard analysis and evaluation of safety risk
- Hazard resolution (mitigation, elimination)
- Hazard tracking

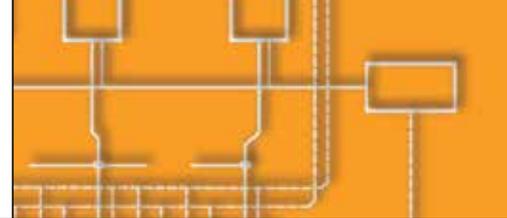
### **3. Safety Assurance**

- Systematic, integrated data monitoring and recording of safety performance

- Real-time assessment with timely information as to safety management and performance
- Internal reviews
- Departmental controls
- Compliance
- Sufficiency monitoring
- Document assurance activities
- Preventive, Predictive, and Corrective Maintenance
- Event reporting/investigations
- Change management
- Safety and Security Certification
- Corrective action plans

#### 4. Safety Promotion

- Training
  - ◆ Competencies and Training
  - ◆ Employee Safety Training
  - ◆ Safety Rules and Procedures Training
  - ◆ Training Recordkeeping and Compliance with Training Requirements
- Contractor Safety
- Safety Communications
- Hazard and safety risk information
- Safety committees
- Hazardous materials





Due to the timing of the PTASP's approval and the required phased approach for effective implementation, implementation was ongoing and not all elements had been fully implemented at the time of this audit.

## Open Corrective Action Plans (CAPs)

At the time of this audit, the only open CAP pertaining directly to traction power was CAP FTA-17-1-10. This CAP relates to traction power cable securement, insulation and replacement, negative return system upgrades, and expansion joint elimination programs. Metrorail is evaluating an alternative cable connection design, which requires a pilot process before determining the appropriate long-term engineering modifications. The current estimated completion date for the CAP as a whole is July 29, 2022. This CAP was created based on FTA findings resulting from the 2016 traction power review described below.

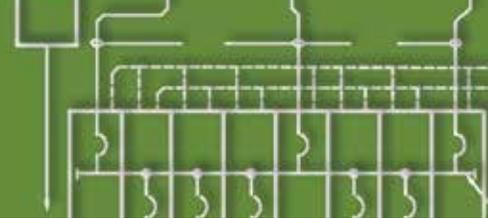
In addition, the WMSC issued a finding on August 13, 2021 requiring Metrorail to develop a CAP to address Metrorail's noncompliance with its Safety and Security Certification Program Plan (SSCPP). This finding was based on information identified during WMSC oversight work including inspections, document reviews, interactions with Metrorail personnel, and work on audits including this audit and the Roadway Maintenance Machine (RMM), Automatic Train Control and Signaling (ATC), and Revenue Vehicle (Railcar) audits.

## History

Metrorail's high voltage and traction power systems were a focus of significant investigation and review in 2015 and 2016, following the fatal January 15, 2015 smoke accident near L'Enfant Plaza Station. This event was the subject of a National Transportation Safety Board (NTSB) investigation and led to the Federal Transit Administration (FTA) conducting a Safety Management Inspection (SMI) of Metrorail. Later in 2015, the FTA assumed direct safety oversight of Metrorail. That FTA oversight continued until the WMSC was created and the FTA certified the WMSC's safety program in March 2019.

Among other recommendations arising from the investigation into the 2015 smoke accident, the NTSB issued Safety Recommendation R-15-025 calling on WMATA to "promptly develop and implement a program to ensure that all power cable connector assemblies are properly constructed and installed in accordance with your engineering design specifications, including the weather tight seals that prevent intrusion by contaminants and moisture."

**Metrorail's high voltage and traction power systems were a focus of significant investigation and review in 2015 and 2016, following the fatal January 15, 2015 smoke accident near L'Enfant Plaza Station.**



Metrorail implemented a corrective action plan over approximately four years to ensure that power cable connector assemblies were properly built and sealed. As of February 2020, the NTSB classifies this recommendation as “closed – acceptable action.”

Prior audits and reviews such as a 2010 Tri-State Oversight Committee (TOC) Audit had found that there were inconsistent traction power practices across regions, that housekeeping issues (debris, cleanliness, proper storage) in tie-breaker stations and traction power substations were not consistently addressed, and that traction power maintenance and test sheets were often incomplete. Additional areas of concern included the absence of station electrical prints on site, a lack of clear written measurement tolerances for traction power testing, and a lack of an overall maintenance plan for traction power.

The FTA's 2015 SMI found, among other things, that Metrorail must do more to prevent and manage conditions that cause smoke in tunnels, including replacing all defective cables, resuming cable insulation resistance testing (meggering), cleaning insulators, and inspecting or replacing third rail jumper cables. The SMI also identified maintenance backlogs, and separate inventory issues where a lack of parts had negatively impacted departments, including traction power.

In March 2016, Metrorail shut down entirely for a day to perform cable inspections in underground portions of the system. The shutdown on March 16, 2016 was two days after a March 14, 2016 smoke and fire event near McPherson Square Station that had similarities to the January 2015 accident near L'Enfant Plaza Station. These inspections in only the underground portion of the system identified more than 350 areas requiring repair, including at least 27 that required emergency repairs. Metrorail inspected above ground cables separately and stated that it would improve cable inspection training and documentation. Metrorail also began the process of developing a dedicated traction power organization and program as directed by FTA findings.

Until that time, Metrorail had utilized power personnel within Track and Structures/ Systems Maintenance (TSSM) and Transit Infrastructure and Engineering Services (TIES) departments to inspect and repair power systems. That Power Branch became the current Traction Power Maintenance department that, as described later in this report, is responsible for inspection and repair work today.

In May 2016, the FTA directed Metrorail to immediately repair traction power elements on the Red Line between Van Ness and Medical Center stations and on the Blue, Orange and Silver Line between Potomac Ave Station and the elevated interlocking east of Stadium-Armory Station referred to as the D&G junction.

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**In March 2016, Metrorail shut down entirely for a day to perform cable inspections in underground portions of the system.**

**Later in 2016, FTA Special Directive 17-1, the FTA's Traction Power Electrification System Investigation Final Report and a Tri-State Oversight Committee (TOC) Audit conducted in coordination with the FTA's SMI identified required actions to address safety deficiencies.**

In June 2016, Metrorail initiated a special investigation of Metrorail's traction power system to address 58 open accident investigations related to electrical arcing that occurred within approximately six months.

Later in 2016, FTA Special Directive 17-1, the FTA's Traction Power Electrification System Investigation Final Report and a Tri-State Oversight Committee (TOC) Audit conducted in coordination with the FTA's SMI identified required actions to address safety deficiencies related to Metrorail's traction power system. Some of these required actions included items identified by Metrorail's special investigation.

The FTA's directive required 47 actions to address 22 safety findings related to:

- roles, responsibilities and resources for the system
- system infrastructure
- system inspection and maintenance programs
- capital projects to upgrade and replace or rehabilitate system components.

The required actions followed an increase in electrical arcing events at insulators, cables, connector assemblies, and track fastening components. As noted above, one of these CAPs, FTA-17-1-10, remains open at the time of this audit.

In total, the event investigations and other oversight had identified deteriorated and compromised conditions due to age, deferred maintenance, limited replacement of secondary cables, and increased exposure to water and moisture with contaminating materials. The FTA identified the potential for issues with the negative return system and stray current corrosion.

The FTA also identified that staffing was not adequate to complete required preventive and corrective maintenance. The TOC's audit found 43 percent compliance with yearly yard isolation test inspection requirements and four other procedures that were below 90 percent compliance (the Maintenance Control Policy set a 98 percent goal). Other procedures had not been communicated to field personnel, were not tracked in compliance reports, had frequencies entered into the Maximo database that did not match the frequencies specified by engineering documents, or did not have detailed documented descriptions at all. For numerous inspections that were marked as complete, data sheets were not available. In other cases, outdated and incomplete versions of forms were being used to document inspections. Training for power mechanics was not systematically tracked.



The FTA directive noted that Metrorail had previously eliminated preventive maintenance programs to test traction power feeder cables for insulation integrity, had limited corrosion control testing, and had significantly reduced cleaning programs.

The FTA directive also noted that Metrorail had recently reinstated limited tunnel and insulator cleaning programs, and had begun cable replacement and power system upgrade work.

At the time of this audit, the most recent internal review that focused specifically on Metrorail's Traction Power Inspection and Maintenance was completed by WMATA's Quality Assurance, Internal Compliance & Oversight (QICO) in June 2017.

That internal review identified the need for a new training curriculum given that there was no technical training in place for new TRPM personnel, the need for improved document control, and the need for effective staffing. Corrective actions included completing electrical facility room inspection records, addressing the use of an unapproved lockout/tagout procedure, implementing improvements to and regular revisions of the Traction Power Maintenance Control Policy to address errors and responsibility changes, a need for consistent documentation such as logbook entries, a lack of PMI procedures for new equipment, a need for supervisors to perform quality control checks, a need for completed forms to include work order numbers, a need to address a backlog of open work orders, and a need for oversight and control of electronic records management practices.

Following that review, initial drafts of the new TRPM-1000 manual were circulated in 2017 and 2018 to provide overall inspection and maintenance procedures. The manual was finalized and approved in March 2019. The TRPM-1000 was recently updated in March 2021. At the time of this audit, TRPM was developing a second manual, the TRPM-2000 Maintenance Operations & Maintenance Administration Program, that would specify the roles and responsibilities of Traction Power Maintenance and related personnel involved in maintenance, training, compliance, materials storage and handling, and calibration of test equipment related to the traction power system.

More recently, Metrorail has continued some power system rehabilitation or upgrade programs and has made other adjustments in some locations such as the installation of cable shield monitors. A majority of the traction power rehabilitation and installation work is conducted by contractors, with Metrorail personnel beginning regular maintenance and after the systems are in use and any warranty period expires.

**Initial drafts of the new TRPM-1000 manual were circulated in 2017 and 2018 to provide overall inspection and maintenance procedures. The manual was finalized and approved in March 2019. The TRPM-1000 was recently updated in March 2021.**



**The new power room had been put into service on December 12, 2020 without a Temporary Use Notice (TUN), and did not have proper protective relay settings.**

One aspect of these power upgrades is what Metrorail has described as an eight-car train program. The power changes required to run all eight-car trains depend on several factors, including the frequency (headway) trains are scheduled. This program now includes more of a focus on state of good repair efforts.

Recent safety event investigations have identified additional areas that require improvements.

For example, investigation W-0084 demonstrated the safety implications of not maintaining a state of good repair and not applying complete safety certification and acceptance processes. In this event, on the Green and Yellow Line on December 13, 2020, relays that were beyond their expected useful life failed, which tripped feeder breakers in a traction power station. As described below, Metrorail was not conducting or tracking certain required preventive maintenance on the solid-state DC relays (176 relay and 182/183 relay) that were beyond their expected useful life. After those relays failed, the electrical load shifted to a tie-breaker station with new switchgear that had been activated with improper settings, which led to those breakers tripping as well. The new power room had been put into service on December 12, 2020 without a Temporary Use Notice (TUN), and did not have proper protective relay settings in place to match the protective relay function algorithm incorporated into this new equipment. The algorithm in this equipment was different from the algorithm incorporated into other equipment that had previously been successfully incorporated into the Metrorail system. These failures contributed to the need for customer evacuations the following day from trains that stalled when power went down and could not be restored remotely when riders were then stranded on two trains near Fort Totten and Georgia Ave-Petworth stations for an extended period. The Metro Transit Police Department (MTPD) later evacuated the customers to the roadway without proper safety precautions such as Warning Strobe and Alarm Devices (WSADs).

Investigation W-0074 demonstrated that traction power supervisors were not providing adequate oversight of personnel. This improper roadway worker protection event on the Red Line near Rockville Station on November 26, 2020 demonstrated gaps in roadway worker protection knowledge, and a general lack of review by supervisors of roadway job safety briefings.

Additional safety events related to the improper restoration of third rail power in 2020 and early 2021, and associated WMSC findings issued in 2020 primarily related to the Rail Operations Control Center (ROCC), have also led to Metrorail adding to the Power Desk in the ROCC. In summer 2021, the power desk transitioned to fully reporting to TRPM and added new staff to provide approximately 15 power desk controllers, 5 assistant superintendents and one superintendent. Later in 2021, Metrorail plans to implement a new power restoration procedure that Metrorail developed under CAP C-0037.



## Current Structure

Metrorail has several departments that are responsible for aspects of high voltage and traction power programs.

Traction Power Operational Engineering (TPOE), a division of Maintenance of Way Engineering (MOWE), is responsible for day-to-day power engineering and operational needs. Engineering and Architecture (ENGA) develops procedures for Preventive Maintenance Instructions (PMIs) and is involved in aspects of work that Metrorail contracts out. Metrorail SOP 114-02 designates ENGA and TPOE as equally responsible for engineering modification instructions (EMIs). TPOE, within MOWE, is led by a director. ENGA's power-related work is led by a director of traction power engineering. The two leaders have different responsibilities. The two departments stated that they work together on Metrorail's internal engineering needs for power system rehabilitation projects.

Traction Power Maintenance (TRPM), a division of Rail Infrastructure Maintenance and Engineering (RIME), is responsible for, among other duties, carrying out preventive and corrective maintenance in the field. TRPM personnel in the field are generally divided into regions that are each responsible for a defined area of the system. A separate division, known as the PMI group, is responsible for certain work that is deemed more complex (regardless of the location of that work). At the time of this audit, Metrorail had recently adjusted the personnel in various management positions in TRPM. Metrorail was also just beginning the use of a Power Desk in the ROCC that was staffed by and was reporting to TRPM.

Significant rehabilitation work and some other tasks are carried out by contractors overseen by TRPM or by departments such as Project Implementation and Construction (PICO) in Capital Delivery (CAPD).

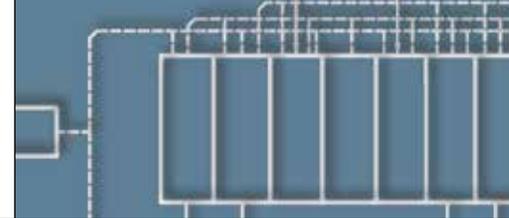
Certain inspection or internal oversight responsibilities are carried out by other groups such as the Department of Safety and Environmental Management (SAFE).

## Audit Work

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

An exit conference was held on June 18, 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.



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

## Personnel Interviewed

- **General Superintendent, TRPM**
- **Assistant General Superintendent, TRPM (2)**
- **Superintendent, TRPM**
- **Assistant Superintendent, TRPM (2)**
- **Area Supervisor Electrical Power, TRPM**
- **Special Project Manager, TRPM**
- **Supervisor Crew Support, TRPM**
- **Supervisor, TRPM**
- **AA Mechanic, TRPM**
- **A Mechanic, TRPM**
- **B Mechanic, TRPM**
- **C Mechanic, TRPM**
- **Mechanic Helper, TRPM**
- **Director, Traction Power Operations Engineering (TPOE)**
- **Manager Power Operations & Maintenance Engineering, TPOE**
- **Manager Corrosion Control Engineering, TPOE**
- **Electrical Engineer Supervisory Control and Data Acquisition (SCADA), TPOE**
- **Acting Area Supervisor Electrical Power, TRPM**
- **Project Manager, Traction Power, CAPD PICO**
- **Senior Program Manager, CAPD PICO**
- **Safety and Security Certification Coordinator (contractor), CAPD PICO**
- **Construction Inspector, CAPD PICO**
- **Construction Engineer-Electric, CAPD PICO**
- **Change Management Coordinator, CAPD PICO**
- **Technical Skills Maintenance Training (TSMT) Instructor, TSMT**
- **Safety Certification & Engineering Manager, SAFE**

## Documents Reviewed

- January 2019 SSPP
  - WMATA Transit Agency Safety Plan (PTASP) V1.0  
October 8, 2020
  - Safety and Security Certification Program Plan (SSCPP) January 2020, Rev. 4
  - WMATA Manual of Design Criteria (Release 9, Revision 3, November 2016)
  - FTA Special Directive No. 17-1, Notice No. 1, Required Actions to Address Findings from Traction Power Electrification System Investigation at WMATA (December 9, 2016)
  - FTA Traction Power Electrification System Investigation Final Report (December 9, 2016)
  - Procedure No. 123-01, Rail Infrastructure Asset Maintenance and Engineering Roles and Responsibilities, Rev. 0 (March 5, 2021)
  - Organization charts (CAPD PICO RBIR AC and TP Power Team, TPOE–Traction Power Operational Engineering, TRPM)
  - CAPD PICO RBIR AC and TP Power Team Roles and Responsibilities (April 6, 2021)
  - TRPM Roles and Responsibilities (no date/identifier)
  - Budgeted employees and vacancies spreadsheet for ENGA, PICO, RAIL, SPPM
  - Job descriptions for:
    - **Electrical-Power Technician HV:**
      - Mechanic AA Electrical-Power Technician HV, (no date)
      - Mechanic A Electrical-Power Technician HV (dated 8/21/1980)
      - Mechanic B Electrical-Power (dated 8/21/1980)
      - Mechanic C Electrical-Power Technician HV (dated 1/8/1991)
      - Mechanic Helper (dated 12/3/1998)
    - **Systems training instructor (dated 4/17/2015)**
- Position descriptions for:
    - **Mechanic Electrical Maintenance and Test Technician, AA, A, B, C, helper (dated 9/12/2019)**
  - Enterprise Learning Management (ELM) transcript for all TRPM mechanics
  - TRPM Training schedule for April-July 2021 (version 1)
  - Basic Electric Theory daily lesson plan (February 14, 2021)
  - Basic Electric Theory Participant Manual (February 14, 2021)
  - Basic Electric Theory Training Program slides (last updated February 14, 2021)
  - AC Rooms and AC Switchgear daily lesson plan (Reviewed 4/19/2021)
  - AC Rooms and AC Switchgear training slides (Reviewed April 19, 2021)
  - AC Rooms and AC Switchgear training (April 19, 2021)
  - Low Voltage Circuit Breaker Overcurrent Protection Training Program slides (Reviewed 4/19/2021)
  - Low Voltage Circuit Breaker Overcurrent Protection Participant Manual (April 19, 2021)
  - Low Voltage Circuit Breaker Overcurrent Protection daily lesson plan (Reviewed April 19, 2021)
  - High Voltage AC Circuit Breakers daily lesson plan (Reviewed April 19, 2021)
  - High Voltage AC & DC Circuit Breaker Training Program slides (Reviewed April 19, 2021)

## Documents Reviewed (continued)

- High Voltage AC & DC Circuit Breakers Participant Manual (April 19, 2021)
- Relay Protective Devices daily lesson plan (Reviewed April 19, 2021)
- Relay Protective Devices Introduction to the Substation Maintenance Profession slides (April 19, 2021)
- Relay Protective Devices Participant Manual (April 19, 2021)
- Uninterruptible Power Supplies daily lesson plan (Reviewed April 19, 2021)
- Uninterruptible Power Supplies Participant Manual (April 19, 2020)
- Electrical Safety for Traction Power daily lesson plan (Reviewed April 14, 2021)
- Electrical Safety for Traction Power daily lesson plan (November 19, 2019)
- Electrical Safety for Traction Power Participant Manual (March 13, 2017)
- Electrical Safety for Traction Power Introduction to Electrical Safety slides (Reviewed April 14, 2021)
- Circuit Breaker Racking Position Procedures slides (November 19, 2019)
- Circuit Breaker Racking Position Procedures slides (November 21, 2019)
- Nomenclature Course daily lesson plan (Reviewed April 14, 2021)
- Nomenclature Traction Power Substation slides (Reviewed April 14, 2021)
- Tools and Material Handling daily lesson plan (Reviewed April 15, 2021)
- Introduction to Tools and Material Handling slides (Version April 15, 2021)
- Traction Power Substations daily lesson plan (Reviewed April 16, 2021)
- Traction Power Substations Training Program slides (April 16, 2021)
- Traction Power Substations Participant Manual (April 16, 2021)
- Introduction to Substation Maintenance daily lesson plan (Reviewed April 16, 2021)
- Introduction to Substation Maintenance slides (April 16, 2021)
- Introduction to Substation Maintenance Participant Manual (April 16, 2021)
- Liquid Filled Transformer Maintenance daily lesson plan (Reviewed April 16, 2021)
- Liquid Filled Transformer Maintenance training (Reviewed April 16, 2021)
- Rectifiers and Rectifier Transformers training (Reviewed April 16, 2021)
- Rectifiers and Rectifier Transformers Training Program slides (Reviewed April 16, 2021)
- Rectifiers and Rectifier Transformers Participant Manual (April 16, 2021)
- List of PPE issued to TRPM Maintenance Personnel
- Completed TRPM Daily Job Safety Briefings (November 22–28, 2020; February 7–13, 2021; April 19–25, 2021; July 26–August 1, 2021)
- List of TRPM equipment assets by location, April 22, 2021
- Tool and equipment calibration status list (spreadsheet)
- New Radio User Request Expansion Form
- DiVal glove test list, November 20, 2020
- AC Power Project List, April 12, 2021

## Documents Reviewed (continued)

- Current Active and Processing Traction Power Major Contract Equipment Scopes (spreadsheet)
- List of Planned Traction Power SOGR Contracts
- List of Ongoing and Completed Facility Rehabs
- List of equipment out of service as of April 1, 2021
- Reliability Centered Maintenance Planning (RCMP) traction power reliability reports (September 2019 through March 2021)
- Completed TRPM Supervisor's Field Maintenance Audit forms, area supervisor (9/4/2020, 9/8/2020, 9/9/2020, 9/10/2020, 9/24/2020)
- Completed TRPM Supervisor's Field Maintenance Audit forms, shift supervisor (September 13–20, 2020)
- QICO Internal Review of Metrorail Traction Power Inspection and Maintenance (June 21, 2017)
- TRPM Hotline Safety Calls and Closed Date spreadsheet
- TRPM Incidents & Accidents spreadsheet (January through December 2020)
- List of traction power corrective maintenance work orders for February 2020 and February 2021
- MPLN Monthly TRPM Preventive Maintenance Summary Reports (September 2019 through March 2021)
- Maintenance Scheduling for Electrical Equipment, MOWE, Rev. 2 (April 12, 2021)
- TRPM Active Preventative Maintenance Schedule (spreadsheet)
- PMI (Preventive Maintenance Inspection) for SCADA Systems Traction Power Substation, Rev. September 30, 2016
- Monthly PM status for electrical/TP facilities (spreadsheet)
  - **A-Line, B-Line** (January 2019)
  - **C-Line, D-Line, J-Line** (February 2019)
  - **E-Line, F-Line, G-Line** (March 2019)
  - **K-Line, N-Line** (January 2020)
- Battery PM status (spreadsheet)
  - **Quarterly battery PM:** January 2019, May 2019, February 2020, March 2021
  - **Bi-Annual battery PM:** 2019 and 2020
- UPS annual battery load test status (spreadsheet)
  - **JGB-OCC** (2019, 2020)
- Medium voltage air and air blast breaker status (spreadsheet)
  - **Annual PM**
    - **A-Line, B-Line, C-Line, D-line, J-Line** (2019)
    - **E-Line, F-Line, G-Line, K-Line, N-Line** (2020)
  - **2-year PM, all lines** (2019, 2020)
- Medium voltage vacuum breaker status (spreadsheet)
  - **Annual PM**
    - **A-Line, B-Line, C-Line, D-line, J-Line** (2019)
    - **E-Line, F-Line, G-Line, K-Line, N-Line** (2020)
  - **3-year PM, all lines** (2019, 2020, 2021)
- DC Cathode and Feeder Breaker (spreadsheet)
  - **Annual PM, all lines** (2019, 2020)
- Emergency Trip Station (ETS) 3-year PM status, all lines for January 2015 to April 2021 (spreadsheet)

## Documents Reviewed (continued)

- Stationary Generator monthly PM (spreadsheet)
  - **A-Line, B-Line** (January 2019)
  - **C-Line, D-Line, J-Line**, (February 2019)
  - **E-Line, F-Line, G-Line** (March 2019)
  - **K-Line, N-Line** (January 2020)
- TRPM memorandum description of Maximo work deferral and bypass status (no date)
- Facilities Infrastructure Map for all stations
- Eaton Instructions for Installation, Operation and Maintenance of Type VCP-W Vacuum Circuit Breakers (December 2006)
- Powell P-51000 PowlVac Metal-clad Switchgear (Rev. 11/2003)
- Powell 63kA A SD Circuit Breaker (2/2005)
- ASCO Automatic Transfer Switch Operator's Manual
- CP Myers Controlled Power Installation, Operation & Maintenance Manual High Speed DC Switchgear Type HSN (Rev. 11, 2/2009)
- Powell Low Voltage Metal-Enclosed Type NDC DC Switchgear (August 2014)
- Sécheron MBS Range High-speed circuit-breaker panels instruction manual (9/4/2019)
- GE Power Circuit Breaker Instructions (Rev. GEH-1803B)
- PV System 38 Metal-Clad Switchgear Instructions (IB-65000)
- Powell PowlVac PV38 Electrically Operated Ground and Test Device Instructions (IB-65060) (1/2004)
- Powell Type PV-AM POWL-VAC Vacuum Circuit Breaker (IB-77100) (9/2003)
- Virginia Transformer Corp. Instructions for Receiving, Installing, Operating and Maintaining Liquid-Filled Power Transformers (February 25, 2008)
- VG Controls Multi-Function Protection Relay Operating Manual (7/2016)
- SMC Electrical Products Type 64 Structure Ground Relay High Resistance Model Operation and Calibration Manual (7/15/1997)
- Sécheron Operation and Maintenance Training DC Switchgear Training Program for Orange, Red and Green Lines Upgrade, slides (January 22, 2020)
- ABB Installation and Instruction Manual Dry-type transformers
- Virginia Transformer Corporation Installation, Operation & Maintenance Manual (2017)
- Virginia Transformer Corp. Instructions for Receiving, Installing, Operating and Maintaining Liquid-Filled Transformers (November 1, 2000)
- Benning Installation and Startup Manual, WMATA UPS splitting instructions (Version 1.0, 5/1/2017)
- Temporary Order No. T-21-04, ACS Limits for Blue Line Spring 2021 Shutdown (Approved 2/12/2021, Rescinded 5/24/2021)
- EMI-003-MOWE-POWER, Third Rail Cable Connection Pilot (Rev. 2, 4/2/2021)
- EMI 220272-CENI Engineering, Jumper Expansion and Transition Power Cables Replacement Systemwide (Rev. 6, 12/11/2018)
- ETP-001-MOWE-POWER, GAP Rails Eliminations -E06 TBS Pilot Test (Rev. 1, 7/10/2020)
- AC Power Room Rehabilitation Program, draft slides
- AC Power Project List (4/12/2021)
- Traction Power State of Good Repair Priority Planning List (2/18/2020)

## Documents Reviewed (continued)

- List of AC Power contractors that performed, repairs, inspections, or maintenance on the WMATA Rail System as of April 1, 2018
- List of Traction Power contractors that performed, repairs, inspections, or maintenance on the WMATA Rail System since April 1, 2018
- Contractor license information
- Dominion Energy Switchgear Replacement at Vienna Station Authorization to Proceed (December 5, 2019)
- Dominion Energy Switchgear Relay Replacement Pentagon City TPSS Work Authorization (April 17, 2020)
- PEPCO Switchgear Installation at Greenbelt TPSS Work Authorization (March 12, 2021)
- PEPCO Switchgear Replacement at West Hyattsville TPSS Work Authorization (December 3, 2020)
- PEPCO Switchgear Installation at 33rd Avenue TPSS Work Authorization (March 12, 2021)
- PEPCO Switchgear Installation at Albion Road TPSS Work Authorization (March 12, 2021)
- Dominion Energy Switchgear Installation at Cameron Run TPSS Work Authorization (March 30, 2021)
- Dominion Energy Switchgear replacement at Tilbury TPSS Work Authorization (February 11, 2019)
- PEPCO Switchgear Replacement at Farragut West Work Authorization (June 3, 2020)
- PEPCO Switchgear Replacement at Foggy Bottom Work Authorization (June 3, 2020)
- PEPCO Switchgear Replacement at Deanwood Work Authorization (June 3, 2020)
- Master Agreement between WMATA and the Potomac Electric Power Company (November 20, 1972)
- Master Agreement between WMATA and the Virginia Electric and Power Company (April 24, 1973)
- PEPCO quote for Gallery Place Station (July 29, 2019)
- PEPCO quote for Silver Spring Station (July 29, 2019)
- Dominion Energy quote for Switchgear Replacement Duke Street TPSS (December 20, 2018)
- Dominion Energy quote for Switchgear Replacement Tilbury TPSS (December 20, 2018)
- Dominion Energy quote for Switchgear Replacement Eisenhower Ave. TPSS (December 26, 2018)
- PEPCO Switchgear Replacement at Cleveland Park Work Authorization (December 11, 2020)
- Dominion Energy Switchgear Replacement Duke Street TPSS Work Authorization (January 28, 2019)
- Dominion Energy Switchgear Replacement at Van Dorn TPSS Work Authorization (January 28, 2019)
- Dominion Energy Switchgear Replacement at Cameron Run TPSS Work Authorization (January 28, 2019)
- Dominion Energy quote for Switchgear Replacement at East Falls Church Station (December 12, 2019)
- Dominion Energy quote for Switchgear Replacement at Pentagon City TPSS (March 25, 2020)
- Dominion Energy quote for Switchgear Replacement at Cameron Run TPSS (March 4, 2021)
- TRPM Regional Operations personnel shift list by location (5/3/2021)

## Documents Reviewed (continued)

- TRPM list of all personnel
- SAFE Project Assessment Form, AC Switchgear Room Rehabilitation (FQ17044) (assessed 5/3/2021)
- SAFE Project Assessment Form, AC Switchgear Room Rehabilitation (FQ19218) (assessed 5/3/2021)
- List of SAFE involvement in High-Voltage and Traction Power (June 4, 2021)
- IRPG/TRPM Meggering Data tracker, spreadsheet (4/30/2021)
- Temporary Order, No. T-21-14, ACS Limits for Green Line Summer 2021 Shutdown (Approved 5/19/2021, Rescinded 8/31/2021)
- Memorandum to all TRPM and MOC Staff, Maintenance Dispatching for Power System Faults and Emergencies (11/9/2016)
- Memorandum to TRPM Supervisors and Managers, Manpower Management (12/7/2020)
- Memorandum to all WMATA Employees, Roadway Worker Protection Program (6/30/2016)
- SOP No. 209-01, TRPM Supervisor's Field Maintenance Audit (Rev. Original, 3/25/2020)
- SOP No. 100-09, General Order & Track Rights System (GOTRS) (Rev. Original, 6/4/2018)
- SOP No. TRPM 1000-05, TRPM Red Tag Switching Procedures (Rev. Original, 9/25/2017)
- TRPM 1000 Electrical and Traction Power Systems Maintenance and Inspection Manual (Rev. 1.6, 3/19/2021)
- TRPM Maintenance Operations & Administration Bulletin (MOAB) 2020-11, Trip Logging Requirements for Non-Revenue Vehicles (November 16, 2020)
- TRPM Maintenance Safety Bulletin (MSB) 2019-01, Proper Identification of Traction Power Negative Return Disconnect Switches
- TRPM MSB 2020-01, Rectifier/Rectifier Transformer Maintenance (January 20, 2020)
- TRPM MSB 2020-01, Usage and Wear of Safety Helmets & Hard Hats (January 1, 2020)
- Completed Roadway Job Safety forms (July 26–August 1, 2020; November 22–28, 2020; February 7–13, 2021)
- Work order details for 14656964, 14742673, 14744746, 15528842, 15557729, 15562751, 15959127
- iCAPa status list for the June 21, 2017 Metrorail Traction Power Inspection and Maintenance Internal Safety Review
- PMI test reports for January through March 2021 (341 documents)
- Gannett Fleming/Parsons Transit Asset Inventory and Condition Assessment Project (TAICA) Phase I Revenue and Non-Revenue Facilities Inventory and Condition Assessment, Tier A and B Condition Assessment Report, 16-FQ10060-QICO-01 (July 24, 2017)
- Gannett Fleming/Parsons Transit Asset Inventory and Condition Assessment Project (TAICA) Inventory and Condition Assessment of Tier C & D Facilities, 17-FQ15191-AMA-001 (December 22, 2017)
- SOP 121-02, Thermal Imagery Analysis and Tracking (Rev. 1, 5/16/2018)
- C3M Safety and Security Certification Management Plan, Traction Power System Upgrades (Red/Green/Orange Lines) (September 19, 2019)
- Blue Line Rail Power System Upgrades Certifiable Item List (Rev. 5/14/2021)

## Documents Reviewed (continued)

- Red/Green/Orange Lines Traction Power System Upgrades Certifiable Item List (5/11/2021)
- TUN-FQ17165-10, Certifiable Element/Sub-Elements: Tie Breaker Station, J02TB2-Farrington (5/15/2020)
- TUN-FQ17165 status of O & M Manuals (5/15/2020)
- J02TBS#2 New 750VDC Switchgear Operational Substantial Completion Inspection Testing Procedures (4/15/2020)
- FQ17165 Substantial Completion Inspection Form (4/15/2020)
- TRPM internal system status report (spreadsheet)
- TRPM-2000, Maintenance Operations & Administration Management Program (MOAMP) (August 1, 2021)
- Agency Peer Review on Oil-Filled Traction Power Transformers Manufactured by Virginia Transformer Corporation, Jacobs Engineering white paper (April 8, 2021)
- Memorandum, Potomac Yard Rectifier Transformer Failure Report (October 30, 2007)
- Memorandum, J01TP Cameron Run Transformer #1 Investigation Summary (September 22, 2019)
- Mandatory Management and Supervisor Training spreadsheet tracker (as of June 16, 2021)
- TRPM Training matrix (spreadsheet)
- Completed Compliance, Safety, and Inspection (CSI) sheets for April 2021
- TRPM Safety Hazard Log
- TRPM Monthly Safety Meeting minutes (January–May of 2021)
- CSI compliance audits and dirty data reports from Maximo
- CAP 17-1-13 schedule (spreadsheet)
- Response from SPPM regarding FY22-27 Capital Improvement Program funded Traction Power State of Good Repair
- Completed turnover spreadsheet for TRPM Assistant Superintendent change in shifts
- Supervisor/Area Supervisor's Field Audit Reports for May through June 20, 2021
- PMI Supervisors' Meeting Minutes for June 17, 2021
- List of POWR Equipment Overdue for calibration
- List of TRPM Equipment calibration
- FQ17165 Blue Line Rail Power Systems Upgrades Org. Chart and Position Roles and Responsibilities
- FQ19061 Red/Green/Orange Org. Chart and Position Roles and Responsibilities
- Traction power state of good repair solicitation (FIRPG211191)
- Red, Green, Orange (RGO) Line Rehab Project documents
- Emails regarding RGO and 8-car train project cutovers from December 2020
- C08TP Shirley Highway Work Plan Phases, Drawings
- Substation upgrade reports (92)
- TPRM capital project construction inspector Daily Reports, any project (May to June 20, 2021)
- List of storage facilities/locations for traction power equipment and salvaged TRPM equipment
- REAM monthly meeting minutes with engineering for May 19, 2021
- TRPM crew assignment sheet (6/20/2021)
- FQ19061, Modification of DC Switchgear Wiring (January 11, 2021)



What the **WMSC** Found

# What the **WMSC** Found

## Positive Practices

This audit identified that Metrorail has made significant progress in its traction power programs over the last five years. Although additional improvements are required, the progress that has been made increases the likelihood that problems will be prevented and that problems that do occur will be identified and mitigated in a timely fashion.

The WMSC identified a number of positive practices while conducting this audit including:

- While multiple personnel expressed the importance of traction power staffing continuing to increase, Metrorail has taken positive steps in this area in the period since the 2016 FTA findings that more resources were required
- Metrorail is conducting a thermal imaging program
- Metrorail has established a corrosion control testing program
- Metrorail has taken initial steps to determine ways to prioritize traction power system replacement and repair
- Metrorail recently began conduit collapse inspections
- Given the age and parts availability, Metrorail is keeping some switchgear lineups that are being replaced so that parts can be used elsewhere if needed
- Metrorail is collecting feedback from participants in training classes as part of efforts to improve classes
- As part of the process to implement WMATA's Public Transportation Agency Safety Plan, Metrorail has designated safety risk coordinators in its departments and is beginning familiarization training for those individuals on the safety management system (SMS)

**Metrorail has made significant progress in its traction power programs over the last five years.**



**Safety Certification is a critical and systematic process to ensure that hazards are proactively identified and mitigated prior to the activation of new equipment or construction projects in order to avoid potential safety events.**



## Findings and Minimum Corrective Actions

**Metrorail is not complying with its safety certification and approval requirements that are specified in its SSCPP before installing and placing traction power systems into service.**

Safety Certification is a critical and systematic process to ensure that hazards are proactively identified and mitigated prior to the activation of new equipment or construction projects in order to avoid potential safety events. However, Metrorail is not following its processes such as the Safety and Security Certification Program Plan (SSCPP) as they relate to the activation of traction power assets.

For example, interviews for this audit confirmed that Metrorail activated new switchgear at multiple locations as part of its Red, Green and Orange Line (RGO) power upgrade project without first obtaining required safety approvals, including a Temporary Use Notice (TUN). One location also remained in service after a TUN had expired. The TUN is intended under Metrorail's procedures to provide for temporary use with specific safety mitigations in place until all outstanding issues are resolved and a final certificate of compliance is issued through the safety certification process.

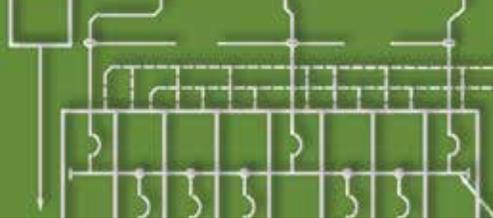
WMATA SSCPP Section 3.10.1 specifies that:

**"A Temporary Use Notice (TUN) must be issued for a facility or system that has not completed the safety certification process prior to use by WMATA personnel and contractors:**

- When the facility or system is under the control of the contractor/ vendor; and the facility/system is to be used by others; and
- On any portion of the current WMATA system.

**When initiated, an expiration date, as determined by the scope of the project and not to exceed six months, is assigned to the TUN and is tracked to assure action is taken to address and close any outstanding issues as documented on the TUN. If issues remain after the expiration date, a new TUN must be developed and issued with a new expiration date."**

In the cases identified in this audit, including parts of the RGO project described above, Metrorail allowed power to be cut over to new equipment despite the fact that a TUN had not been completed and issued. In interviews, WMATA personnel stated that this was done because if the power were not cut over, there would be a disruption to revenue service. Metrorail personnel also stated that the complexity of a power project and, therefore, the required documentation, also contributed to steps being taken outside of Metrorail's documented safety certification and activation process to rely on informal, verbal approvals.



**Metrorail allowed power to be cut over to new equipment despite the fact that a TUN had not been completed and issued.**

Other interviews identified gaps in understanding of responsibilities related to cutovers for new equipment, and a lack of clear, widespread guidance and training for employees and contractors directly involved in projects that may require safety certification.

This included individuals who have been directly involved in the cutover process for an extended period who indicated that they did not know that a TUN or certificate of compliance is required to put equipment into revenue service.

The Department of Safety and Environmental Management's (SAFE/Safety Department) safety certification team acknowledged that equipment has been put into service without signed TUNs.

The Safety Department has also approved TUN extensions well after the original TUN had expired while allowing the system to remain in service during the period when no TUN was in place. For example, the Safety Department signed an extension of a TUN for the Eastern Avenue E07 Tie Breaker Station on May 27, 2021. However, the original TUN had expired on March 3, 2021. On June 30, 2021, Metrorail also provided the WMSC with a TUN for College Park E09 Tie Breaker Station that had expired on June 7, 2021. A document attached to that TUN stated that there was a plan to extend the TUN, but that extension had not been signed.

In addition, other aspects of the safety certification process for new equipment have not been effectively carried out. As described above, a power room that was put into service on the Green and Yellow Line on December 12, 2020 without a TUN did not have proper protective relay settings in place to match the protective relay function algorithm incorporated into this new equipment. This contributed to the need for customer evacuations the following day from trains that stalled when power went down and could not be restored remotely. Identifying proper relay settings and other safety and operational features of new or rehabilitated equipment or systems should be critical aspects of the safety certification process. Had this been identified in the safety certification process, this safety event could have been prevented.

WMATA approvals in the safety certification process are particularly important given Metrorail's decision to have contractors generate baseline preliminary hazard analyses (PHAs), certifiable items lists (CILs) and other safety certification documentation for projects those contractors are delivering. Metrorail policies require internal review and approval of these documents, and that Metrorail personnel ultimately sign off on any TUNs and other safety certification documentation, including the final certificate of compliance that documents Metrorail's assessment that the safety certification process has been properly completed.



**Metrorail's safety certification team also indicated that there may be projects they are not aware of that should be going through safety certification.**



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CAPD indicated that at the time of this audit they were developing checklists for certificate of compliance packages.

Individuals interviewed for this audit stated that significant improvements are required for the TUN process, including to ensure contracts allow for sufficient time to review the documentation and to obtain timely sign off. SAFE's progression of a proposed TUN for final approvals cannot begin until testing is completed, which may be minutes or hours before the system is scheduled to be activated for revenue service.

The large number of TUNs Metrorail issues adds to challenges with the timeliness of reviews. With hundreds of TUNs each year, and tight schedules that do not provide space to address a potentially failed test of equipment, Metrorail appears to be placing equipment into service to meet planned schedules regardless of whether it has final approvals specified in WMATA's rules, policies and procedures.

Metrorail's safety certification team also indicated that there may be projects they are not aware of that should be going through safety certification, because there is no single centralized list available to them of current projects or the projects' statuses and SAFE is not included in reviews of contract scopes of work prior to the contracts going out for bids.

**Minimum Corrective Action:** Metrorail must follow its own safety certification processes outlined in Metrorail's SSCPP, including as it relates to Temporary Use Notices. Metrorail must fully train personnel on the requirements of the SSCPP, and must establish processes to ensure all aspects of the SSCPP are complied with, including as it relates to not placing systems into service without completed Temporary Use Notices (TUNs) or completion of the safety certification process. Metrorail must ensure that information about all projects is shared with the safety certification team, and that subject matter experts participate throughout the process. (Note: CAP in this area may incorporate elements of C-0118 developed in response to the WMSC finding issued on August 13, 2021 related to systemic safety certification deficiencies.)

**Metrorail is not documenting, tracking and conducting all preventive maintenance inspections that are required by WMATA policy, manuals and instruction.**

For several PMIs, including surge arresters (annual), annunciators, bus ducts, low voltage AC breakers (three-year) and ETS boxes, Reliability Centered Maintenance Planning (RCMP) stated that no preventive maintenance (PM) requirement exists, however there are PMs and required



**Metrorail is not tracking completion of these procedures or otherwise systematically ensuring the work is properly scheduled.**

PM frequencies listed in Metrorail's maintenance manuals, separate procedures, or Maintenance Control Policy. Metrorail is not tracking completion of these procedures or otherwise systematically ensuring the work is properly scheduled.

A sampling of Maximo work orders also demonstrated that TRPM is not conducting certain essential Preventive Maintenance Inspections (PMIs) on DC relays (176 relay and 182/183 relay). This is particularly concerning because these solid-state relays are beyond their life expectancy. These PMIs also did not appear on RCMP's monthly compliance tracking lists that are intended to ensure that required maintenance is scheduled and completed. Relays in good working condition are essential to keeping the power system healthy. No Maximo work orders nor any test sheets could be provided for the last PMI conducted on the E05 Traction Power Substation Feeder DC Breaker 32 176 (DC Overcurrent) and 182/183 (Recloser) relays. These PMI procedures should have been carried out on all of these solid state relays, however they have not been conducted.

As described above, two of these type of relays failed on December 13, 2020, leading to two trains carrying riders becoming stranded in tunnels near Georgia Ave-Petworth and Fort Totten stations (W-0084). Proper maintenance may have prevented these failures or identified that these failures were imminent so that the relays could be repaired or replaced.

Document reviews and interviews identified that Metrorail's component failure tracking reports include indicators such as revenue service delays and specific locations that have had problems in the past month, but do not provide substantive details on the causes of failures that could be used to identify trends in root causes of failures or the need to verify completion of or to increase the frequency of one or more PMIs.

For required PMIs that Metrorail is tracking, Metrorail stated overall compliance is 99 percent. PMIs that Metrorail's tracking shows were not conducted in 2019 include 2 of 6 ETS inspections and 1 of 3 transformer oil inspections. ETS boxes are used to de-energize power in an emergency, and transformer oil inspections are intended to mitigate the risk of transformer problems including transformer explosions.

**Minimum Corrective Action:** Metrorail must identify all preventive maintenance work that is required and ensure that all required preventive maintenance work is properly scheduled, documented, tracked and conducted. Metrorail must identify any additional preventive maintenance work or inspections that are required to make up for work that was not completed, and must assess whether the lack of maintenance requires any preventive maintenance to be conducted on a more frequent basis.

**Although Metrorail has made significant improvements to its traction power systems since 2015, Metrorail continues to rely on vital elements of the traction power system that are beyond their useful life.**



**Metrorail is relying on vital traction power equipment that is beyond its useful life, and has not fully followed through on implementation of prioritized renewal plans to ensure a state of good repair.**

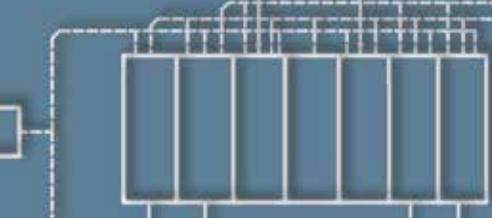
Although Metrorail has made significant improvements to its traction power systems since 2015, Metrorail continues to rely on vital elements of the traction power system that are beyond their useful life.

For example, in the December 13, 2020 safety event described above (W-0084), customers were stranded on two trains near Georgia Ave-Petworth and Fort Totten stations after relays that were beyond their useful lives failed, shifting the electrical load to newly installed switchgear. That switchgear had improper relay settings, so that backup power feed also de-energized (see finding 1). When, as in this event, type 176 relays fail, Metrorail only learns of the failure if a technician does work on the breaker.

Metrorail had been conducting a relay modernization program to upgrade the existing electromechanical and solid-state relays (many of which are beyond their life expectancy) to multi-purpose (MPR)/digital microprocessor-based relays as part of Metrorail's corrective action plan for FTA 17-1-13 in response to a finding that WMATA did not have a formal program for assessing the condition of relays at traction power substations prior to proposed upgrades. Metrorail completed eight locations. However, Metrorail has now removed that program from the capital budget after the CAP was closed based on the creation of the program, despite the purpose of a CAP being to institute lasting change. It is not clear whether Metrorail currently plans to install even those relays that have already been procured for 10 additional locations, let alone other locations systemwide as had been previously committed to. The WMSC may reopen a closed CAP if necessary.

Failure analysis reports from September 2019 through April 2021 highlighted other trending issues such as burnt trip coils that can be leading indicators of more significant problems. A common cause of burnt trip coils, particularly with older switchgear, is the infiltration of particulate matter and the corrosion of smaller components. Protections against this would include thorough cleaning of breakers during regular preventive maintenance and taking steps to clean tunnels or otherwise manage particulates in the air such as metal and brake dust.

It is positive that Metrorail now has a priority list of traction power replacement needs based on age, history, operational issues and criticality, and is attempting to change out approximately 39 tie-breaker or power substations over the course of a decade (through 2026). This prioritization assessment includes an identification of elements of the system that remain in service 40 years after Metrorail opened, parts availability and



**Because upgrades to new equipment cannot be implemented all at once, other mitigations are necessary.**

other aspects. As this audit was being conducted, Metrorail was separately pursuing a first large-scale contract for the replacement of electrical equipment in nine tie breaker stations and 12 traction power substations to upgrade power capacity. The prioritization sets elements of the Red Line as priority 1 and priority 2. Other traction power substations or tie breaker stations that have not been upgraded since 2004 would follow under additional contracts. Significant portions of this project include upgrading substations for eight-car trains at expected service frequencies, while other aspects, including the Red Line between Medical Center and Shady Grove, include replacing obsolete systems that have parts that are no longer available.

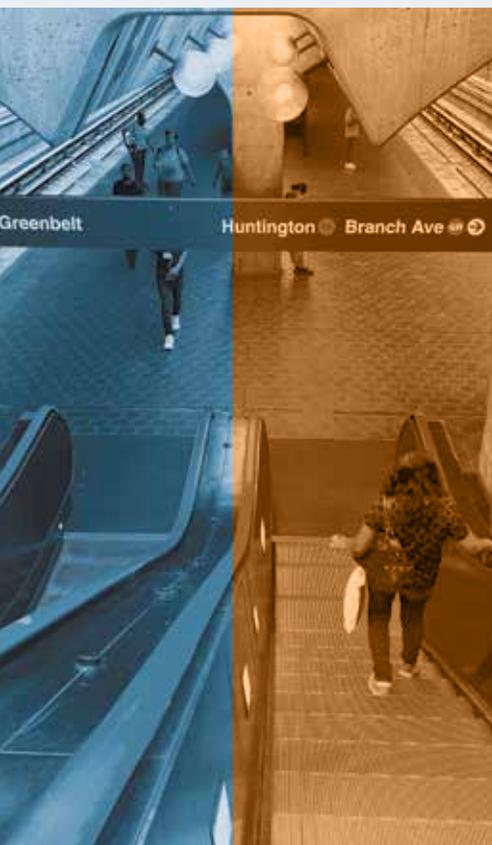
However, the contract does not address more immediate needs related to equipment that remains in use beyond its useful life, in some cases without proper preventive maintenance (see finding 2).

Given the age of systems that will remain in service and parts availability challenges, Metrorail is keeping some of the switchgear lineups that have been replaced so that the parts can be used elsewhere if needed, but Metrorail is not yet fully tracking those parts or ensuring adequate storage for those parts.

Because upgrades to new equipment cannot be implemented all at once, other mitigations are necessary. Allowing relays and other critical equipment to remain in service as-is, well beyond their expected useful life, indicates a systemic issue of not properly planning for and implementing safety improvements and continually ensuring a state of good repair. If there are barriers to achieving this, mitigations are available such as increasing the scheduled frequency of preventive maintenance until long-term rehabilitation programs are fully implemented.

Interviews for this audit also identified that there are a number of “temporary” cable changes or splices that have been allowed to remain in the system as effectively permanent connections, which similarly require documentation and tracking, a heightened level of inspection and maintenance, and prioritization for proper permanent replacement.

**Minimum Corrective Action:** Metrorail must develop and fully implement plans and processes to ensure the traction power system is in and will remain in a state of good repair. For example, Metrorail must continue to fund the relay modernization program through completion system wide, must define, implement and sustain other traction power modernization efforts to prevent systemic issues, and must identify and implement any interim mitigations required until these modernization efforts are complete.



**Metrorail is not comprehensively reviewing or conducting adequate internal oversight, review and coordination of PMI test data.**

**There is inadequate awareness, documentation, interdepartmental coordination, training and supervisory oversight to ensure knowledge of and compliance with documented procedures.**

Metrorail is not comprehensively reviewing or conducting adequate internal oversight, review and coordination of PMI test data to ensure that proper procedures are followed and that the system is meeting safety requirements.

A review of documents provided for this audit identified forms such as daily inspection reports, supervisory field audit sheets, pre-job safety briefings, and TRPM Power AC Unit Substation/AC Room Facility Inspection Data Sheets that were not completed or were not completed with the required level of detail.

Supervisory Field Audits are missing information, Pre-job Safety Briefings and PMI datasheets are missing the supervisor's signature, Daily Inspector Reports are missing referenced information (e.g., escort is mentioned in the document; however, the person is not included in the WMATA personnel section of the document), some forms used are out of date or have blank version control fields, and TRPM Power AC Unit Substation/AC Room Facility Inspection Data Sheets are not filled out properly.

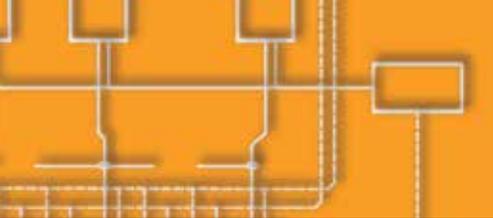
The same forms were filled out in many different ways, yet still were approved by supervisors. This suggests training deficiencies related to the use of the forms (or issues with the forms themselves), and deficiencies in training on or understanding of supervisory oversight responsibilities.

In addition, investigation W-0074 into an improper roadway worker protection event near Rockville Station on November 26, 2020 identified that Traction Power Maintenance personnel had not been conducting adequate roadway job safety briefings, and that supervisors had not been providing required oversight of those briefings or appropriately reviewing roadway job safety briefing forms as required.

Supervisors would benefit from additional training such as maintenance management training to do their jobs effectively. The listed mandatory management and supervisor training requirements for supervisors do not include courses on actual management of maintenance and inspection activities to ensure the effectiveness of such activities. In any case, at the time of this audit, five new supervisors were overdue for the limited, general new supervisor training that Metrorail requires.

Supervisors and other managers interviewed stated that supervisors are put in supervisory positions without any meaningful training on how to carry out supervisory duties. Although these individuals may have significant technical knowledge, they are not provided with the opportunity to learn how to effectively act as a manager or with all specific responsibilities.





**Work conducted outside of approved procedures leads to unreliable records, or records that are skewed.**



Supervisor Field Maintenance Audits, for example, could be a valuable tool to ensure work is properly done and employees continually improve and grow. However, the forms provided for this audit demonstrate that the reports are completed in a superficial fashion with vague, general comments.

Employees interviewed for this audit also expressed a desire for more refresher and equipment-specific training, which Metrorail is taking steps to make more available.

Work conducted outside of approved procedures leads to unreliable records, or records that are skewed. For example, personnel interviewed for this audit reported instances where items entered into Maximo with the wrong category or code have led to REAM reports that do not accurately reflect current reliability trends or PMI completion rates. This creates a risk that a safety trend may not be properly identified in a timely fashion.

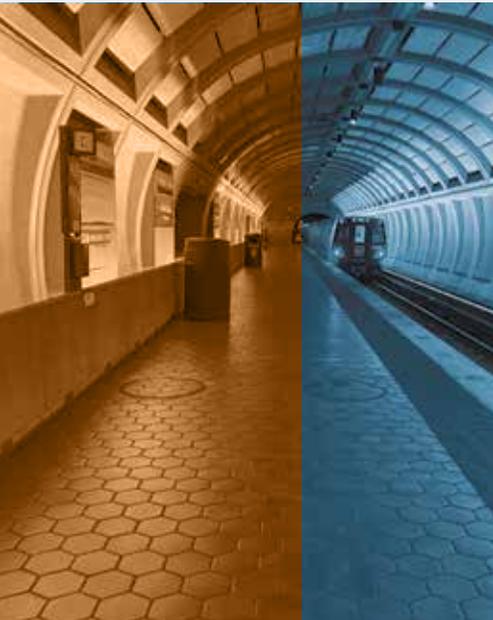
TPOE engineers reported receiving significant pushback when they have attempted to directly review PMI test sheets and data to develop an independent assessment of the system's health, to confirm that test reports are being properly completed, and to determine whether the system is operating within documented safe parameters. While in other respects this audit did not identify the same degree of departmental siloing that the WMSC has identified in other audits, the lack of complete coordination and cooperation of engineering and operations groups is a concern. Engineering review of PMI data and test sheets would help ensure the proper procedures are followed as stated in the PMI, proper test sheets are being used to collect the data, and that the data is within proper ranges and tolerances.

The TRPM-1000 Manual does not provide additional details on completion of the forms for reference, and a TRPM-2000 Manual that is intended to focus on maintenance management and administration remained in development at the time of this audit.

Some employees interviewed for this audit were not familiar with specific procedures related to their work, or with which manual or policy governs their work. Others stated that they did not believe there were written procedures for actions such as cable crimping, heat shrink applications, or various preventive maintenance actions, and they simply acted based on years of experience. These procedures are specified in Metrorail documents.

When compliance personnel have identified these or other issues in their spot checks or audits, they frequently close the issues based solely on a response from an area supervisor that the issue has been corrected, without always requiring documentation. The WMSC was told that this is due to the traction power compliance staff consisting of only two people for the entire system.

**Metrorail does not monitor which employees may or may not have training on specific equipment such as AC and DC switchgear that is installed in their assigned region.**



**Minimum Corrective Action:** Metrorail must specify requirements for, develop and implement adequate initial and refresher training for all traction power personnel (frontline employees and supervisors/managers) to ensure that they have a complete understanding of and fully and accurately document the tasks, processes, procedures and other responsibilities that they are required to carry out. These requirements may vary based on position and role. Metrorail must establish and implement a process to ensure that engineering and operations departments collaborate to provide oversight of procedures, test results and other activities, such as regular spot checks.

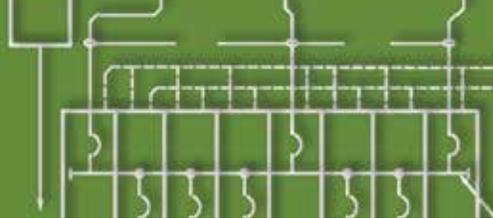
**Traction Power Maintenance employees do not get all required information and training to maintain equipment that they are directed to work on, and there is no process in place to ensure that personnel are trained on specific equipment prior to working on that equipment.**

Different traction power equipment designs, manufacturers or installations require specialized knowledge to properly maintain and repair, however Metrorail has no process to ensure that Traction Power Maintenance employees have been trained on new equipment before they are assigned to work on that equipment.

For example, Metrorail does not monitor which employees may or may not have training on specific equipment such as AC and DC switchgear that is installed in their assigned region at the time employees move from one region to another during a job assignment pick or other transfer. The only way this information can be identified is by looking up an individual's training history if a supervisor were to request such a search before a specific job assignment, or by attempting to search for a specific course. However, training course codes have not been consistent over time, making a course-based search difficult to rely upon, and supervisors are not required to have maintenance management training that could serve, among other things, as a basis to trigger such a question.

Technician job classifications also do not indicate the actual responsibilities of a given employee, and do not provide specific information regarding the capabilities of that employee to work on specific equipment. Metrorail does not have specific training standards and specific performance expectations for each classification (D, C, B, A, AA). Employees are able to move up to the next level after passing certain tests designed to indicate general competence and knowledge. These tests do not identify the specific types of equipment that Metrorail has appropriately trained each technician to work on.

Maintenance and inspection employees get limited training on new equipment because Metrorail does not have mockups that can be used for detailed hands-on training that is provided by the manufacturer or by Metrorail employees who get that initial manufacturer training. Metrorail personnel stated that the new equipment



**Metrorail does not have mockups that can be used for detailed hands-on training.**



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that is installed in the system cannot be effectively used for this purpose since that would impact the warranty, so many employees are only able to see the manual and look at the equipment, but do not get any hands-on experience. Metrorail could require mockups be provided as part of project contracts for use in training to improve maintenance of the equipment in the field. The circumstances are similar for equipment in Silver Line Phase 2, which remained under construction at the time of this audit.

In a positive effort by personnel involved in traction power training, given the limitations, they attempt to assign spaces in classes in a way that brings in some people from each division of the department, with slightly more seats provided for the region expected to most immediately be working on the equipment.

A positive aspect of the WMSC's review in this area is that Metrorail instructors generally revamp the initial training information provided by manufacturers in an effort to make it more understandable and useful to frontline employees in any future classes that may be led by Metrorail instructors.

This finding is similar to Finding 11 in the 2021 Automatic Train Control & Signaling Audit.

**Minimum Corrective Action:** Metrorail must specify, implement and document training requirements that must be met prior to work on specific equipment in the field. Metrorail must establish a process to set and document training requirements for each new type of equipment. Metrorail must develop and implement a process to ensure that technicians are only assigned to work on equipment that they have been fully and properly trained to work on.

**Metrorail is not effectively identifying, tracking and mitigating hazards related to high voltage and traction power.**

Metrorail is not maintaining a hazard log for traction power, and has not yet established adequate safety promotion to ensure employees are aware of the required systemic approach to reporting and mitigating hazards.

In response to the WMSC's March 2021 request for hazard logs for traction power, Metrorail stated that the Safety Department did not have any hazards in its hazard management module for Traction Power Maintenance in 2020. Metrorail also said it had no documents or prioritization plans related to hazard risk assessment.

The two safety hotline calls listed in the documents provided for this audit as related to traction power do not involve issues raised by departments responsible for traction power. One, dated in the spreadsheet as October 22, 2020, relates to snowmelter preventive maintenance instructions that Automatic Train Control (ATC) Maintenance personnel were concerned violated SOP 28's safety requirement that third rail power

**Managers interviewed for this audit stated that they had not been aware of a requirement to notify the Safety Department of some conditions or occurrences.**

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be de-energized for such work. This was covered in the WMSC's ATC Audit. The other call, dated December 23, 2020, was based on a Track and Structures crew operating a prime mover in the New Carrollton Yard that reported a WMATA vehicle that belonged to TRPM ran the stop sign at a road crossing, nearly creating a collision.

Managers interviewed for this audit stated that they had not been aware of a requirement to notify the Safety Department of some conditions or occurrences, because they were under the impression that an entry into Metrorail's Safety Measurement System automatically notified appropriate parties. Even then, the system was being used to enter information about incidents and occurrences, not about hazards, and there had not yet been safety management system or PTASP training.

When the WMSC provided additional opportunities to provide hazard logs, Metrorail provided a limited hazard log that appeared to begin in September 2020. Based on minutes of departmental safety committee meetings from January through May 2021, this log includes items that rose to the departmental safety committee in that time period.

It appears Metrorail has project-specific hazard logs for at least some capital projects, but has not instituted the comprehensive hazard tracking and management process envisioned by the PTASP that became effective on December 31, 2020.

**Minimum Corrective Action:** Metrorail must take definitive steps including training personnel to implement safety management systems principles such as hazard identification, tracking, mitigation and monitoring, and must develop, implement and monitor procedures to ensure that hazards are properly identified and addressed.

### **Metrorail is behind schedule on its floating slab testing to monitor for deterioration due to stray current.**

Metrorail has taken the positive steps of establishing a corrosion control and testing program for floating slabs as required due to FTA findings in 2016 and CAP FTA-17-1-4, which the FTA closed in March 2019. However, this testing program is now behind schedule.

Floating slabs are sections of reinforced concrete that support the tracks in direct fixation areas that require a floating slab as a mitigation to reduce the impact of vibration from passing trains. The rebar in the slabs can deteriorate rapidly due to corrosion if there is uncontrolled stray current and improper bonding.

Initially, Metrorail had identified 26 floating slabs that would need to be tested over the course of the program created due to FTA-17-1-4. In interviews for this audit, Metrorail personnel stated they have now identified a total of approximately 75 floating slabs that need to be tested.



**Metrorail is not currently on schedule to complete this testing in 2023.**

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**Current as-built schematics are critical to safe and effective maintenance and inspection of traction power facilities.**

In November 2017, Metrorail had set a five-year timeframe to test all floating slabs across the system starting in 2018, and said it would then prioritize testing after that time.

Metrorail is not currently on schedule to complete this testing in 2023.

**Minimum Corrective Action:** Metrorail must assess whether additional resources are needed to complete floating slab testing on schedule, and to ensure that the program continues as required. If such resources are required, Metrorail must implement the appropriate changes.

**The latest as-built schematics are not available in each traction power facility, as required by the TRPM-1000 and Metrorail preventive maintenance instructions.**

Current as-built schematics are critical to safe and effective maintenance and inspection of traction power facilities, but personnel interviewed for this audit stated that there are multiple traction power substations and tie-breaker stations without current schematics.

Several people interviewed for this audit also stated that the log books documenting entry to and work in each room are not always signed as required to document who has been in the room and what tasks have been carried out.

The TRPM-1000 Manual and Metrorail preventive maintenance instructions require current schematics in each power room. Accurate schematics are required for employees to fully and safely carry out their work.

While several people interviewed for this audit said schematics in traction power rooms are more frequently present and correct now than in the past, some mechanics are regularly bringing separate schematics with them to have an available reference. These other schematics may or may not include all changes that have been carried out in the room.

The presence and accuracy of these schematics in each room are supposed to be verified through supervisor field maintenance audits, however that process does not appear to have been effective to this point.

TRPM acknowledged this deficiency.

**Minimum Corrective Action:** Metrorail must document that all traction power facilities have current as-built schematics, and must develop and institute an effective process to ensure that these schematics remain present and up-to-date.

## RECOMMENDATIONS

### ① Metrorail does not have a policy, process or procedure to ensure effective prioritization of corrective maintenance work orders.

Managers interviewed for this audit stated that there is no systematic approach to identifying when a corrective maintenance work order is submitted, or to determining how to prioritize corrective maintenance work orders.

One manager stated that any issues having an impact on revenue service are generally addressed first, but that there is no documented process to determine which other corrective maintenance work orders are most important to address.

Maximo tickets can be entered with a priority level, but in practice Metrorail does not fully utilize that feature.

Managers stated that they sift through work orders to try to figure out what is most important based only on their experience.

**Possible Corrective Action:** Metrorail may develop and implement a process to effectively prioritize and address corrective maintenance work orders.

### ② Metrorail risks equipment quality and availability issues that impact operational safety due to gaps in materials tracking, storage, and procurement practices.

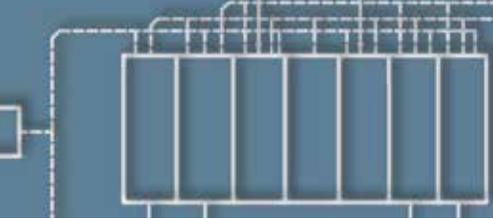
Critical repairs can be compromised without a comprehensive list of equipment that Metrorail has on hand. If Metrorail has equipment but is not aware of that, due to a lack of tracking of traction power equipment that is kept for spare parts, then those spare parts cannot be used and accessed in a timely manner to prevent or address safety issues. Information provided for and interviews during this audit identified that Metrorail does not have an inventory of all salvaged equipment, and that some facilities are not fully monitored.

Metrorail has also experienced problems with data centers due to the procurement of improper batteries. The incorrect batteries were used for Metrorail data centers, which led to a need to replace them in just a few years. These batteries were procured without consulting Metrorail's battery experts in traction power departments.

Metrorail has experienced other issues, including with batteries, due to insufficient planning for order lead times.

**Possible Corrective Action:** Metrorail could complete an inventory of all parts and materials on hand and establish a process to ensure that this inventory is updated in a complete and timely fashion as salvaged materials are brought to storage.





**Some tools are overdue by several months, while others are overdue for calibration by more than eight years.**

**The Metrorail system and staffing has grown significantly since the 1980s, and job responsibilities have evolved outside of the written job description.**

### **3 Metrorail databases include many electrical tools that are beyond their required calibration dates.**

Metrorail provided a list of hundreds of tools used for traction power work that are overdue for calibration. Some tools are overdue by several months, while others are overdue for calibration by more than eight years.

These tools include digital multimeters, clamp meters, relay test sets, handheld radios, and insulation testers, each of which must be calibrated to carry out work safely or to properly complete inspections that help ensure that the system element the tool is used on is safe.

Tools 3-16 months past certification date include those assigned to traction power field locations, Greenbelt Yard and West Falls Church Yard.

Even if other tools that were last due for calibration in 2013, 2014 or 2015 are not intended to still be in use, not documenting that creates a risk that the tools remain available for use on Metrorail property for use without proper calibration.

**Possible Corrective Action:** Metrorail may revise, establish, and provide adequate training on procedures to regularly review lists of tools, ensure tools are up to date on calibration, ensure tools out of calibration are promptly removed from service until re-calibration, document when any tools are permanently removed from service, and appropriately mark those tools to ensure they are no longer used in the WMATA rail system.

### **4 Some WMATA job descriptions have not been reviewed in more than 30 years.**

Despite significant changes to the Metrorail system (and to general workplace technology), multiple traction power job descriptions have not been updated since the 1980s.

For example, the job descriptions for Mechanic A (Electrical-Power Technician) and Mechanic B (Electrical-Power) provided to the WMSC during this audit have not been updated since 1983 and 1980 respectively. A “Mission-Essential Worker” designation was applied to these existing job descriptions in January 2020.

Such a significantly outdated job description can contribute to challenges in hiring people with the appropriate skillsets and to challenges in determining the actual number and type of employees required to conduct work fully and safely.

The Metrorail system and staffing has grown significantly since the 1980s, and job responsibilities have evolved outside of the written job description.

**The job descriptions also predate system safety requirements and the defined need for interdepartmental cooperation to achieve a positive safety culture.**

For example, current position descriptions for Mechanic Electrical Maintenance and Test Technicians approved in 2019 include references to Engineering Modification Instructions (EMI) and knowledge of electrical standards such as those from the Insulated Cable Engineering Association (ICEA), National Fire Protection Association (NFPA), and Institute of Electrical and Electronics Engineers (IEEE). The older job descriptions do not include this information, despite the need to apply these standards to provide the greatest level of safety.

As the WMSC identified in a similar recommendation in the recent Revenue Vehicle (Railcar) Audit, 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 may develop and implement a procedure to ensure that job descriptions and responsibilities are reviewed on a specified regular basis to reflect current operating realities, current code requirements, and current regulatory requirements.

## Other Observations

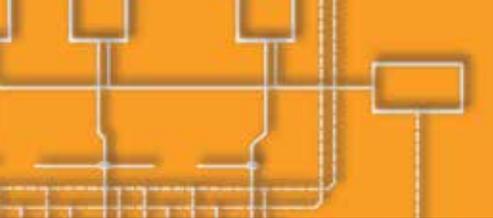
This audit was conducted during the ongoing, long-term COVID-19 public health emergency.

Initially, health precautions due to the public health emergency reduced daily staffing and the capacity of training courses. Training course capacity had expanded at the time this audit was conducted.

Metrorail generally maintained the pre-existing traction power crew work hours during overnight shifts during the public health emergency.

At the time of this audit, Metrorail was also preparing to take custody of the Silver Line Phase 2 extension to Dulles International Airport and Ashburn, including a new rail yard and numerous traction power assets.



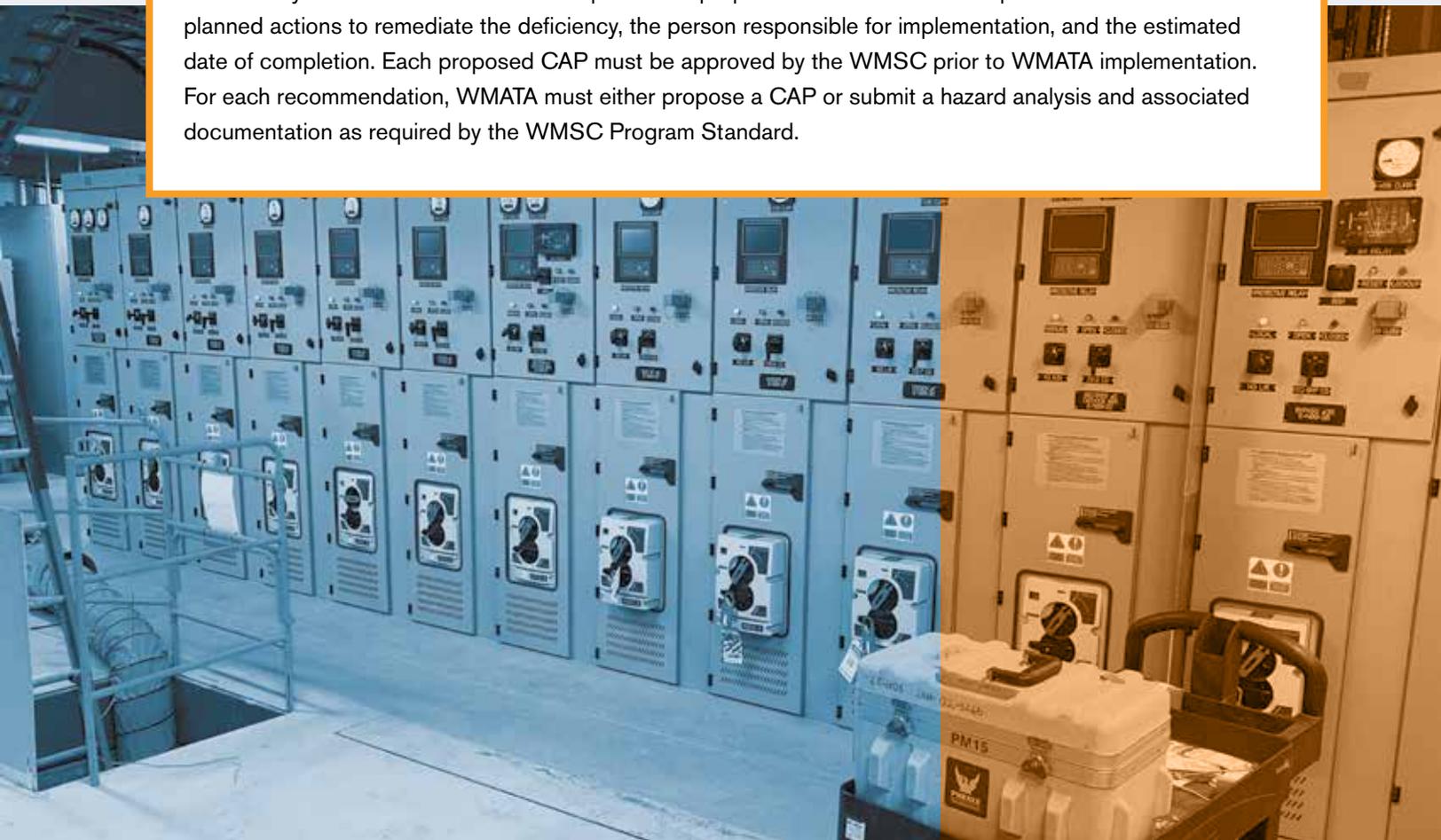


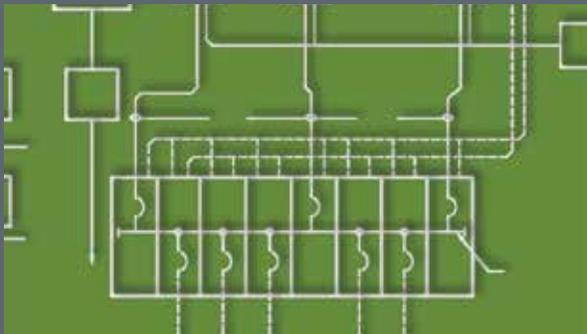
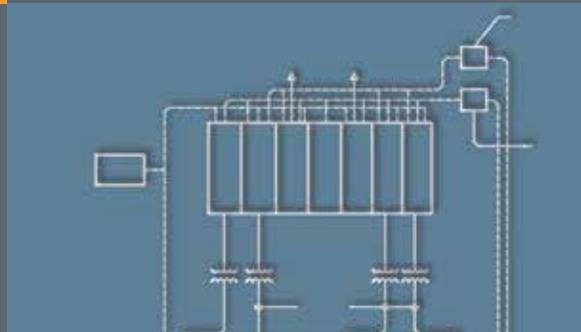
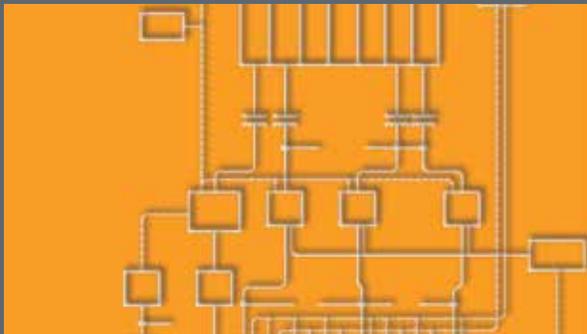
These preparations included work to hire new employees that would be used to adjust maintenance region responsibilities. The new region is expected to be responsible for regular maintenance work on the entirety of the Silver Line, removing that responsibility from the region that is based at the West Falls Church Yard.

Several individuals interviewed for this audit expressed suggestions that may improve Metrorail's capabilities and efficiencies, but that do not relate to items that are findings in this audit. For example, some mechanics requested additional support in the learning and upgrade process to move from one grade level (D, C or B) to another (C, B, A or AA), and another suggested an improved switching suit used by other electrical workers outside of Metrorail that could provide the same level of electrical protection while making it easier to see clearly and maneuver precisely.

## 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. For each recommendation, WMATA must either propose a CAP or submit a hazard analysis and associated documentation as required by the WMSC Program Standard.





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