

Tri-State Oversight Committee



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DRPT

Three-Year Safety and Security Review of the Washington Metropolitan Area Transit Authority

Radio and Communications Systems

Elements 15 and 16

Review Conducted: February 2015

Draft Report: April 9, 2015

Final Report: July 8, 2015

Introduction

Representatives from the Maryland Department of Transportation (MDOT), the District of Columbia Department of Transportation (DDOT), and the Virginia Department of Rail and Public Transportation (DRPT) comprise the Tri-State Oversight Committee (TOC), which provides regular oversight of the Washington Metropolitan Area Transit Authority (WMATA) Metrorail system. To comply with State Safety Oversight Final Rule 49 Code of Federal Regulations Part 659 (Part 659), the Federal Transit Administration (FTA) requires states to designate a State Safety Oversight (SSO) agency to administer safety and security programs for rail transit and fixed guideway systems within their jurisdictions. Specifically, 49 CFR Part 659 requires TOC to conduct an on-site safety review of each element of the WMATA System Safety Program Plan (SSPP) at least once every three years. These reviews must assess WMATA's implementation with all 21 elements of its SSPP and seven elements of its Security and Emergency Preparedness Plan (SEPP), along with related plans and procedures. Beginning in 2013, the TOC has split its Three-Year Safety and Security Review topic areas into separately occurring reviews spread out during a three-year period.

The following report documents the observations and findings of the TOC's review of radio and communications systems maintenance. This predominantly involved the radio system, though other assets were evaluated and are described later in this report. Generally, this review focused whether WMATA's maintenance program complies with its own written plans as well as industry standards and best practices. The relevant SSPP elements for this review were all or part of:

- Element 15: Maintenance Audits and Inspections
- Element 16: Training and Certification

The TOC Program Standard and Procedures defines WMATA requirements for these elements in Section 12 and in Appendix B. Specific requirements are cited further, below.

Methodology

In advance of the review, the TOC requested and reviewed relevant WMATA plans, procedures, checklists, and reports. The on-site portion of the review occurred Feb. 9-10 and 12, 2015. During the on-site review sessions, the review team interviewed WMATA personnel and reviewed various documents and records on-site to assess compliance with procedures. As the review progressed, TOC representatives discussed preliminary findings and addressed questions from WMATA personnel. This report identifies conditions evident during the review period, regardless of the current progress of potential remediation activities.

In attendance during the interviews from WMATA were several personnel from departments sharing responsibility: the Communications Branch (COMM), Track and Infrastructure Engineering Services (TIES), Shop and Material Support (SAMS radio

repair), Information Technology (IT), and Technical Training and Document Control (TTDC). The Office of Emergency Management (OEM) Director joined part of the first day by conference call. Additional personnel from Quality Assurance and Warranty (QAAW) and Safety and Environmental Management (SAFE) observed; WMATA conducted a simultaneous Internal Safety and Security Audit.

The first day involved interviews and discussion regarding: COMM/TIES/SAMS organizational structure and staffing; radio network architecture; maintenance procedures and checklists; MAXIMO integration; methods for interdepartmental communication regarding radio repair and calibration; interoperability for external first responders; training for COMM technical and radio users agency-wide; and ongoing system upgrade projects. The second day involved follow-up discussions on topics from the previous day, as well as inspection of MAXIMO records for preventive maintenance inspections, corrective maintenance, and related key performance indicators. The review team also covered some non-radio communications systems, such as the fiber-optic network and Emergency Trip Station phones. The third day focused on the Fire and Intrusion Alarm (FIA) system.

Findings are categorized as Findings of Non-Compliance or Findings of Compliance with Recommendation. A Finding of Non-Compliance refers to an instance of WMATA operating out of compliance with an applicable internal or external written requirement, plan, policy, rule, standard, or procedure. All findings require WMATA to develop an appropriate Corrective Action Plan (CAP) and take action to achieve compliance with the applicable requirement.

A Finding of Compliance with Recommendation refers to a condition whereby WMATA may technically be conducting business in compliance with existing WMATA, TOC, or FTA procedures and requirements; however, there may be no relevant written plan, policy, or procedure in place, or the existing plan, policy, or procedure is not in accordance with industry best practices. Even if the issue is not “non-compliant,” these findings may also be safety-critical in nature. In response to a Finding of Compliance with Recommendation, WMATA is required to formally respond in writing with an appropriate CAP to update relevant plans, policies, rules, and/or procedures, or to address a particular identified resource or organizational issue. If WMATA determines no CAP is necessary, the agency must complete and provide a full, documented hazard analysis in accordance with its hazard management procedure in order to justify taking no action and accept the level of risk associated with the finding.

This review, including all findings presented in this report, intends to assist WMATA with enhancing system safety throughout Metrorail operations. WMATA received a draft of this report and provided comments, which were considered for integration into this Final Report. **Upon receipt of this Final Report, WMATA has 45 days to submit CAPs in response to each finding. Each proposed CAP must include the planned action, person responsible, and estimated completion date.** TOC thanks WMATA for providing updates on progress already made toward addressing the findings. TOC

requests that WMATA resubmit the material along with its proposed CAPs so that they can be consistently approved and verified.

The TOC would like to thank WMATA personnel for their time, cooperation, and forthrightness throughout the review process.

Current Conditions

Radio communications maintenance is the responsibility of the Superintendent - Communications System Maintenance, who reports to the Assistant General Superintendent - ATC and Communications; this person in turn reports to the TIES General SuperRadio Communications group of COMM is organized by geographic areas, with 26 technicians, 3 shift supervisors, and a manager who works across three shifts. There are also COMM groups for Field Maintenance and Electrical Safety and Security, discussed later in this report.

WMATA uses a Comprehensive Radio Communications System (CRCS) that supports MTPD, Metrobus, Metrorail, PLNT, and ELES pagers. The equipment is a Motorola 3.0 SmartZone trunked simulcast UHF (490 MHz) system operated in the digital mode. The system includes ten RF antenna sites above ground, one of which acts as a donor site feeding radio to fiber converters. The radio signals are then distributed over WMATA-owned fiber to 26 stations, where it is reconverted back to radio frequency for distribution to the tunnels and station areas. The system has 21 channels: 14 for voice, four for Automatic Vehicle Location/bus data, one for police data (Computer Aided Dispatch), and one for paging. Users are assigned to talk groups with related users, so they do not hear unnecessary transmissions from other talk groups.

This system has reached the end of manufacturer support by Motorola. WMATA acknowledges the end-of-life status of this system and plans on issuing a solicitation in summer 2015 to upgrade the radio infrastructure to a P25 700 MHz system. WMATA has begun incremental upgrades of the Zone Controller and MASTR site to P25 technology. WMATA has been granted 16 700 MHz frequencies, which it plans to have licensed by the end of 2015.

An older conventional VHF (160 MHz) system was decommissioned in January 2015. RTRA and maintenance groups were among the last to switch from the analog VHF to the digital UHF system.

In tunnels, the signals are broadcast and received by a system of approximately 270 bi-directional 490 MHz amplifiers and radiax cable. The radiax cable is mounted on tunnel walls and acts as a continuous antenna. It is fed by the transmitter/receivers with bi-directional amplifiers about every 2,200 feet to boost the signal. BDAs are configured in a cascaded configuration along 26 segments. Antennas are also located on the platform mezzanine in stations to provide radio coverage in the public areas of the stations.

WMATA also owns and maintains 800 MHz BDAs that share the same radiax as the 490 MHz BDA system. These BDAs are typically spaced along the radiax at 1,000 foot intervals due to the higher cable loss at 800 MHz. These BDAs are installed to support the public safety systems of local and county jurisdictions in the tunnels. The 800 MHz BDA system uses above-ground antennas to receive the signals for redistribution in the tunnels and station areas.

COMM/TIES personnel reported that, per the CRCS system design, there are several known areas of poor to no radio coverage within the system. This condition exists in non-public areas of stations, such as Train Control Rooms, and in an approximate 150 foot area of phasing just outside each tunnel portal where the in-tunnel radio signals meet above-ground radio signals at or nearly at the same signal strength, and as a result are out of phase due to signal delays in the fiber system. Based on numerous interviews and records reviews, it does not appear that radio users throughout WMATA are aware of this situation, which may cause them to confuse “dead spots” requiring repair with known areas with a permanent lack of coverage, per system design (see Finding of Non-Compliance 1). WMATA has a radio upgrade project underway to enhance these antennas to expand coverage into selected “back room” areas of the stations only, but not to the other known areas of phasing.

COMM conducts its own maintenance of its radio infrastructure. Above-ground remote antenna sites are inspected annually, with bi-weekly site inspections for cleanliness and general alarms. The below-ground antennas (BDAs) are also inspected annually. WMATA maintains both the 490 MHz and 800 MHz BDA systems.

Subscriber radios (i.e., portables, mobiles and railcar units) are sent to SAMS (operated by TSSM) for repair, when necessary. When faulty, railcar radios are removed by CMNT these too are sent to SAMS for repair. Mobile radios in buses are the responsibility of the private contractors.

TTDC is responsible for technical training of communications technicians. At the time of this review, CAP 10-176 remained open from the 2010 Triennial Review; this involved lack of formal technician training on the 490 MHz radio system. It is projected for full implementation by October 31, 2015. So far, TTDC has developed the first half of eight courses anticipated regarding CRCS maintenance. TOC encourages TTDC/COMM to have its instructor(s) receive training from system manufacturers as part of this curriculum development, and for any new equipment in the future. The training section beginning on page 94 of the COMM Maintenance Control Policy identifies mandatory training and objectives for on-the-job training.

Regarding non-radio communications equipment, COMM Field Maintenance is responsible for CCTV, FIA panels, public address speakers, station emergency intercoms, and other non-safety related equipment. Some of these assets were covered during the TOC’s 2014 Triennial Review of Stations Maintenance. Diagnostic systems monitor CCTV and FIA, which means that preventive maintenance does not occur; problems generate e-mail alerts to assigned personnel. FIA panels in kiosks at stations

are nearing obsolescence and are gradually being replaced as they fail. See Finding of Non-Compliance 5 and Findings of Compliance with Recommendation 9 and 10 below regarding Field Maintenance open preventive maintenance work orders, inspection procedures, and communication from the Maintenance Operations Center (MOC)/Rail Operations Control Center (ROCC).

IT conducts testing of Emergency Trip Station (ETS) phone every six months. Although IT does not use MAXIMO, it keeps a separate database documenting its inspection cycle and open tickets. Subway emergency shaft telephones were covered during the TOC Triennial Review of Subway Emergency Egress.

This review identified six Findings of Non-Compliance and 12 Findings of Compliance with Recommendation. The implementation of corrective actions in response to all findings will result in improved functionality and maintenance of radios and communications systems and prevention of recurrence of various radio coverage issues that have arisen during previous incidents.

Findings of Non-Compliance (NC)

Finding of NC 1: Mobile and portable radio users throughout WMATA lack adequate training to understand limitations on functionality. Many end users have not received thorough training on the 490 MHz portables and mobiles. WMATA has transitioned all system users from the conventional VHF system to the digital trunked 490 MHz system over the past year. COMM personnel noted that some end users do not understand the meaning of various features and tones of the digital portable and mobile radio equipment; as a result, they assume there are widespread dead spots when in fact there may be an issue with their individual radios. The end users should be able to understand the meaning of the signal strength bars along with various signal tones and alerts, such as “out of range,” denied access, and busy signal. End users should be trained to understand their responsibility and the importance of checking the calibration of their radios and confirming full battery charge of their radios prior to use. Further, there are known, permanent areas without full radio coverage (such as Train Control Rooms, phasing areas just outside the tunnels, and emergency egress shafts, per design of the system); front-line personnel may incorrectly assume their radios are supposed to function fully in these areas. It is also important for external first responders to be aware of the permanent lack of coverage in these areas, which can be critical during an emergency. A complete training and certification program is part of SSPP Element 16 under 49 CFR Part 659.

Recommended CAPs:

- In the interim, prepare a Safety Bulletin featuring digital portable radios and key features and message tones, as well as the types of areas without full radio coverage. Provide the bulletin to the TOC for verification.
- Devise a schedule and instructional materials for end user level training authority-wide so each user of the radio system has a basic understanding of all features and functionality of the portable and mobile radio equipment in use by

WMATA. This training should also fully inform users about areas that do not have radio coverage. Upon completion of classroom training, WMATA should provide TOC with evidence that all training has been completed.

- Institute bulletins and training for first responders to be aware of areas that are permanently lacking in radio coverage, such as portal entrances and emergency egress shafts. Provide these bulletins to TOC for verification.

Finding of NC 2: MAXIMO records showed numerous radios had outdated calibration dates. WMATA requires its radios to be calibrated biennially; records showed some radios were multiple years out of date, particularly in MTPD and some not calibrated since 2008 in Automatic Train Control. COMM indicated that coverage issues encountered by MTPD have been improving steadily over the past year, partly attributed to a focused effort on ensuring MTPD portable radios were properly calibrated and batteries were fully charged and properly conditioned. Although SAMS reports that it provides a monthly list of radios due for calibration to each department, the departments do not turn in the radios for calibration in a timely manner.

Recommended CAPs:

- Devise a program to ensure portable radios are not used for extended periods beyond calibration. Consideration should be given to prevent radios from being operated once they are substantially beyond the annual calibration date. If a radio passes a certain number of months overdue, an email could be directed to the supervisor of the using unit that on a specified date the radio will be disabled in the system. The system affiliation tables can then be checked to confirm the radio is not in use before it is disabled. The end result is that the radio will be returned to SAMS for repair since it will not work.
- Implement and/or enforce a program for WMATA departments to notify SAMS/COMM when portable or mobile radios are out of service/no longer used and then remove the equipment from MAXIMO.
- Provide the written process for either or both initiatives to TOC.

Finding of NC 3: WMATA currently does not conduct system-wide radio performance testing on a regularly scheduled basis. Performance testing of the CRCS system and the public safety radio system BDAs should be done regularly by WMATA to try to determine trouble spots before end users encounter them. Users of these systems, including police, fire, and EMS, do not regularly travel the train routes or have a regular presence in the station areas. A routine testing preventive maintenance procedure will discover areas and equipment in need of repair/calibration before a first responder needs to depend on the system. Maintenance inspections of all infrastructure/equipment is part of SSPP Element 15 under 49 CFR Part 659.

Recommended CAP:

- Establish a routine preventive maintenance procedure to thoroughly test the radio communication system across the full WMATA system, both above ground and below ground in the tunnels. Provide the procedure, checklist, and evidence of implementation to the TOC.

Finding of NC 4: The completeness of preventive maintenance inspection checklists varies considerably. TOC and COMM together explored a sample of checklists in MAXIMO. Many had a blank or non-existent Supervisor's signature line. Many did not list the power levels of radio equipment before system alignment; this information is important for proper adjustment of radio equipment and long-term tracking and identification of potential problems. Many did not include the serial number of BDAs to facilitate the identification and tracking of units that fail repeatedly.

Recommended CAPs:

- Develop a Supervisor quality assurance/control (QA/QC) process to improve the completeness of documentation prepared by technicians. Provide written documentation of the QA/QC process to the TOC.
- Modify all Job Plan checklists to include line item for supervisor signature and the equipment serial number. Provide the new checklists to the TOC.
- Conduct OJT to train all personnel on how properly complete inspection checklists. Provide evidence of the completed OJT to the TOC.

Finding of NC 5: MAXIMO showed a backlog in incomplete PMI work orders for COMM Field Maintenance. Some PMI work orders were open since August 2014, at the time of this review in February 2015. COMM Field Maintenance indicated some of these were related to equipment that no longer exists. However, many remained open without explanation. The 948 missed PMIs from 2014 may include less frequent inspections that are vital to system safety and will not reoccur for a year or more. Please also see Finding of CWR 8 regarding calculations of manpower needed to fully complete PMIs and repair work.

Recommended CAPs:

- Improve COMM configuration management procedures (possibly in the COMM Maintenance Control Policy) so COMM is informed of equipment no longer in use, and that respective due dates for maintenance are removed from MAXIMO. WMATA still intends preserve historical information in MAXIMO. Provide the new procedure or policy to the TOC.
- Determine the reasons for outstanding 2014 Field Maintenance PMI work orders, and take additional measures (through improved procedures, enforcement, and/or additional human capital resources) to complete the backlog. Also provide a log of open Field Maintenance PMI work orders from the previous six months to verify elimination of the backlog before CAP closure.

Finding of NC 6: The SSPP does not reference the Maintenance Control Process manual. Sections 3 and 15 of the SSPP reference maintenance, which is relevant to COMM, but do not fully describe maintenance processes as required by 49 CFR Part 659. However, this information is included in the COMM Maintenance Control Policy, which can simply be referenced in the relevant SSPP sections.

Recommended CAP:

- Update the SSPP to include a reference to the current Maintenance Control Policy manual, and provide the updated SSPP to the TOC.

Findings of Compliance with Recommendation (CWR)

Finding of CWR 1: WMATA does not have a mechanism to alert personnel of areas with temporarily inoperable radio infrastructure or poor coverage. WMATA does not inform radio system users of known issues with the radio infrastructure caused by ongoing maintenance or unresolved corrective maintenance. It is important for front-line personnel to be aware of these areas in real-time so they may plan accordingly during Job Safety Briefings.

Recommended CAPs:

- Determine a method to notify system users of known system problems and poor coverage areas. Suggestions include a real-time list of deficiencies on the WMATA internal website or an online map showing the system and areas without coverage. Provide TOC with verification of the new method in action (real-time list or map).
- Modify procedures so the real-time list of areas with temporary radio outages is checked before all field work on the right-of-way and discussed during Job Safety Briefings. Provide the modified Job Safety Briefing procedure and form to the TOC.

Finding of CWR 2: WMATA departments do not have a consistent program to ensure personnel are using fully charged radios. In addition to the lack of training noted in Finding NC 1 on how to properly interpret radio indications, there are not processes in place to ensure users have radios that are adequately charged and charged for enough duration of time to allow full strength functionality. Personnel reported that radios are sometimes only charged for 10-15 minutes between consecutive shifts, resulting in users with drained batteries that affect coverage and functionality. RTRA recently began to mitigate this issue by providing “radio lockers” that require radios to be off limits after being in use for a shift; this can be a beneficial practice.

Recommended CAPs:

- Create departmental or authority-wide procedures for radio charging so that devices are not being used during consecutive shifts with minimal charging in-between. Provide the new procedures to the TOC.
- Devise a portable radio battery management process for systematic conditioning, recycling, charging, and redeployment of batteries to the field so that batteries in use are providing an adequate level of service. SAMS could facilitate this during annual calibration, if it had an inventory of extra batteries and battery chargers/conditioners, so that the radio then has a 100 percent operational battery when it is returned to the end user. Provide written documentation of the new process to the TOC.

Finding of CWR 3: The trouble reporting process for radio users from external agencies is on an ad hoc basis. WMATA maintains the BDAs installed in the tunnels for first responder radio systems (these operate independently of the WMATA CRCS). However, there is no assigned reporting conduit for external first responders to notify WMATA of radio performance problems. The current process is for a first responder to send an email to a known COMM Maintenance Supervisor or to an OEM representative.

Recommended CAP:

- Formalize a universal reporting mechanism for first responders to submit maintenance requests into WMATA COMM, perhaps through use of an online form. Provide verification the new mechanism is implemented (such as screenshots of an online form and written communication to external responders of the new process).

Finding of CWR 4: Preventive Maintenance Inspection (PMI) checklists do not always identify the acceptable limits for measurements taken during inspections. Maintenance of minimal variations of power levels and deviations is necessary to keep a simulcast system optimized for best performance.

Recommended CAP:

- Update PMI checklists to include the acceptable technical values for each parameter to be adjusted or measured during site preventive maintenance or equipment repair. This information should include, but not be limited to, power and signal levels, noise levels, receiver sensitivity, deviation, frequency and reflected power in the antenna system. WMATA should provide all applicable updated checklists to the TOC.

Finding of CWR 5: COMM internally lacks MAXIMO capabilities in the areas of pulling open issues and reporting on maintenance history of specific equipment, among others. COMM does not have the technical ability to easily create reports from MAXIMO regarding maintenance, high failure rate of equipment, and reliability tracking. COMM relies on another group to provide most Reliability Reports. The MAXIMO subject matter expert for the COMM Branch is a Supervisor who must also conduct his full-time job tasks as a supervisor and, thus, has limited time to spend on MAXIMO. Personnel must program complex queries to gain information in some cases. TOC observed COMM staff's difficulty in gaining access to basic information.

Recommended CAPs:

- Evaluate a process to improve the MAXIMO capabilities of the COMM Branch, such as a position with time dedicated to MAXIMO.
- Finalize and implement ongoing plans and a job description to hire a dedicated MAXIMO subject matter expert for the COMM Branch. Submit evidence of the new hire or dedicated position to the TOC.

- Provide additional training on the current version of MAXIMO and typical features/functionality to all COMM Supervisors who use MAXIMO regularly. Submit completed training rosters to the TOC.

Finding of CWR 6: Radio trouble tickets do not always include contact information for the person reporting the problem. Maintenance Operations Control (MOC) and the Rail Operations Control Center (ROCC) do not always record contact information of the reporting person in order for COMM to investigate. This information is important when technicians determine that a reported radio problem is not due to infrastructure or system equipment defects, and the user's radio may be in need of calibration or repair or a user is not properly using the radio.

Recommended CAPs:

- Modify and enforce MOC procedures to require the entry of the reporting person's name and telephone number in MAXIMO for corrective maintenance work orders. Inform MOC personnel of the importance of gathering this information for follow-up. Provide the new/modified MOC procedures to the TOC.
- Modify and enforce COMM procedures so that technicians document in the work order, before closure, whether trouble was found and was or will be corrected, whether monitoring will occur in the reported area, or whether they have contacted the reporting source to confirm whether the user's specific radio is inoperable (when possible). This will confirm for other technicians and supervisors what steps have already taken place. Provide the new/modified COMM procedures to the TOC.

Finding of CWR 7: There is no consistent process to ensure COMM opens new corrective maintenance work orders for repair actions found during PMIs. COMM does not have a consistent process identifying who is responsible for entering a new order into MAXIMO when a technician identifies a need for corrective maintenance while performing a PMI. Records reviews and discussions determined that some corrective maintenance work orders were entered by the technician; some were entered by the Supervisor, and in some cases the PM was closed but it is not noted whether the unresolved work was entered into a corrective maintenance work order. This shared responsibility leaves the potential for one employee to assume the other has already opened the new work order, and the defect is not fixed. Also, new Work Order numbers are not routinely added to the PM checklist or work order for confirmation.

Recommended CAPs:

- Modify Job Plan checklists to include a line item for confirmation that any ensuing corrective actions were entered into MAXIMO, with identification of the new work order number. Submit the modified checklists to the TOC.
- Clarify (possibly through the COMM Maintenance Control Policy) whose responsibility it is to enter a new work order ticket based on defects found during inspections and routine maintenance. Submit the instituted policy to the TOC.

Finding of CWR 8: The COMM Branch, especially SAMS and Field Maintenance, are significantly understaffed. The Field Maintenance group of COMM reported that there are approximately 4,000 PM inspections to be performed every month. It was also reported that the Field Maintenance group of COMM has 80 technicians (or 40 maintenance crews) responsible for maintenance. This means that each crew has to perform at least 5 PM inspections per day in addition to corrective maintenance, which is not realistic given the duration of inspections. Likewise, SAMS has only two technicians, who are responsible for maintaining and repairing an inventory of more than 6,000 portable and mobile radios. The SAMS manager indicated they receive over 13,000 work orders annually for radio repair, in addition to the 3,000 radios they should calibrate per year. The repair work orders alone equate to SAMS needing to fix seven radios per hour, which is unlikely to occur. This does not account for calibration of the radios, (250 per month). SAMS reported no maintenance backlog, but would change if radios authority-wide in need of repair were identified (through measures suggested through other findings in this report) and biennially recalibrated as required. Some personnel from other departments such as ATC reported that it can take weeks to receive radios back from calibration. Please also see Finding of NC 5 regarding incomplete PMIs from 2014.

Recommended CAP:

- Submit a request for increased budget for additional maintenance support personnel in future budgetary cycles. In support of increased staff, an evaluation should be made to determine the cost of sending the backlog of repairs to an outside vendor. Consideration should also be given to the anticipated workload generated if the users do bring their radios in for annual inspections and calibration in a timely manner. Submit the budget request and evidence of new hires or rededicated positions to the TOC.

Finding of CWR 9: There is, in some cases, only a single maintenance procedure to cover inspections of different types of COMM Field Maintenance equipment. For example, the FIA inspection procedure/checklist is generic, but there are several different equipment types installed over the years. COMM Field Maintenance skips some steps on older equipment, but the reason for skipping them is not stated. New equipment does not always result in the provision of new inspection procedures/checklists, and as a result procedures cover only the legacy equipment or systems. There are engineers dedicated to COMM radio communications, but not to COMM Field Maintenance; this may prevent attention to the full incorporation of engineering needs during procurement.

Recommended CAP:

- Ensure that PM procedures and checklists are created for each type/manufacturer of equipment. Provide new checklists to the TOC.
- Ensure through a new process or dedication of resources that, in the future, CENI or a designated COMM Field Maintenance engineer will routinely create new inspection procedures and checklists following receipt of new equipment. Submit the written process and/or evidence of assigned personnel to the TOC.

Finding of CWR 10: MOC/ROCC does not appear to consistently open corrective maintenance work orders when an associated incident work order is created.

Incident work orders may be opened during urgent problems with infrastructure or equipment. However, incident work orders are not assigned to specific maintenance personnel for closure and do not result in an alert to maintenance management. Maintenance management sometimes learns of unresolved, major problems with infrastructure or equipment from reading daily ROCC reports the following day.

Recommended CAP:

- Modify MOC/ROCC procedures to ensure that corrective maintenance work orders are opened and linked to incident work orders. Submit the new MOC/ROCC procedure to the TOC.

Finding of CWR 11: COMM is not fully involved in Joint Development and Adjacent Construction (JDAC) projects that may negatively impact radio coverage.

New radio dead spots can arise when buildings are erected above or beside the Metrorail right of way. Although WMATA's JDAC office has requirements for developer coordination with the transit agency when construction occurs within a certain distance from the right of way, it does not appear that radio coverage is considered. In addition, development that falls outside of WMATA's distance threshold may also have affects that WMATA must determine and mitigate. With the volume of transit-oriented development around stations such as Eisenhower Avenue and NoMa, it is imperative that impacts to Metrorail's safety-related systems are known.

Recommended CAP:

- Ensure through JDAC procedures and meeting agendas that all affected WMATA departments, including COMM, have a chance to determine whether proposed development has a less obvious impact on infrastructure and systems. This will allow departments such as COMM to have the ability through capital budgeting to compensate for and mitigate potential impacts.

Finding of CWR 12: WMATA's railcar and portable radio communications systems are in need of a comprehensive safety analysis due to reported failures and findings identified throughout this report.

Although the TOC's review found numerous areas where improvements to maintenance, training, and implementation of new programs would eradicate or mitigate some radio problems, WMATA's radio communications systems may have other unknown deficiencies that are causing users to report widespread dead spots. A safety analysis can take into account implementation of the recommended CAPs throughout this report.

Recommended CAP:

- Conduct a comprehensive system safety analysis of WMATA's entire radio communications system to also include procedures, maintenance practices, human capital management, talent management and succession planning. The analysis should consider and evaluate all foreseeable failures of this system that

could result in a loss of radio coverage or degradation of signal. WMATA should consider taking a similar approach as it employed in the comprehensive system safety analysis that was conducted on WMATA's ATC system following the 2009 Ft. Totten accident.

Persons Interviewed

- [REDACTED] (COMM)
- [REDACTED] (IT)
- [REDACTED] (IT)
- [REDACTED] (COMM)
- [REDACTED] (COMM)
- [REDACTED] (COMM)
- [REDACTED] (TIES/SMNT)
- [REDACTED] (COMM/SAMS)
- [REDACTED] (TTDC)
- [REDACTED] (CENI)
- [REDACTED] (CENI)
- [REDACTED] (COMM)
- [REDACTED] (IT)

Documents Received / Reviewed

- WMATA 2014 SSPP Signed, January 2014
- COMM Branch Maintenance Control Policy 20141124133540, July 1, 2014
- COMM All Assets, file dated January 15, 2015
- COMM ALL Master PMs, file dated January 15, 2015
- CRCS System Diagram (2), May 28, 2003
- COMM Remote Site Radio Cleaning PMI, September 19, 2012
- CRCS BDA Alignment PMI-Ver 1.0 Final, April 30, 2013
- CRCS Headend Alignment PMI_Ver 2.0 Final, March 29, 2013
- PSRS BDA Alignment Procedures for The District of Columbia Fire Department 800 MHz PSRS PMI-Final, Jun 25, 2013
 - 4 OM Systems Manual
 - TLS 350 Manual (TLS-3XX Series Consoles Operator's Manual, Veeder-Root, 2013)
 - TLS 450 Manual
 - WMATA Q119862 General Overview – CRCS Redundant Antenna System, May 28, 2010
 - ASTRO Digital XTL5000 Mobile Basic Service Manual, April 20, 2005
 - CW Sentry 3G Manual Ver3 0 06-01 (3)
 - Fire Alarm O&M Manual for WMATA S.E. Bus Depot Replacement, October 12, 2012
 - Gas Detection O&M Manual for WMATA S.E. Bus Depot Replacement, October 12, 2012

- Section 1 PPT Presentation: Comprehensive Radio Communication System Underground Distributive Antenna System Supplemental Training, May 13, 2010
- Section 2 Kaval Manuals:
 - DCM000000056 WMATA CRCS Line Amp BDA 1300 Manual Rev2, June 28, 2005
 - DCM000000108 CRCS FO HE System Manual Rev2, June 13, 2003
- Section 3 Test Procedure:
 - CRCS BDA Alignment Procedure, November 2, 2007
 - CRCS FOHE Alignment, January 3, 2008
- Section 4 Misc. Cut Sheets:
 - AirCell_Catalog Radiating
 - Finding Solving IM, April 21, 2010
 - Industry Best Practices for Radiating Cable Installation in
- SmartZone Manuals:
 - 025-9035-001
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 - CEB & DLM CKT pg 8-5 Manual, July 16, 2003
 - Centracom_Gold Elite Userguide
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 - Servercardsbook, November 1999
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- Public Address System Documents:
 - 421m AGC Leveler, April 1, 2000
 - 450 Priority Mixer, July 1999
 - 528E Voice Processor, April 1, 2000
 - DFR11EQ Shure
 - SE30, ©1981
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 - SPL 371
 - Sysmetrix 305 Dist. Amp, June 1998
 - TOA Mixer
 - Volume A-manual
 - Volume B-manual

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- RAMEX IIS – Catalog Brochure Documents:
 - Emergency Intercom, May 2007
 - Mass Transit Intercom, May 2007
 - Medical Intercom, May 2008
 - Parking Intercom, May 2008
 - Product Catalog, Feb 2009
 - Toll Station Intercom, May 2008
 - Tunnel intercom, May 2008
- RAMEX IIS – Central Units:
 - DB-GE 100 English – CI LowRes
 - DB-GE 200 English-CI LowRes
 - DB-GE 700 English-CI LowRes
 - ge200_e, December 2, 2002
 - ge700_e, December 19, 2002
- RAMEX IIS – Configuration Files, Installation Charts:
 - CTF Station Location, January 2009
 - JGB Station Location 2, April 2009
 - OCC Station Location, September 2008
 - Relay Output Chart CTF, January 2009
 - Relay Output Chart JGB, March 2009
 - Relay Output Chart OCC, September 2008
- RAMEX IIS – Configuration Files, Installation Instructions:
 - EE411 Installation – Connections
 - ES43x Installation – Connections
 - ET901A Connections
 - G7CNETLAN Connections
 - G7DSPIP4 Connections
 - Installing CCT Software
 - Installing G7CNETLAN Card
- RAMEX IIS – Configuration Files, Operating Instructions:
 - EE411 Oper Instr. Insert
 - OCC CTF Operating Instructions, September 2008
- RAMEX IIS – EE Masters:
 - DB-EE 420R English – CI LowRes
 - DB-EE 442 English-CI LowRes
 - DB-Serie 411 English-CI LowRes
- RAMEX IIS – EF Security Station:
 - DB-EF562 EN-CU-HRes

- RAMEX IIS – EE Stations:
 - db-series 430-en-cu-hires
- RAMEX IIS – IOIP:
 - DS-G7-CNET-LAN-EN-CI
 - ES 931 IoIP Substation
 - ET-901-CI-EN-V1.1-0507, May 2007
 - IoIP-CI-EN-V1.1-0906, September 2006
 - IP-Terminal_e
 - PM-Cnet-lan-EN-Y20-0206, February 2006
- RAMEX IIS – Network Cards:
 - DB-G7-CNETE1 English-CI LowRes
 - DB-G7-CNETW English-CI LowRes
 - G-TEL - LowRes
- RAMEX IIS – Software:
 - CCT5-7: Pro57A_e, March 2007

During the on-site interviews, the following maintenance records were reviewed from MAXIMO database:

- CRCS Quantar PM 10829824, April 4, 2014
- CRCS Quantar PM 11120954, August 20, 2014
- Remote Radio Site Preventative Maintenance Program Facility – Job Plan 4360 Hybla Valley, July 1, 2014
- Remote Radio Site Preventative Maintenance Program Facility – Job Plan Rockville, November 24, 2014
- PSRS Line Amp Alignment Datasheet and Checklist, Segment: A07-A06 TR1, January 14, 2015
- CRCS Line Amp Alignment Datasheet & Checklist, Segment 16 EO6 Mid Tunnel TR1, December 22, 2014
- CRCS Line Amp Alignment Datasheet & Checklist, Segment 15, E1, January 7, 2015
- CRCS Line Amp Alignment Checklist E2 Segment 16, December 9, 2014
- CRCS Line Amp Alignment Head End Segment 16, December 8, 2014
- Sampling of KPI Open Reports
- Sampling of PKI Reports Open more than 30 days. December 20, 2014 – February 20, 2015

During and following the on-site interviews, the following documents were provided and reviewed:

- MPLN Monthly Preventive Maintenance Summary, July through December 2014 (six documents)

- FIA Preventive Maintenance Inspection checklist
- System Maintenance Org Chart, February 10, 2015
- Work Order Details of “No Trouble Found Report - E04 No Radio Reception in Station, October 8, 2014
- Work Order Details of “No Trouble Found Report – No Radio Communication D07 to D08 OPS2, October 8, 2014
- Work Order Details – Train Unable to Communicate with OCC between A08 and A09 Track 2, January 30, 2015
- WT_Calibration RTRA Handheld Radios Overdue Report, February 10, 2015
- WT_Calibration COMM Test Equipment Due for Calibration in the Next 30 Days Report, February 10, 2015
- WT_Calibration, AFCS Equipment Due for Calibration in the Next 30 Days Report, November 1, 2014
- WT_Calibration, ATCS Equipment Due for Calibration in the Next 30 Days Report, November 1, 2014
- WT_Calibration, CMNT Equipment Due for Calibration in the Next 30 Days Report, November 1, 2014
- WT_Calibration, COMM Equipment Due for Calibration in the Next 30 Days Report, November 1, 2014
- WT_Calibration, TRST Equipment Due for Calibration in the Next 30 Days Report, November 1, 2014
- WT_Calibration, POWR Equipment Due for Calibration in the Next 30 Days Report, November 1, 2014
- WT_Calibration, POWR Equipment Due for Calibration in the Next 30 Days Report, October 1, 2014
- WT_Calibration, TRST Equipment Due for Calibration in the Next 30 Days Report, October 1, 2014
- WT_Calibration, AFCS Equipment Due for Calibration in the Next 30 Days Report, October 1, 2014
- WT_Calibration, ATCS Equipment Due for Calibration in the Next 30 Days Report, October 1, 2014
- WT_Calibration, CMNT Equipment Due for Calibration in the Next 30 Days Report, October 1, 2014
- WT_Calibration, COMM Equipment Due for Calibration in the Next 30 Days Report, October 1, 2014
- CENI Training Contract Language
- TTDC Training Materials, Records, and Syllabi
- TSSM Profile Sorts by Job Title / Code / Department
- ESS/ENV Maximo and Workflow Business Process
- ROCC/MOC Incident Work Order examples
- FIA PM Instructions, April 3, 2013
- Log of open Field Maintenance work orders
- Passenger Emergency Reporting System PM Instructions, September 2014