SPECIAL PROJECT INTERIM REPORT

MARCH 5, 2020

SILVER LINE PHASE 2 REVIEW

OIG Interim Report of Findings & Recommendations

This report provides the General Manager/CEO with an independent assessment of critical issues affecting the completion of the Dulles Metro Rail Project (Silver Line – Phase 2) (the Project). We are issuing this report now, in a similar vein to our Management Alerts and prior to Substantial Completion, to provide the Washington Metropolitan Area Transit Authority (WMATA) some observations and recommendations. This report may assist management in refining and possibly adjusting their engagement priorities and resources as they continue efforts to resolve problem areas and obtain the necessary assurances that all safety and reliability objectives are met.

We note at the outset that the OIG remains concerned about the expense and efficacy of currently proposed mitigations to the issue of cracks in the concrete panels. The OIG has engaged an independent contractor to inspect each panel to determine the current condition of each and to report if any currently show signs of corrosion or the presence of cracks. Metropolitan Washington Airports Authority's (MWAA) contractor has represented to the OIG that their initial review has identified cracks in 24 panels. Once the OIG's contractor inspects all the panels using stringent inspection criteria, we will be able to accurately report our findings relating to the panels, remediation and future inspections.

While discussions regarding the remediation of the concrete panels continue, additional areas of concern have arisen during our review. Some of these concerns have already been the subject of intense consideration, and some less so. In this report we focus on the following issues that, along with the others previously identified, are of critical importance and merit high priority in management's attention:

- Effectiveness of the Quality Management Program Audit;
- Criticality of the Systems Integration Program Plan;
- Automatic Train Control ("ATC") system;
- Effectiveness and resolution of issues documented in the Non-Conformance Reporting systems;
- Ongoing, unresolved Rail Yard issues (ballast, insulated rail joints, surge arresters, turnouts/switches and fuel center); and,
- Spare Parts.

The OIG concludes that all of these issues derive from two major over-arching shortcomings: ineffectiveness and inconsistency of the Project Contractor's Quality Management Program in resolving reported problem areas, and the absence of a single design-build systems integrator who views the core systems and infrastructure holistically.

For proper context, we should note that Phase 2 of the Silver Line Project was awarded by MWAA in two parts. A design-build consortium was awarded the contract for mainline construction, wayside connections, and six new stations (Package A). A separate

contract was awarded to another contractor to construct a new service and inspection maintenance yard in Loudoun County (Package B). As we report on the issues cited above, we will reference the Package A and Package B contractors individually where appropriate. In some cases, our comments may apply to both Package A and Package B contractors.

The WMATA Project staff has previously provided the Board of Directors with updates regarding some of these issues in their Silver Line Board presentations. Our report complements those updates and provides further context, findings, and recommendations for WMATA's consideration.

Quality Management Program and Quality Audits (Packages A and B)

Under the Cooperative Agreement between WMATA and MWAA, Section 2.7.8(4)(c) allows WMATA to, "*Participate with MWAA in its oversight of the Contractor's Quality Control/Assurance Program. WMATA may participate in quality audits of the Contractor that are performed by MWAA, subject to prior notification to WMATA to allow for proper scheduling and coordination."*[1]

Quality Assurance and Quality Control are terms that are often used interchangeably, but there are important differences between the two concepts. Quality Assurance services are primarily used by the Owner and Owner's Engineer to evaluate whether a Contractor is achieving specified conditions and design standards. Quality Assurance sets out the quality processes that should be followed. Quality Assurance can be measured before a project begins or while a project is undergoing construction.[2] Quality Control is more often the responsibility of the design-build contractor and refers to oversight and inspection of the project elements as the construction proceeds. While Quality Assurance ensures all the processes are following standards, Quality Control is the quality check of the result. The two concepts work together to provide the basis for a Quality Management Program.

OIG found unresolved quality audit findings during a review of the Project Quality Audit Report. This audit was led by MWAA and supported by WMATA's staff. Specifically, there was inadequate documentation for the requisite Software Documentation Plan and inadequate documentation supporting good Configuration Management practices for the ATC system, which is discussed further in this report.

WMATA Project staff also recently expressed higher levels of concern about the overall quality planning and quality control for rail systems work.[3] WMATA staff reported that the Contractor's Monthly Integrated Testing Reports required by the Quality Program

[1]To facilitate the successful completion for the second phase of the Project, in August 2013, MWAA and WMATA entered into a Cooperative Agreement whereby MWAA would undertake primary contracting authority and managerial control for the design-build contract, and WMATA would assume responsibilities as Technical Advisor. WMATA's primary responsibilities under the Cooperative Agreement are to ensure that the Phase 2 Work is performed in accordance with the WMATA Design Criteria and Requirements, and that the work, when completed, is fit for revenue service and acceptance into the Adopted Regional System (ARS).[1]

[2]https://asq.org/quality-resources/quality-assurance-vs-control.

[3]WMATA Letter P2A-270, January 28, 2020.

Plan have not been provided.[4] The absence of these monthly reports makes WMATA's oversight participation, as contemplated in the Cooperative Agreement, very difficult.

OIG Observations

A comprehensive and auditable Quality Management Program is paramount for the success of a design-build program. The Quality Management Program impacts all phases of the Project: assuring conformance with all design deliverables; ensuring appropriate and complete documentation for as-built drawings; monitoring non-conformance reports to identify early and mitigate quality deficiencies; reviewing and assuring compliance with contractor and subcontractor performance tests; conducting material and component assessments, and ensuring certifications where required. These critical activities must be coordinated closely with WMATA in their role as Technical Advisor and consistent with WMATA's Design Criteria.

The OIG has found some inconsistencies in the effectiveness of Quality Control and the Quality Audit processes and compliance with the Cooperative Agreement requirement.

WMATA should continue to require MWAA and its contractor(s) to be responsive to the requirements of the Quality Program Plan and to respond and mitigate all Quality Audit findings. The OIG plans to review and report findings and recommendations for the results of all Quality Audits.

System Integration Program Plan

Under the Cooperative Agreement, Section 2.7.B(5)(c) requires WMATA's concurrence in the System Integration Program Plan: "*Before accepting the Contractor's System Integration Program Plan, MWAA will obtain WMATA's concurrence that the Plan adequately addresses applicable WMATA requirements.*"

The Contractor's System Integration Program Plan is a critical submission wherein the Contractor will outline the processes for bringing together the component subsystems into one system and ensure that they function together as a system. The Plan is executed by using a series of detailed testing and commissioning activities that document how each supplier has installed and tested its system in isolation, and that the supplier is satisfied its system is ready to be further tested and integrated into the overall system. The Contractor must ensure that all required factory acceptance testing, first article testing and later testing and commissioning, meet all the Contract and WMATA technical and performance requirements.

[4]MWAA Phase 2 Quality Program Plan, Section 8.12, "*The plan shall provide for an Integrated Systems Testing Report that tracks and report the status of integrated testing and that is updated and submitted to the OWNER or its representative monthly.*

The OIG has observed that there is not a singular, designated system integrator in the design-build Contractor's Project organization with holistic system integration responsibility. Rather, the Contractor is relying on several major subcontractors to perform the system integration function for their respective subsystems and subcontractors. The absence of a single, dedicated systems integrator and reliance on subcontractors' separate integration activities are problematic. Coordinating with multiple contractors and subcontractors on system integration deliverables may adversely impact schedule goals and successful overall integration.

As early as 2016, WMATA commented on the need for a comprehensive list of integrated tests, which was a requirement of the Contractor's Quality Program Plan. From 2016 forward, WMATA has continued to request that the Contractor provide the required list of integrated tests. In July 2017, during a discussion of the System Acceptance Plan, the Contractor agreed to prepare a Master Testing and Commissioning Plan; however, WMATA found this document included only a format for the list of tests, with most required tests missing. A revised Integrated Test Plan was submitted by the Contractor in October 2018 that again included only systems tests, which was deemed incomplete by WMATA. Further correspondence shows that WMATA has not accepted the Contractor's position, supported by MWAA, that its submission of a design structure matrix, showing individual subcontractor testing activities only, is adequate to satisfy the integrated testing documentation anticipated and required by the Quality Program Plan.

OIG Observations

At this juncture, it is clear that MWAA does not have WMATA's concurrence for acceptance of the Systems Integration Program Plan as required by the Cooperative Agreement. Without such concurrence, the requisite framework for observing and monitoring the quality and effectiveness of systems integration testing is made more difficult, if not wholly compromised.

WMATA should continue to press for sufficient documentation from MWAA and its Contractors demonstrating the thoroughness of all individual and integrated system testing and commissioning activities, with special attention to core system interdependencies.

WMATA has in place a robust and detailed Rail Activation Plan ("RAP") and Yard Activation and Mobilization Plan (YAMP) that set out the tasks and responsibilities that must be accomplished before the new rail line is accepted by WMATA. The WMATA Project team includes senior managers who participated in the acceptance of Phase 1, which helps to ensure that the new rail line meets all design, performance, and safety requirements.

RAP tasks include pre-operational testing with static and dynamic testing of non-revenue train movements, systems integration testing, Safety and Automatic Train Control ("ATC") certifications, updates for operational and maintenance practices, transfer of assets and associated warranties, emergency response drills, personnel and equipment

assignments, punch list development, and numerous other tasks to provide an effective transition of Phase 2 into WMATA's ownership and control.[5]

The OIG believes that the RAP is an excellent vehicle for providing coordination and oversight for the transition of the Phase 2 project work from MWAA to WMATA and is well informed by the acceptance activities and lessons learned for Phase 1.

The OIG recommends that WMATA management continue accelerating higher priority RAP activities to provide assistance to the WMATA Project staff. Given the additional attention that will be required for acceptance of the Systems Integration Program Plan, WMATA may want to increase the number of staff observing the Operational Readiness Testing and all tie-in activities.

Automatic Train Control (ATC) (Package A)

Since its inception, WMATA has used some elements of ATC on its main line system to facilitate the safe movement of its trains. The ATC system consists of the car-borne and wayside train control and signal system and integrates all the vital and non-vital functions for controlling the train. ATC is comprised of three sub-systems:

1. Automatic Train Protection (ATP) – this sub-system uses coded track circuit technologies and helps avoid train-to-train collisions by maintaining safe separation distances between trains, ensures allowable train speeds are not exceeded, controls interlockings and switches, and monitors door openings.

2. Automatic Train Supervision (ATS) – this sub-system provides for management of headways (time between trains) and helps manage the capacity of the system by speeding up or slowing down trains. The system works by monitoring the location of the train and interacting with the Operations Control Center, which controls schedule and routing adjustments.

3. Automatic Train Operation (ATO) - The ATO subsystem is primarily a wayside system that is designed to manage train startup and acceleration, maintain running speed enroute, and stop the train smoothly at the proper position along the station platform. Automatic Train Operation controls trains so that, between stations, they will move at the speed specified by the automatic train protection and automatic train supervision sub-systems.

The WMATA ATC system was designed to allow for fully automated train operations; however, WMATA has modified its use of ATC and ATO functionalities based upon its operational experience and desire to maximize safety performance.

Given the criticality of the ATC system for many aspects of WMATA's services, the OIG has a special interest in any issues associated with implementing and integrating ATC for Silver Line Phase 2. These concerns are enhanced by the fact the provider of the

[5] *Silver Line Phase 2 Rail Activation Plan, Dulles Corridor Metrorail Project, Rev 1, December 28, 2018.*

ATC system for Phase 2 is different than the provider of the ATC system for Phase 1, with the two systems physically interfacing at Wiehle-Reston East. While both companies supporting Phase 1 and 2 ATC systems are well known to WMATA, Phase 1 ATC design reflects the company's newest technology, and this will be a critical interface point between the two systems.[6] There are new communications and signaling components being used, and new software and applications must be integrated into the existing ATC system. While these integration risks are manageable, it is imperative that these systems fully comport with all WMATA Design Criteria and any deviations and/or changes are properly documented.

The OIG met with WMATA Project staff and those engineers responsible for facilitating Systems Acceptance for the Contractor's ATC work product. Among other accountabilities, the Project's Systems Acceptance staff is responsible for ensuring that the configuration management processes and software documentation planning meet WMATA's requirements for the ATC system for Phase 2.[7] Project staff reported several areas of concern involving contract requirements not being met for testing (included in Bid Documents and agreed by MWAA and its Contractor that may affect WMATA system acceptance and schedule completion).[8]

ATC Quality Program Audit

The OIG also reviewed the results of a critical July 2018 MWAA-led quality audit of the ATC Quality Program.[9] This audit, in which WMATA Project staff participated, was intended to assess the adequacy and effectiveness of the Contractor's ATC Quality Requirements. Based on prior observations and submissions by the contractors, the Systems Acceptance staff was concerned that the contractors could not identify and track individual configuration items (CIs) and could not properly document functional capabilities and interdependencies, especially those arising from design changes.

The quality audit findings were not satisfactory. The audit revealed significant deficiencies in the system development methodologies and documentation processes for delivering the ATC system. The audit found that the Contractor had not documented a process for identifying and correcting ATC deficiencies, did not have a Software Documentation Plan, did not have Discrepancy Tracking Procedures and Tools, and did not have adequate Configuration Management procedures for reporting hardware and current status. The prime contractor was given the opportunity to comment on the audit findings but was unable to explain how its quality processes for Configuration Management would work in tandem with its subcontractors. MWAA generally agreed with the audit's findings; however, MWAA elected to close the audit without follow-up at that time.

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[6]https://www.mwaa.com/sites/default/files/archive/mwaa.com/file/Tab_19 Recommendation_to_Award_a_Sole_Source_Contract_for_Equipment_for_the_WMATA_Automatic_Train_Control_Training_Facility.pdf.
[7]Configuration management (CM) is a systems engineering process for establishing and maintaining consistency of a product's performance, functional, and physical attributes with its requirements, design, and operational information throughout its life, ANSI-EIA-649-A Standard: NATIONAL CONSENSUS STANDARD FOR CONFIGURATION MANAGEMENT.
[8]MWAA 8.1.2, Quality Program Plan, R1, March 11, 2013.[9]*Design-Build Lead Contractor (Package A) ATC Quality Program, July 12, 2018.*
[9]*Design-Build Lead Contractor (Package A) ATC Quality Program, July 12, 2018.*

The OIG notes that the July 2018 audit was 'process-oriented,' but the audit was undertaken to determine whether the predicate control processes were sufficiently evolved, and whether adequate Configuration Management practices were in place, in advance of later field testing and commissioning activities. As the OIG review continued in 2019, Systems Acceptance staff indicated there had been little improvement in providing the requested documentation and more recent testing confirmed that the deficiencies previously found had not been addressed. WMATA engineers told the OIG it is difficult to quantify what is not known regarding the acceptability of ATC drawings because WMATA has not been provided information as to how the contractors maintain their drawings in-house relative to their field drawings. In the absence of red-lined and/or as-built drawings, these drawings are only in the field and are not subjected to configuration management procedures.[10]

In December 2019, the Contractor sought to expand its Software Documentation Process to respond to some of WMATA's concerns regarding software development for the N06 Tie-in.[11] The Contractor's position is that the various Contract specification requirements regarding software documentation, validation and verification, and specifically for ATC software, apply only to the "executive software" (which was developed for Phase 1). The Contractor further contends that the requirements do not apply to modifications of the "application software" as has been developed by the subcontractor. WMATA does not agree with the Contractor's position and has cited further shortcomings including the timing and quality of engineering documentation submissions by the ATC subcontractor and lack of evidence that corrective action procedures are being implemented.[12]

Several other examples of unresolved concerns about the quality and detail of the ATC system were provided to the OIG, including failure to document version control; missing key documents; lack of a comprehensive Configuration Management Plan for ATC hardware; and undocumented coding changes. These concerns were discussed with WMATA Project staff. The OIG was initially informed that planning was underway to refresh and possibly expand last year's audit scope and that this audit was a priority effort. However, scheduling the audit has taken some time. At a February 12, 2020 meeting with the Federal Transit Administration Project Management Oversight Consultant (PMOC), MWAA indicated that the audit will commence February 26, 2020. OIG confirmed that the second audit was started and completed on February 26, 2020, however as of the date of this report, the results were not available. When OIG receives the results of the audit, we will evaluate and comment as appropriate.

[10]Redlines are original drawings that have been marked, often in red pencil, to document design changes. As-builts documents how the design is actually being constructed and delivered; and are also known as the "final set" of annotated field drawings and specifications representing the final build.
[11]*Summary of B&C Software Development Process, Revision 02, 12-3-19*.
[12]WMATA Letter P2A-270, January 28, 2020.

OIG Observations

As the Silver Line Phase 2 Project approaches Substantial Completion, it was not anticipated that demonstration of appropriate configuration management practices and the software documentation plan for the ATC system would be absent or incomplete at this stage of Project completion. The unresolved issues with ATC system acceptance requirements create the potential for even more schedule delay beyond what is already reported. Additionally, these deficiencies do not engender confidence in system safety.

The July 2018 ATC Quality Audit focused on process and quality controls. The OIG recommends that all future Quality Audits for ATC components and systems fully address all prior Quality Audit deficiencies and be informed by actual test results, validated design drawings, and physical inspections. Further, we recommend WMATA accelerate the participation of WMATA's in-house ATC functional owner/WMATA ATC subject matter experts and update the scheduling and tasking of RAP support activities.

OIG recommends that WMATA ensure that the quality audit conducted on February 26, 2020, properly addresses the issues identified above such as failure to document software version control, undocumented coding changes, missing key documents and software validation and verification.

Non-conformance Reporting and Issues Requiring Resolution (Packages A and B)

There are three primary processes for reporting substantive design/build deficiencies within the Project: Non-conformance Report ("NCR") (Package A) or Deficiency Report ("DR") (Package B); Issues Requiring Resolution ("IRR") initiated by MWAA; and WMATA's internally generated Oversight Issues List ("OIL"). The OIG observed that the NCR/DR and IRR processes have not fully operated as intended. Following our review of Project correspondence and staff interviews, we observed that some concerns reported by WMATA Project staff were not placed into these tracking reports and/or resolutions were made without clear mitigations, documentation, or closure acceptable to WMATA Project staff. We found reports of failures and deficiencies where either root cause analyses were not conducted, or the results were not shared or shared timely with WMATA. In addition, there do not appear to be consistent review processes in place that address the timeliness and prioritization for resolutions and mitigations of non-conforming issues.

It is certainly to be expected that in a large, complex design-build project such as the Silver Line extension there will be a significant number of normal errors and omissions that will result in non-conformance reporting. It is not uncommon that as a project is being built there will be design changes that may result from value engineering, the resolution of unforeseen circumstances and site conditions, or accommodating a design- build error where the rework may not be economically justified or required to maintain safety or operational effectiveness. In fact, on this Project there were several thousand entries made onto non-conforming reports. What becomes critical to the successful delivery of the Project is due diligence in applying the quality assurance processes that

drive effective quality control practices in the field and in the supply chain. Clearly there are some key deliverables in this Project that would have benefited from more resources and more attention being paid to long-standing reports of non-conformance.

OIG Observations

All non-conforming reports, and WMATA's internally generated Oversight Issues List, should be thoroughly reviewed, and issues resolved consistent with WMATA's Design Criteria to ensure that all contract requirements, design and technical standards, and applicable codes are satisfied. The OIG notes that WMATA's Systems Safety and Environmental (SAFE) group has been active in their duties. WMATA Project staff and SAFE should continue to work closely in monitoring the resolution of safety-critical items.

WMATA should request that MWAA require the design-build Contractors and involved sub-contractors to provide root cause analyses and mitigations for all key component failures (e.g., surge arresters, insulated rail joints) and fully document design variances and mitigations to ensure compliance with all safety, performance, and reliability requirements, and to inform follow-on inspection, testing, and maintenance protocols.

Rail Yard Ballast (Package B)

The OIG has conducted a review of the ballast issues. The OIG found that ballast problems were identified early in the Rail Yard construction. WMATA Project staff informed the OIG of accounts that the track subcontractor rejected several carloads of ballast for poor quality in the Fall of 2017. On February 22, 2018, an IRR was forwarded by MWAA to the Contractor reporting there were many areas of tamped track bed which had concentrated and excessive fines instead of consistently graded AREMA #5 ballast. The subcontractor responded on March 6, 2018, that they had investigated the report and concluded the issues only involved two areas proximate to the ballast loading area.[13]

Subsequently, the Contractor's Quality Control staff and MWAA performed random visual inspection of track bed and again found "concentration of fines are visually evident on the surface of the ballast."[14] A later inspection on April 11-12, 2018, by the Engineer of Record, also identified areas of concentrated fines and approximately 5000 feet of track that was identified as potentially fouled. The track subcontractor indicated they would remediate the non-compliance.

In November 2018, a third-party contractor hired by MWAA, conducted another survey of the ballast in the Rail Yard. Their report found that 41 of 97 sampled locations indicated at least moderate fouling. In May 2019, MWAA directed the same third-party contractor to collect samples at five (5) locations, the results of which indicated that three (3) of the samples did not meet AREMA #5 requirements regarding allowable fines.

[13]Design-Build Package B Lead Contractor _P2B_1022 correspondence.

[14]Dulles Field Notes April 11-12 (2018) (Ballast Supplier Corrective Procedure)

Another visual survey conducted by WMATA's track inspector on August 10, 2019, also noted deficient ballast at key switch points and other areas. More recently, in October, November, and December 2019, MWAA and WMATA collaborated on another survey and sampling effort consisting of a total of ninety (90) sampling locations, half of which were selected by MWAA and WMATA field staff, and the remainder were selected by MWAA's independent consultant.

WMATA provided the OIG with their February 26, 2020, letter to MWAA titled, "*Contract CRB0020_07 - Dulles Phase 2 WMATA Oversight - Package B Fouled Ballast at Dulles Yard Letter No. WMATA-P2B-177*." The letter indicated in part, "As you know, WMATA's Office of Inspector General (OIG) issued a Management Alert on August 19, 2019, recommending a comprehensive survey and testing of ballast at the Dulles Yard. Subsequently, WMATA and MWAA conducted site inspections, and identified 90 additional ballast sampling locations." In addition, the letter indicated, "WMATA's review of the data from the 90 additional sampling locations, together with data from the previous 97 samples collected…. shows that more than a quarter of the Package B ballast has a fouling index greater than 6."

As a result of the findings, WMATA is requiring the following remediation:

1. Ballast cleaning/replacement shall be performed at all locations that were identified in the PSI data to have a Fouling Index (FI) greater than an FI of 6. This would include the 20 locations identified from the 90 samples processed in 2019, plus the 41 locations identified from the 97 samples processed in 2018;

2. Remediation shall extend 25 feet up-station and down-station (50 linear feet in total) from the location of the sample;

3. Remediation shall extend from toe-of-shoulder to toe-of-shoulder to a depth of 12-inches below the bottom of the cross ties, and include the entire area between rails, below rails, below ties, and the shoulders. The remediation must be continuous so that no pockets or dams are formed that could trap drainage water. This is required because there was evidence of water ponding at some areas where ballast samples were collected;

4. Following completion of the ballast remediation, re-sampling by an independent entity retained by MWAA shall be performed at 20 locations, randomly selected, to confirm the effectiveness of the remediation effort; and

5. Additionally, after the ballast remediation, re-tamping and resurfacing shall be conducted, and track profile reestablished in the areas impacted by the ballast remediation.

OIG Observations

Given the ongoing unresolved and contested issues involving the Rail Yard ballast, the OIG issued a Management Alert to the General Manager on August 19, 2019. The OIG provided this Management Alert because ballast performance can affect safety, operational reliability, and maintenance costs once WMATA takes ownership and control of this project. Further, the OIG recommended that WMATA not accept the current conditions for ballast without mitigation.

While it is accurate to say that Federal Track Safety Standards do not require clean ballast as a matter of regulation, nor do AREMA guidelines clearly stipulate minimal ballast condition installed in new rail yards, there is a reasonable expectation on the part of WMATA that the ballast delivered to the Rail Yard should be clean and not fouled.

WMATA should not accept the project unless the five conditions they have set in their February 26, 2020, letter are met.

For an unused, new Rail Yard, the OIG recommends that WMATA accept only a clean ballast condition.

Insulated Rail Joints at Rail Yard (Package B)

Insulated rail joints are an important component of a rail track system and are used to connect two sections of rail together. The insulated rail joint allows sections of track to be electrically insulated from each other to facilitate safe signaling. Joint bars and bolt fasteners are used to join rail tracks together before the two rails are welded.

A failure of the joint, resulting in two sections of track being uninsulated, poses a significant risk to personnel safety and operational efficiency. Insulated rail joints are continuously subjected to dynamic loads generated by rolling stock, stresses due to thermal expansion, and electrical potential. Insulated rail joints are regarded as safety-critical sections of the rail network; therefore, the rail joints must be installed, inspected, and maintained properly.

Insulated Joint

During early testing of the insulated joints in the Rail Yard, there was an abnormally high number of failures that the Contractor later attributed mainly to poor installation. WMATA Project staff attempted to confirm the Contractor's assertions and determine the frequency and extent of the failures. WMATA staff requested manufacturer information, installation method, all results of electrical isolation testing, replacement and/or remediation details, and results from the root cause analyses of the failures. Not all requested information was provided timely and Project staff is continuing to monitor the results of electrical testing conducted in December 2019. MWAA agrees with WMATA Project staff that no failed insulated joints will be accepted. The OIG was informed that resolution of the insulated rail joint issues is being currently discussed between MWAA and WMATA.

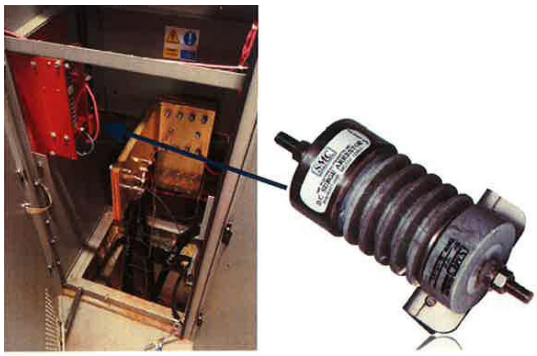
OIG Observations

WMATA Project staff should request a more detailed failure chronology for all failed insulated rail joints, with accompanying root cause analyses and any other field or manufacturer's testing results. The manufacturer and installer should attest that the insulated rail joints meet all safety and performance requirements. The performance of the insulated rail joints should be closely monitored during Operational Readiness Testing to ensure no additional failures or anomalies occur during rail traffic and simulated normal operations.

Surge Arresters (Packages A and B)

Surge arresters are used to protect WMATA's electrical equipment against the effects of over-voltages, or surges. Surges can be caused naturally, such as by a lightning strike, or as a result of internal switching operations. The surge arrestor protects downstream devices from damage by diverting the current through the arrester and, in most cases, to earth. Various types of surge arresters are used depending on the systems and devices protected and operating environment.

Surge Arrester



The OIG was informed by WMATA Project staff there had been several surge arresters that failed testing early in 2019. WMATA Project staff inquired about the failures and were told that appropriate steps were being taken by the manufacturer to mitigate any problems, but staff was initially provided no further information despite making several requests. As more surge arresters were installed, it was reported that some arresters were continuing to exhibit undesirable voltage tolerances.

On April 3, 2019, MWAA provided WMATA Project staff with a copy of the lead electrical contractor's Surge Arrester Analysis Report.[15] The report included information provided by the surge arrester supplier about failures earlier in the year. The supplier had been notified on February 18, 2019, that four surge arresters had been activated on the Silver Line Phase 2 rail extension between February 9-15, 2019. The supplier was further advised that due to the critical nature of the issue, additional surge arrester testing should be conducted. The supplier conducted a forensics review of four activated (failed) arresters and six additional non-activated arresters. Among the six non-activated arresters, three passed the supplier's quality testing and three failed, with the failures being noted as "conducting below the test voltage." The supplier's forensic report concluded that the four activated units caused track arcing during rail polishing and Dynamic Testing.[16] The supplier attributed the other failures on other electrical transients that caused the reduced conduction voltage. An installed surge arrester is shown above.

The supplier's report noted that the life of the surge arrestor is based on the surge current level, time duration, and quantity of transients the surge arrester is exposed to over its useful life. They also stated, in their experience, that new track installations, where rail arc energy occurs, the rail arcing subsides once the track and third rail seats. The report was provided to lead electrical contractor on March 4, 2019, and subsequently forwarded to the Package A Design-Build lead on April 2, 2019.

On July 29, 2019, the Package A design-build lead provided WMATA with a copy of a later report of surge arrester failures from the lead electrical contractor. The lead electrical contractor reported that it reviewed the supplier's forensic report findings and

[15]Lead Electrical Contractor July 25, 2019 correspondence to Package A Design-Build Lead, SUBJECT: Surge Arrester Activation reports.
[16]http://www.dullesmetro.com/news-and-updates/press-releases/rail-polishing-trains-moved-onto-phase-2-tracks/ *Rail-Polishing Trains Moved onto Phase 2 Tracks, February 7, 2019.*

reviewed subsequent arrester failures. Significantly, there were 23 surge arrester events reported through July 19, 2019, involving both positive and negative voltage conditions. The lead electrical contractor reviewed and found no anomalies with the System Configuration. They reviewed the specifications and the performance characteristics for the supplier's installed arrester and then compared data sheets with two other suppliers and those suppliers' compliance with the European surge arrester standard EN-50163.20. The lead electrical contractor concluded that the supplier's surge arrester was not appropriately rated for the 750v WMATA system and should not be used. In its place, the lead electrical contractor recommended using another supplier whose surge arresters were more tolerant of voltage changes.

WMATA Project staff responded to the lead electrical contractor's report and remedial actions on September 5, 2019, questioning the strength of the determination for the root cause(s) for the arrester failures and the absence of involvement by the Engineer of Record, among other comments. Based on our most recent information, the Package A design-build lead and lead electrical contractor have responded to some but not all of WMATA's concerns. The OIG has also been advised that another surge arrester failure was reported in the Rail Yard on February 21, 2020, reflecting ongoing unacceptable surge arrester performance.

OIG Observations

Surge arrester failures were reported as early as February 2019 with the activation of four arresters and test failures of other installed and uninstalled arresters. Subsequent investigations by the lead electrical contractor were more in-depth, and its recommendation was to replace the arresters with a more voltage tolerant arrester, which it represents may be the correct solution to arrester failures. In both the lead electrical contractor and subcontractor analyses there were inconclusive findings as to root causes; however, there were potential causes cited that related to exposure during 'rail polishing,' DC Switchgear and TPS testing, and indeterminant track arcing. Identification of root cause in arrester failures is important to WMATA to ensure that this matter has been resolved and that future incidents do not occur.

Given the frequency of failures and criticality of this component, WMATA should very closely monitor surge arrester performance during the upcoming testing and commissioning, and later System Acceptance, to ascertain whether or not the root cause(s) for electrical transients can be more clearly identified. There are several internal and external potential causes for voltage fluctuations and WMATA may be able to identify and mitigate those before revenue service.

WMATA should also review the impacts of using a higher rated surge arrester in this extension of the Silver Line within the context of surge arrester sizing and performance on the remainder of the system. As WMATA balances its trainset lengths and moves to increase line capacities, the power needs and devices to protect upstream and downstream devices will be more critical.

Turn-outs/Switches (Package B)

On August 12, 2019 the OIG team met with the WMATA Project staff and contract Subject Matter Expert co-located at the Rail Yard. The staff and technical advisor expressed specific concerns about the chronic failures of turnouts (#8) failing to meet required track geometry standards and exhibiting 'tight gage' conditions.

A turnout is defined as an arrangement of a switch and a frog connected by closure rails, by means of which rolling stock may be diverted among different tracks.[17] The frog is an important part of the rail switch (rail turnout) and the intersection of two railway lines. Turnouts are numbered according to the length of a switch determined by the angle of the frog (the point in the switch where two rails cross). In the Rail Yard, almost all turnouts are classified as #8 turnouts.

When the rails leading into the switch cannot be properly aligned, the distance between the rails (gauge) may be adversely affected. In the Rail Yard, there have been repeated issues with a narrower than acceptable distance where the rails are too close together, called a tight gauge condition.

During an April 11-12, 2018 field inspection, MWAA documented improper placement of the concrete ties leading into the switch and turnout. When a train approaches a turnout, the distance between ties is reduced to provide further support for the rail as more loading forces are applied. Adequate space must also be allowed for movement of the rods that physically move the rail. MWAA noted that although the track construction was a "work in progress," there were several locations where the tie spacing was too proximate to the moveable switch rods that this fact contributed to the problem.[18]

[17]AREMA Turnout Terminology- 101-08.
[18]Dulles Field Note April 11-12 (2018).

The track subcontractor indicated it was aware of the tie spacing issues as the work was incomplete and that a crew would complete the installation of the switches and adjust the tie spacing. This work is now complete.

The OIG was also advised that the track subcontractor has been working with the switch manufacturer on adjusting (re-milling) the switch points to facilitate closure and proper operation. As of the date of this report, based on our most recent information the OIG was further advised that the tight gauge at the #4 rod on many of the #8 turnouts, and more recently discovered on some of the #10 turnouts, has recently been further reworked and found by MWAA and WMATA to be acceptable for the purposes of running test trains. This acceptance was conditioned on further inspection after the test train activity and further mitigation efforts as required to achieve compliance with contract requirements. The gauge, as currently exists, is still tighter than allowed by the design tolerance requirement of the contract but is now at least within WMATA maintenance tolerance.

OIG Observations

A tight gauge increases the strain on track fastenings and will cause the flange of the wheel to start grinding against the edge of the rail. This condition causes high flange forces to occur and the flange may ride over the rail, possibly leading to a derailment.

WMATA Project staff repeatedly requested information regarding the high frequency of #8 turnout failure rates and sought information on the causes of the tight rail conditions over a period of several months. Due to the tight gage conditions not being fully resolved, WMATA's track consultant has been closely monitoring the resolution, including switch point tolerances, the stability of the track bed, ballast, and tie placement.

Fuel Center (Package B)

WMATA uses a number of diesel-fueled maintenance vehicles to ferry work crews, supplies, and equipment to support the operations and maintenance of the main line railway and Rail Yard. WMATA planned to have a Fuel Center which services WMATA fleet vehicles located in close proximity to the service track area; however, MWAA approved the Contractor's Yard track layout resulting in the Fuel Center being relocated to another part of the Rail Yard contrary to WMATA's expressed preferences.

In July 2018, following site visits to the new Fuel Center location and discussions with MWAA and the Package B Design-Build Lead, WMATA expressed a number of functional and safety concerns about the Fuel Center's design and compliance with WMATA Design Criteria.[19] WMATA's specific issues and concerns were:

- Dispenser sumps (observed using polyethylene versus fiberglass on underground dispensers)
- Sump penetration and cover (use of rubber boots versus fiberglass bulkhead fittings; use of metal connections versus required fiberglass and O-ring)
- Underground Storage Tank piping (drawings reflected use of single-wall versus double-wall vent piping)
- Track Containment pads (lack of provisions for drainage and oil/water separator)
- Layout of the fueling island and the resulting difficulties with area drainage
- Absence of comprehensive and detailed Civil Design drawings with all required elements

WMATA's letter further explained, in some detail, why the requested changes would improve performance and safety. This included WMATA's experiences with material selection (fiberglass preferred to non-fiberglass), the potential results from improper drainage control exacerbated by rain or snow events, and close proximity of the fueling island to other structures and potential for vehicles to backing in for fueling.

Responding to WMATA's concerns, MWAA sent a letter to its Design-Build Package B Lead Contractor on July 27, 2018, repeating the observations from the site visit and reinforcing WMATA's Design Criteria requirements. Later, on October 17, 2018, MWAA issued DL-095, which included the requested changes in dispenser sump materials, sump covers, fittings and the oil/water separator for the track spill containment pan. MWAA confirmed these directions to WMATA in an October 23, 2018 letter, but MWAA also indicated that the relocation of the island would not be requested of its Design-Build Package B Lead Contractor.

On March 6, 2019, MWAA issued DL-103 indicating that the track spill containment pan shall incorporate a gravity oil/water separator, as required by the Package B Statement of Work.[20]

On April 30, 2019, the Design-Build Package B Lead poured concrete on the Fuel Center containment pad area and over the Underground Storage Tanks (USTs).

On May 3, 2019, WMATA Project again notified MWAA of its requests for details and drawings being used to build over the USTs, all civil details for islands, information for the oil/water separation at track containment pans, and information on the rebar at the fuel unloading areas. The WMATA Project Manager also indicated that the construction of slab over the USTs does not comply with WMATA's Design Criteria.[21]

[19](WMATA-P2B-154 July 13, 2018).

[20]Section 3.6.8.10 and the WMATA Design Criteria, Section 16.1.9.4.1.

[21]16.1.9.2.13. Pour reinforced concrete pad over USTs. Pad shall be a minimum of 12 inches thick.

On May 10, 2019, WMATA, MWAA, and the Package B Design-Build Lead conducted an informal walk-through to discuss WMATA's construction concerns and the missing details and lack of adequate civil drawings showing the details and dimensions of all components.

On May 23, 2019, Package B Design-Build Lead submitted drawings that only showed the storm connection, but no specific detail of pipes. The drawing did not include the oil/water separator, and the submittal was not accepted.

On June 25, 2019, another meeting was held with the Package B Design-Build Lead to discuss the unresolved issues and need for detailed drawings. The Package B Design-Build Lead was again advised it needed to submit civil drawings showing any changes related to the fuel center, including modified track pans and updates in specifications.

Without any responsive actions by the Design-Build Package B Lead Contractor, on August 13, 2019, a report from WMATA's Fire Marshal was sent to MWAA outlining possible safety and fire code violations with the work to date on the Fuel Center.[22]

OIG Observations

The performance and technical specifications for the Fuel Center are straight-forward and should not have presented the Contractor with any significant challenges. For more than a year, the Contractor did not fully respond to WMATA's requests for design drawing details and did not demonstrate compliance with clear requirements; however, construction continued. MWAA made efforts to support the WMATA Project team, but for reasons that are not clear, MWAA did not issue any IRR for the Fuel Center.

[22]WMATA Fire Marshal Report (email August 9, 2019).

While the cost to build the Fuel Center is small in comparison to the Rail Yard costs, the provision of a fueling center without proper safeguards to control fuel storage and to facilitate the safe movement of vehicles may result in more maintenance and heightened risk of environmental incidents and other accidents.

WMATA should continue to demand that the final construction of the Fuel Center fully complies with all WMATA Design Criteria requirements and request that MWAA issue the appropriate IRR to document the known deficiencies.

WMATA should request the assistance of Loudoun County Fire Marshal & Life Safety Office to review the current status of the Fuel Center in advance of any reviews that may have been planned later in the Rail Activation Plan.

Spare Parts (Packages A and B)

Section 2.7.B(3)(f) of the Cooperative Agreement specifies: "*Pursuant to the spare parts provisions in Division 1 of the Phase 2 Design-Build Contract, review the Contractor's proposed listing for spare parts, special tools, test equipment, consumables and personnel training, and provide MWAA with WMATA's selections for parts, tools and training not more than 21 days after WMATA's receipt of the proposed listing*."

WMATA learned during Phase 1 that special attention was needed to allocating resources for getting accurate information on spare parts inventories, special tools, and training requirements. With any new system there are expectations that many system components will perform "as new" and as specified; however, WMATA has no experience with some system components in the newly integrated operating environment. If these individual components do not perform as specified or experience unexpected failure rates, and if WMATA maintenance staff have not been fully trained on new systems requirements, WMATA's safety and operational reliability may be affected.

OIG was advised that WMATA Project staff had rejected several submissions of spare parts, special tools, test equipment, consumables, and training as being inadequate or incomplete. Discussions are continuing between MWAA and WMATA, and there is an expectation that there will be further discussions about the planned monetary set-aside to address ongoing, unresolved issues relating to this requirement.

OIG Observations

In the Silver Line Lessons Learned/After Action Report Phase 1 Report,[23] WMATA staff commented on several problem areas involving spare parts, and related requirements, that occurred during the Rail Activation and Acceptance phase of the Project:

- *There was inadequate identification and coordination of spare parts requirements, the timing for their delivery and information required for tracking receipt and entering into WMATA's storage system(s).*
- *Training was believed by many to be insufficient for various reasons, including, inadequate training material and/or time to review training material, inadequate notice and last-minute changes of training classes, and insufficient field/practical training.*
- *The development by MWAA of asset information required by WMATA was late in its initiation and delivery.*
- *The provision of O&M manuals, as-built, and record information from the Contractor was not completed prior to ORD, and continued to remain incomplete for some time after ORD.*

Given this history and the criticality for successful resolution of spare parts deliverables for Silver Line Phase 2, the OIG concludes this is a high priority for the Project.

Summary of Recommendations

Silver Line Phase 2 is entering a critical phase that represents the culmination of several years' work and considerable expense. MWAA has overall responsibility for the Project and its Contractor performance. To reach the preferred outcomes, full transparency and the cooperation of MWAA and its contractor(s) and subcontractors will be required as the completed work is commissioned and transitioned to WMATA.

OIG recommends that WMATA's Board of Directors not accept the project until the issues identified above are resolved to the satisfaction of WMATA management. In addition, the following actions should also be taken to address these issues:

1. Require MWAA and its Contractor to respond to unresolved ATC quality audit findings and refresh the audit scope to include a review with information now available from current and planned ATC testing and commissioning activities;
2. Accelerate the participation of WMATA's in-house ATC functional owner/WMATA ATC subject matter experts, including their participation in new quality audits;

[23]Washington Metropolitan Area Transit Authority, Dulles Corridor Metrorail Project, Silver Line Phase 1, Lessons Learned/After Action Review, Revision 1, October 30, 2015, FINAL REPORT.

3. Require MWAA and its Contractors to provide assurances that there is a thorough evaluation of all integrated system testing and commissioning activities, with special attention to core system interdependencies since there is no single dedicated Contractor systems integrator;

4. Require MWAA and its Contractor to undertake a comprehensive review of both closed and open NCR, DR, IRR, and OIL logs and categorize and prioritize remedial actions for all safety critical non-conforming reports and provide WMATA evidence of such review and remediation;

5. Accelerate RAP and YAMP activities in advance of planned schedules to provide assistance in resolving those known and higher risk areas of identified concern;

6. Require MWAA and its Contractor to meet the five conditions in WMATA's February 26, 2020, letter for the remediation of the ballast;

7. Require MWAA, its Contractor, and the manufacturer and installer of insulated rail joints to provide all information relating to the frequency, root causes, and mitigations for resolving insulated joint failures, including all functional testing, and to attest that the insulated rail joints meet all safety and performance requirements;

8. Closely monitor the performance of the insulated rail joints during Operational Readiness testing to ensure no additional failures or anomalies occur during rail traffic and simulated normal operations;

9. Review the impacts of using an alternately specified surge arrester in this extension of the Silver Line and within the context of surge arrester sizing and performance on the remainder of the WMATA system;

10. Require MWAA and its Contractors to ensure that the spare parts requirements are wholly satisfied and fully support WMATA's training and new asset management system requirements;

11. Require MWAA and its Contractor to provide evidence that the final construction of the Fuel Center fully complies with all WMATA design criteria requirements and request that MWAA issue the appropriate IRR to document the known deficiencies; and

12. Request the assistance of Loudoun County Fire Marshal & Life Safety Office to review the current status of the Fuel Center in advance of any reviews that may have been planned later in the Rail Activation Plan.

Please provide a response to our recommendations by April 4, 2020.

TO REPORT FRAUD, WASTE, OR ABUSE

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