Washington Metropolitan Area Transit Authority L'Enfant Plaza Station Electrical Arcing and Smoke Accident
Washington, D.C.
January 12, 2015

Accident Report

NTSB/RAR-16/01
PB2016-103217

National Transportation Safety Board

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Notation 8619C
Adopted May 3, 2016

Railroad Accident Report

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490 L'Enfant Plaza, S.W.
Washington, D.C. 20594

National Transportation Safety Board. 2016. Washington Metropolitan Area Transit Authority L'Enfant Plaza Station Electrical Arcing and Smoke Accident Washington, D.C., January 12, 2015. Railroad Accident Report NTSB/RAR-16/01. Washington, DC.

Abstract: On January 12, 2015, at 3:15 p.m. eastern standard time, Washington Metropolitan Area Transit Authority (WMATA) southbound Yellow Line train 302, with about 380 passengers on board, stopped after encountering heavy smoke in the tunnel between the L'Enfant Plaza station and the Potomac River bridge in Washington, DC. The operator of train 302 told the Rail Operations Control Center (ROCC) that the train was filling with smoke and he needed to return to the station. The ROCC allowed train 510, following train 302, to enter the L'Enfant Plaza station, which also was filling with smoke. Train 302 was unable to return to the station before power to the electrified third rail, which supplied the train's propulsion power, was lost. Some passengers on train 302 evacuated the train on their own, and others were assisted in evacuating by first responders from the District of Columbia Fire and Emergency Medical Services Department. As a result of the accident, 91 people were injured, including passengers, emergency responders, and WMATA employees, and one passenger died. WMATA estimated the total damages to be $120,000.

The safety issues and conditions identified in this accident, which illustrate WMATA's lack of a safety culture, are the WMATA response to smoke reports, tunnel ventilation, railcar ventilation, emergency response, and oversight and management of WMATA.

As a result of the investigation of this accident, the National Transportation Safety Board makes safety recommendations to the Federal Transit Administration, the mayor of the District of Columbia, the District of Columbia Office of Unified Communications, the District of Columbia Fire and Emergency Medical Services Department, and the Washington Metropolitan Area Transit Authority.

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Figures and Tables

Acronyms and Abbreviations

AIMS	Advanced Information Management System
ATS	automatic transfer switch
AVR	automatic voltage regulator
BART	Bay Area Rapid Transit District
CFR	*Code of Federal Regulations*
CFM	cubic feet per minute
CM	chain marker
CRCS	Comprehensive Radio Communication System
d.c.	direct current
DOT	US Department of Transportation
ETS	emergency trip station
FAST Act	Fixing America's Surface Transportation Act
FEMS	Fire and Emergency Medical Services Department (District of Columbia)
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
HSEMA	Homeland Security and Emergency Management Agency (District of Columbia)
IC	incident commander
ICAO	International Civil Aviation Organization
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
MAP-21	Moving Ahead for Progress in the 21st Century Act
MCC	motor control center
Metrolink	Metro Transit-St. Louis
MOU	memorandum of understanding
MSC	Metro Safety Commission

MTP	Metro Transit Police Department (WMATA)
NATSA	North American Transit Services Association
NFPA	National Fire Protection Association
NIMS	National Incident Management System
NTSB	National Transportation Safety Board
OSC	on-scene incident commander
OUC	Office of Unified Communications (District of Columbia)
PATCO	Port Authority Transit Corporation
PSAP	public safety answering point
PSRS	Public Service Radio System
RKE	Raymond (Kaiser Engineers) Inc.
recon crew	reconnaissance crew
ROCC	Rail Operations Control Center
RTU	remote terminal unit
SEPTA	Southeastern Pennsylvania Transportation Authority
SMI	safety management inspection
SMS	safety management system
SOP	standard operating procedure
SSO	state safety oversight
SSOA	state safety oversight agency
TOC	Tri-State Oversight Committee
UK	United Kingdom
USC	*United States Code*
WMATA	Washington Metropolitan Area Transit Authority
UMTA	Urban Mass Transportation Administration

Executive Summary

On January 12, 2015, at 3:15 p.m. eastern standard time, Washington Metropolitan Area Transit Authority (WMATA) southbound Yellow Line train 302, with about 380 passengers on board, stopped after encountering heavy smoke in the tunnel between the L'Enfant Plaza station and the Potomac River bridge in Washington, DC. The operator of train 302 told the Rail Operations Control Center (ROCC) that the train was filling with smoke and he needed to return to the station. The WMATA ROCC allowed train 510, following train 302, to enter the L'Enfant Plaza station, which also was filling with smoke. Train 302 was unable to return to the station before power to the electrified third rail, which supplied the train's propulsion power, was lost. Some passengers on train 302 evacuated the train on their own, and others were assisted in evacuating by first responders from the District of Columbia Fire and Emergency Medical Services Department (FEMS). As a result of the accident, 91 people were injured, including passengers, emergency responders, and WMATA employees, and one passenger died. WMATA estimated the total damages to be $120,000.

The National Transportation Safety Board (NTSB) has been concerned with the safety of the WMATA rail system since 1970, when it conducted a special study of the proposed transit rail system while it was still under construction. The resulting report, NTSB/RSS-70/1, *Study of Washington Metropolitan Area Transit Authority's Safety Procedures for the Proposed Metro System*, resulted in one safety recommendation to WMATA to "develop the capability within WMATA for system safety engineering and apply system safety principles to all aspects of the proposed [rail] system to identify, assess, and correct those deficiencies identified by the analysis." This accident is the 13th WMATA rail accident investigated by the NSTB since WMATA rail began operation in 1976. The NTSB has issued 101 safety recommendations to WMATA since 1970.

Our investigation of this accident revealed a range of safety issues and conditions at WMATA that illustrate the transit organization's lack of a safety culture:

- **WMATA response to smoke report.** A smoke detector near the location of the heavy smoke activated at 3:04 p.m. but was not displayed at the ROCC because of a loose wire that prevented communication with the Advanced Information Management System. Other nearby smoke detectors activated later, and those were displayed at the ROCC, but WMATA had no procedures for response to smoke detector activations. WMATA's standard operating procedure states that at the first report of smoke, all trains should be stopped in both directions, but this did not happen on the day of the accident. Instead, the ROCC told the operator of a train carrying revenue passengers to look for smoke, which was WMATA's routine response to reports of smoke or fire.
- **Tunnel ventilation.** The WMATA station and tunnel ventilation systems were designed in the 1970s when no industry standard existed for emergency ventilations for subway transit systems. The systems were designed for heat removal and temperature control, not for emergency smoke removal. Over the years since WMATA began operation, several studies have identified the need for emergency smoke removal and have recommended

increasing the capacity of ventilation fans. Investigators learned that control operators in the ROCC were not trained on strategies for configuring station and tunnel ventilation fans, and therefore, on the day of the accident, the under-platform fans in the L'Enfant Plaza station were turned on in exhaust mode, blanketing train 302 in smoke and pulling smoke into the station.

- **Railcar ventilation.** WMATA did not instruct train operators how to shut down the railcar ventilation systems because there was no written procedure. In addition, operators had to ask the ROCC for permission to shut them down, and then the ROCC provided the specific steps to the train operators. However, those steps did not shut down all the ventilation systems on all the cars immediately. Therefore, on the day of the accident, smoke was pulled into most of the railcars on train 302 through the fresh air intakes.
- **Emergency response.** On the day of the accident, the District of Columbia Office of Unified Communications, which maintains the 911 emergency call system, was slow in processing the first 911 call reporting the smoke. First responders reported that when they arrived at the L'Enfant Plaza station, they were directed to the wrong tunnel to look for train 302. Evacuating passengers reported that egress through the tunnel was difficult because of dim lighting and obstacles along the safety walkway. The FEMS incident commander appeared to ignore the WMATA Metro Transit Police incident commander and did not take into account the multiple agencies involved in the response and the consequent need for elevation to a Unified Command structure.
- **Oversight and Management.** In the years since the 2009 accident at Fort Totten, substantial improvements have not been made, and many of the same safety management deficiencies remain today. The Tri-State Oversight Committee (TOC) has lacked sufficient resources, technical capacity, and enforcement authority to provide the level of oversight needed to ensure safety at WMATA. The TOC also has not met the requirements of the Moving Ahead for Progress in the 21st Century Act that was enacted in 2012. This accident also identified deficiencies in the safety oversight of WMATA by the Federal Transit Administration.

The National Transportation Safety Board determines that the probable cause of the Washington Metropolitan Area Transit Authority L'Enfant Plaza station electrical arcing and smoke accident was a prolonged short circuit that consumed power system components resulting from the Washington Metropolitan Area Transit Authority's (WMATA) ineffective inspection and maintenance practices. The ineffective practices persisted as the result of (1) the failure of WMATA senior management to proactively assess and mitigate foreseeable safety risks and (2) the inadequate safety oversight by the Tri-State Oversight Committee and the Federal Transit Administration. Contributing to the accident were WMATA's failure to follow established procedures and the District of Columbia Fire and Emergency Medical Services Department's being unprepared to respond to a mass casualty event on the WMATA underground system.

As a result of its investigation of this accident, the NTSB issues safety recommendations to the Federal Transit Administration, the mayor of the District of Columbia, the District of Columbia Office of Unified Communications, the District of Columbia Fire and Emergency Medical Services Department, and the Washington Metropolitan Area Transit Authority.

1. Introduction

1.1 The Accident

On January 12, 2015, at 3:15 p.m. eastern standard time, Washington Metropolitan Area Transit Authority (WMATA) southbound Yellow Line train 302 stopped after encountering heavy smoke in a subway tunnel between the L'Enfant Plaza station and the Potomac River bridge.[1] After the train stopped, the rear car of the train was about 386 feet from the south end of the L'Enfant Plaza station platform. The train operator contacted the WMATA Rail Operations Control Center (ROCC) to notify the ROCC that the train was stopped because of heavy smoke.

A following train, train 510, which was stopped at the L'Enfant Plaza station at 3:23 p.m., also was affected by the heavy smoke. This train stopped about 100 feet short of the south end of the platform, but its cars were entirely within the station. Train 510 was evacuated while it was stopped at the station platform.

WMATA Metro Transit Police Department (MTP) officers and L'Enfant Plaza station managers provided assistance in guiding people from the underground platform to the surface. After a period of time, some of the passengers aboard train 302 self-evacuated. Emergency responders were dispatched to the scene and helped evacuate passengers from train 302.

As a result of the smoke, 91 people were injured, and 1 passenger died. Property damages were estimated by WMATA to be $120,000.

1.2 Washington Metropolitan Area Transit Authority

WMATA is a regional transit provider in the Washington, DC, metropolitan area. The rail and bus divisions of WMATA serve about 4 million people within a 1,500-square-mile area covering the District of Columbia; Montgomery and Prince George's Counties in Maryland; Arlington, Fairfax, and Loudoun Counties in Virginia, and the cities of Alexandria, Fairfax, and Falls Church, Virginia.[2]

WMATA was created on February 20, 1967, as an interstate Compact agency among the District of Columbia, the state of Maryland, and the commonwealth of Virginia to plan, develop, build, finance, and operate a regional transportation system in the National Capital area. The US Congress enacted legislation that consented to the Compact.

A board of eight voting directors and eight nonvoting alternate directors governs WMATA. The directors are appointed from the District of Columbia, Virginia, Maryland, and the federal government, with each appointing two voting and two alternate directors. The directors are appointed for terms coinciding with their terms on the appointing bodies. For the District of Columbia, the appointing body is the Council of the District of Columbia; for

[1] Unless otherwise indicated, all times are eastern standard time.

[2] The WMATA divisions are referred to as "Metrorail" and "Metrobus."

Virginia, the Northern Virginia Transportation Commission; for Maryland, the Washington Suburban Transit Commission; and for the federal government, the secretary of the US Department of Transportation. The WMATA board is responsible for policy; financial direction; oversight, including safety oversight; and WMATA's relationships with its customers, jurisdictional partners, and Compact signatories from Maryland, Virginia, and the District of Columbia.

Construction of the WMATA rail system began in 1969. The first phase of the WMATA rail system began operation in 1976, and the newest line of the rail network began operation July 26, 2014. Today, there are 91 rail stations in service within a 118-mile network. (See map at figure 1.)

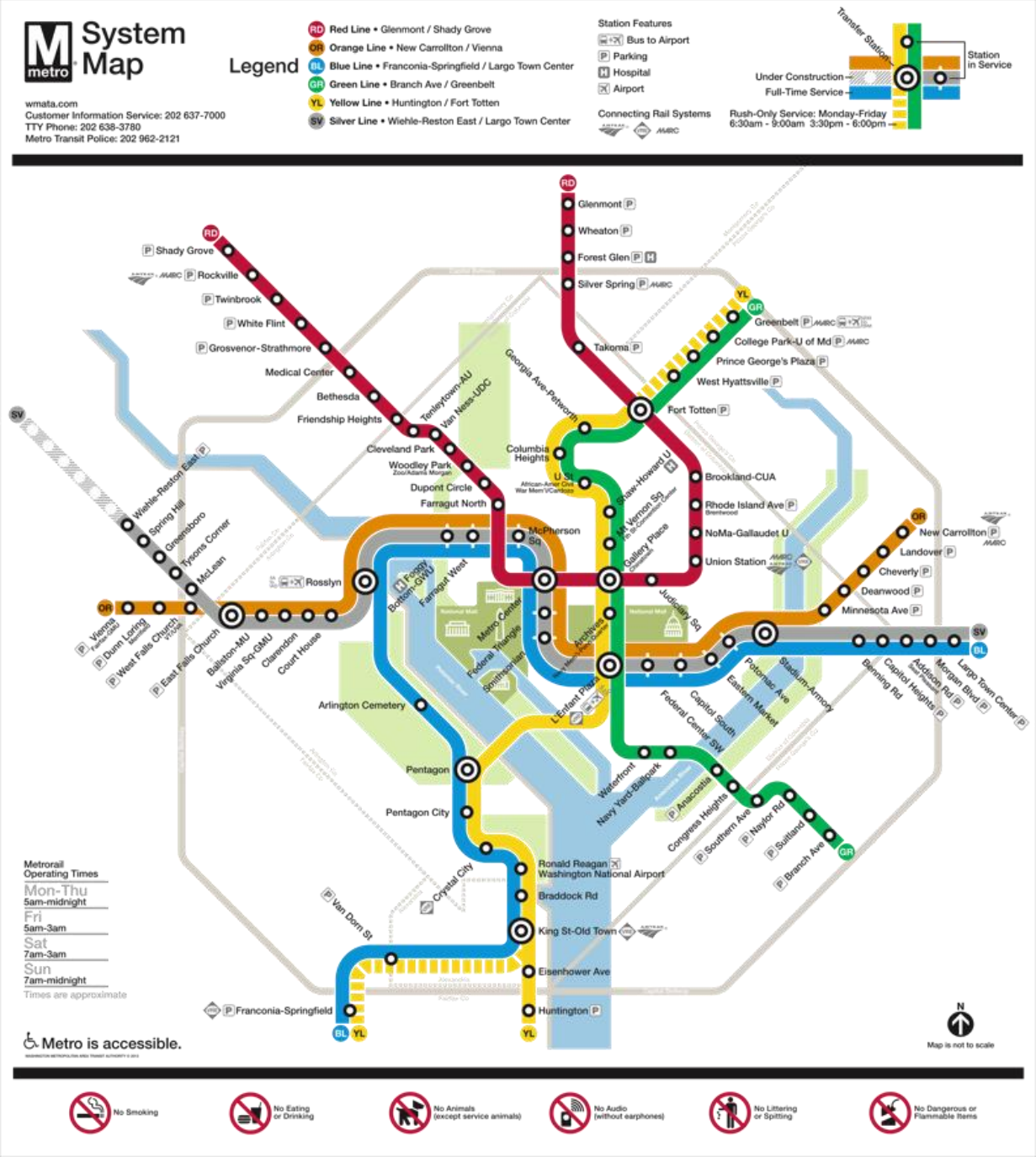

Figure 1. WMATA rail system map.

The rail system consists of six color-coded lines and about 1,100 railcars. The system has underground (subway) and surface stations. WMATA provided more than 263.4 million passenger rail trips from July 1, 2013 through June 30, 2014, averaging 721,800 passenger trips per day. In 2014, WMATA rail's highest daily ridership was 818,076 people.

The L'Enfant Plaza station is in the Southwest Federal Center neighborhood of Washington, DC. The station was opened in 1977. It is a transfer station, with two levels; the

upper level has two side platforms and is used by the Green and Yellow Lines. The lower level has a center platform and is used by the Blue, Orange, and Silver Lines. The station serves five of the system's six rail lines; only the Red Line is not routed through this station.

WMATA trains are electric with propulsion power supplied from an electrified direct current (d.c.) contact rail, known as the third rail, with 750 volt d.c. Collector shoes (paddles) extending from the undercarriage of the train ride along the surface of the third rail and conduct power from the third rail to the train's propulsion system. The third rail is shielded by a fiberglass reinforced plastic cover (cover board) to protect WMATA workers and others from accidental contact.

The WMATA rail system has about 50.5 miles of tunnel trackage. In the underground portion of the system are 82 fan shafts and 116 ventilation shafts. Ninety-eight of these fan and ventilation shafts are also used for emergency egress. An additional 32 shafts serve only as emergency egress shafts, making 130 emergency egress shafts in total. Each of these emergency egress shafts contains a stairwell to the surface to be used in the event of an emergency.

WMATA's Advanced Information Management System (AIMS) is a supervisory control and data acquisition system. AIMS monitors, sends, and receives data and controls between the wayside equipment, such as signals, power, smoke detectors, intrusion, and other equipment and systems, and the ROCC. The data are used to create graphic displays on ROCC controller screens that provide control operators with the information they need to manage traffic flow around the rail system and to recognize and respond to one-time events such as isolated equipment failures.

Safety oversight for WMATA is regulated by the Federal Transit Administration (FTA) within the US Department of Transportation (DOT). In accordance with federal statutes and regulations (Moving Ahead for Progress in the 21st Century Act [MAP-21], Fixing America's Surface Transportation [FAST] Act, and Title 49 *Code of Federal Regulations* [*CFR*] Part 659) the Tri-State Oversight Committee (TOC) is the designated state safety oversight agency (SSOA) for the WMATA rail system.[3]

1.3 Tri-State Oversight Committee

The TOC is a joint effort among the District of Columbia Department of Transportation, the Maryland Department of Transportation, and the Virginia Department of Rail and Public Transportation. The TOC is responsible for developing a program standard for WMATA's safety and security plans; approving those plans; and investigating accidents and hazardous conditions as prescribed in federal regulation. The TOC is responsible for requiring WMATA to develop corrective action plans for safety deficiencies; approving the corrective action plans; and conducting independent reviews of the implementation of safety and security plans on at least a

[3] (1) The Moving Ahead for Progress in the 21st Century Act (MAP-21), Public Law 112-141. (2) The Fixing America's Surface Transportation Act (FAST Act). Public Law 114-94. (3) Until the FTA completes rulemaking to enact the authority of MAP-21 and the FAST Act, the current version of 49 *Code of Federal Regulations* (*CFR*) Part 659, issued in April 2005, remains in effect.

triennial basis. The TOC does not have regulatory authority to enforce its findings with fines, civil actions, or other penalties; such enforcements must be made by state legislatures.[4]

WMATA is unique in that it is the only rail transit agency in the country with a SSOA made up of representatives from three jurisdictions (Maryland, Virginia, and the District of Columbia). The Virginia Department of Rail and Public Transportation and the Departments of Transportation of Maryland and the District of Columbia established the TOC in 1997 by a memorandum of understanding (MOU). Amended in 2008 and again in 2010, the MOU specifies that the TOC be composed of six representatives, two from each of those agencies. The secretaries of transportation of Maryland and Virginia and the director of transportation of the District of Columbia serve on the TOC executive committee and select their respective members assigned to the TOC. The MOU specifies that TOC members must select a chair and a vice chair who serve in those capacities for 2 years. At the end of the 2-year term, the vice chair becomes the chair, and a new vice chair is selected by the TOC members.

The TOC was required by Title 49 *CFR* 659.15 to develop and adopt a system safety program standard, a document that establishes the relationship between the oversight agency and the rail transit agency and that specifies the requirements that the rail transit agency must follow. The program standard must include requirements for safety practices to reduce the likelihood of unintentional acts or circumstances that may lead to death, injury, or property damage and security practices to reduce intentional acts or circumstances. The TOC does not conduct regular independent inspections of equipment, infrastructure, or operations as part of its safety oversight activities.[5] The TOC relies on WMATA to respond appropriately and in a timely manner to any safety concern, finding, or recommendation the TOC makes.

1.4 US Department of Transportation

The National Transportation Safety Board (NTSB) has long been concerned about the safety oversight of rail rapid transit, also called a rail fixed guideway system.[6] Since its founding as a multi-modal safety board, the NTSB has addressed this concern with the DOT multiple times. The NTSB began its call for safety plans, system safety, and safety oversight in 1971 with a special study of rapid transit safety (NTSB 1971). The study identified shortcomings in systematic analyses accounting for the disparities in design specifications in dissimilar systems, emergency preparedness, and safety practices. The NTSB recommended that the DOT's Urban Mass Transportation Administration (UMTA) require system safety plans for all projects that included the safety organization, outputs from the safety effort, methods for identifying hazards and evaluating risk, and documentation.

Since 1967, the NTSB has investigated more than 60 rail transit accidents in the United States (see appendix C); issued 109 safety recommendations to the FTA and its

[4] MAP-21 requires each SSOA to have investigative and enforcement authority for the safety of fixed guideway public transportation systems.

[5] TOC Program Standards and Procedures, Exhibit F3, January 2011. NTSB Docket, DCA15FR004.

[6] A *rail fixed guideway system* means any light, heavy or rapid rail system; monorail; inclined plane; funicular; trolley; streetcar; or automated guideway used primarily for carrying passengers.

predecessor, UMTA (see appendix D); and issued 7 safety recommendations directly to the secretary of the DOT (see appendix E) addressing rail transit safety oversight.

The NTSB first addressed safety oversight of rail transit with the secretary of transportation after a head-on collision of two trains of the Greater Cleveland Regional Transit Authority that occurred on July 8, 1977 (NTSB 1978). Sixty people were injured in that accident. The NTSB subsequently made the following safety recommendation to the secretary of transportation:

R-78-10

> Develop oversight capability to insure that the safety of rail rapid transit systems will be regulated and enforced by a responsible state or federal agency. Within the Department of Transportation, accountability for the oversight should be assigned to the administration that controls federal grants to aid rail rapid transit.

In 1987 the NTSB classified Safety Recommendation R-78-10 "Closed—Unacceptable Action." In that action the NTSB stated its continuing concern about passive federal safety oversight of rail transit systems and its belief that further dialogue with the DOT on the issue at that time would prove futile. The NTSB further noted that it would continue to address this important safety issue in future pertinent accident investigations.

On July 28–29, 1980, the NTSB held a public hearing on rail rapid transit safety. Twenty-five witnesses testified during the hearing on fire safety issues, emergency evacuation from rail rapid transit systems, and safety oversight of transit systems. The NTSB examined fire safety issues in transit railcar design; emergency exit from railcars; emergency tunnel ventilation; evacuation from tunnels; emergency procedures including training, drills, and testing; emergency communications, equipment, and mobility; and local, state, and federal safety oversight of rail rapid transit properties.

Following the 1980 hearing the NTSB issued a safety effectiveness evaluation of rail rapid transit safety (NTSB 1981). The evaluation examined four NTSB investigations of rail rapid transit fires:

- Bay Area Rapid Transit District (BART) train No. 117 on January 17, 1979: 1 firefighter died of smoke inhalation and cyanide poisoning and 56 people injured from smoke inhalation
- Southeastern Pennsylvania Transportation Authority (SEPTA) Block 8 northbound train on September 6, 1979: 148 people injured, suffering from smoke inhalation, cuts, bumps, and bruises
- Upper Darby, Pennsylvania, Bullet Car 204 operating on SEPTA on November 13, 1979: 54 passengers admitted to hospitals, 3 suffering from severe burn injuries and the rest from smoke inhalation
- New York City Transit Authority train on June 25, 1980: 10 people injured from smoke inhalation

The evaluation concluded that there were many fundamental safety problems common to all rail rapid transit systems and that numerous serious safety problems existed that could lead to catastrophic accidents if not corrected. Further, the NTSB concluded that the self-regulating approach to rail rapid transit safety was largely reactive rather than preventive, exposing the public to substantial risk if a fire occurred. Also, this approach had failed to provide an effective process for the development of safety performance standards and had not provided effective safety oversight to assure a minimum level of safety. In the evaluation the NTSB recommended that the secretary of transportation propose federal legislation that would explicitly authorize the establishment of safety standards for rail rapid transit systems and pending the enactment of such legislation, establish federal guidelines for rail rapid transit equipment and operations (R-81-01 and -02). The NTSB issued 18 safety recommendations to UMTA addressing design criteria, emergency response and management, and safety oversight (R-81-03 through -20). In 1982 the NTSB classified recommendations R-81-01 and -02 "Closed—Reconsidered" because at that time it concluded that detailed regulation of rail rapid transit safety should not lie with the federal government. The NTSB classified nine of the recommendations to UMTA "Closed—Unacceptable Action" and nine "Closed—Acceptable Action or Acceptable Alternate Action."

On July 23, 1991, the NTSB issued a safety study, *Oversight of Rail Rapid Transit Safety* (NTSB 1991). The study stated the following:

> Although the NTSB had concluded in the early 1980s that regulation and enforcement of transit system safety could be handled by the states, with the federal government providing a measure of oversight through the investigation of accidents, incidents, or conditions that could affect the safety of passengers, the lack of action taken by the state governments in response to NTSB safety recommendations and the occurrence of more accidents in the mid- and late 1980s in which safety oversight was raised as an issue prompted the NTSB to undertake a study to examine the adequacy of current oversight of rail rapid transit safety.

The study addressed the actions needed to improve the oversight of rail rapid transit safety. The following safety issues were addressed in the study:

- the effectiveness of current oversight activities exercised by the District of Columbia and states in which rail rapid transit systems are operating
- the usefulness of rail rapid transit accident and injury data
- the federal government's role in the oversight of rail rapid transit safety

As a result of this study, the NTSB issued safety recommendations to UMTA (R-91-33 through -36, see appendix D), the District of Columbia and states in which rail rapid transit systems were operating (R-91-37), and the secretary of transportation (R-91-38, see

appendix E).The recommendations focused on an effective oversight program of rail rapid transit safety.[7]

In December 1991 the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), was signed into law. ISTEA redesignated UMTA as the FTA and defined the states' responsibility for rail fixed guideway systems safety and outlined the requirements for state safety oversight. Under ISTEA, states were responsible for the safety of the rail fixed guideway systems within their borders. Each state was required to establish a SSOA that sets requirements for rail transit safety and monitors the performance of rail transit agencies in accordance with those requirements. Through rulemaking, the FTA promulgated Title 49 *CFR* Part 659, which established minimum requirements for the safety programs that the state agencies implement and oversees the efforts of the state agencies in carrying out the programs. Part 659 became effective January 26, 1996.

After the investigation of the July 11, 2006, derailment of Chicago Transit Authority train No. 220 and electrical arcing in a tunnel that resulted in injuries to 152 people, the NTSB made four safety recommendations to the FTA (NTSB 2007). Those recommendations included modification of the FTA's program to ensure that a SSOA would take action to address all safety deficiencies and to develop and implement an action plan to enhance the effectiveness of state safety oversight (SSO) programs.

On June 22, 2009, a WMATA train struck the rear of a stopped WMATA train on above-ground track near the Fort Totten station in Washington, DC (NTSB 2010). Nine people including a train operator were killed, and 52 people were transported to local hospitals. The investigation found that although safety program plans were in place, they were not effectively implemented and overseen. As a result, the NTSB made the following safety recommendation to the DOT:

R-10-3

> Continue to seek the authority to provide safety oversight of rail fixed guideway transportation systems, including the ability to promulgate and enforce safety regulations and minimum requirements governing operations, track and equipment, and signal and train control systems.

On December 26, 2012, the NTSB classified this safety recommendation "Closed—Acceptable Action" based on the enactment of MAP-21, which gave the FTA expanded safety oversight authorities.[8] The NTSB closed this recommendation in good faith with

[7] Safety Recommendation R-91-37 to California, Florida, Georgia, I11inois Mary1and, Massachusetts, New Jersey, New York, Ohio, Pennsylvania, Virginia, and the District of Columbia: Develop or revise, as needed, existing programs to provide for continual and effective oversight of rail rapid transit safety. The elements of the oversight program should include reviews of maintenance and inspection records, accident investigation activities, audits of system safety program plans, reviews of the transit system safety department, reviews of training programs, monitoring of accident data, and periodic inspections of equipment and infrastructure. Classified "Closed—No Longer Applicable on September 4, 2002.

[8] The president signed MAP-21 into law on July 6, 2012, with an effective date of October 2, 2012.

the expectation that the FTA would exercise its expanded authorities within the time specified in the act.

The FAST Act, signed into law December 4, 2015, amended the federal public transportation programs and expanded FTA authority. MAP-21 and the FAST Act made a number of fundamental changes to these programs in Title 49 *United States Code* (USC) Chapter 53. Section 5329, Public Transportation Safety Program, requires the secretary of transportation (delegated to the FTA) to create and implement a National Public Transportation Safety Plan, a public transportation safety certification training program, a public transportation agency safety plan, and a SSO program to improve the safety of all public transportation systems that receive funding from the FTA. A transit asset management system and performance measures and targets are required in section 5326 not later than 1 year after the date of enactment (by July 6, 2013) to ensure a state of good repair of all transit assets.

1.5 Previous NTSB Investigations of WMATA

The NTSB has investigated 13 accidents on the WMATA rail system, including this accident, and has issued 106 safety recommendations to WMATA (see appendix F). The 12 previous accidents are the following:

Smithsonian Interlocking (1982) On January 13, 1982, about 4:30 p.m. a WMATA Blue/Orange Line train 410 derailed at the Smithsonian Interlocking (NTSB 1982).[9] While being operated manually, the train had been unintentionally routed into a crossover track at the interlocking. Without requiring a supervisor, who was at the location, or the train operator to ascertain that it was safe to do so, the WMATA ROCC allowed the supervisor to back the train out of the crossover track. As this was being done, the rear car derailed and struck the end of a reinforced concrete barrier wall separating the two main tracks in the tunnel. The aluminum sidewall of the car was severed, and the main passenger compartment was breached. About 220 passengers were on board; 3 were killed, and 25 were injured. The NTSB determined that the probable cause of the accident was—

> the failure of the ROCC to stop movement of trains through the Smithsonian Interlocking until it ascertained the nature of and corrected the switch misalignment; the failure of the ROCC over a 3-day period to note discrepancy reports concerning a wayside control failure in the Smithsonian Interlocking and to order repairs; the failure of the on-scene rail transportation supervisor to check conditions at the original lead end of train 410 before initiating the reverse movement of the train; and the failure of the train operator to timely recognize the train had derailed and to apply the brakes in emergency. Contributing to the accident was WMATA management's failure to put in place an adequate program of initial and recurrent training for ROCC and Metrorail operating personnel and its failure to adopt adequate rules and procedures for safe operation of trains in the manual mode.

[9] *Interlockings* are sites at which tracks join together to allow crossing from one track to another. An interlocking includes the track switches and associated signals and control machinery necessary to connect track and to ensure safe operation through the connected or crossing track.

Shady Grove Station (1996) On January 6, 1996, WMATA train T-111 failed to come to a stop at the above-ground Shady Grove, Maryland, passenger station, the final station on the Red Line (NTSB 1996). The four-car train ran by the station platform and continued about 470 feet into the WMATA rail yard north of the station, where it struck a standing, unoccupied subway train that was awaiting assignment. The operator of train T-111 was killed; the train's two passengers were not injured. The NTSB determined that the probable cause of this accident was—

> the failure of WMATA management and board of directors (1) to fully understand and address the design features and incompatibilities of the automatic train control system before establishing automatic train operation as the standard operating mode at all times and in all weather conditions, (2) to permit operating department employees, particularly ROCC controllers and supervisors, to use their own experience, knowledge, and judgment to make decisions involving the safety of Metrorail operations, and (3) to effectively promulgate and enforce a prohibition against placing standby trains at terminal stations on the same track as incoming trains. Contributing to the severity of the injuries to the train operator was the disproportionate amount of crush sustained by the lead cars of the colliding trains.

Silver Spring Station (1997) On October 28, 1997, about 2:28 p.m., a visually impaired passenger stepped from the platform into the gap between two railcars of WMATA train T-106 and fell to the track bed. He was fatally injured when the train departed the station.[10]

Silver Spring Station (1999) On November 12, 1999, about 9:31 p.m., southbound WMATA train No. 154 struck a passenger when he fell in between the second and third cars of a six-car train on track no. 2 at the Silver Spring station on the Red Line.[11] The passenger was attempting to board the train when he fell and became wedged between the left side of the train and the loading platform edge. The passenger died.

Woodley Park Station (2004) On Wednesday, November 3, 2004, about 12:49 p.m., WMATA train 703 collided with train 105 at the Woodley Park-Zoo/Adams Morgan station in Washington, DC (NTSB 2006). Train 703 was traveling outbound on the Red Line and ascending the grade between the Woodley Park-Zoo/Adams Morgan and the Cleveland Park underground stations, when it rolled backward about 2,246 feet and struck train 105 at a speed of about 36 mph. Train 703 was not carrying revenue passengers. Train 105, a train with revenue passengers, was in the process of discharging and loading passengers at the Woodley Park-Zoo/Adams Morgan station. There were about 70 passengers on board train 105. Some passengers had exited the train just before or during the collision. The District of Columbia Fire and Emergency Medical Service (FEMS) transported about 20 people to local hospitals. The NTSB determined that the probable cause was "the failure of the operator of train 703 to apply

[10] The NTSB did not issue a report on this accident. For more information on this accident, visit http://www.ntsb.gov/investigations/SitePages/dms.aspx and search for NTSB accident number ATL98FR003.

[11] The NTSB did not issue a report on this accident. For more information on this accident, visit http://www.ntsb.gov/investigations/SitePages/dms.aspx and search for NTSB accident number ATL00FR002.

the brakes to stop the train, likely due to his reduced alertness. Contributing to the accident was the lack of a rollback protection feature to stop the train when operated in the manual mode."

Dupont Circle Station (2006) On Sunday, May 14, 2006, about 10:16 a.m. eastern daylight time, a southbound Red Line train struck and killed a WMATA employee as the train was about to enter the Dupont Circle station in Washington, DC (NTSB 2008a). The employee was an automatic train control system mechanic who had been working with two other mechanics at the interlocking just north of the Dupont Circle station. All three mechanics had moved between the two main tracks north of the interlocking to stay clear of a northbound train that was leaving the station. As the southbound accident train was arriving, the two other mechanics remained in the clear between the two trains as they passed and were not injured. According to signal system data logs, the southbound train was moving about 40 mph as it traveled past the interlocking. The NTSB determined that the probable cause of the accident was—

> the failure of the automatic train control system (senior) mechanic to stay clear of the approaching southbound train either because he was not aware of the presence of the train or because he lacked a physical reference by which to identify a safe area outside the train's dynamic envelope. Contributing to the accident were WMATA Metrorail right-of-way rules and procedures that did not provide adequate safeguards to protect the wayside personnel from approaching trains, that did not ensure that train operators were aware of wayside work being performed, and that did not adequately provide for reduced train speeds through work areas. Also contributing to the accident was the lack of an aggressive program of rule compliance testing and enforcement on the Metrorail system.

Eisenhower Ave. Station (2006) On November 30, 2006, about 9:30 a.m., a northbound WMATA Yellow Line train struck and killed two WMATA employees who were performing a routine walking inspection along an outdoor section of main track near the Eisenhower Avenue station in Alexandria, Virginia (NTSB 2008b). The accident occurred as the northbound train was traveling along track normally used for southbound traffic. The NTSB determined that the probable cause was—

> the failure of the walking track inspectors to maintain an effective lookout for trains and the failure of the train operator to slow or stop the train until she could be certain that the workers ahead were aware of its approach and had moved to a safe area. Contributing to the accident were WMATA Metrorail right-of-way rules and procedures that did not provide adequate safeguards to protect wayside personnel from approaching trains, that did not ensure that train operators were aware of the wayside work being performed, and that did not adequately provide for reduced train speeds through work areas. Also contributing to the accident was the lack of an aggressive program of rule compliance testing and enforcement on the Metrorail system.

Mt. Vernon Square (2007) On January 7, 2007, about 3:45 p.m., northbound WMATA train 504 derailed one car as the train traversed a crossover from track 2 to track 1 (NTSB 2007b). The accident occurred in an underground tunnel on the Green Line near the

Mt. Vernon Square station at chain marker (CM) E2 23+28.[12] The train was traveling about 18 mph as it approached the station. The train consisted of six cars. The fifth car from the head end of the train derailed. About 80 passengers were on board at the time of the accident. Twenty-three passengers were transported to local hospitals for treatment and released. The NTSB determined that the probable cause was—

> a wheel climb on car 5152 that was initiated by a rough wheel surface created when the wheel was trued with a milling machine, the lack of quality control measures to ensure that wheel surfaces were smoothed after truing, the lack of a guard rail on the No. 8 turnout, and WMATA's failure to have an effective process to implement safety improvements identified following similar accidents and related research projects.

Fort Totten Station (2009) On Monday, June 22, 2009, about 4:58 p.m. eastern daylight time, inbound WMATA train 112 struck the rear of stopped inbound train 214 (NTSB 2010). The accident occurred on above-ground track on the Red Line near the Fort Totten station in Washington, DC. The lead car of train 112 struck the rear car of train 214, causing the rear car of train 214 to telescope into the lead car of train 112, resulting in a loss of occupant survival space in the lead car of about 63 feet (about 84 percent of its total length). Nine people aboard train 112, including the train operator, were killed. Emergency response agencies reported transporting 52 people to local hospitals. The NTSB determined that the probable cause of the collision was—

> (1) a failure of the track circuit modules, built by GRS/Alstom Signaling Inc., that caused the automatic train control system to lose detection of train 214 (the struck train) and thus transmit speed commands to train 112 (the striking train) up to the point of impact, and (2) WMATA's failure to ensure that the enhanced track circuit verification test (developed following the 2005 Rosslyn near-collisions) was institutionalized and used systemwide, which would have identified the faulty track circuit before the accident.[13]
>
> Contributing to the accident were (1) WMATA's lack of a safety culture, (2) WMATA's failure to effectively maintain and monitor the performance of its

[12] *Chain markers* are located every 100 feet along the right-of-way. The markers show the line designation, the track number, and the distance in feet (using surveyor's notation) from the marker to the center of the Gallery Place station for the Yellow and Green Lines.

[13] On June 7, 2005, a failure in the train-wayside communication system resulted in the ROCC manually routing trains departing Rosslyn, rather than automatic routing from the wayside. A ROCC controller misrouted an outbound train from Rosslyn, causing following trains to back up between the Foggy Bottom and Rosslyn stations. A train stopped within a track circuit between the two stations, and the automatic train control subsystem failed to detect the presence of the train in the track circuit. This allowed speed commands to be transmitted to the train immediately behind the stopped train. The operator of that train saw the train ahead, realized his train was not slowing, and applied the train brakes. His train stopped about 50 feet behind the stopped train. Eventually, the first train moved forward, and the train that had stopped to prevent a collision moved ahead until it was occupying the track circuit previously occupied by the first train. The track circuit again failed to detect the presence of the train, allowing speed commands to be transmitted to the following train. The operator of the following train saw the train ahead, determined that his train was moving too fast, and applied his train's emergency brakes. His train stopped about 20 feet behind the other train.

> automatic train control system, (3) GRS/Alstom Signaling Inc.'s failure to provide a maintenance plan to detect spurious signals that could cause its track circuit modules to malfunction, (4) ineffective safety oversight by the WMATA Board of Directors, (5) the Tri-State Oversight Committee's ineffective oversight and lack of safety oversight authority, and (6) the Federal Transit Administration's lack of statutory authority to provide federal safety oversight.
>
> Contributing to the severity of passenger injuries and the number of fatalities was WMATA's failure to replace or retrofit the 1000-series railcars after these cars were shown in a previous accident to exhibit poor crashworthiness.

Falls Church, Virginia (2009) On November 29, 2009, about 4:28 a.m., WMATA train 902 struck the rear of a standing WMATA train at the West Falls Church rail yard in Falls Church, Virginia (NTSB 2012a). No passengers were on board either train at the time of the collision; however, two WMATA maintenance department car cleaners were on board the struck train. The employees sustained minor injuries from the accident and were treated and released by a local hospital. The operator of train 902 also sustained minor injuries and was treated and released by a local hospital. The NTSB determined that the probable cause of the accident was "the failure of the train operator to control the movement of his train as it approached the standing train, possibly due to his fatigue."

Rockville, Maryland (2010) On January 26, 2010, about 1:40 a.m., a hi-rail vehicle—a truck or automobile that can be operated on either highways or rails—operating southbound about 0.9 miles north of the WMATA Rockville station struck and fatally injured two automatic train control technicians who were working on the right-of-way replacing an impedance bond between the tracks (NTSB 2012b). The hi-rail vehicle was traveling down the track in the reverse gear at about 13 mph. The NTSB determined that the probable cause of the accident was inadequate safeguards by WMATA to protect roadway workers from approaching hi-rail vehicles, and to ensure hi-rail operators were aware of any wayside work being performed. Contributing to the accident was—

> the inadequate communication of vital information concerning ongoing work by the ROCC; the lack of an appropriate and effective lookout by the hi-rail vehicle operator and crew to carefully observe the track on approach; and the ineffective lookout for trains and/or hi-rail vehicles on the part of the automatic train control technicians.

Farragut North Station (2010) On February 12, 2010, about 10:16 a.m., outbound WMATA Red Line train 156, consisting of six passenger cars, departed the Farragut North station on the No. 2 main track and was routed by the automatic train control system into a pocket track (NTSB 2012c).[14] The train operator completed the move into the pocket track and stopped the train briefly about 180 feet before the red signal at the exit from the pocket track.

[14] A *pocket track* is a short track, typically between two main lines, that is used to turn a train around to reverse direction, to store trains until they are placed in service, and to stage track equipment.

The operator then moved the train at 7 mph past the signal and through a derail.[15] The front wheel set of the lead car derailed, causing the operator to apply emergency braking and the train to stop 27.9 feet after the point of derailment. At the time of the accident, train 156 was carrying 345 passengers. Three passengers sustained minor injuries: two passengers were treated on scene and released, and the third passenger was transported to a local hospital, treated, and released on the same day. The NTSB determined that the probable cause of the accident was—

> the train operator's failure to follow proper operating procedures, which resulted in her operating the train past a red signal and over the interconnected derail. Contributing to the accident was the failure of WMATA management to provide proper supervision of the train operator, which resulted in the incomplete configuration of the train identification and destination codes leading to the routing of the train into the pocket track.[16]

[15] A *derail* is a device used to prevent occupation or fouling of a track by unauthorized movements of trains or unattended rolling stock. It works by derailing the equipment as it rolls over or through the derail.

[16] The automatic train control system uses the *destination code* to automatically route a train to a destination.

2. Accident Description

2.1 Events Preceding the Accident

Train 301 was the last southbound train that departed the L'Enfant Plaza station on the Yellow Line before the accident. The train operator told NTSB investigators that he made a normal station stop at L'Enfant Plaza and departed at 2:54 p.m. toward the Pentagon station. He said he did not observe anything out of the ordinary while traveling through the tunnel between L'Enfant Plaza and the Potomac River bridge.

A smoke detector at a drainage pump station on the Yellow Line about 1,940 feet south of the south end of the L'Enfant Plaza platform (CM L2 70+50) activated at 3:04:54 p.m.[17] During the investigation, WMATA stated that this alarm was not received by AIMS and displayed at the ROCC, or at any location, because of "an open wire."[18]

At 3:06:40 p.m. an electrical circuit breaker on a circuit feeding power from L'Enfant Plaza to the third rail of the southbound Yellow Line tripped and remained open, degrading power to this section of the third rail.[19] However, the third rail continued to receive power from an electrical feed south of the accident site. (See figure 2.)

[17] (1) CM L2 70+50 means the Yellow Line, 7050 feet from the Gallery Place station. (2) Times with hours, minutes, and seconds are reported for selected critical times in the accident sequence. These times are taken from recorded data.

[18] *Open wire* meant that the detector was not connected to AIMS, causing the notification failure.

[19] The southbound Yellow Line track is designated track 2; the northbound Yellow Line track is track 1.

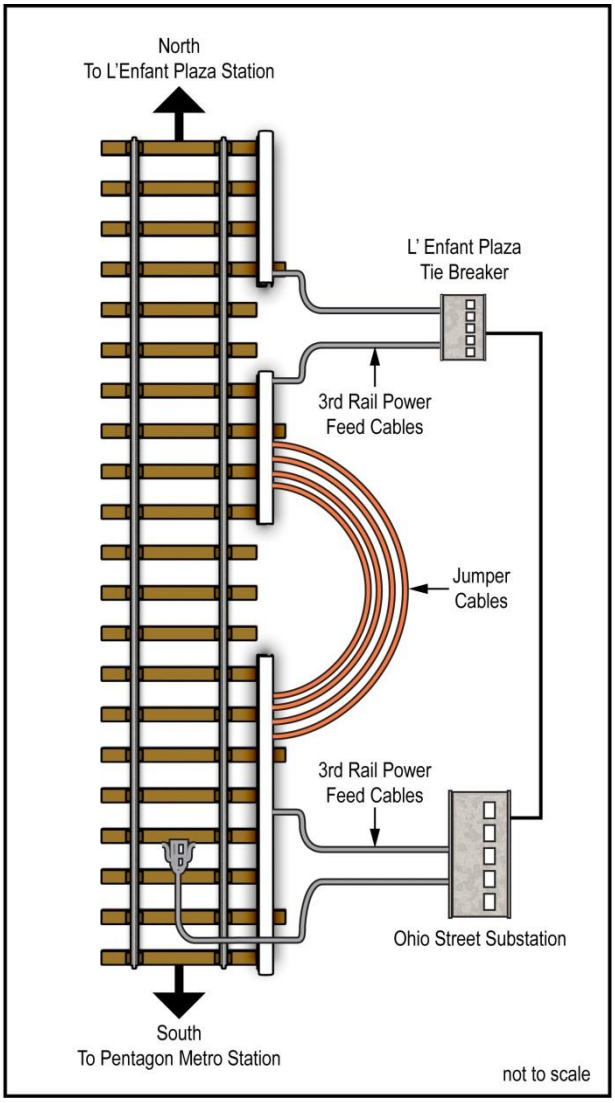

Figure 2. Power supply to third rail in tunnel south of L'Enfant Plaza.

At 3:07:21 p.m., the operator of northbound Yellow Line train 508, traveling on track 1 through the tunnel between the Potomac River bridge and the L'Enfant Plaza station, reported to the WMATA ROCC that there was smoke in the interlocking at L'Enfant Plaza. In response, the ROCC train control operator instructed the operator of southbound train 302 to inspect for smoke while approaching L'Enfant Plaza.[20] The train 302 operator told NTSB investigators that while he was stopped at the platform, he had seen no smoke coming out of the tunnel at the south end of the platform.

[20] WMATA Standard Operating Procedure (SOP) #6, Fire and Smoke on the Roadway, required that all trains stop when fire or smoke was reported. SOP #6 is at appendix G.

2.2 Accident Overview

WMATA train 302, consisting of six railcars, was traveling southbound on track 2 of the Yellow Line toward the Pentagon station with about 380 passengers aboard. The train was 450 feet long. (See appendix B for a timeline of the accident.)

At 3:14 p.m. train 302 departed L'Enfant Plaza. Moments after entering the south tunnel, between L'Enfant Plaza and the Potomac River bridge, the train encountered smoke. At 3:15:15 p.m., the train operator stopped the train in the tunnel. When train 302 stopped, an on-duty WMATA MTP officer on board train 302 reported to the MTP at 3:15:24 p.m. that there was fire on the train and smoke in the tunnel.[21] This initial report was relayed to the train control operator in the ROCC about 20 seconds later, at 3:15:45 p.m. The train had traveled about 836 feet beyond L'Enfant Plaza before coming to a stop, and the rear railcar of the train was about 386 feet from the south end of the L'Enfant Plaza platform. Passengers told NTSB investigators that the train had come to an abrupt stop in the tunnel and that the emergency lights in the railcars had come on.

At 3:15:52 p.m. Green Line train 510, 450 feet long with six railcars, departed the Archives station en route to the next station, L'Enfant Plaza.[22] Train 510 was traveling southbound on track 2 following train 302.

At 3:17:17 p.m. the operator of train 302 radioed the ROCC to report that the train was stopped in the tunnel because of heavy smoke and that he needed to return to L'Enfant Plaza. The return operation required the operator to key down the console of the lead car in the train, go to the opposite end of the train, and key up the console of the rear railcar.[23] The train would then be able to move in the opposite direction back to the L'Enfant Plaza platform.

The train operator made announcements to the passengers, instructing them to stay calm and assuring them that arrangements were being made to return to the platform. The train operator walked through the train to the rear railcar, to key up that railcar to serve as the lead railcar in the train to return to the station.

Passengers told NTSB investigators that they saw the train operator walk through the railcars asking passengers to remain calm and not open the emergency exit doors and saying that the train would return to the station. After a short time, estimated by passengers to be about 5 minutes, the railcars began to fill with smoke that became thicker, resulting in passengers' having difficulty breathing. Passengers crouched on the floor of the railcars in an attempt to escape the smoke. While passengers awaited emergency responders, several dialed 911.

[21] (1) Two on-duty MTP officers on board train 302 were traveling as passengers to another duty assignment. (2) NTSB investigators determined that there was smoke in the tunnel but no fire on the train.

[22] Both the Yellow and the Green Lines use the same track between the Archives and the L'Enfant Plaza stations.

[23] *Key down* means to lock the control mechanisms in the operating compartment of the railcar in the neutral position, disabling train control from that end of the train. *Key up* means to unlock the control mechanism in the operating compartment of the railcar to enable the control of train movements.

At 3:17:38 p.m. the ROCC instructed train 510 to stop, on track 2, between Archives and L'Enfant Plaza. The assistant superintendent on duty in the ROCC then instructed a senior rail control operator to take over as radio control operator, which he did, about 5 minutes later, at 3:22:10 p.m. The senior rail control operator then instructed train 510 to proceed to and service L'Enfant Plaza, and about 3:23 p.m. the train stopped at the L'Enfant Plaza platform. Heavy smoke in the station caused the train operator to stop about 100 feet short of the south end of the platform. (See figure 3.)

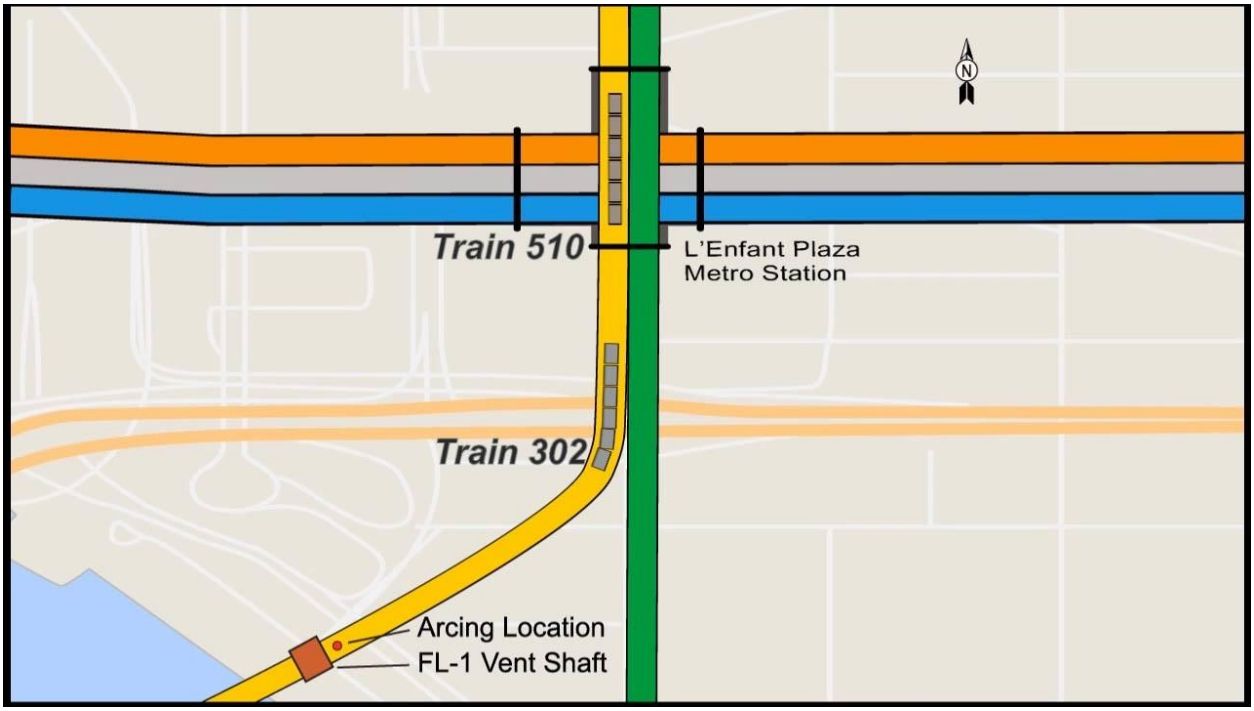

Figure 3. Accident site.

The MTP evacuated the passengers and the operator of train 510 from the train and the station. During this time the train operator continuously attempted to contact the ROCC by radio to report the smoke and the evacuation, but she received no response from the ROCC. As she was escorted out of the station by the MTP, the operator of train 510 again attempted to contact the ROCC using the telephone at the station kiosk, but she was unsuccessful. NTSB investigators learned that the ROCC did not know that train 510 had been evacuated by the MTP.

The MTP escorted the train 510 operator back into to the station to move train 510 out of the station to vacate the track at that platform. The train operator boarded the standing equipment and commenced closing doors to set up the train for movement. During this process, the L'Enfant Plaza station emergency third rail power cut-off switch was activated by first responders, disconnecting third rail power on all Yellow and Green Line tracks. Because of the lack of power, no further actions could be taken to move the train. Shortly after the failed attempt to move train 510, the train operator was again escorted out of the station.

Once the operator of train 302 had reached the other end of the train, at 3:18:45 p.m. he keyed up the rear car to be ready to return to L'Enfant Plaza, and at 3:18:50 p.m. he notified the

ROCC of this. At 3:21 p.m. the ROCC instructed the train operator to shut down the ventilation system on the train, which the operator attempted to do by opening the ventilation circuit breaker on the railcar closest to L'Enfant Plaza.[24] At 3:32:01 p.m. the train operator told the ROCC that some passengers had self-evacuated. The ROCC train control operator told the train 302 operator that train 510 had arrived at L'Enfant Plaza and that this restricted movement back to the station. At 3:32:30 p.m., the emergency brakes on train 302 activated automatically due to a decrease in the brake pipe pressure. The train operator began to check each railcar to determine the cause of the emergency brake activation; while he was doing this, the power to the third rail was degraded, rendering the train incapable of movement.

At 3:22:34 p.m., the ROCC reported to the District of Columbia Office of Unified Communications (OUC) that there was smoke in the L'Enfant Plaza station.[25] FEMS arrived at L'Enfant Plaza at 3:31:12 p.m. and established an Incident Command at 3:40 p.m. Firefighters disconnected third rail power and subsequently arrived at the rear of train 302 at 3:50 p.m.

After firefighters opened a side door in the rear railcar, passengers exited train 302 through that door and stepped onto the safety walkway. Firefighters carried one passenger off the train; that passenger later died. Firefighters escorted the passengers along the safety walkway to the L'Enfant Plaza station, through the station, and out to the street. Injured passengers were then transported to local hospitals for medical evaluation and treatment. All passengers were evacuated by 4:27 p.m.

2.3 WMATA Train Information

2.3.1 Train 302

Train 302 (the accident train) originated in Greenbelt, Maryland, and had made several trips across the system on January 12, 2015, before the accident. The train operator boarded the southbound train at the Fort Totten station about 30 minutes before the accident. The train operator was located in the control cab in the lead railcar; two WMATA MTP officers also were on board the train.[26] The train 302 operator told NTSB investigators that he had no problems with the operation of the train and that the braking system of the train was fully functional.

As train 302 departed the Mt. Vernon Square station (three stations before L'Enfant Plaza), the train operator noted a small trash fire on the track and reported it to the ROCC. The train operator told NTSB investigators that while traveling south toward L'Enfant Plaza he overheard a radio transmission and heard that "there was a little bit of smoke at L'Enfant Plaza."

[24] At the time of the accident, WMATA procedures required train operators to receive permission from the ROCC before shutting down the ventilation system.

[25] The District of Columbia Office of Unified Communications receives emergency 911 calls and dispatches the appropriate emergency responders.

[26] The two MTP officers were traveling to their next assignments.

2.3.2 Recorded Data

NTSB investigators reviewed and analyzed data from the event recorder on train 302, data from AIMS, and surveillance video from inside the L'Enfant Plaza station. Most WMATA railcars are equipped with event recorders that continuously record train operating parameters such as speed and braking.[27]

Train 302. Only four railcars in the train consist had event recorders. Event recorder data from those four railcars showed that the train departed L'Enfant Plaza southbound on track 2 at 3:14:25 p.m. The train's speed increased to 17 mph and then slowed to 15 mph. After the train traveled 182 feet, the battery voltage on the railcars began to drop from a normal voltage of 37 volt d.c. Investigators determined that this drop in voltage was due to degraded power because the circuit breaker tripped on the circuit that provided power from the north. Event recorder data indicated that train 302 came to a stop at 3:15:15 p.m. after traveling a distance of about 836 feet. At 3:16:35 p.m., the lead railcar was keyed down. At 3:18:45 p.m., the data show that the trailing railcar was keyed up. At this time data also show that the ventilation systems were on.

At 3:32:28 p.m., event recorder data indicated that the brake pipe pressure had dropped below 70 pounds per square inch, resulting in an emergency brake application on the train. This loss in brake pipe pressure and resulting emergency brake application was due to the degraded third rail power. After the train operator notified the ROCC that the emergency brakes had applied, he was instructed to recharge the brake pipe and begin preparations to move the train. Event recorder data show that beginning at 3:33:34 p.m., the train operator made several attempts to recharge the brakes; however, those efforts were unsuccessful. Event recorder data show that at 3:48:42 p.m. at least one door in the train consist was open.

Train 510. Data from AIMS showed that train 510 departed the Archives station on the Green Line at 3:15:52 p.m. en route to L'Enfant Plaza. At 3:17:45 p.m. train 510 stopped between Archives and L'Enfant Plaza on track 2 as instructed by the ROCC. Train 510 arrived at the L'Enfant Plaza station at 3:23:18 p.m. according to both AIMS data and the WMATA security video of the L'Enfant Plaza Yellow Line platform.

2.4 Injuries

One passenger died, and 91 people, including passengers, WMATA employees, and emergency responders, were injured and treated at medical facilities. (See table 1.) The medical diagnoses of 87 of the 92 people were related to smoke inhalation. The other five people were treated for related problems: chest pain, shortness of breath, pneumonitis, and carbon monoxide exposure/poisoning. One passenger administered cardiopulmonary resuscitation (CPR) to the passenger who later died. Other passengers reported experiencing difficulty breathing, and some had nausea and vomiting.

[27] The accident train consisted of two each of the 1000-, the 3000-, and the 6000-series railcars. The 1000-series railcars do not have event recorders.

Table 1. Injuries.

Injury Severity[a]	Train 302 Passengers	WMATA Employees[a]	Emergency Responders[b]	Total
Fatal	1	0	0	1
Serious	3	0	0	3
Minor	75	11	2	88
Total	79	11	2	92

[a] Title 49 *CFR* 830.2 defines serious injuries as those which require hospitalization for more than 48 hours, commencing within seven days from the date the injury was received; result in a fracture of any bone (except fractures of fingers, toes, or nose); involve lacerations which cause severe hemorrhage, nerve, muscle, or tendon damage; involve injury to any internal organ; or involve second or third-degree burns, or any burns affecting more than five percent of the body surface.

3. Accident Investigation and Analysis

The origin of the smoke that caused the accident was about 1,910 feet south of the L'Enfant Plaza station, or about 1,100 feet south (in front) of the stopped train. At this location was a ventilation fan shaft, identified as FL-1, that also housed a drainage pump and an emergency exit from the tunnel. If a train had to be evacuated while inside the tunnel, the train could disembark passengers at the emergency exit platform from track 1 and track 2. Passengers evacuating could also step up from the track bed to the emergency exit platform and then use an emergency exit staircase to reach the surface. The tunnel bores for tracks 1 and 2 are connected at the bottom of the FL-1 shaft. Because FL-1 is also an emergency exit, the third rail terminates at each end of the emergency exit platform, and four cables maintain the electrical continuity of the third rail along the length of the platform. (See figure 4.) This arrangement ensures that passengers do not have to step over the third rail when evacuating from a train. This is true for tracks 1 and 2 on either side of the emergency exit platform.

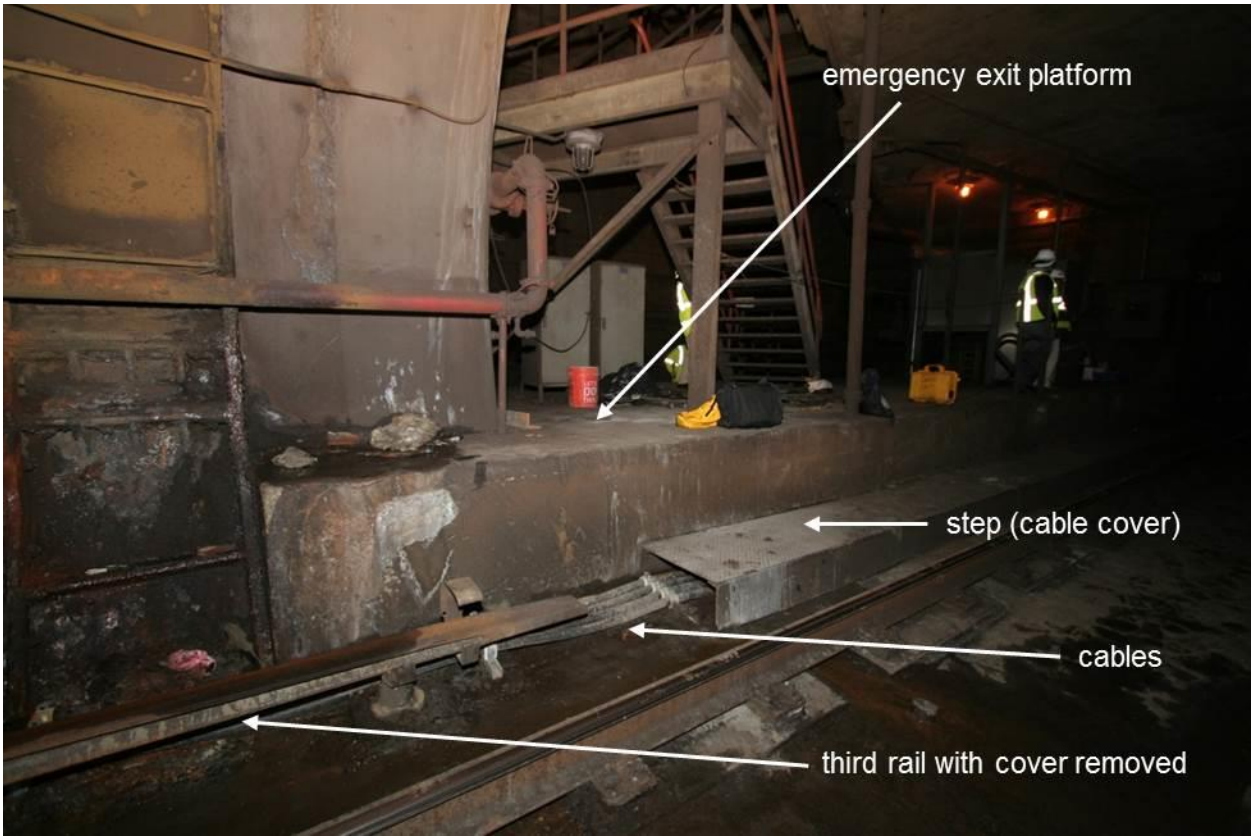

Figure 4. Emergency exit at FL-1 next to track 2 in Yellow Line tunnel south of L'Enfant Plaza.

The cables used to bridge the gap in the third rail were connected to the third rail at the ends of the platform with sections of flexible cable, called pigtail cables. The connections between cables and pigtail cables used lugs and bolts to fasten the cables. The lugs and bolts were then enclosed within a fiberglass insulating cover. This arrangement is called a cable

connector assembly (See figure 5.) The other end of each pigtail cable was welded to the third rail. There were four sets of these cables in parallel used to connect the two ends of the third rail across the gap created by the emergency exit platform. The cables and the pigtail cables were single conductor cables constructed from copper strands covered with an insulating layer and a protective jacket. The cable conductors were nominally 1 inch in diameter and had specifications typical for cables used for traction power. The cables had a low smoke rating; the pigtail cables were not rated for their smoke emission characteristics.[28]

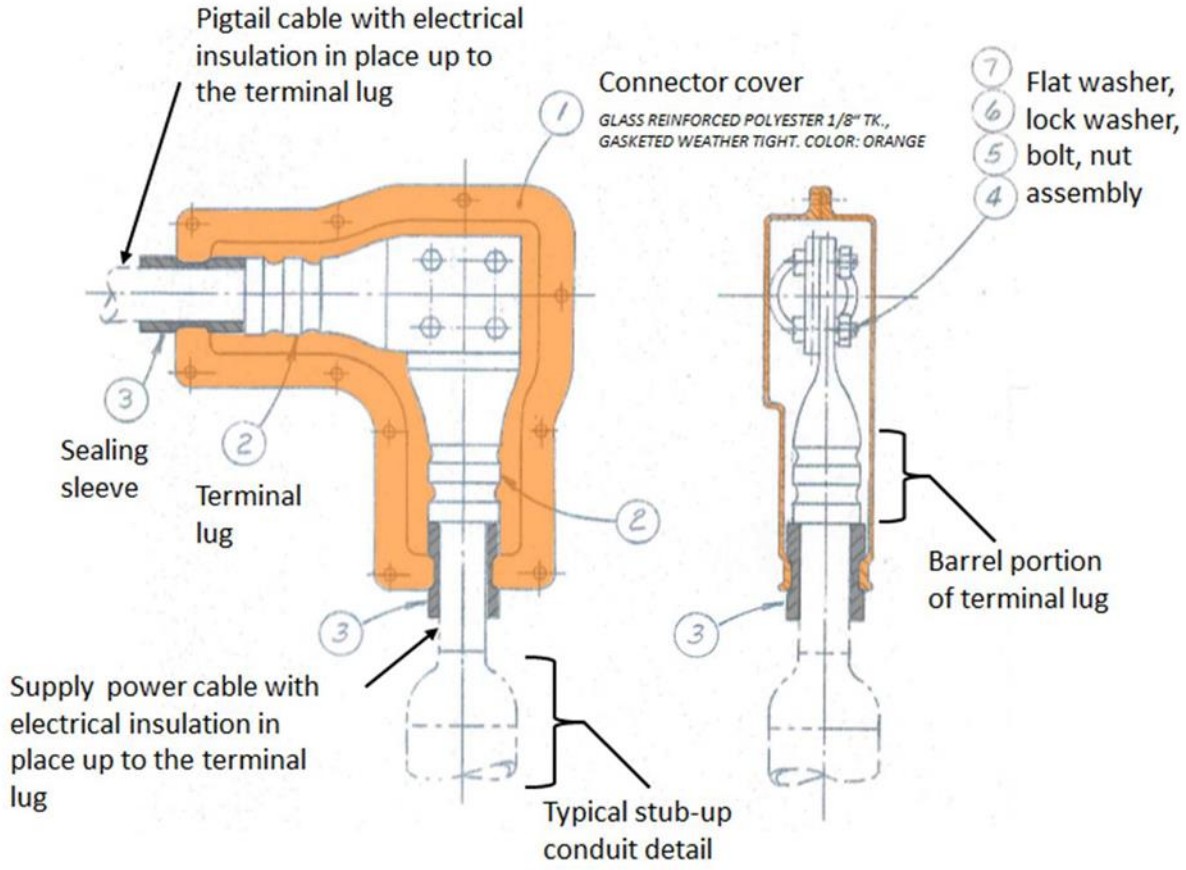

Figure 5. Cable connector assembly.

3.1 Electrical Arcing

Investigators observed an area where the third rail components, including cables, cable connector assemblies, and portions of the third rail cover board, were damaged or consumed entirely. The majority of the damage was concentrated in the area around the cable connector assemblies of the cables where the third rail terminated to accommodate the emergency exit platform at the north end (the end closest to train 302). (See figure 6.)

[28] (1) Cable specification: General Cable, BICC Brand MI 1000 kcmil, EPR/XLPO (Cross Linked Polyolefin, a thermoset jacket material with low smoke characteristics that is free of halogens) 90°C dry or wet, 2KV LS for CT use traction power cable 09-02. (2) Pigtail cable specification: Okonite Company, PLT 3 1/C 1000 kcmil CU Okonite (EP) – CSPE (UL) RHH VW-1, 2000V, SUNRES for CT use.

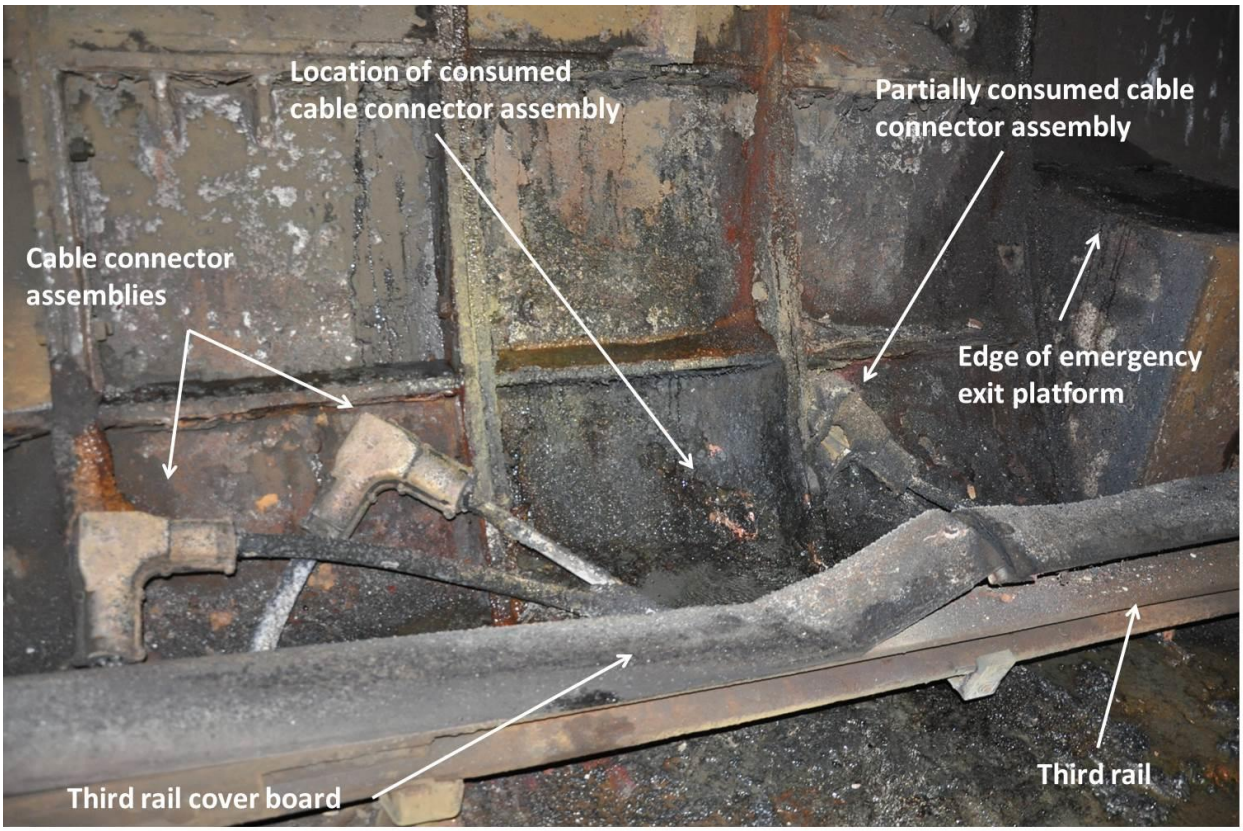

Figure 6. Damaged cables and cable connector assemblies, and cover board.

The tunnel wall casing in this area was constructed of ribbed plate steel sections bolted together. Investigators noted resolidified molten copper on one of the steel plates near the floor, directly behind an area where a cable connector assembly had previously been, before it was consumed in the accident. Another cable connector assembly in this area was partially consumed. Portions of all four of the cables had been consumed. (See figure 7.) The ends of the severed cables exposed the copper conductor that melted and beaded, and the insulating sheathing had been burned and thermally damaged, leaving the remaining copper wire strands bare. The melted and beaded copper conductors at the ends of the severed cables is consistent with conductors that have experienced electrical arcing.

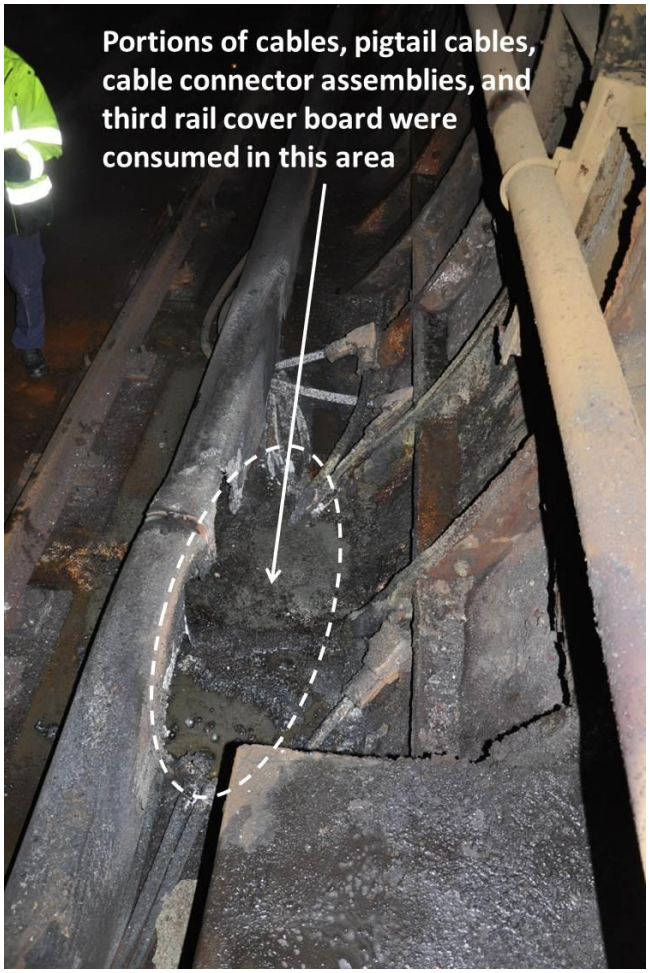

Figure 7. Location of consumed third rail components.

Investigators noted that the third rail cover board exhibited an area where the polymer resin binder had been completely burned and pyrolized, leaving just the fiberglass reinforcement behind.[29] (See figure 8.) The damaged portion of the third rail cover board was adjacent to the location of the cables and cable connector assemblies that were damaged by electrical arcing. A horizontal soot trail and gradient of thermal damage along the interior face of the third rail cover board was consistent with air flow in the tunnel that drifted north toward the L'Enfant Plaza station at the time of the accident.

[29] *Pyrolysis* is chemical change brought about by the action of heat.

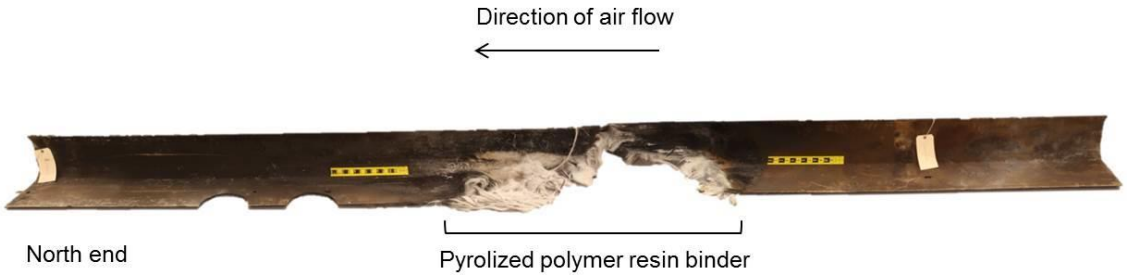

Figure 8. Thermally damaged third rail cover board.

The L'Enfant Plaza electrical arcing event consumed about 16 feet of the affected third rail power cables and portions of the cable connector assemblies. The consumption of these materials hindered the examination of material evidence at the incipient point of failure. Therefore, it was necessary to examine similar electrical arcing and smoke events within the WMATA network to collect additional evidence and establish a probable failure mechanism. Two smoke incidents occurred in the WMATA tunnel system after the January 12, 2015, accident: February 11, 2015, at the Court House station and May 19, 2015, at the Friendship Heights station. NTSB investigators examined materials from these incidents along with those from L'Enfant Plaza to help understand the cause of these smoke events.

Examination of third rail components from the Court House and Friendship Heights incidents revealed evidence of an arc tracking failure mode in which an electrical leakage current develops over an insulating surface.[30] This leakage current is enabled by the presence of contaminants and moisture on the surface of the insulation. The leakage current generates heat and electrical scintillations that damage the insulation by carbonization, which reduces its electrical resistance.[31] Over time this mechanism continuously degrades the insulation until a low-resistance electrical short circuit occurs. In the evidence from the Court House incident, arc tracking was identified on the cable connector end of a pigtail cable. In the Friendship Heights incident, arc tracking was identified on the third rail end of a few pigtail cables. (See figure 9.)

[30] Electrical *arc tracking* is a type of electrical arcing that occurs on insulating surfaces when contaminants and moisture accumulate in a manner such that leakage currents can flow along the insulating surface, allowing a short circuit to develop. Patricia L. Cahill and James H. Daily, Aircraft Electrical Wet-Wire Arc Tracking, DOT/FAA/CT-88/4 (Atlantic City, NJ: US Department of Transportation, Federal Aviation Administration Technical Center, August 1988).

[31] *Scintillations* are minute electrical discharges that create small flashes of light.

Figure 9. Pigtail cable from Friendship Heights incident.

NTSB investigators found that electrical arc tracking can occur at a cable connector assembly if the power cable terminal lugs are not sealed in a weathertight connector, called a sealing sleeve, allowing contaminants in the external environment access to the bare lugs inside the connector.[32] Under these conditions, electrical arc tracking can occur when contamination extends between the conducting surface of the terminal lugs and ground, creating an electrically conductive path along the outside surface of the cable. The presence of moisture is a necessary condition for the accumulated contaminants to become electrically conductive. Arc tracking is a relatively low-current phenomenon and will not instantly result in a high-power short circuit. Over time, cumulative degradation of the insulating material caused by the electrical arc tracking can cause a low resistance path between the lugs and ground, creating a short circuit that can generate fire and smoke in tunnels.

3.2 Water Intrusion

On February 11, 2015, NTSB investigators examined the accident site and photographed the tunnel structure with emphasis on water infiltration and rusting of the steel liner plates. Many locations of active or past water infiltration were noted. The tunnel in the area of the electrical arcing damage was wet, with puddles of water in locations where the cables were damaged and

[32] A weathertight enclosure resists moisture and particulate infiltration and accumulation that can exist in tunnel environments.

consumed. (See figure 10.) Investigators also saw water flowing between the wall casing plates in an area where electrical damage was observed. They also saw water dripping from the tunnel casing above the location of the electrical damage onto third-rail components.

Figure 10. Standing water near north end of third rail (postrepair photo).

Track 1 (northbound track) of the Yellow Line south of L'Enfant Plaza had a cable installation similar to that used on Track 2 (accident track) to bridge the gap in the third rail along the length of the emergency exit platform. The environment where the cable connector assemblies were lying was not as wet as what was seen in track 2. However, there was moisture and water puddles along the track bed. The cables were coated in moist, mud-like debris. (See figure 11.)

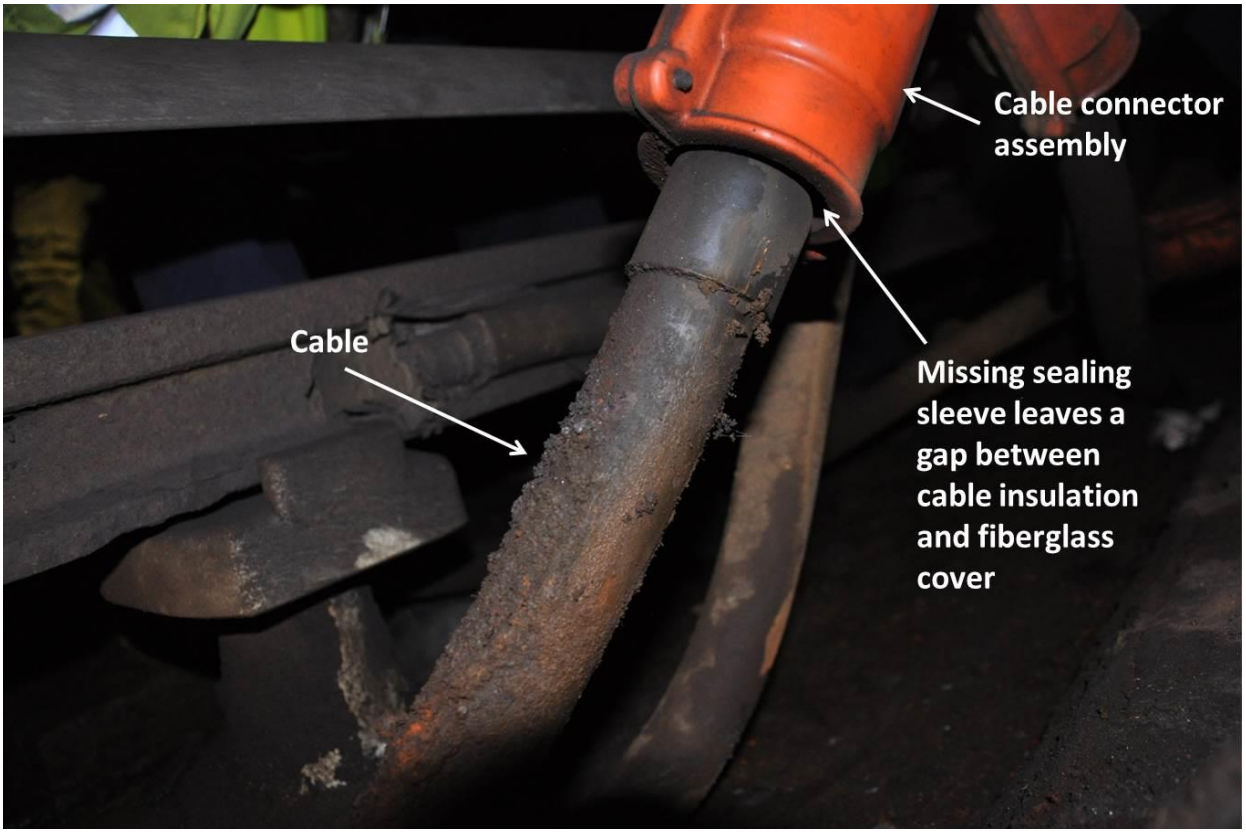

Figure 11. Track 1 cable coated with moist mud-like contaminants, and cable connector assembly without sealing sleeve.

Examination of installed and undamaged cable connector assemblies at L'Enfant Plaza revealed that sealing sleeves intended to make the assemblies weathertight were missing. (See figure 11.) If the sealing sleeve is not used, a gap between the cable and the connector cover provides a route for contaminants and moisture to enter the cable connector assemblies where the lug ends of the cables are bolted together. After the accident, NTSB investigators examined cable connector assemblies in multiple locations and found that many were not in accordance with WMATA's engineering design specifications, including some that had been replaced after the accident. Contamination and moisture inside the cable connector assembly and along the cable's insulation can create a path to an electrically grounded surface such as a steel tunnel liner or a wet track bed. Both of these electrically grounding surfaces existed at the origin of the electrical arcing. The NTSB concludes that electrical arc tracking was aided by the presence of contaminants and moisture on third rail cables and inside cable connector assemblies. The NTSB further concludes that WMATA's third rail electrical power cable systems are susceptible to electrical arc tracking at improperly constructed power cable connector assemblies, which can lead to short circuits that can generate fire and smoke in tunnels. The cable connector assemblies were at the center of the area where electrical components had been consumed; one connector assembly was entirely consumed, and one was half consumed. The ends of the pigtail cables that would have attached to the third rail from this set of cables did not show any signs of distress. The NTSB concludes that the electrical short circuit initiated from either the consumed or the damaged cable connector assembly.

On June 8, 2015, after the investigators discovered multiple instances of missing sealing sleeves in the cable connector assemblies throughout the WMATA system, the NTSB issued Safety Recommendation R-15-25 to WMATA:

> Promptly develop and implement a program to ensure that all power cable connector assemblies are properly constructed and installed in accordance with your engineering design specifications, including the weather tight seals that prevent intrusion by contaminants and moisture.

The NTSB has classified this recommendation "Open—Acceptable Response."

In the L'Enfant Plaza accident, the damage to the cables was more severe than at Court House, and large portions of the cables were consumed. More sustained arcing occurred at L'Enfant Plaza because the cables were lying in water and resting against the steel tunnel wall (liner), allowing the arcing to be sustained as the cables were being consumed. The NTSB therefore concludes that intrusion of water at the electrical arcing site contributed to the severity of the accident. The smoke in the tunnel was generated by electrical arcing that consumed about 16 feet of electrical power cables and insulation, portions of four fiberglass cable connector assemblies, and about 5 feet of the fiberglass third rail cover board. The water in the area of the electrical arcing would have also vaporized and contributed to the perceived volume of smoke. The NTSB concludes that the electrical arcing that resulted in the consumption of the cables that were resting against the tunnel wall was the origin of the smoke at the accident location.

There is evidence showing that the water intrusion near the accident site, which has been ongoing for an extended period of time, has not been effectively mitigated. Before 2013, WMATA conducted tunnel leak inspections annually to identify the location and the severity of water intrusion into the tunnels. NTSB investigators obtained tunnel leak reports for 2010 through 2012 for the southbound Yellow Line tunnel between L'Enfant Plaza and the Potomac River bridge. The reports identified many leaking locations near the site of the electrical arcing. Some of the locations were identified repeatedly in consecutive reports. The WMATA reports noted leaks in nine locations in a length of the tunnel about 290 feet long in which the electrical arcing occurred. In two of those locations, a leak was recorded in each of the years from 2010 through 2012. Both leaks were recorded as being active in 2010 and rated severe in 2011 and 2012. After 2012, WMATA stopped conducting tunnel leak inspections; instead, leak inspection was added to the WMATA tunnel structural inspections that are conducted every 2 years. However, evidence from other sources continued to point to water intrusion near the accident site. After the accident, NTSB investigators reviewed thermal imagery video from March, June, and October 2014 that captured the 290-foot stretch of the southbound Yellow Line tunnel section where the electrical arcing occurred.[33] All three videos showed changes in the temperature signature consistent with the presence of water near the electrical arcing site. In addition, a preconstruction survey conducted in October 2014 as part of the nearby redevelopment of the Southwest Waterfront (the Wharf project) documented the

[33] WMATA has a geometry car, which is a specialized measurement railcar, that was equipped with thermal imaging cameras. These cameras were used primarily to identify heat sources near electrical components in the WMATA rail system. WMATA representatives told NTSB investigators that the thermal imaging also was effective in identifying water due to the low temperature caused by the presence of water.

condition of the Yellow Line tunnels, fan shafts, and pump stations near the construction. The preconstruction survey report showed multiple locations with either active leaks or stains and corrosion on tunnel walls near the electrical arcing location. Based on this evidence, the water leaks near the electrical arcing location had been ongoing for more than 4 years and WMATA failed to mitigate the leaks effectively.

The investigation team noted active water intrusion at the location of the electrical arcing. The water was flowing into a drainage channel on the tunnel floor, indicating that the drainage system was working correctly. Water intrusion has been identified as a common problem for WMATA's tunnel system. Tunnel water leaks are a common occurrence in subsurface facilities because of the water table and ground saturation. At the NTSB's June 23-24, 2015, investigative hearing on this accident, a WMATA representative stated that "there are approximately at any given time between 3,000 [and] 5,000 water leaks within the system." He stated that even though repairs are made, "it is not unusual to have reoccurring water leaks near vent shafts, vent structures." When asked about persistent, recurring water intrusion, he said, "We discharge approximately 2 million gallons of water a day, which in layman's terms [is] about three Olympic-size swimming pools." Water leaks in the southbound Yellow Line tunnel away from the site of the electrical arcing and in the Yellow Line northbound tunnel also have been identified.

As part of its 2010 Triennial Safety and Security Review, the TOC examined WMATA structures including the tunnels.[34] Water intrusion was one of the findings, Area of Concern 14C-7:[35]

> Current preventive maintenance practices do not appear sufficient to fully address water intrusion issues observed by the review team. Water intrusion is common in WMATA tunnels and other underground facilities, as well as in structures that extend below the groundwater level. As such, WMATA stations and tunnels show some leakage problems. Walk-in inspections of the concrete linear tunnel running from Potomac Avenue to Stadium Armory and the steel linear tunnel running from L'Enfant Plaza to Waterfront revealed evidence of water intrusion and rust damage along the side wall joints. In addition, water leakage was noted on the utility floor at the time of inspection at Forest Glen Station. Water leaks were also noted from coffer structure roof joints and from gull roof through the center glass roof at Capitol Heights Station, Addison Road Station, Landover Station, and East Falls Church Station. At Medical Center Station and Metro Center Station, acoustic ceiling tiles were missing or partially falling, due to water leakage. Falling acoustic ceiling tiles are hazardous to the patrons and should be repaired.

To close this finding, WMATA must:

[34] Title 49 *CFR* 659.29 requires a SSOA to conduct a safety and security review once every 3 years at a minimum.

[35] The TOC identified as Areas of Concern observations that were in compliance with existing WMATA policies and procedures and with TOC program standards but that could be improved using best practices.

- Evaluate current preventive maintenance practices related to water intrusion to determine if they adequately address the issues noted in the finding.
- Provide the written evaluation results to TOC.

The TOC included in the review walking inspections of sections of the Green Line tunnel between the L'Enfant Plaza and the Waterfront stations. The inspections "revealed evidence of water intrusion and rust damage along the side wall joints." The review recommended that WMATA "evaluate current preventive maintenance practices related to water intrusion."[36] This Area of Concern was closed on June 28, 2011, based on documents provided by WMATA that showed leak repair work. The WMATA tunnel leak reports after 2010 continued to show the presence of severe or active leaks at locations that had been reported as repaired, and many leaking areas were identified in consecutive years.

As previously mentioned, WMATA stopped conducting tunnel leak inspections after 2012. Instead, WMATA added leaks to the list of items inspectors should look for or inspect during biannual tunnel structural inspections. These inspections focused on the condition of the structural components of a tunnel including steel liner elements, the concrete invert slab, the drainage system, and tunnel fan shafts and fan shaft structures. The most recent structural inspections of the Yellow Line tunnels between L'Enfant Plaza and the Potomac River bridge in both northbound and southbound directions were performed in October 2014. The inspection report rated all parts of the tunnel structure "Fair" or "Satisfactory," except the drains, which were rated "Poor." The report identified items such as aging chain marker signs, missing and raised nose plates on steps (horizontally projecting edges of stair treads), a grab bar covered by wires, vertical cracking on a tunnel wall, and a clogged drain. Also reported was a tunnel leak at a joint that was dripping water onto the track structure (rated "Poor"). This 2014 report did not identify leaks near the accident site, although other inspections, such as the thermal imaging and the Wharf project preconstruction survey, both conducted at roughly the same time, in October 2014, showed that water intrusion was present during this time. Comparison of the recent tunnel inspection reports with the earlier leak inspection reports shows that the current structural inspections captured far fewer water leaks than the leak inspections. The NTSB therefore concludes that including leak inspections with WMATA tunnel structural inspections was not effective in identifying leaks.

WMATA records show that during two separate periods in 2013 (March and July), tunnel leaks were mitigated in the southbound Yellow Line tunnel in about the same area where the electrical arcing occurred (CMs 69+00–71+00). However, no such repairs were performed in 2014. WMATA records also show that leaks in the southbound Yellow Line tunnel near the accident site were repaired on February 7, 2015, after the electrical arcing accident. Although WMATA has a system for rating the severity of tunnel water leaks, currently it has no system for prioritizing repair work based on leak severity. In addition, WMATA has no tracking system to monitor the conditions of the leaks. The NTSB concludes that the WMATA tunnel repair program was not effective in mitigating recurring water intrusion like that found in the

[36] As part of the triennial safety and security review mandated by 49 *CFR* Part 659, recommendations were made to address issues that were not in compliance with the regulations, WMATA policies and procedures, and the TOC program standard. The TOC does not have regulatory jurisdiction to levy fines or penalties for noncompliance.

southbound Yellow Line tunnel. Therefore, the NTSB recommends that WMATA review and revise its tunnel inspection, maintenance, and repair procedures to mitigate water intrusion into tunnels (R-16-08). The NTSB further recommends that when the revision of tunnel inspection, maintenance, and repair procedures recommended in Safety Recommendation R-16-08 has been completed, WMATA train maintenance employees on the new procedures, and ensure that the procedures are implemented. The NTSB also recommends that the FTA issue regulatory standards for tunnel infrastructure inspection, maintenance, and repair, incorporating applicable industry consensus standards into those standards.

Investigators noted construction activity at street level near the electrical arcing location. These construction activities were part of the Wharf project begun in late 2014. As noted above, a preconstruction survey in October 2014 documented the condition of the Yellow Line tunnels before the Wharf project construction began, and the survey report documented multiple locations with either active leaks or stains and corrosion on tunnel walls near the electrical arcing location. The NTSB concludes that water intrusion into the Yellow Line tunnel south of L'Enfant Plaza predated the adjacent construction of the Wharf project, and therefore the construction was not a factor in the initiation of the electrical arcing.

3.3 Tunnel Ventilation

Ventilation fans were located throughout the WMATA system at strategic locations to remove smoke and heat from the tunnels. The fans could be operated in either a supply mode, to draw fresh air into the tunnels and stations, or an exhaust mode, to pull air from the tunnels and stations to the outside. The fans could be operated either remotely from the ROCC or locally from control panels near the fans.

Smoke was not observed in the station as train 302 departed L'Enfant Plaza at 3:14 p.m., but the train operator stopped the train about 836 feet beyond the south end of the station after encountering heavy smoke. In response to reports of smoke, at 3:16:09 p.m. a ROCC train control operator activated the under-platform fans in exhaust mode in the L'Enfant Plaza station, enveloping train 302 in smoke. It was not until 3:24:28 p.m. that fans in the ventilation shaft near the smoke origin were activated in emergency exhaust mode by the ROCC. At this point, train 302 was already blanketed in smoke. Train 510 also was enveloped in smoke once it arrived at the L'Enfant Plaza platform. (See figure 12.)

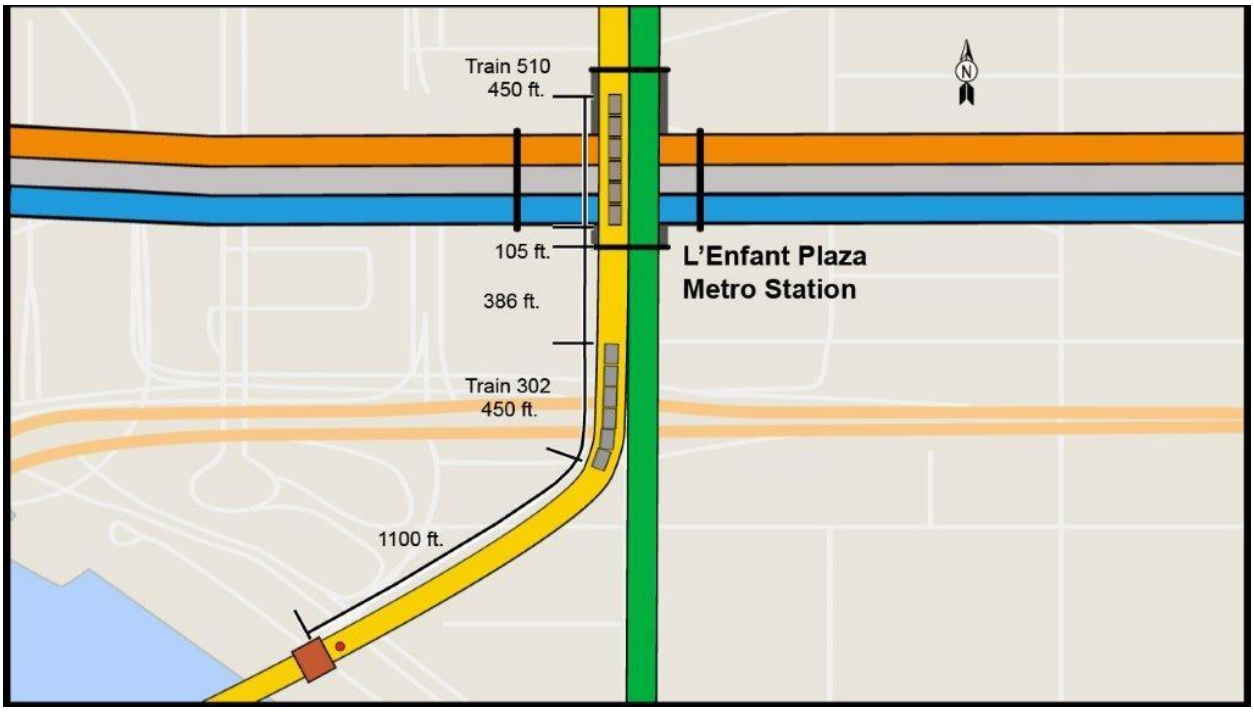

Figure 12. Electrical arcing location.

A ventilation shaft, FL-1, containing ventilation fans was located about 1,940 feet south of the L'Enfant Plaza station and about 24 feet south of the source of the smoke. (See figure 12.) At 3:24:28 p.m. these ventilation fans were activated in exhaust mode by a ROCC train control operator. At this point train 302 was already blanketed with smoke. Also, the railcar ventilation system, which draws air from the outside into the railcar, was still pulling smoke into the railcar because it had not been shut off by the train operator. Because both the station fans and those in the ventilation fan shaft were activated in exhaust mode there was no supply of fresh air to aid in moving the smoke through the tunnel to the outside and away from the train.

The FL-1 ventilation shaft contained four fans. Each fan had a rated capacity of 50,000 cubic feet per minute (CFM) (air flow). NTSB investigators found that two of the four fans had tripped an overload circuit breaker and were not operational.

Initial reports from the train 302 operator suggested that the smoke was ahead of train 302, because the train had traveled from a smoke-free environment into a smoke-filled environment. WMATA standard operating procedure (SOP) #6, Smoke and Fire on The Roadway, contained key actions that must be taken by the ROCC train control operators when a train encounters smoke in a tunnel, but it did not address tunnel ventilation strategies. (See SOP #6 at appendix G.)

NTSB investigators learned that although WMATA trained ROCC train control operators on tunnel ventilation fans, the training did not contain strategies for the proper use of the fans. A control operator who was working on the day of the accident told investigators that when a report of smoke was received, she put the fans in exhaust to "pull everything out." When asked whether that was the best way to deal with smoke in her experience, she said, "well I'm not going to say

it's the best way; it's just the way I do it." NTSB investigators found that at the time of the accident, WMATA did not have detailed written tunnel ventilation procedures for the ROCC staff, and the NTSB issued safety recommendations to address this. (See Safety Recommendations R-15-9 and -10, below.) WMATA responded to these safety recommendations on August 11, 2015, stating that a third party had been contracted to update standard operating procedures for fire and life-safety processes in tunnels and underground stations. WMATA stated that a final report would be submitted to the NTSB in mid-March for review. However, WMATA has not submitted a final report on the updating of its standard operating procedures as of the date of this report.

Other transit agencies have developed detailed ventilation procedures for responding to train fires and smoke events in tunnels, and some have automatic tunnel ventilation systems.[37] A common procedure is to identify the most likely location of the smoke or fire and start the ventilation fans on one side of the smoke or fire in supply mode and the ventilation fans on the other side in exhaust mode. This procedure is designed to move smoke away from the passengers and the evacuation route. Once the ventilation fans are operating, the control operators are to check with personnel at the site to verify that the fans are working properly and to make any necessary adjustments.

The 1970 NTSB report *Study of Washington Metropolitan Area Transit Authority's Safety Procedures for the Proposed Metro System* identified the failure to subject "all phases of planning and development to a disciplined analysis for safety purposes" (NTSB 1970). In particular, the NTSB identified in-tunnel emergency procedures for crowd control under panic conditions as a safety concern that could cause panic or serious injury. The report stated that WMATA should use a system safety approach to identify all possible emergencies and develop plans and physical facilities to cope with them.

On July 11, 2006, one car of Chicago Transit Authority train number 220 derailed in the tunnel between Clark/Lake and Grand/Milwaukee station in Chicago, Illinois (NTSB 2007a). About 1,000 passengers were on the train. Electrical arcing occurred between the derailed car and the third rail, generating smoke. This accident caused injuries to 152 passengers. The NTSB issued Safety Recommendation R-07-12 to the FTA recommending that all rail transit agencies be informed about the circumstances of this accident and urged to "examine and improve, as necessary, … their ability to … remove smoke from their tunnel systems." Safety Recommendation R-07-12 is classified "Closed—Acceptable Action."

NTSB investigators determined that WMATA had not developed adequate training for ROCC personnel to respond to reports of smoke in the tunnels. Proper operation of tunnel and station ventilation fans during smoke incidents is critically important, because optimal fan operation, including directing airflow correctly, can have a significant effect on the tunnel environment and passenger egress procedures. Optimal fan operation must take into account the location and direction of the smoke and the direction of passenger evacuation in a tunnel. The NTSB concludes that WMATA did not have a written procedure for operating ventilation fans in response to smoke and fire events in a tunnel. The NTSB further concludes that WMATA did

[37] Automatic tunnel ventilation systems detect fire and smoke and activate ventilation fans automatically based on predetermined scenarios.

not have effective training on the proper operation of tunnel ventilation fans. WMATA told NTSB investigators that since this accident control operators have received training on the operation of tunnel ventilation fans.

During the investigation, the NTSB issued the following urgent safety recommendations to WMATA:

R-15-9 (Urgent)

> Develop and implement detailed written tunnel ventilation procedures for operations control center staff that take into account the probable source location of smoke and fire, the location of the train, the best evacuation route, and unique infrastructure features; these procedures should be based on the most effective strategy for fan direction and activation to limit passengers' exposure to smoke.

R-15-10 (Urgent)

> As part of the implementation of the procedures developed in response to Safety Recommendation R-15-9, incorporate the use of the procedures into your ongoing training and exercise programs and ensure that operations control center staff and emergency responders have ample opportunities to learn and practice activating ventilation fans.

The NTSB classified these safety recommendations "Open—Acceptable Response" on March 24, 2016, based on WMATA's contracting a professional and technical services firm to update WMATA's emergency standard operating procedures for fire and life safety processes in tunnels and underground stations.

The NTSB also issued two urgent safety recommendation to the American Public Transportation Association on February 11, 2015:

R-15-11

> Inform your members of the circumstances of this accident and the risks posed by inadequate written procedures for ventilation processes during smoke and fire events in a tunnel environment. Urge your members to assess their procedures for verifying consistency with industry best practices, such as those outlined in the National Fire Protection Association's NFPA 130, *Standard for Fixed Guideway Transit and Passenger Rail Systems*.®

R-15-12

> Urge your members to conduct regular training exercises that use written ventilation procedures to provide ample opportunities for employees and emergency responders to practice those procedures.

These safety recommendations were classified "Closed—Acceptable Action" on April 7, 2016, based on APTA's reporting that it issued the requested alerts to its members, added the issue to

its 2015 rail conference as a special, one-of-its-kind session named Systems Assurance Trifecta, and included the issue for discussion at the June 21, 2015, Rail Safety Committee meeting.

3.3.1 Tunnel Ventilation History

WMATA's ventilation system was designed and built in the 1970s. At the time of construction, there was no established industry standard for emergency ventilation systems for subway transit systems. The current industry standard, the National Fire Protection Association's (NFPA) NFPA 130, *Standard for Fixed Guideway Transit and Passenger Rail Systems*, was not published until 1983 (NFPA 2010). Therefore, NFPA 130 was not part of the design criteria for the major portion of the WMATA system that was built before 1983, including the original section of the Yellow Line in which the accident occurred.

The original design criteria required that ventilation "fan shafts shall be equipped with two or more fans each of 50,000 CFM capacity." The original design required that each ventilation fan should have a capacity of 50,000 CFM in the forward (exhaust from tunnels) direction and 35,000 CFM in the reverse (supply to tunnels) direction. Although the original design included "removal of fumes or smoke"[38] as one of the purposes of the ventilation system, it focused on heat removal and temperature control. In fact, multiple subsequent evaluations of the WMATA ventilation system have stated that the ventilation fan shafts were not designed for emergency smoke removal (Parsons Brinckerhoff Quade & Douglas 1987; De Leuw, Cather & Company 1985, 1998).

Beginning in 1983, WMATA contracted for a series of studies on the tunnel ventilation system. The main focus of these studies was to assess the system's performance in the event of a fire inside a tunnel and to propose recommendations to improve the system. The first study was performed by Raymond (Kaiser Engineers) Inc. (RKE) (RKE 1983). The study concluded that the ventilation system "has limited capabilities in maintaining air flow past a fire incident train" and "cannot control the smoke and hot air from relatively small to relatively severe train fires." Based on this conclusion, RKE recommended that WMATA "develop means of improving the ventilation system at critical locations."

A later review conducted by Parsons Brinckerhoff Quade & Douglas, Inc. (a subsidiary of Parsons Brinkerhoff) (Parsons Brinckerhoff Quade & Douglas 1987) concluded that to maintain an adequate airflow, it would be necessary to increase individual fan capacity and provide blockage devices in the open tunnels that would block the fire-free tunnel segments if a fire occurred.

In 1985, De Leuw, Cather & Company (now part of Parsons Corporation), completed a study on the ventilation system that arrived at the same findings as the RKE studies, which were (1) the system capacities were generally not sufficient to produce the required critical air velocities (2) it would have been necessary to increase total ventilation fan shaft capacities in addition to providing blockage devices to meet the critical velocity criteria (De Leuw, Cather & Company 1985). The NTSB concludes that WMATA failed to address the capacity problems of the ventilation system that were identified by engineering studies. The NTSB recommends that

[38] DCCO Design Criteria, Section VI C, Revision 12, 1973.

WMATA improve the capacity of tunnel ventilation fans to conform to the requirements of NFPA 130. The NTSB also recommends that WMATA develop location-specific emergency ventilation configurations based on engineering studies of the WMATA tunnel ventilation system.

3.3.2 Tunnel Ventilation Inspection, Maintenance, and Testing

Seven days after the accident, NTSB investigators conducted a postaccident examination of the ventilation fan shaft system at FL-1. The examination found that the ROCC was unable to remotely execute a command to switch the operation modes of the FL-1 fans from supply to exhaust because of a fault in the signal to the local fan control panel. In addition, fans SVF5 and SVF7 (two of the four fans) were inoperable because overload breakers were in the tripped position. The ROCC remote command failure was identified to be associated with a fault in the signal from the remote terminal unit (RTU) to the local fan control panel. When the signal to the fan control panel was sent under normal conditions, that is, without the signal fault, a signal from the ROCC to place the fans at FL-1 in exhaust mode, a command would be generated at the ROCC and sent to the RTU at L'Enfant Plaza.[39] The RTU would then generate a signal that was transmitted to the local fan control panel. At the fan control panel, the system signal would trigger the relays in the control panel and would change the fan mode from supply to exhaust.

NTSB investigators found that the command from the ROCC was generated and transmitted to the RTU at L'Enfant Plaza. The RTU, however, was not generating or transmitting the signal to the fan control panel at FL-1. Investigators determined that the circuit board control card in the RTU at L'Enfant Plaza was defective. The fans could be activated by the ROCC, but because the circuit board control card was defective, fan direction could not be changed from supply to exhaust. The RTU control card was replaced, and all command and control functions for the fans at FL-1 were exercised and determined to be functional.

During the examination at FL-1, the overload breakers for fans SVF5 and SVF7 were reset, and all four fans were tested and found to be operational using the local fan control panel. The fan shaft system was activated in both exhaust and supply modes using the fan local control panel, and nothing remarkable was noted. However, during the ROCC remote command functional tests of the fan system at FL-1, fans SVF5 and SVF7 were found to have reverted to the overload tripped condition that was initially found at the start of the examination.

The tripped overload breakers for fans SVF5 and SVF7 were found to be associated with a low supply voltage (480 volts a.c.) from the WMATA Ohio Street Power Substation. WMATA personnel assessed the electrical system for the FL-1 ventilation fan shaft equipment and determined that the state of the electrical system was based on the original designs and equipment installed in the 1980s. The automatic transfer switch (ATS), the automatic voltage regulator (AVR), and the motor control center (MCC) were found to be deficient. NTSB investigators found that the ATS was installed based on the factory default settings and never adjusted to meet the operational constraints of the fan system. These settings caused the ATS to prematurely transfer the load to the emergency source during fan startup. The AVR was found to be in a bypass mode that permitted the AVR to maintain electrical connectivity to the load

[39] The remote terminal unit (RTU) sends the appropriate command between the ROCC and the ventilation fans.

without providing voltage regulation after an internal failure occurred. A tripped thermal switch was found, but the cause was not determined. The MCC motor starter components were original and nearing the end of their service life. In addition, the assessment determined that the fan motors freewheeled (rotated while not under power) at significant speeds in any direction during peak rail traffic. This resulted in higher than usual motor currents if the fans were commanded to operate in the opposite direction and could cause the circuit breaker to trip and disable the fan motors. After the accident, the ATS was adjusted to be more tolerant and to prevent unnecessary load transfers.

The WMATA tunnel inspection procedures included biannual inspection of tunnel ventilation fan shafts and shaft structures. WMATA procedures required monthly preventive maintenance of the tunnel ventilation fans. The checklist for the monthly maintenance contained 21 items that covered visual inspection and local operation of the fan and associated components, as well as the remote operation of fans by a ROCC train control operator. Ventilation fan shaft maintenance was usually performed by a crew of two mechanics during regular service hours. For remote operation of the fans, the maintenance crew was required to contact the ROCC and request the control operator to operate the fans in both exhaust and supply modes. NTSB Investigators reviewed the records of preventive maintenance work at FL-1 for September, October, November, and December 2014. The December preventive maintenance was the last performed before the electrical arcing event. All records showed no issues on any of the task items including remote operation of fans. WMATA further reviewed maintenance records for FL-1 and found that the requirement to test the fans by remote operation from the ROCC had not been properly completed or performed since January 2014.

AIMS historical records of fan operations from the same time periods were also reviewed. The AIMS data showed no evidence of remote fan commands from the ROCC on the dates of the preventive maintenance. WMATA was notified of this inconsistency and conducted an internal investigation, which determined that no remote testing of fans was actually performed for FL-1 during preventive maintenance from September through December 2014.

Because of the improper maintenance tests and inspections of the ventilation fan system at FL-1, NTSB investigators were unable to determine when the RTU circuit board control card became defective. The investigation determined that ROCC line controllers could switch fan operation at FL-1 from "emergency on—exhaust" to "emergency on—supply" but that line controllers could not switch fan operation at FL-1 in the other direction, that is, from "emergency on—supply" to "emergency on—exhaust" at the time of the accident. The NTSB therefore concludes that had the maintenance procedures in place at the time of the accident been followed correctly, the fault in the remote control of the fans could have been identified and corrected during the scheduled monthly inspection. The remote control fan operation had not been correctly tested since January 2014, therefore, the RTU must have become defective at some point in the year before the January 2015 accident. The NTSB concludes that the conditions discovered after the accident—the inability to execute remote commands to the tunnel ventilation system, the tripped overload breakers, the defective RTU card, and the deficient ATS, AVR, and MCC—resulted from WMATA's inadequate maintenance.

Investigators reviewed preventive maintenance records and AIMS data logs of additional ventilation fans. Comparison of the maintenance records and AIMS data showed the same

inconsistency between the preventive maintenance records and the AIMS data logs found for FL-1. The NTSB concludes that WMATA did not comply with its ventilation fan inspection and maintenance procedures. On February 11, 2015, the NTSB issued the following urgent recommendation to WMATA:

R-15-8 (Urgent)

> Assess your subway tunnel ventilation system to verify the state of good repair and compliance with industry best practices and standards, such as those outlined in the National Fire Protection Association's NFPA 130, *Standard for Fixed Guideway Transit and Passenger Rail Systems*.

The NTSB classified this safety recommendation "Open—Acceptable Response."

3.4 Smoke Detectors

NTSB investigators reviewed records of smoke detector activations around the time of the accident. The first smoke detector activation was at 3:04:54 p.m. from the smoke detector located above the drainage pump station at the bottom of the FL-1 vent shaft. The second smoke detector activation was at 3:19:19 p.m. from a smoke detector located inside a service room in the L'Enfant Plaza station. The distance between these two smoke detectors was about 1.950 feet, and the time between the two activations was 14 minutes 25 seconds. (See figure 13.) There were no smoke detectors between these locations. After these two smoke detector activations, there were 24 additional smoke detector activations in the L'Enfant Plaza station and on the Yellow Line between the station and the FL-1 vent shaft. The 32nd activation occurred at 7:19:54 p.m.

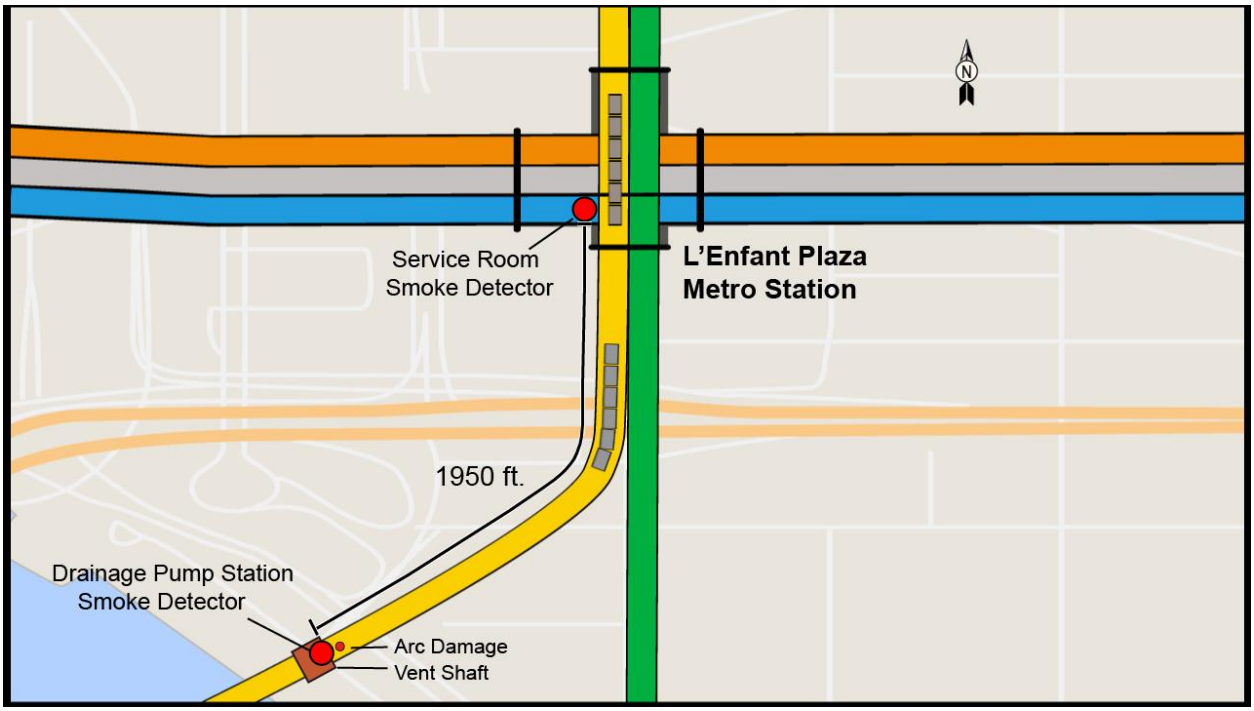

Figure 13. Smoke detector locations.

The first smoke detector activation at 3:04:54 p.m. was not received by the ROCC or at any other location. WMATA told investigators that this alarm was not received because of a loose wire that prevented connection with AIMS.

The MTP officer on board train 302 reported fire and smoke to MTP communications at 3:15:24 p.m. The MTP relayed this information to the ROCC at 3:15:45 p.m., 10 minutes 51 seconds after the first smoke detector activation, and the ROCC made the initial call to FEMS at 3:22:34 p.m., 17 minutes 40 seconds after the first smoke detector activation.

The smoke detector activation at 3:19:19 p.m. from the detector located inside the L'Enfant Plaza station was received in the ROCC; however, WMATA SOP #6, *Fire and Smoke on the Roadway,* or any other WMATA procedures, did not specify actions to be taken by control operators in response to smoke alarms. The NTSB recommends that WMATA develop and implement procedures for actions to be taken by ROCC personnel when smoke detectors alarm (R-16-12). The NTSB further recommends that once action to address Safety Recommendation R-16-12 is completed, WMATA train all ROCC personnel on the new procedures for responding to smoke detector alarms. This training should include regular refresher training. The NTSB also recommends that WMATA incorporate smoke alarms in periodic emergency drills and exercises. The NTSB recommends that WMATA include in its efficiency testing program (rules compliance testing program) a specific test to ensure appropriate emergency actions are taken by ROCC supervisors and control operators in response to an alarm.

NTSB investigators determined that WMATA did not have the capability to determine the exact location of smoke in its system. On January 20, 2015, WMATA provided an early

action item stating that it was exploring installing zoned smoke detection using emergency trip station (ETS) boxes for location and transmitting information. In addition, WMATA planned to explore the installation of wireless smoke detectors, with detectors installed about 800 feet apart throughout the tunnel network. The current WMATA design includes smoke detectors that are located only in the stations, at ventilation shafts, and in the traction power substations. This spacing is too far apart to identify the origin of smoke. On February 27, 2015, WMATA provided a report that recommended the use of video analytic technology for smoke detection. However, no further reports of these planning efforts by WMATA have been reported to the NTSB. Because the WMATA system lacked zoned smoke detection, control operators in the ROCC customarily relied on train operators to report smoke in the rail system and to investigate such reports, which contradicted its own procedure requiring that all trains in both directions be stopped following a report of smoke or fire.

Accurate location information of smoke in a tunnel environment is an important element in tunnel ventilation strategy. (See section 3.3 for more information.) A supply of fresh air in combination with fans exhausting smoke from the tunnel increases survivability during a major fire and smoke event. The NTSB recommends that WMATA install and maintain a system that will detect the presence and location of fire and smoke throughout the WMATA tunnel and station network. The NTSB further recommends that WMATA develop procedures for regular testing of all smoke detectors.

3.5 Tunnel Washing and Insulator Cleaning

Before the accident, WMATA had identified a need to wash tunnels and clean insulators to remove contaminants that had accumulated on tunnel components, and it had implemented a tunnel-washing and insulator-cleaning program across the system. A May 20, 2015, internal WMATA memorandum noted that tunnel washing previously was performed with some regularity. The memorandum discusses a tunnel-washing crew that performed this work in July 2005. Throughout the investigation, WMATA personnel told NTSB investigators that the program had been suspended before the January 12 accident because of environmental concerns about the chemicals used for cleaning. A WMATA representative later stated that the tunnel-washing program was still ongoing and had never been suspended, and that 30,000 third rail insulators had been cleaned in the previous 5 years. Another WMATA representative said that the program had been suspended not because of environmental concerns, but for convenience, and that there were higher priorities for the work force. A WMATA representative told NTSB investigators that no risk assessment had been conducted before the tunnel-washing program was changed. NTSB investigators observed dirty cable connector assemblies and insulators near the L'Enfant Plaza, Court House, and Friendship Heights stations, indicating that the tunnel-washing program was ineffective. The NTSB concludes that WMATA was not following its tunnel-washing and insulator-cleaning procedure. The NTSB recommends that WMATA conduct a risk assessment before any preventive maintenance program is initiated, changed, or discontinued.

3.6 Railcar Ventilation

All WMATA railcars have ventilation systems that use a combination of fresh and recirculated air to meet interior heating or cooling needs. At the time of the accident, WMATA did not have a railcar ventilation system shutdown procedure for train operators. Instead, SOP #6 required the ROCC to provide instructions to train operators for shutting down the railcar ventilation system. On the day of the accident, there was a delay in the ROCC's providing instructions to the train 302 operator for shutting down the ventilation system, and smoke entered the passenger compartments through the fresh air intakes. (See 3.7, Rail Operations Control Center.)

Investigators evaluated the ventilation systems of all six railcars; the lead railcar was keyed up, and all ventilation systems were shown to be operating normally. Then a test operator, a 10-year WMATA employee, shut down the ventilation systems, demonstrating the way it would have been done on the day of the accident:

With the train stopped and the lead railcar console keyed up, the test operator

1. shut down the ventilation system using a key
2. opened the ventilation system circuit breaker

After this test, the ventilation system on only the lead railcar immediately shut down, and those on all the other railcars remained operational. Investigators conducted the same test with the train in motion, and the results were identical: the ventilation system on the lead railcar immediately shut down, and those on all the other railcars remained operational. The NTSB therefore concludes that at the time of the accident WMATA did not have a procedure for train operators to follow that would immediately shut down the ventilation systems on all the railcars in a train. The NTSB further concludes that when the operator of train 302 shut down the ventilation system, only the ventilation system on the leading railcar shut down immediately, and the ventilation systems of all the other railcars remained operational.

According to WMATA, it began developing an emergency ventilation system shutdown procedure soon after the January 12, 2015, accident. WMATA vehicle engineers demonstrated for NTSB investigators their recently developed procedure that immediately shuts down the ventilation systems on all railcars in a train:

With the train stopped and the console of the lead railcar keyed up, a WMATA engineer

1. keyed the console down
2. shut down the ventilation system using a key
3. opened the ventilation system circuit breaker
4. keyed the console up

After the demonstration NTSB investigators verified that the ventilation systems in all the railcars shut down less than 4 seconds after the WMATA engineer initiated the procedure. WMATA engineers told investigators that the procedure works on all the railcar series in use on the WMATA rail system. On the 5000-series railcars, the shutdown of the ventilation systems is delayed by about 1 to 2 minutes. The engineers stated that WMATA was taking steps to fix the delay so the 5000-series railcar ventilation systems will shut down immediately upon initiation of the new ventilation Emergency Shutdown Procedure, which is dated March 19, 2015. The NTSB concludes that the requirement for a train operator to receive permission from the ROCC to shut down the ventilation systems on a train, and the lack of a procedure for shutting down all the ventilation systems on a train from the lead railcar, contributed to the smoke entering the railcars in train 302. The NTSB recommends that WMATA ensure that all train operators are trained and regularly tested on the appropriate procedure for emergency shutdown of railcar ventilation. The NTSB further recommends that WMATA incorporate a specific test in its efficiency testing program to ensure that train operators understand the procedure for emergency shutdown of railcar ventilation.

Since the accident, WMATA has given train operators autonomy to make the decision to shut down the train ventilation systems without permission from the ROCC. WMATA Permanent Order T-15-01 modifies operating rule 3.85 to authorize train operators to shut off a train's ventilation system when they observe any smoke in the immediate area. Further, the permanent order details the procedure for shutting down the ventilation system in a train as follows:

1. To shut down the EV system, Stop the Train[40]
2. Key [down] the console
3. Place Door Key in EC Control Switch on Auxiliary Control Panel[41]
4. Turn key to EC Off position and hold in EC Off position until the EV system shuts down
5. Trip the EV Circuit Breaker on the Operator's Circuit Breaker Panel
6. Key up the console and resume schedule
7. When authorized by ROCC and clear of smoke area, turn on EV system by resetting EV Circuit Breaker on the Operator's Circuit Breaker panel

According to WMATA these instructions were given to WMATA personnel responsible for train operations in an update to the *Metrorail Safety Rules and Procedures Handbook*, as an Office of Rail Transportation Operations Personnel Notice, and in scheduled training.

[40] The EV system refers to the ventilation system.

[41] The EC control switch refers to the ventilation system switch.

3.7 Rail Operations Control Center

The ROCC, which operates 24 hours a day, 7 days a week, has full authority and jurisdiction (with certain limitations) to control WMATA mainline rail transit operations. The ROCC is located in Landover, Maryland, and is staffed by superintendents, assistant superintendents, supervisors, control operators, and other employees who together manage the WMATA rail system.

The ROCC facility is fitted with work consoles (video display screens) and a radio communications system (between the ROCC and the train operators of the individual trains of the WMATA system) that train control personnel use to monitor and coordinate the movements of individual trains and execute train control movements as necessary.

The ROCC supervisors are responsible for coordinating activities in the ROCC, ensuring that the control operators perform their jobs correctly, and ensuring proper actions are taken to mitigate emergencies. It is also the responsibility of the supervisor to declare an emergency.

WMATA control operators in the ROCC are responsible for monitoring train movements, changing train routes as needed, recognizing emergencies, and coordinating the response. They are in regular radio communication with train operators. A two-person team is responsible for an assigned segment of the rail system. Each team splits the duties of train radio communications and controls, with one control operator responsible for communications via phone, radio, and intercom, and the other control operator responsible for train movements and sending remote signals to infrastructure components such as fans and electrical circuit breakers. The same control operators that handled normal traffic on a particular line segment handled emergencies. In other words, during this accident the team assigned to the Yellow Line was responsible for responding to the electrical arcing and for all other trains on the Yellow Line.

The operating rules and emergency response procedures governing ROCC supervisors and control operators are contained in the *Metrorail Safety Rules and Procedures Handbook*, effective July 17, 2012, and the *Department of Rail Transportation Rail Operations Plan Book for Major Incidents*.

New control operators undergo a 26-week training program that includes classroom and on-the-job training and simulator training. After completing the training program, a control operator must pass a final examination to be considered qualified.

The ROCC used a series of SOPs that contained the orders, rules, procedures, and best practices to be employed to ensure safety in operations. ROCC SOP #6, *Fire and Smoke on the Roadway*, included the procedures to be followed by WMATA personnel if fire or smoke was reported. (SOP #6 is at appendix G.) Procedure 6.5.1 outlined the train operator's responsibility to "Stop their train if possible before reaching the fire or smoke, and immediately notify ROCC." The ROCC supervisor responsibilities were found in Procedures 6.5.2 through 6.7.7, which outline the steps the ROCC supervisor was to take when fire or smoke was reported in tunnels and in above-ground locations. In all instances of fire or smoke reported in a tunnel, the procedure required the ROCC supervisor to "stop all trains in both directions," and to "instruct the train operator to turn off the train's [environmental] system …." The procedures included

guidance for train movement away from the fire or smoke (such as reversing train direction), and fire department notice. However, there were no procedures to guide ROCC personnel in the appropriate actions to take when smoke alarms were received. (See section 3.4 on smoke detectors.)

The control operator was required to manually input ventilation commands, and there were no predefined scripts or instructions based on prior analysis to aid in effective tunnel ventilation during a smoke or fire emergency.

On the day of the accident, the ROCC received a report of smoke from train 508 near L'Enfant Plaza and later a report of smoke on board train 302 after it left L'Enfant Plaza. Contrary to SOP #6, the ROCC train control operator did not stop all trains in both directions after the first report of smoke; instead, the control operator instructed the train 302 operator to look for smoke as train 302 approached L'Enfant Plaza. Also, when the ROCC received the report of smoke on train 302 immediately after the train had left the station, the control operator did not instruct the train 302 operator to shut down the ventilation system and return to the L'Enfant Plaza station. Instead, the control operator told the operator to "stand by," conveying to the operator to wait for further instructions before returning to the station. Although at first the control operator told the train 510 operator to stop, a short time later the operator was told to continue to L'Enfant Plaza. The NTSB concludes that the ROCC supervisor failed to ensure that the emergency procedures contained in SOP #6 were followed by the control operators.

The ROCC control operator responsible for train movements on the Yellow Line on the day of the accident told NTSB investigators that after the train 302 operator reported smoke, she told the train 510 operator twice to stop the train. The control operator said that she saw train 510 stop outside of the interlocking. She also told investigators that she could not recall how train 510 got to the platform. While reviewing audio recordings from the ROCC, NTSB investigators heard a voice other than the control operator's instruct train 510 to "service the platform." NTSB investigators learned that the assistant superintendent on duty in the ROCC instructed a senior rail control operator to take over as control operator, which he did. The senior rail control operator then instructed train 510 to proceed to and service the L'Enfant Plaza platform.

At 3:25 p.m. the MTP requested that the ROCC stop train traffic from entering the upper level of L'Enfant Plaza because of the lack of visibility. During the evacuation of train 510 by the MTP, the train 510 operator attempted to contact the ROCC to report the smoke and the evacuation, first by radio and later using the telephone at the station kiosk as she was being escorted out of the station by the MTP. She was unsuccessful in contacting the ROCC because of the excessive radio and telephone traffic. The ROCC continued to allow trains to enter and exit the station throughout the emergency response. During an NTSB review of video footage from security cameras inside the L'Enfant Plaza station, investigators noted that 56 trains (on all four tracks of both levels) passed through the station from the time the operator of train 302 announced that he had stopped because of smoke until the evacuation of the passengers from train 302. Investigators learned that the ROCC did not know that the MTP had evacuated train 510.

The ROCC radio controller told investigators that reports of smoke were common and they receive such reports every day. She said it could be fog or something else unrelated to the rail system, and she did not want to make an assumption. She said that to verify a report of smoke, she needed a train that could investigate the report. After smoke was reported near L'Enfant Plaza, train 302 was told to look for smoke near the station. Investigators learned that it was common practice at WMATA to use trains to investigate for fire or smoke instead of stopping all trains and using a qualified person with proper personal protective equipment to follow up a report of fire or smoke on the wayside.

There are many fire and smoke incidents in the WMATA rail system. The WMATA incident data collected in 2014 indicate that the system averages 5.8 fires per month and 2.9 smoke incidents per month, or 69 reported fires and 35 smoke incidents annually (WMATA 2015, chart 7).

The control operator told investigators that she "had no periodic updating or training … we've had manpower issues … no classroom training unless you've had an incident." When she was asked about an emergency procedures manual, she said "we try to [stay] pretty close to the procedure." She said she was overwhelmed by the events on the day of accident. She also said she was not authorized to reverse a train without supervisor approval. She described the situation inside the ROCC on the day of the accident: "The right hand did not know what the left hand was doing." She further stated the following:

> Throughout the incident I could not see my partner. I had to get out of my seat a couple of times to talk to my partner or stand up and bend over to try to communicate—I mean it was people deep, people on the phone. People running around, people asking questions. There is a certain amount of calm that for me works better in chaos than a bunch of chaos trying to undo chaos.

The NTSB concludes that had WMATA followed its standard operating procedures and stopped all trains at the first report of smoke, train 302 would not have been trapped in the smoke-filled tunnel. However, the WMATA standard operating procedures did not specify whether all trains are to be stopped at locations with multiple levels. The NTSB believes that until the source of smoke is identified, all trains should be stopped in the area where smoke is reported. The NTSB therefore recommends that WMATA revise SOP #6 to clarify which trains should be stopped until the source of smoke is identified. The NTSB also concludes that WMATA put passengers at risk by routinely using trains with revenue passengers to investigate reports of smoke or fire. Therefore the NTSB recommends that WMATA revise its standard operating procedures to require that (1) suitably trained, qualified, and properly equipped personnel investigate reports of wayside fire or smoke and (2) these reports are not investigated using trains with revenue passengers. The NTSB also concludes that the ROCC supervisor failed to ensure that all trains in both directions were stopped after smoke was reported, which was inconsistent with the WMATA standard operating procedure. The NTSB also concludes that ROCC supervisors and control operators were not proficient in executing emergency response procedures. The NTSB recommends that WMATA review and revise as necessary its ROCC emergency response procedures for smoke and fire. The NTSB further recommends that WMATA retrain ROCC supervisors on all standard operating procedures for emergencies. The NTSB also recommends that WMATA develop and incorporate a comprehensive program for

training ROCC control operators in emergency response procedures including regular refresher training. The NTSB further recommends that WMATA conduct regular emergency response drills and develop a program to test the efficiency of the ROCC to ensure that standard operating procedures are properly followed during emergencies.

Control Operator Performance. The NTSB evaluated fatigue as a possible factor in the actions and decision-making processes of the two ROCC train control operators on duty at the time of the accident. This assessment was based exclusively on work histories provided by WMATA, which disclosed that both employees were working regular shifts (1:00 p.m. to 9:00 p.m.) and had been on duty for just over 2 hours at the time of the accident. No information about their sleep history in the days before the accident was available. The available evidence did not indicate significant risk factors for fatigue, but without sufficient information about the employees' sleep history, the NTSB was unable to determine to what extent, if any, fatigue affected their individual or collective performance at the time of the accident.

3.8 Radio Communications

Below-ground communication in the WMATA system is supported by two separate radio systems. The Comprehensive Radio Communication System (CRCS) is used by WMATA personnel and the MTP to support routine operations and security within the system. The Public Service Radio System (PSRS) is used by FEMS and the MTP to support emergency response operations. Both radio systems are maintained by WMATA personnel.

The CRCS performed normally throughout the course of the accident response, and the following discussion will focus on the PSRS.

The PSRS is based upon a dual frequency 460 MHz/800 MHz Motorola 4.1 trunk radio system originally installed around 2003. Above-ground coverage over the geographical extent of Washington, DC, is provided by 10 repeater sites. The above-ground communication system is tied to a below-ground system designed to cover the tunnels in the WMATA rail system.

Before 2013, the PSRS used 16 frequencies on the 800 MHz band and 15 frequencies on the 460 Hz band, with 25 KHz spacing to support about 250 talk groups across 20 city agencies (police, fire, and others) and a control system located at the Public Safety Communications Center in northwest Washington, DC.

At the time of the accident, the OUC was in the process of upgrading to a dual frequency 700 MHz/800 MHz Motorola P-25 7.11 trunk radio system. During this transition, the PSRS operated both systems in a dual-hybrid mode using a Motorola SmartX Site Converter in the Public Safety Communications Center to provide interfacing between the systems.

The PSRS uses an RF "leaky" coaxial cable in WMATA tunnels to serve as a distributed antenna system. This cable is specially engineered to allow radio signals to leak into and out of the cable along its length. Because of this signal leakage, line amplifiers are inserted at regular intervals to boost the signal to maintain acceptable levels. Radio transmissions broadcast by this cable can be received by any radio subscribing to the trunk radio system. Radio transmissions received by this cable from a subscribing radio are in turn linked to the trunk radio system. In

this way, two-way radio communications are supported in the tunnels. All electronic voice communication signals are converted to optical signals for relay between the below- and the above-ground segments. WMATA maintains the communications infrastructure for both the WMATA system and the PSRS below-ground system (through a memorandum of agreement). Because the below-ground component of the DC PSRS is primarily used by first responders, the system experiences a relatively low frequency of use compared with the WMATA CRCS. This has the potential to delay problem identification, which may first be revealed during an actual emergency response.

On January 7, 2015, the OUC notified WMATA that FEMS had lost radio coverage at L'Enfant Plaza; there was coverage in the stations but poor coverage in the tunnels. WMATA told investigators that it had been troubleshooting a different issue that may have led to the PSRS problem. While in the process of investigating the FEMS radio coverage problem, WMATA requested access to the DC Equipment Room where the above- and below-ground systems interface. WMATA was scheduled to have access to the room on January 14, 2015, 2 days after the L'Enfant Plaza accident.

On the day of the accident, emergency responders quickly found that below-ground communication using the PSRS in and near the L'Enfant Plaza station was unreliable, and they resorted to using runners to convey information. Performance measurements taken on January 14 indicated the below-ground signal uplink level into the DC Equipment Room was too low to support reliable below-ground communications. The result was intermittent PSRS communications in stations and tunnels across the entire underground system. After the accident, WMATA engineers determined that a mismatch between the signal levels in the below- and above-ground portions of the PSRS compromised the ability of any PSRS radio operating underground to successfully access the trunk radio system. WMATA personnel identified an effective solution by increasing the total signal level from the below ground component to the above ground PSRS integration center. With this change, FEMS portable radios operating in WMATA tunnels could once again reliably operate using the PSRS. The NTSB concludes that PSRS communication problems were identified but not remediated before the accident. The NTSB also concludes that WMATA's radio-testing procedure in place at the time of the accident was insufficient to identify PSRS communication problems in a timely manner.

In the wake of the accident, WMATA has significantly increased the frequency and rigor of its PSRS radio testing protocols. Voice-quality testing is now conducted using an industry standard at seven locations in each station, including all station entrances, tunnel entrances, and three platform locations.[42] This testing now collects voice quality data at each location once a week in the District of Columbia and once every other week in the other jurisdictions. A location that does not receive a passing score is entered into a WMATA-maintained system for service and for tracking the status of the service request.[43]

[42] The delivered audio quality standard promulgated by the Telecommunications Industry Association is being used for testing. The standard rates the understandability of audio quality on a scale of 1 to 5.

[43] A delivered audio quality standard score of greater than 3.4—understandable with little or no repetition required, some noise or distortion may be present—is a passing score.

3.8.1 ROCC Communications with DC FEMS

On January 12, emergency responders discovered that above-ground communications between the incident commander (IC) on scene and the FEMS liaison in the ROCC were also unreliable. The ROCC was previously located in downtown Washington, DC, and communications between the FEMS IC and the FEMS liaison in the ROCC could be supported using hand-held radios.[44] After the ROCC was moved to Landover, Maryland, in 2009, FEMS began using an existing base-station radio in the ROCC maintained by Montgomery County to support communications in an emergency. This arrangement appeared to work satisfactorily until FEMS changed its radio map to support the ongoing PSRS upgrade. The issue was anticipated in December 2014, but reprogramming of the base-station radio used by the FEMS liaison at the ROCC to support the new radio map had not been completed before the January 12 accident. The FEMS liaison told NTSB investigators that on the day of the accident the base-station radio in the ROCC did not work, and he had to go outside the building and use a mobile radio in a FEMS vehicle. This hampered his ability to maintain close contact with first responders on scene while efficiently interacting with ROCC staff. The NTSB concludes that communications between the FEMS liaison in the ROCC and the FEMS IC were delayed and inefficient. In the wake of the accident, the OUC has installed a dedicated, rack-mounted radio and external antenna system (owned by the District of Columbia) at the ROCC that is configured to communicate with both FEMS and police department first responders.

3.9 Emergency Response

At 3:15:24 p.m. one of the two uniformed WMATA MTP officers on board train 302 radioed MTP communications and reported that there was a fire on board train 302, the train was stopped in the tunnel, and immediate assistance was needed. The MTP informed the ROCC of the report from train 302. At 3:15:57, a ROCC control operator announced on the Yellow Line train operations frequency that there was heavy smoke and low visibility. At 3:22:34 p.m., the ROCC called the OUC to request FEMS to respond to heavy smoke at the L'Enfant Plaza station. The call ended at 3:24:15 p.m. At 3:26:53 p.m. the OUC dispatched FEMS units to L'Enfant Plaza; the first FEMS units arrived at the station beginning at 3:31:12 p.m.

The then chairman of the WMATA board, when asked about his safety concerns or issues during an interview with NTSB investigators, said he continued "to have a concern, really brought to bear by L'Enfant, of our relationship with first responders when things go forward. … clearly, was shown to be an area of weakness."

3.9.1 Washington Metropolitan Area Transit Authority Metro Transit Police

One of the two MTP officers on board train 302 stated that she and the other MTP officer had boarded the lead railcar of the train at L'Enfant Plaza. One of the MTP officers said that, as the train headed south, she felt the train immediately stop. She said she looked out the window in the front of the train and saw what she described as a ball of orange in front of the train. She

[44] FEMS also had a process in place to embed a liaison officer in the ROCC if a major emergency response was needed in the WMATA system, and an FEMS liaison reported to the ROCC during the accident response.

remained in the lead railcar and radioed MTP communications to report that she had seen smoke or fire. She also spoke with passengers and transmitted over the railcar intercom that they were trying to return to the platform.

The other uniformed MTP officer, also in the lead railcar, spoke to the train operator and suggested they "get to the back of the train to reverse the train." She said that as they were talking, the train started to fill with smoke. She and the train operator started walking toward the rear of the train to reverse the train. She said that she spoke with passengers as she moved through the train, telling them to stay calm and that they were trying to return to the platform.

3.9.2 Washington Metropolitan Area Transit Authority Incident Command Structure

WMATA had adopted the National Incident Management System (NIMS) incident command structure in its SOP #1A, *Command, Control, and Coordination of Emergencies on the Rail System*.[45] This SOP defines the incident commander as follows:

> [The] senior non-WMATA fire or police department official, or federal official, who is controlling and coordinating all activities of the incident while non-WMATA fire, police, federal department personnel are involved and will coordinate these actives with WMATA's on-scene commander typically from the command post.

According to SOP #1A, the on-scene incident commander (OSC) is "the first MTP officer or official that arrives at the scene of the incident …." During an emergency, the duty of the WMATA MTP first responder who assumes the role of the OSC is to control the activities of WMATA resources and stabilize the scene. In an emergency, the OSC is supposed to transfer incident command when a fire department or law enforcement agency arrives at the scene. According to SOP #1A, after a fire or police department first responder assumes the IC role, the WMATA OSC "will control WMATA resources and assist the IC in managing the scene." The SOP identifies the following personnel authorized to assume the role of the OSC in the absence of MTP personnel:

- Train operator
- Rail transportation supervisor
- Chief operations supervisor
- Superintendent
- Line manager
- Managing director
- Assistant general manager, rail

[45] The MTP has, in parallel, adopted General Order No. 364, *Incident command system*, which is similar in content to SOP #1A to govern MTP operations.

- Deputy general manager, operations

The SOP states that when none of the above personnel are at the scene, the ROCC shall appoint an OSC. Upon arrival of one of the above listed personnel, the appointed OSC shall relinquish control and responsibility to that person. Transfer of the OSC was required to be a formal face-to-face reassignment of command from one individual to another.

3.9.3 District of Columbia Emergency Call Processing

The OUC maintains a 911 emergency call system, or public safety answering point (PSAP) system. It provides 911 emergency telephone call processing and the initial fire, rescue, and emergency medical dispatch services to public safety incidents.

Documents provided to investigators by OUC officials stated that OUC 911 call taker and dispatcher employees are trained and certified in emergency dispatch protocols and that the training and certification process includes protocols for multiple fire events including train accidents and fires. However, the OUC had not participated in a WMATA-specific training activity in the 5 years before the L'Enfant Plaza accident.

The 911 call takers attended a 24-hour classroom training program conducted by Priority Dispatch Corporation.[46] OUC officials described the training using, in part, the description of the course on Priority Dispatch Corporation's website:

> … the Fire Priority Dispatch System takes the science of structured call processing to the fire-rescue environment, the Protocol uses logic-based Case Entry and Key Question interrogation to safely and accurately prioritize responses to fire-rescue incidents. Post-Dispatch and Pre-Arrival Instructions provide a Zero-Minute Response to callers at the scene, thereby improving scene safety and response effectiveness.[47]

On January 12, 2015, the call from the ROCC to the PSAP (OUC) lasted 2 minutes 11 seconds. NFPA Standard 1221 states, "Ninety percent of [emergency] calls shall be processed in 64 seconds"(NFPA 2016). The OUC did not dispatch FEMS until 2 minutes 38 seconds after the conclusion of the call from ROCC. On the day of the accident, there was a lapse of almost 5 minutes from the call from WMATA to the initial dispatch of FEMS to the scene. The NTSB concludes that the OUC's call processing delayed the emergency response to the accident. The NTSB therefore recommends that the OUC audit its PSAP to validate compliance with the standards published by the National Emergency Number Association or another similar standards organization.[48] The audit should (1) determine the average length of time that call takers use to process an emergency call and dispatch emergency service and (2) compare those

[46] Priority Dispatch Corporation provides products and training for emergency call centers.

[47] Definition of Fire Priority Dispatch System, excerpt from description of Emergency Fire Dispatch Certification course taught by Priority Dispatch Corporation. http://www.medicalpriority.com/efd_certification, accessed January 12, 2016.

[48] National Emergency Number Association (The 9-1-1 Association), http://www.nena.org/?page=Standards, accessed February 25, 2016.

results with those of other comparable PSAPs (R-16-04). The NTSB further recommends that upon completion of action satisfying Safety Recommendation R-16-04, the OUC develop call-processing standards for the PSAP to ensure that 911 calls are processed in accordance with those of other comparable PSAPs (R-16-05). The NTSB further recommends that the OUC train call takers for the PSAP on the standards developed in Safety Recommendation R-16-05 and include the standards in recurrent training.

3.9.4 Accident Site Access

The L'Enfant Plaza station is located directly beneath the intersection of 7th Street and D Street in the Southwest quadrant of the District of Columbia. The station has three street level entrances, at different sides of the station, with escalators, stairways, and elevators providing access. At street level the entrances are identified with pylons bearing a white letter "M" against a dark background.

Signage identifying the train lines that service the various station platforms and levels is located on the platform levels. Investigators observed signage on the train platforms that identified tracks, but there was no signage in the tunnels that identified the tracks and the direction of the tracks to assist emergency responders.

At 3:31:12 p.m., a FEMS rescue squad arrived at L'Enfant Plaza and proceeded to the track 2 platform preparing to locate the train. After disconnecting third rail power, the rescue squad entered the tunnel. About 3:50 p.m., the squad arrived at the rear railcar of train 302.

A FEMS reconnaissance (recon) crew had been dispatched at 3:44:44 p.m. to search for train 302. The supervisor of the recon crew told investigators that the crew entered the L'Enfant Plaza station with the assignment (from Incident Command) to search the tunnel for the stopped train. The upper level platform was filled with heavy gray smoke, and WMATA officials directed the FEMS recon crew to the southbound tunnel of track 1 at the southern end of the platform, saying, "this is the tunnel where the smoke is coming from." (See figure 14 for tunnel diagram.) The tunnel entrance was labeled "Track 1," but there was no sign there or inside the tunnel indicating that inside the tunnel the track diverges and that the Yellow Line track goes toward the Pentagon station and the Green Line track goes toward the Waterfront station. However, train 302 was stopped on track 2, which is accessed from the platform opposite track 1, about 386 feet inside the tunnel going toward the Pentagon Station, although the FEMS recon crew was unaware of this fact.

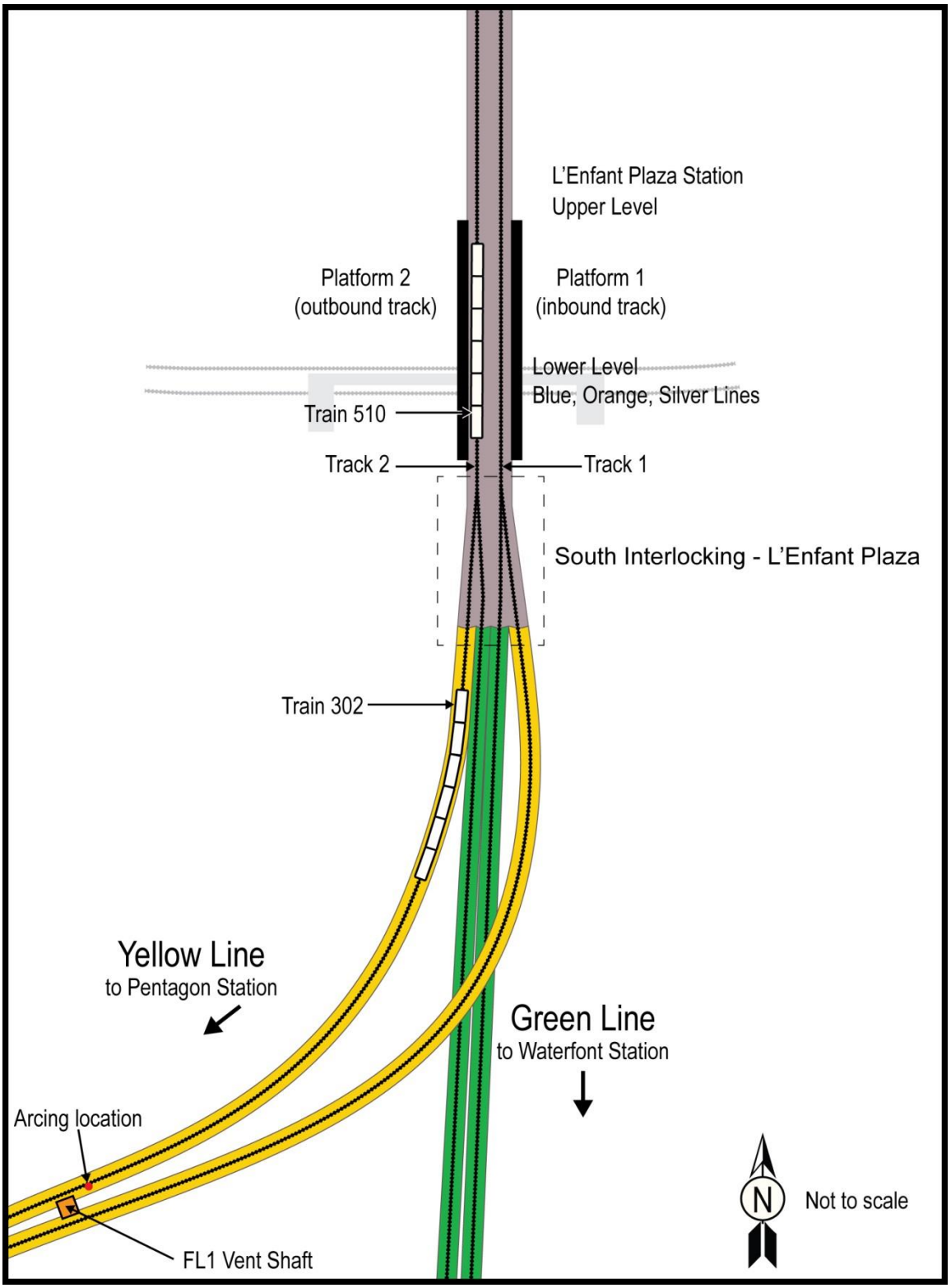

Figure 14. L'Enfant Plaza station diagram.

The FEMS recon crew moved through the tunnel, which was filled with smoke that was so dense that the crew could not see the opposite wall of the tunnel. The crew supervisor told

investigators that the smoke began to dissipate as they continued through the tunnel. After they had walked some distance through the tunnel, the smoke had cleared and they could see down the track, but they did not see a train. At that point, the crew realized that they were in the wrong tunnel, so they turned around and walked back toward the L'Enfant Plaza station platform. As they approached the station platform, the smoke had cleared substantially, and they saw an opening in the tunnel wall that had been obscured by smoke when they first entered the tunnel. Through the opening in the wall they could see a train and other firefighters (the rescue squad). The crew then joined the rescue squad and assisted in the evacuation effort.

In this situation, the emergency responders stated that they followed the directions of WMATA personnel into the wrong tunnel. The tunnel entrance signage provided the track number but not the line designation and direction. There was no signage inside the tunnel that could be used by emergency responders as guidance to the correct response location. This is particularly important where tunnel bores diverge. The NTSB concludes that without line identification and direction signage at tunnel entrances and in tunnels, emergency response personnel may have difficulty navigating, which may delay their response efforts. Therefore, the NTSB recommends that WMATA install line identification and direction signage at tunnel entrances and inside tunnels.

3.9.5 Tunnel Evacuation Route

The west side of the Yellow Line track 2 tunnel south of the L'Enfant Plaza station has a safety walk for WMATA employees and for use by train evacuees if a train in the tunnel needs to be evacuated. The walkway is concrete and about 1 1/2 feet wide. The surface of the walkway is about 2 1/4 feet above the top of the rail. The track bed also can be used as an evacuation path.

The tunnels were lit by fluorescent lights affixed to the tunnel walls above the walkway at 24-foot intervals. Fluorescent lighting also was located at the bottom of the ventilation fan shafts and the shaft stairs (the emergency exit stairs). This lighting was intended to provide ambient low-level illumination in the tunnels and ventilation fan shaft stairways. The WMATA *Manual of Design Criteria* specifies that the average level of illumination in the subway tunnels is to be maintained at a minimum level of 1.0 foot-candle.[49]

During a postaccident inspection of the Yellow Line tunnel south of L'Enfant Plaza NTSB investigators and WMATA noted that almost all of the light fixtures in the tunnel appeared to be covered in dust and soot. Investigators also noted that 7 of the 48 tunnel lighting fixtures encountered were not functioning. The combination of dust, soot, and nonfunctioning lights appeared to have reduced the amount of light in the tunnel. NTSB investigators and WMATA jointly measured the level of light at 10-foot intervals along the tunnel between L'Enfant Plaza and the FL-1 ventilation fan shaft. About 66 percent of the light measurements taken along the walkway and 27 percent of the measurements taken on the track bed (the tunnel floor) were 0.0 foot-candles.

[49] NFPA Standard 101 specifies a 1.0 foot-candle minimum illumination for emergency lighting (NFPA 2015, section 7.9.2).

During the postaccident inspection of the tunnel, investigators saw various obstacles along the safety walkway and track-bed floor, including conduit and junction boxes, that could cause people to trip or slip. Several passengers who were evacuated from the tunnel told investigators that using the walkway between the stopped train and the station platform was challenging because of the very dim or nonexistent lighting in the tunnel and because wall fixtures intruded into the space over the walkway. The NTSB concludes that the lack of emergency lighting in the tunnel and the conduit and junction boxes on the tunnel wall above the walkway were safety hazards to passengers evacuating through the tunnel. After the illumination measurements, WMATA implemented a tunnel lighting maintenance program.

After the accident, WMATA established a dedicated maintenance crew to replace and repair tunnel lighting and to clean tunnel walkways of any debris or retired equipment left behind in the underground portions of the system that may obstruct non-designated passageways for rail personnel or emergency responders. (See section 5.1.) The NTSB recommends that WMATA implement a regular schedule for the inspection and removal of obstructions from safety walkways and track-bed floors to ensure safe passageways for passengers to use during a tunnel evacuation. The NTSB further concludes that the lack of safety standards or regulation addressing emergency evacuation routes, including design and lighting, led to obstructed and poorly illuminated walkways at WMATA that increased the risk of injury to people evacuating train 302 in the Yellow Line tunnel. Therefore, the NTSB recommends that the FTA issue regulatory safety standards for emergency egress in tunnel environments.

3.9.6 District of Columbia Fire and Emergency Medical Service

The MTP deputy chief told investigators that when he arrived at L'Enfant Plaza in response to the report of smoke in the station, he learned that train 302 was stopped in the tunnel, which was filled with smoke, and required evacuation. The MTP chief returned to the street level as the first FEMS units were arriving, and he intended to become the OSC for the MTP and serve as the principal emergency coordinator between WMATA and FEMS. Accordingly, he anticipated his role was to promptly communicate to the FEMS IC what was learned about the train that was stopped in the tunnel which required an immediate evacuation, and to be a liaison to the FEMS IC to coordinate the response of the WMATA on-scene resources.

Emergency Response Command Structure. NIMS addresses the basic principles of emergency response procedures and processes and prescribes the incident command process.[50] It is "a systematic, proactive approach to guide departments and agencies at all levels of government, nongovernmental organizations, and the private sector to work together seamlessly … to reduce loss of life, property and harm to the environment." In addition, NIMS provides an alternate command structure—Unified Command—for "incidents involving multiple jurisdictions, a single jurisdiction with multiagency involvement, or multiple jurisdictions with multiagency involvement." Unified Command allows agencies with different legal, geographic, and functional authorities and responsibilities to work together effectively without affecting individual agency authority, responsibility, or accountability. It consists of the ICs from all the agencies involved operating together to form a single command structure, with a predetermined IC in charge of the Unified Command. The IC should, among other activities, arrange for

[50] http://www.fema.gov/national-incident-management-system.

facilities suitable for logistical support of the incident command process (that is, a suitably sized command vehicle or other appropriate accommodation) and ensure that the resources needed by Incident Command to support the incident command process are appropriately and effectively used.[51]

FEMS Emergency Response. Timeline data from FEMS show that the FEMS IC arrived at the scene at 3:38:57 p.m. and assumed incident command at 3:39:05 p.m. and established the Incident Command post in his vehicle. The MTP deputy chief stated that when the FEMS IC arrived on scene, he made several attempts to communicate directly with the IC, but the IC moved his vehicle each time the MTP deputy chief approached it. The MTP deputy chief said that when he was able to speak to the IC and told him about the train in the tunnel, it was his impression that the IC took no immediate action to get to train 302 and instead replied that first he had to get his personnel down there to assess where the smoke was coming from. The IC then closed the window of his vehicle. The MTP deputy chief said the IC did not invite him and another MTP officer into the command vehicle to accompany other incident command support personnel. The MTP deputy chief told investigators that he felt excluded from the incident command process.

The FEMS IC told NTSB investigators that he recalled that, shortly after he arrived on scene, he spoke with someone he initially presumed was a chief-level MTP officer. The FEMS IC recalled that the MTP officer had told him about the train stopped in the tunnel and said that there were problems with the train brakes.

Investigators also learned that the IC had made no substantive effort during the emergency response to relocate the Incident Command from the IC's vehicle to a more appropriate location that could accommodate all of the people representing organizations that would be expected to support the incident command process. With the involvement of multiple agencies with varied responsibilities, this accident required a Unified Command structure.

At 3:44:44 p.m., 5 minutes 39 seconds after assuming incident command, the IC dispatched a recon crew to search for train 302. At 3:55:44 p.m. FEMS resources were dispatched in response to a "mass casualty incident box alarm." The first FEMS medical unit to respond to this alarm arrived at the scene at 4:17:59 p.m., 22 minutes 15 seconds later, which was about 38 minutes after the MTP deputy chief told the IC that train 302 was stopped in the smoke-filled tunnel and needed to be evacuated.

The accident and the emergency response occurred at the beginning of WMATA's evening rush hour, a time at which one would reasonably presume that FEMS command officers would know that trains would have many passengers. Further, it would be reasonable to presume that after evacuating the train from the smoke-filled tunnel and station, FEMS command officers would recognize that a "mass casualty incident" medical response was likely needed for the large number of people on the train and would promptly initiate such a response upon arriving at the scene. Several passengers and an emergency responder told investigators that they saw confusion

[51] http://www.fema.gov/national-preparedness, https://www.fema.gov/mitigation-best-practices-portfolio, http://www.nfpa.org/codes-and-standards/document-information-pages?mode=code&code=1600.

among evacuees at street level and few medical response vehicles and personnel and WMATA personnel to provide assistance.

Investigators learned that during the response FEMS medical units had been dispatched to only two of the three L'Enfant Plaza station entrances. People that were evacuated from train 302 who exited the station at the third entrance found no ambulances or medical personnel there.[52] Consequently those passengers who needed immediate medical assistance had to walk to one of the other station entrances to obtain medical assistance or seek treatment on their own.

FEMS designates incident commanders from the rank of battalion fire chief or higher rank.[53] FEMS Special Order, Series 2009, No. 50, describes the criteria for captains to act as battalion fire chiefs. The IC for this accident was an acting battalion fire chief. FEMS Bulletin 84, Minimum Training and Recertification Standard, prescribes the training requirement for the lower position of captain, but it does not contain criteria for the position of battalion fire chief. The NTSB concludes that the lack of formal training criteria for the battalion fire chief position may pose unnecessary risk with respect to incidents requiring the incident command process.

The FEMS IC, an acting battalion fire chief, was unable to provide a persuasive explanation why he did not take immediate action to find the train and why he made no effort to find a space to conduct the incident command process that could accommodate all of the people who would be supporting the incident command process. He told investigators that he had not attended the NIMS ICS 300 (Intermediate Incident Command Systems) and ICS 400 (Advanced Incident Command Systems) training courses.[54] He had taken only ICS 100 (Introduction to the Incident Command System) and ICS 200 (Incident Command System for Single Resources and Initial Action Incidents). The NTSB concludes that the IC had not been effectively trained in the skills and practices of the incident command process.

The MTP deputy chief was excluded from the incident command process. The FEMS IC should have established the Incident Command in a space that could accommodate all of the people supporting the Incident Command and included the MTP deputy chief in the incident command process. The NTSB concludes that the IC should have elevated the incident response to a Unified Command structure. The NTSB also concludes that in the initial phase of the emergency response, the IC did not take appropriate immediate action to provide emergency assistance to passengers on train 302. The NTSB recommends that FEMS implement measures to train all command officers who will serve in the role of incident commander in the skills and practices of NIMS incident command and unified command processes. This training should include regular refresher training.

Emergency Preparedness. Investigators found that WMATA last conducted a full-scale tunnel evacuation training drill in March 2010. This activity addressed a "rail improvised explosive device tactical" drill in the tunnel between the Rosslyn and the Foggy Bottom stations and involved FEMS and other local emergency services agencies. No FTA

[52] No medical personnel were stationed at the entrance to the L'Enfant Plaza Promenade.

[53] An acting battalion fire chief can also be designated as an incident commander.

[54] ICS 400 specifically addresses the Unified Command process.

federal regulations stipulate the frequency of emergency drills on rail transit properties. In contrast, Title 49 *CFR* 239.103, "Passenger train emergency simulations," requires annual emergency drills on commuter and intercity rail properties. At the time of the accident, FEMS had not conducted any on-site tunnel-evacuation drills with WMATA since early 2010. NFPA 130 outlines the standards and benefits of emergency training exercises, drills, and critiques and prescribes that drills shall be conducted at least twice per year.[55] However, after the accident, WMATA reported that it planned to conduct quarterly drills with local emergency response agencies. (See section 5.1.) Since the accident, following its quarterly drill plan, WMATA has conducted four training drills, including one with FEMS that simulated a stopped train in a smoke-filled tunnel. The NTSB concludes that quarterly emergency response drills, particularly those in tunnels, would better prepare WMATA and local emergency response agencies to respond to emergencies on the WMATA system. The NTSB recommends that WMATA conduct emergency response drills with local emergency response agencies in accordance with NFPA 130, document lessons learned, and develop and implement additional procedures as necessary to effectively respond to emergencies.

The investigation determined that FEMS had not conducted WMATA tunnel evacuation emergency drills in the 5 years before the accident. On the day of the accident, FEMS provided inadequate medical response on scene to evacuated passengers and had assigned an IC with inadequate training on the incident command system, contributing to the delay in evacuating train 302. The NTSB concludes that FEMS was unprepared to respond to a mass casualty event in WMATA's underground system. Therefore, the NTSB recommends that the mayor of the District of Columbia convene an independent panel of experts to (1) assess FEMS' preparedness to respond to mass casualty events in the WMATA underground system, (2) identify and make recommendations to improve this preparedness, and (3) share the findings of that assessment with the other local jurisdictions with WMATA underground systems.

Accident After-Action Review. An important postevent practice, employed by the incident command process, is for an emergency services agency, as well as the transportation operator, to conduct an after-action review of the emergency services response to the event, which identifies the successes and potential deficiencies of the response and prospective remedial efforts. This critique of an emergency response can provide important information that can be used to improve emergency response procedures. WMATA and the District of Columbia Homeland Security and Emergency Management Agency (HSEMA) normally conduct independent after-action reviews of their respective emergency responses and should have done so for this accident.

Investigators requested information on an after-action review from WMATA; WMATA responded that it had not conducted an after-action review. Information from an after-action review can help WMATA assess and improve its emergency response to future accidents. In contrast, Federal Railroad Administration (FRA) regulations applicable to railroads that operate intercity or commuter passenger service include a provision at Title 49 *CFR* 239.105, "Debriefing and critique," that requires an after-action review following each accident and

[55] 9.10.2 "Exercises and drills shall be conducted … to prepare the authority and participating agency personnel for emergencies." 9.10.4 "Drills shall be conducted at various locations on the system as well as at various times of the day so as to prepare as many emergency response personnel as possible."

emergency training drill. The NTSB concludes that WMATA missed the opportunity to improve its emergency response and procedures by not conducting an after-action review of its emergency response to the accident. The NTSB therefore recommends that WMATA revise its standard operating procedures to require that an after-action review be conducted of all emergency responses to events with passenger or employee fatalities, and publish the results, including both the successes and the potential deficiencies of the WMATA responses, to help ensure that deficiencies are appropriately remediated.

NTSB investigators requested information on this topic from FEMS and HSEMA, and HSEMA responded on behalf of the District of Columbia, stating that an after-action report was being compiled but would not be ready for release until a final internal review was conducted.[56] No further documentation on this topic was provided to investigators.

[56] HSEMA had been tasked by the District of Columbia office of the Mayor to address this.

4. Oversight and Management

4.1 US Department of Transportation

On June 23, 2015, the NTSB convened a 2-day investigative hearing to gather additional factual information for the ongoing investigation of the accident. The investigative hearing focused on the following areas:

- the state of WMATA's infrastructure
- emergency response efforts
- WMATA's organizational culture
- FTA and TOC efforts for public transportation safety

Based on testimony from representatives of the TOC and the FTA during the hearing, the NTSB concluded that neither the regulatory changes the FTA can make as a result of MAP-21 nor the proposed Metro Safety Commission (MSC), an independent organization that would assume the responsibilities of the TOC, will likely resolve the deficiencies identified in safety oversight of WMATA. (See section 4.2 for discussion of the MSC.) Without adequate oversight, accidents and incidents will continue to place the riders of the WMATA system at risk.

The NTSB acknowledged the challenges in managing oversight authorities and responsibilities among different jurisdictions under separate bureaucracies for transit agencies with rail transit systems that cross state borders. Currently three SSOAs exist for transit agencies operating across state boundaries:

- WMATA: District of Columbia, Maryland, and Virginia
- Port Authority Transit Corporation (PATCO): Pennsylvania and New Jersey
- Metro Transit-St. Louis (Metrolink): Missouri and Illinois

The NTSB also recognized a 2006 report by the US Government Accountability Office, which stated that although the oversight programs of PATCO and Metrolink appeared to be working well, WMATA's oversight program "experienced difficulty obtaining funding, responding to FTA information requests, and ensuring audit findings are addressed"(GAO 2006).

These ongoing concerns with WMATA's safety management and lack of effective oversight to correct these concerns led the NTSB to issue recommendations to the DOT to seek an amendment to 45 USC §1104(3) to list WMATA as a commuter authority, thus authorizing

the FRA to exercise regulatory oversight of the WMATA rail system.[57] The NTSB issued the following urgent safety recommendations to the DOT on September 30, 2015.[58]

R-15-31 (Urgent)

> Seek an amendment to Title 45 *United States Code* Section 1104(3) to list the Washington Metropolitan Area Transit Authority as a commuter authority, thus authorizing the Federal Railroad Administration to exercise regulatory oversight of the Washington Metropolitan Area Transit Authority's rail system.

R-15-32 (Urgent)

> After Title 45 *United States Code* Section 1104(3) is amended to include the Washington Metropolitan Area Transit Authority, direct the Administrator of the Federal Railroad Administration to develop and implement a plan to transition the oversight of the Washington Metropolitan Area Transit Authority's rail system to the Federal Railroad Administration within 6 months.

In an October 9, 2015, response letter to the NTSB chairman, the secretary of transportation declined to implement the NTSB recommendations.[59] Instead, the secretary chose to continue FTA oversight with more aggressive actions but still within the framework of MAP-21, including the FTA's assuming safety oversight of the WMATA rail system.

The FAST Act amended MAP-21 to provide additional FTA oversight of public transportation safety programs. In addition to the authority to issue performance standards for public transportation vehicles, the FTA may issue minimum safety standards to ensure the safety operation of public transportation systems. These standards, to the extent practicable, shall take into consideration relevant recommendations of the NTSB, best practices developed by the public transportation industry, any minimum safety standards or performance criteria being implemented across the public transportation industry, and any additional information that the secretary of transportation determines necessary and appropriate.

The FAST Act also allows the FTA to issue restrictions and prohibitions to address unsafe conditions or practices. Additional FTA enforcement authority includes the authority to withhold funds for noncompliance with safety requirements, to issue nationwide safety directives, and to prohibit or restrict operations. It also allows the FTA to withhold or direct funds for correcting safety deficiencies.

The FAST Act further expanded the FTA's safety oversight authority by providing for withholding of funds in states with deficient safety oversight programs, directing state funds to

[57] The FRA exercises regulatory oversight of three transit properties: Southeastern Pennsylvania Transportation Authority, New Jersey Transit, and Port Authority Trans-Hudson.

[58] (1) The safety recommendation letter is attached as appendix H.

[59] This letter is attached as appendix I.

address identified safety issues, and the assumption of direct safety oversight in the event the FTA determines a SSOA is deficient.[60]

As to NTSB Safety Recommendations R-15-31 and -32, the FAST Act provides for the secretary of transportation to temporarily administer the SSO program if that program is not being carried out, has become inadequate to ensure the enforcement of federal safety regulations, or is incapable of providing adequate safety oversight consistent with the prevention of substantial risk of death or personal injury. The FTA assumed safety oversight of WMATA in October 2015 after determining that the TOC was deficient.

The FTA's safety authority does not wield the same regulatory enforcement tools to compel safety compliance that are available to the FRA. The FTA envisions using a safety management system (SMS) approach to implement the National Public Transportation Safety Plan that systemically and proactively identifies the factors that contribute to unsafe events and prevents or minimizes the likelihood of their occurrence. The NTSB agrees that an SMS is a critical component of assuring organization safety. However, MAP-21 and 49 *CFR* Parts 659 and 674 do not provide regulatory enforcement tools to compel compliance that are available to other safety enforcement agencies such as the FRA. In contrast, MAP-21 requires each state to establish enforcement, and the only tools available to the FTA are withholding or directing funds. Historically, FTA safety oversight reviews would focus on the overall safety performance of an entire organization, the effective implementation of the methods for identifying and evaluating safety risks and for mitigating exposure to those risks, instead of relying solely on compliance with regulatory requirements or technical standards.

At the NTSB investigative hearing on June 23–24, 2015, the FTA associate administrator was asked how the FTA could effect safety change without having enforcement capability like the FRA has, using inspections, audits, and enforcement to achieve safety. The FTA associate administrator responded that what the FRA oversees—urban rail, light rail, commuter rail—is different from the public transit the FTA oversees. The administrator said that with the variety of transit the FTA covers, it is very difficult to conduct enforcement for all the types of transit. Working to improve culture, instead, is the same for a variety of transit. The administrator also addressed the funding discrepancy between the FRA and the FTA: the FRA has hundreds of staff including field inspectors, and the FTA has a safety staff of about 30 and 2 accident investigators. The administrator concluded that the FTA will never have an enforcement presence in the field similar to the FRA's, so an approach is needed that emphasizes changing the culture and making the culture one in which ignoring safety or doing things that are unsafe is unacceptable.

Also at the hearing was the deputy chief inspector of railways in the United Kingdom (UK) Office of Rail Regulation, which oversees all railways, metros, and tramways in the UK. When asked if there was a distinction in the approach to safety for these different systems, he said "No, none whatsoever." He went on to say that the laws of physics and energy are the same and that "a steel wheel or a steel rail has the capability of coming off" if not

[60] Under the FAST Act, if a state's SSO program is deemed not sufficient, the secretary of transportation may withhold up to 5 percent of the state's section 5307 funds (Urbanized Area Formula Grants) until the deficiency is resolved.

properly managed, "so we apply safety legislation uniformly across all forms of guided transport."

The NTSB is concerned about the sustainability of the FTA program. Although the FAST Act provides for the FTA to assume safety oversight when a SSOA is inadequate, it is meant to be a temporary solution. The FTA has stated that its direct oversight of WMATA will continue until the District of Columbia, Maryland, and Virginia establish a new SSOA to replace the TOC that is compliant with current law and capable of performing its safety responsibilities. It is likely that this task will take up to 2 years, requiring legislation from each jurisdiction and a memorandum of understanding among them.

Conversely, the FRA has inspection, oversight, regulatory, and enforcement authority and conducts regular safety compliance inspections of railroads. Title 49 *CFR* Part 209 describes the procedures used by the FRA in its enforcement of federal railroad safety statutes and regulations. According to appendix A to Part 209, those statutes include the Federal Railroad Safety Act of 1970 and a group of statutes enacted before 1970 referred to as the "older safety statutes." Other statutes include the Rail Safety Improvement Act of 1988, which raised the maximum civil penalties available under railroad safety laws and made individuals liable for willful violations of those laws.

The FRA administers and enforces the federal laws and related regulations designed to promote safety on railroads and exercises jurisdiction over all areas of railroad safety, such as track maintenance, inspection standards, equipment standards, and operating practices. It also administers and enforces regulations enacted under railroad safety legislation for locomotives, signals, safety appliances, power brakes, hours of service, transportation of explosives and other dangerous articles, and the reporting and investigation of railroad accidents. Railroad and related equipment, facilities, and records are inspected, and required reports are reviewed.

The FRA issues and enforces railroad safety regulations. FRA inspectors document noncompliance on inspection reports. The FRA has several tools available when inspectors find that railroad are non-compliant with applicable regulations. It can issue civil penalties, individual liability penalties, compliance orders, and emergency orders. In contrast, the FTA and the TOC do not have such tools.

The FRA fulfills its mission through safety compliance inspections, audits, and accident investigations. Annually the FRA develops a National Inspection Plan. The Plan is intended to reduce accidents by providing guidance to each FRA regional office on how inspectors in each of the five FRA disciplines—track, operating practices, motive power and equipment, signal and train control, and hazardous materials—should divide their work by railroad and state. Under this approach, the FRA uses data models to focus its inspectors' efforts in places deemed likely to have safety problems. The FRA headquarters uses accident inspection and other data to specify, by inspection discipline, numeric goals for the level of inspection activity to allocate to each railroad. The National Inspection Plan goals may be adjusted based on local knowledge and emerging issues to allow responses to new or unexpected events such as major accidents. The FRA also investigates all safety complaints from individuals, state and federal agencies, railroads, and railroad employees.

The FRA enforces the federal railroad safety regulations and laws with about 400 federal railroad inspectors whose efforts are supplemented by about 165 state inspectors from states that participate in the FRA's State Inspection Program. Both Maryland and Virginia participate in the FRA's program. The state programs are important elements of the National Inspection Plan established by the FRA. State inspectors coordinate with federal inspectors while monitoring the safety practices of each railroad in their respective states. State inspectors are certified by the FRA. As states participating the FRA state program, Maryland employs three FRA-certified inspectors, and Virginia employs six FRA-qualified inspectors. The role of state inspectors is parallel with federal inspectors.

After its investigation of the June 22, 2009, WMATA Fort Totten accident, the NTSB concluded the following:

> The structure of the FTA's oversight process leads to inconsistent practices, inadequate standards, and marginal effectiveness with respect to the state safety oversight of rail transit systems in the United States.
>
> The results of this investigation, as well as the FTA's audit of TOC and WMATA, determined that TOC has been ineffective in providing proper safety oversight of and lacks the necessary authority to properly oversee the WMATA Metrorail system. (NTSB 2010)

The NTSB believes these same concerns existed at the time of the WMATA L'Enfant Plaza accident.

After 4 NTSB studies and 11 NTSB investigations of WMATA accidents, there is still concern that the FTA does not have a program in place to develop safety regulations, execute effective safety oversight of the SSO program, and conduct direct oversight when a state is determined to be inadequate to provide safety oversight in accordance with MAP 21 and the FAST Act. The regulations authorized in MAP-21 are years behind schedule and are not yet finalized. As the FTA associate administrator testified at the June 23–24, 2016, investigative hearing, the FTA has a staff of only about 30 to conduct safety and security oversight for the nation. During the temporary FTA direct oversight of WMATA, the FTA has employees on loan, three each from the FRA and the FAA, to assist in this effort. The NTSB concludes that despite its new authorities under the FAST Act, the FTA still lacks sufficient authority, expertise, and resources to assume temporary, direct safety oversight of rail transit agencies.

On February 19, 2016, the NTSB classified Safety Recommendation R-15-31 "Open—Unacceptable Response" because the DOT's actions fell short of the effective oversight sought by the NTSB recommendation.

4.2 Tri-State Oversight Committee

The NTSB began investigating railroad accidents in 1967 and since then has called for improvements in safety oversight of rail transit systems. In 1971 the NTSB issued Safety

Recommendation R-71-15 to UMTA, later renamed the FTA, calling for system safety plans.[61] (See appendix D.) In 1978, in Safety Recommendation R-78-010, the NTSB called upon the DOT to develop oversight capability to "insure that the safety of rail rapid transit systems will be regulated and enforced by a responsible state or federal agency." (See appendix E.) The NTSB classified this recommendation "Closed—Unacceptable Action" on January 12, 1987, after the DOT took no action. Similar recommendations were made by the NTSB between 1981 and 2015 seeking improved safety oversight of rail transit and, in 2015, specifically, of WMATA.

In 1991, ISTEA assigned to the states the responsibility of safety oversight of rail fixed guideway systems. This began the evolution of today's state safety oversight (SSO) program. Since the establishment of the program, the NTSB has investigated serious accidents on WMATA, and many of these investigations identified inadequate oversight and regulation. (For more information, see section 1.5.) In general, the NTSB investigations of WMATA found that although safety program plans were in place, they were not effectively implemented and overseen.

The NTSB's investigation of the June 22, 2009, WMATA accident near the Fort Totten station revealed that increased regulatory oversight of rail transit properties was needed (NTSB 2010). The NTSB issued Safety Recommendation R-10-3 to the DOT:

> Continue to seek the authority to provide safety oversight of rail fixed guideway transportation systems, including the ability to promulgate and enforce safety regulations and minimum requirements governing operations, track and equipment, and signal and train control systems.

On December 26, 2012, the NTSB classified this safety recommendation "Closed—Acceptable Action" based on the enactment of MAP-21, which gave the FTA expanded safety oversight authorities.[62] The NTSB closed this recommendation in good faith with the expectation that the FTA would exercise its expanded authorities within the time specified in the act.

Under the requirements of MAP-21, the FTA must certify SSOAs, and, as a result of certification, a SSOA can receive federal grant money for up to 80 percent of its operating budget (*Federal Register* 2016, 14230).[63] In the investigation of the L'Enfant Plaza accident, however, the NTSB again found shortcomings in safety oversight of WMATA by the TOC.

The governors of Maryland and Virginia appoint the members of the TOC, and each serves as the respective state secretary of transportation. The third member, from the District of Columbia, was the deputy director of the District of Columbia Department of Transportation.[64] The TOC Executive Committee members change each time the state governors or the mayor of the District of Columbia change through general elections. For example, after the general

[61] Safety Recommendation R-71-15 is classified "Closed—Acceptable Action."

[62] The president signed MAP-21 into law on July 6, 2012, with an effective date of October 2, 2012.

[63] Title 49 *CFR* Part 674, State safety oversight. Final Rule published in the *Federal Register* March 16, 2016, effective April 15, 2016.

[64] The deputy director of the District of Columbia Department of Transportation was serving on the TOC Executive Committee at the time of this accident because the director was serving on the WMATA Board of Directors.

election in 2014, the executive committee member from the commonwealth of Virginia took office on January 21, 2015, 9 days after this accident. Each of the members had extensive duties in their respective jurisdictions, reducing the time they have for their TOC responsibilities. For example, the secretary for Maryland told the NTSB that his responsibilities included transportation policy and the operations of the modal administrations—11,300 employees overall. The District of Columbia deputy director of transportation told the NTSB that he was responsible for the day-to-day operations of the organization, for direct oversight of all the administrations in the organization, and for a range of activities that include planning, design, engineering, construction, and administrative services.

The NTSB learned that the TOC Executive Committee did not hold any meetings and relied on the particular jurisdiction employee appointed to the TOC to bring forward safety issues ad hoc. The NTSB concludes that the structure of the TOC Executive Committee and its failure to effectively guide the TOC reduced the ability of the TOC to execute efficient and effective safety oversight of WMATA.

The WMATA chairman of the board told NTSB investigators that he believed two problems of the TOC are the lack of permanency in the members' status and the difficulty of agreement—on standards, for example—among multiple jurisdictions. In an attempt to improve on the TOC, Virginia Governor McAuliffe, then Maryland Governor O'Malley, and then Mayor Gray of the District of Columbia authorized what they described as an actionable step to establish an independent state oversight agency that would conform to MAP-21 . In doing so they proposed the Metro Safety Commission (MSC), an independent organization that would assume the responsibilities of the TOC. A White Paper, *Optimizing State Safety Oversight of the WMATA Metrorail System,* prepared by the three jurisdictions, contains the proposal (DC/MD/VA 2010).

The White Paper included a discussion of the inherent barriers that the structure and function of the TOC pose for effective implementation of the SSO program. The Paper described the different jurisdictions' ideal SSO program for the oversight of WMATA and proposes actions necessary to achieve that ideal. It proposes to carry out this effort in two phases, acknowledging the time-consuming procedures and negotiations that would be required. Phase one is the creation of a strengthened Interim TOC Oversight Program, and phase two is either the legal creation of an MSC or federal oversight of WMATA's safety oversight functions.

The White Paper proposed specific board membership, director, staff, facility, and funding requirements for the MSC. It included discussion of the need for legal independence and authority for the MSC to conduct and enforce safety oversight of WMATA. However, the Paper included no details about establishing legal authority in a way that overcomes the multijurisdictional problems faced by the current TOC. Finally, it conceded that phase two will entail actions that will "consume years" to create. In the Paper, the authors admitted other challenges such as resources; legislation at the local, state, and federal levels; and budgetary constraints of all three jurisdictions that may further limit progress in achieving an effective safety oversight program. According to testimony of the TOC chairman at the NTSB hearing on June 23–24, 2015, the earliest the MSC would come into existence is 2019.[65]

[65] TOC Plan for Transition to MSC, Exhibit F14, March 9, 2015, NTSB Docket, DCA15FR004.

During the June 2015 investigative hearing on the L'Enfant Plaza accident, the NTSB learned that the TOC had applied to be a SSOA in 2013. In October 2013, the FTA said, the TOC's application was denied because it did not adequately "define a legally recognizable entity to meet the definition of a state safety oversight agency in accordance with MAP-21."

The TOC approach to assuring safety of WMATA consisted of audits, reviewing required WMATA safety plans, following up on reported incidents, and corrective action plans developed as response to audit findings or accident investigations. MAP-21 was enacted to create a national public transportation program to improve safety of all public modes of transportation, calling for increased levels of independent oversight or rail transit agencies. MAP-21 required the establishment of safety performance criteria and performance standards, as well as authorizing the FTA to include vehicle standards in the national public transportation safety plan (a required element in MAP-21). The FTA associate administrator for safety and oversight testified during the investigative hearing that MAP-21 was very similar to the current requirements of 49 *CFR* Part 659, stating, "It just has a higher bar of what's required for the state safety oversight agencies". He also said, "To frame our discussion, it's important to remember that 49 *CFR* Part 659 is the current law of the land for state safety oversight, and that the state safety oversight agencies hold responsibility for safety of their rail transit systems."

Historically, SSOs, such as the TOC, had the primary responsibility for overseeing the safety plans of the rail transit agencies within their states (or multiple jurisdictions as with the TOC). The FTA was responsible for overseeing the work of the oversight agencies and promulgated 49 *CFR* Parts 659 and 674 to guide the SSO program. The FTA also administered the grant programs to offset the cost of new starts, major capital projects/extensions, and operational expenses. The FTA safety and oversight section of the FTA had a small staff to administer the SSO program and begin rulemaking to comply with MAP-21. Notably, FTA authority over rail transit properties is limited to those that receive federal funding.

During the NTSB investigative hearing, the FTA associate administrator was asked whether all of the FRA safety regulations could be moved to the FTA. He responded that a significant problem/obstacle is that FRA cannot deal directly with the properties it oversees, and the FTA must work through the SSOAs. He also discussed the FTA's need to use contractors to provide technical expertise for conducting safety audits, while the FRA has a larger staff that can provide this support.

The NTSB issued urgent Safety Recommendations R-15-31 and -32 to the secretary of transportation on September 30, 2015, recommending an amendment to Title 45 USC § 1104(3) to include WMATA as a commuter authority, thus authorizing the FRA to exercise regulatory oversight of WMATA and to direct the FRA administrator to develop and implement a plan to transition the oversight of WMATA to the FRA within 6 months. (See section 4.1.)

In response to the NTSB's urgent safety recommendations R-15-31 and -32, on October 9, 2015, the secretary of transportation directed the FTA to take responsibility for safety oversight of the WMATA rail system until the three jurisdictions have replaced the TOC with a SSO program administered by a new SSOA that is fully compliant with Title 49 USC § 5329(e). (See the DOT letter at appendix I.)

At its November 2015 meeting, the Metropolitan Washington Council of Governments board of directors was briefed by the then acting administrator of the FTA about the recent announcement by the secretary of transportation directing the FTA to assume temporary safety oversight of the WMATA rail system from the TOC and urging the swift establishment of a new SSOA to provide long-term regulatory safety oversight for WMATA. In addition to pointing out the FTA's oversight activities, the FTA acting administrator noted the Council of Governments' role in supporting Virginia, Maryland, and the District of Columbia to expedite the creation of a new SSOA consistent with federal requirements. This independent MSC, a new legal entity currently under development, will have stronger enforcement authority for safety oversight over WMATA as called for in MAP-21. The FTA acting administrator told area leaders at the Council of Governments that its "role as a catalyst can move the transition effort forward" from the TOC to the MSC. The board of directors pledged to work across borders to advance legislation to establish the multi-state commission.

On January 13, 2016, DOT officials and legislative leaders in Maryland, Virginia, and the District of Columbia said they would not establish an independent safety oversight group in 2016, 2 months after the FTA acting administrator implored them to act well before the 2019 deadline.

The FTA acting administrator has stated that Virginia, Maryland, and the District of Columbia have a year, or until February 7, 2017, to create a safety oversight body for WMATA or risk losing millions in federal transportation funding. In a February 8, 2016, letter to the mayor of the District of Columbia and the governors of Maryland and Virginia, the secretary of transportation wrote that he was frustrated to learn that the jurisdictions would not be pursuing legislation this year to establish a federally compliant safety oversight agency to oversee WMATA rail operations. The FTA final rule at Title 49 *CFR* 674.11 states that "every state that has a rail fixed guideway public transportation system must have a state safety oversight program that has been approved by the FTA administrator" by April 15, 2019, allowing 3 years for the program to be developed and approved (*Federal Register* 2016, 14258). The secretary acknowledged the shortcomings of the TOC and announced that the FTA would assume the lead safety oversight of WMATA. His expectations were outlined as follows:

- The FTA has issued a final determination that the TOC "is incapable of providing adequate safety oversight consistent with the prevention of substantial risk of death or personal injury."
- The State of Maryland, the Commonwealth of Virginia, and the District of Columbia will have 1 year to obtain FTA certification that a new SSO program is consistent with federal requirements. Failure to do so may result in the withholding of "up to 5 percent of the amount required to be appropriated for use in a state or an urbanized area in the state under Section 5307" until FTA certifies the new SSO program.

Letters from the secretary of transportation dated February 29, 2016, to state representatives and senators in Virginia and Maryland urged action to address significant safety issues with oversight of WMATA. The secretary expressed his concern for the safety and reliability of WMATA. He acknowledged that safety oversight is essential to "insure that safety problems, such as those that caused the tragedy at L'Enfant Plaza …, are dealt with swiftly and

that proactive safety improvements are aggressively pursued to prevent such incidents in the first place." The representatives and senators were advised that "failure to take timely action will result in the withholding of up to 5 percent of the entire state's Urbanized Area transit formal funding under 49 USC §5329(e)(8)(C)."

In response, the District of Columbia, the state of Maryland, and the commonwealth of Virginia adopted a memorandum of understanding (MOU) for cooperation in the establishment of the MSC (to replace the TOC) on March 1, 2016 (DC/MD/VA 2016). The parties agreed to commit staff, share information, procure professional services, and develop strategies with the goal of introducing MSC compact language for consideration in calendar year 2016 to the Council of the District of Columbia and in 2017 to the Maryland and Virginia general assemblies. This MOU establishes the commitment for the 3 jurisdiction to begin legislation to establish a state safety oversight agency by state law in accordance with the requirements of 49 USC §5329(e). To achieve FTA certification, the proposed agency must provide a state safety oversight program that includes the following:

- Acknowledgement that the jurisdictions are responsible for safety oversight of WMATA
- The ability to adopt and enforce federal and relevant state law for the safety of WMATA
- That the MSC is established by state law in accordance with 49 USC § 5329(e)
- Appropriate staffing level commensurate with the size and complexity of WMATA
- That employees and other personnel of the MSC are qualified to perform their functions, based on training and substantial progress toward or completion of the Public Transportation Safety Certification Training Program (*Federal Register* 2015, 10619)[66]
- That by law the jurisdictions prohibit WMATA from providing funds to the MSC
- Financial and legal independence from any public transportation entity that the SSOA oversees

Title 49 *CFR* 674.13 includes additional requirements for the proposed MSC, including but not limited to the following:

- The MSC must be financially and legally independent from WMATA
- The MSC must not directly provide public transportation services in the WMATA region
- The MSC must not employ any individual who is also responsible for administration of WMATA
- The MSC has the authority to review, oversee, and enforce the public transportation agency safety plan for WMATA (United States Code 5329(d))

[66] A notice of final interim safety certification training provisions was published in the *Federal Register* February 27, 2015.

- The MSC has investigative and enforcement authority for WMATA safety

The NTSB remains concerned that Maryland, Virginia, and the District of Columbia will continue to encounter constraints such as those recently experienced, thus furthering the delay of the establishment of the MSC or other SSOA. Based on the original proposed plan in the White Paper, enabling legislation was to be complete by June 2016. The NTSB concludes that the projected establishment of the MSC will be delayed by the required legislation.

The NTSB is concerned about the ongoing challenges to effective safety oversight of WMATA. Testimony at the investigative hearing demonstrated that since the 2009 Fort Totten accident significant safety, oversight, and organization issues still exist. Furthermore, the FTA enforcement authority still resides in the withholding of funds from states with SSO programs that are not in compliance and the addition of the authority for the FTA to assume safety oversight when a SSOA is determined to be deficient.

4.3 Washington Metropolitan Area Transit Authority

The problem areas identified during the investigation of this accident include organizational or process safety management functions. These functions in turn influence the behaviors and attitudes of individual employees when they encounter hazardous situations and events. Decisions and processes involving infrastructure, maintenance, policies and procedures, communication, emergency response, employee qualifications, and training in a large and complex system like WMATA depend on multiple groups and functions within the agency.

A systematic way to identify hazards and control risks while maintaining assurance that these risk controls are effective is at the core of an SMS program. The International Civil Aviation Organization (ICAO) defines an SMS program as "an organized approach to managing safety, including the necessary organizational structures, accountabilities, policies, and procedures."[67] (ICAO 2013) The NTSB has identified many transportation accidents where an SMS or system safety program could have prevented injuries and the loss of life. As a result, the NTSB has recommended that aviation, railroad, highway, and marine organizations should establish an SMS or system safety program.

An SMS program establishes processes to collect and analyze data on potential safety problems and then evaluates ways to mitigate and resolve the safety risk before an accident occurs. According to ICAO, the major components to an SMS program include the following (ICAO 2014):

- Safety Policy, which establishes senior management's commitment to continually improve safety and defines the methods, processes, and organizational structure needed to meet safety goals.

[67] ICAO is a UN-specialized agency, created in 1944, that works with 191 signatory countries and global industry and aviation organizations to develop international standards and recommended practices, which are used by countries to develop their civil aviation regulations.

- Safety Risk Management, which determines the need for, and adequacy of, new or revised risk controls based on the assessment of acceptable risk.
- Safety Assurance, which means that management must impose a system of internal evaluation intended to assure the execution of safety-related measures and to make certain that employees understand their roles.
- Safety Promotion, which means that the organization must promote safety as a core value, using practices that support a sound safety culture.

The investigation revealed several instances of noncompliance with existing WMATA policies and procedures. In that regard, this accident is similar to several prior accidents involving WMATA. Specifically, the investigation revealed that ROCC supervisors and rail control operators failed to follow standard operating procedures in response to smoke and fire. As discussed previously, investigators found that sealing sleeves required to make third rail cable connector assemblies weathertight were not installed as required by WMATA engineering design specifications. Additionally, investigators determined that, despite submitting documentation to the contrary, some WMATA employees tasked with safety inspections may not have been completing these key inspections as reported for more than 1 year. This behavior appears to have been intentional noncompliance with established WMATA policies and procedures. Further, investigators found no evidence that, prior to the accident, WMATA line managers discovered these irregularities or took corrective actions regarding these incomplete inspections.

SMS assumes, based on management and employee prioritization of a safety culture, that there will be no intentional noncompliance with established safety protocols, policies, and procedures. In this accident, noncompliance with policies and procedures was a factor contributing to the nature and severity of this accident.

The NTSB investigated WMATA's organizational effectiveness in safety management during its investigation of the June 22, 2009, fatal collision of a WMATA train with the rear of a standing train near the Fort Totten station (NTSB 2010). The accident circumstances included a complex technical failure concurrent with multiple latent conditions in which the failure of track circuit modules caused the automatic train control system to lose detection of the stopped train. Because the system did not detect the stopped train, it did not slow and stop the following train to avoid the collision; instead, it sent speed commands to the striking train up to the point of impact. Further, WMATA failed to ensure the use of a track circuit verification test that would have identified the faulty track circuit before the accident.

The investigation of the Fort Totten accident identified deficiencies in organizational safety management at WMATA. For example, the NTSB concluded that before the June 2009 accident, "WMATA was not adequately assessing the severity of hazardous risk associated with identified anomalies in its automatic train control system." The NTSB also found that WMATA was not reviewing its recorded operational data, nor did it have a nonpunitive system for employees to report safety problems. Among the other findings of the investigation, the NTSB concluded that "shortcomings in WMATA's internal communications, in its recognition of hazards, its assessment of risk from those hazards, and its implementation of corrective actions

are all evidence of an ineffective safety culture within the organization." Based on its findings, the NTSB determined that one of the contributing factors in the probable cause of June 22, 2009, collision was "WMATA's lack of safety culture."

During the NTSB's June 23–24, 2015, investigative hearing on the January 12, 2015, accident at L'Enfant Plaza, WMATA provided testimony and submissions detailing multiple steps the agency has taken to improve its organizational safety management and respond to previous NTSB safety recommendations. Some examples of the mitigation efforts cited by WMATA include the following:

- Implementing a confidential safety reporting system for its employees similar to the FRA's Confidential Close Call Reporting System (also called C3RS), and initiating an anonymous safety hotline
- Developing and implementing a periodic employee engagement survey
- Revising its System Safety Program Plan
- Adopting Military Standard 882 as part of its hazard management procedures
- Creating a safety measurement system database that consolidates information from various data systems within WMATA

The circumstances of the 2009 Fort Totten accident and WMATA's corrective actions cited above, taken in response to the NTSB's resulting recommendations, represent general elements of system safety management such as hazard identification, risk assessment, risk reduction, and verification.[68] The NTSB first addressed WMATA rail system safety in 1970, when it conducted a special study of the proposed transit rail system while it was still under construction (NTSB 1970). The study report resulted in one safety recommendation to WMATA:

R-70-18

> Develop the capability within your organization for system safety engineering and apply system safety principles to all aspects of the proposed [rail] system to identify, assess, and correct those deficiencies identified by the analysis.[69]

Although not widely applied to transit systems at the time, the system safety approach the NTSB recommended to WMATA in 1970 was eventually required of all rail transit agencies' system safety program plans under 49 *CFR* 659.31, Rail fixed guideway systems; State safety oversight; System safety program standard.[70] The NTSB's investigation of the January 12, 2015, accident at L'Enfant Plaza identified several deficiencies in specific safety management elements such as equipment and infrastructure design and maintenance, training, and emergency response that are explicitly included in system safety program requirements at 49 *CFR* 659.31. Two prior

[68] See United States, Department of Defense (11 May 2012). Standard Practice for System Safety. Washington, DC: US DOD. MIL-STD-882E, https://acc.dau.mil/adl/en-US/683694/file/75173/MIL-STD-882E_Final_2012-05-11.pdf.

[69] This safety recommendation was classified "Closed—Acceptable Action" on November 17, 1975.

[70] The FTA first issued the state safety oversight regulation on December 27, 1995.

accidents, decades earlier, identified strikingly similar safety deficiencies in WMATA rail operations.

On January 13, 1982, WMATA Blue/Orange Line train 410 derailed at the Smithsonian interlocking (NTSB 1982). The NTSB's investigation of that accident identified deficiencies in the training of ROCC control operators.[71] The NTSB also identified problems with the WMATA radio system, emergency response and evacuation procedures, communication within the ROCC, and communications among ROCC control operators, train operators, and the MTP. For example, the investigation found the following:

- WMATA ROCC personnel lacked a working knowledge of the rules and procedures, the physical characteristics of the rail system, and the fundamentals of rail transit operation because of WMATA's failure to provide them adequate training.
- The ROCC's failure to properly authorize, direct, and coordinate an evacuation through WMATA rail supervisors and employees on the scene resulted in extended and unnecessary delays in starting evacuation of the train.
- District of Columbia Fire Department radio frequencies were not compatible with WMATA's radio repeater system in the subway. This delayed communication between rescue forces in the subway and above-ground command posts.

The NTSB's investigation of a subsequent collision of a WMATA train with a standing train at the Shady Grove station in Gaithersburg, Maryland, on January 6, 1996, identified further concerns with WMATA's methods of management, decision-making, and communication (NTSB 1996). The probable cause of this accident included—

> the failure of WMATA management and board of directors (1) to fully understand and address the design features and incompatibilities of the automatic train control system before establishing automatic train operation as the standard operating mode at all times and in all weather conditions [and] (2) to permit operating department employees, particularly [Rail] Operations Control Center controllers and supervisors, to use their own experience, knowledge, and judgment to make decisions involving the safety of Metrorail operations.[72]

The NTSB's investigation of the 2009 WMATA Fort Totten accident recognized that organizations with effective safety cultures are generally described as having a commitment to safety that permeates the entire organization; that is, senior management demonstrates a commitment to safety and a concern for hazards that are shared by employees at all levels of the organization. For an organization like WMATA, which relies heavily on technology, to maintain an effective safety culture senior managers must continuously review their organization's performance and practices through monitoring, analysis, and feedback systems (Pidgeon and O'Leary 2000). The NTSB concluded from the Fort Totten investigation that "shortcomings in WMATA's internal communications, in its recognition of hazards, its assessment of risk from

[71] At the time, the ROCC was known as the Operations Control Center (OCC).

[72] The probable cause of this accident is included in its entirety in section 1.5, Previous NTSB Investigations of WMATA.

those hazards, and its implementation of corrective actions were all evidence of an ineffective safety culture within the organization" (NTSB 2010).

WMATA's senior management has had multiple opportunities to incorporate critical changes to its operation identified as a result of previous NTSB investigations of WMATA accidents as well as NTSB investigations of other rail transit agency accidents, NTSB special studies, and NTSB special investigations. WMATA has made some progress, but it is only incremental. Serious deficiencies have continued to affect safe operation of the rail transit system. When responding to NTSB recommendations, WMATA senior management has initially committed to implementing change. However, as the L'Enfant Plaza investigation of ROCC shortcomings demonstrates, WMATA has failed to ensure that the changes become permanent elements of its operation. Incorporating critical changes identified from NTSB investigations is vital to the safe and reliable operation of WMATA's rail system.

The NTSB has issued 101 safety recommendations to WMATA, not including safety recommendations issued in this report, and the system continues to have safety and reliability issues. One of the elements of an effective safety culture is the ability to learn from safety information and implement major reforms when needed. (Reason 1997). The NTSB concludes that WMATA has not effectively used past safety investigations and studies to make lasting changes that become incorporated in its organizational safety culture.

This is particularly concerning after the NTSB specifically cited WMATA's need to adopt lessons from prior accidents and incidents in the Fort Totten investigation and recommendations. Based on the circumstances of the L'Enfant Plaza accident, the persistence or reemergence of known deficiencies identified by previous accident investigations and testimony given at the NTSB's June 23–24, 2015, investigative hearing, the NTSB concludes that although WMATA has taken steps to improve its organizational safety since the 2009 Fort Totten accident, significant safety management deficiencies still exist within the organization. The reemergence of safety issues similar to those identified in accidents that occurred many years earlier, despite WMATA's efforts to improve its organizational culture, is consistent with research findings on organizational culture. For example, when reflecting on 50 years of organizational psychology research, Schein (2015) notes that cultures do not change quickly; rather they "evolve slowly as bits and pieces of them are changed by systematic change interventions. And these interventions work only when the culture changes are clearly tied to the fixing of some organizational problems linked to performance."

These ongoing concerns with WMATA's safety management and the lack of effective oversight within WMATA to correct these concerns illustrate the importance of external safety management oversight and performance monitoring to identify safety deficiencies within a transit property. For example, 49 *CFR* Part 659 establishes responsibility and authority for the FTA and states to ensure that rail systems are effectively meeting the system safety program plan requirements of 49 *CFR* 659.31. Rail transit systems like WMATA are subject to federal and state oversight, however historic limitations of that oversight have resulted in limited external capability and authority to identify and cause WMATA to correct safety deficiencies in its operations like those identified in investigations of this and previous accidents.

Investigators determined that WMATA had numerous safety deficiencies, was noncompliant with internal rules, and failed to follow existing procedures thereby putting the public at risk. During an interview with NTSB investigators, the WMATA chairman of the board stated, "we're doing 2 or 3 years' work every year until we catch up for the stuff that hasn't been done." An effective quality assurance program should measure the effectiveness of an agency's compliance with rules and procedures and of its maintenance programs. WMATA had a quality assurance program that was initially released in 2008 and revised only once, in 2013. NTSB investigators reviewed quality assurance audits conducted in 2014. However, there were no audits of the inspection, maintenance, or repair of tunnel infrastructure. The NTSB concludes that had WMATA effectively used its existing quality assurance program, it would have identified problems such as missing sealing sleeves and procedure noncompliance. The NTSB recommends that WMATA review and revise its quality assurance program to ensure that regular quality assurance audits are included to identify and correct any elements of procedural noncompliance.

5. Postaccident Actions

5.1 Washington Metropolitan Area Transit Authority

On January 20, 2015, WMATA issued the first of two memoranda containing early action items to address initial safety concerns identified during the accident investigation. The action items are listed below:

- Write SOP for train operator to cut EV immediately upon stopping for smoke incident. WMATA issued Permanent Order T-15-01, dated January 21, 2015, outlining new SOP for train operator's authorization to shut down environmental system in train.
- Write SOP for incident management in ROCC to provide specifics for site discipline in the ROCC to avoid cross-talk and unnecessary interactions. WMATA issued Permanent Order T-15-02, dated January 21, 2015, outlining new SOP for restricting distractions in the ROCC.
- Set schedule for next three years for emergency quarterly drills to be conducted wayside. Sequence station, then a tunnel section, then an elevated section (note tunnel and elevated sections shall be between stations). Please sequence each quarter in a separate jurisdiction. Coordinate type of drill and logistics with MTP. WMATA issued memorandum dated January 26, 2015, scheduling upcoming emergency drills to be conducted quarterly. A March 15, 2016, memorandum from WMATA described emergency drills conducted in April, August, and December 2015 and in March 2016.
- Design and implement exterior signage for exterior doors to clearly delineate access in event of emergency. WMATA issued a memorandum detailing design of exterior signage on January 29, 2015. A WMATA memorandum dated March, 2, 2015, details a schedule to have 1,098 cars equipped with exterior signage by June 2015.
- Provide engineering and operations report on all third-rail jumper cables in tunnel sections for condition and installation. WMATA issued a memorandum dated February 27, 2015, detailing third-rail jumper cable inspection, renewal, and maintenance.
- Recommendation on installation of low smoke/low halogen on high-voltage third-rail jumper cables. WMATA issued a memorandum dated February 13, 2015, that showed inventory and risk analysis based on age of high-voltage third-rail cables.
- Install mechanical protection on third-rail jumper cables that may be exposed to wear from vibration against other materials. WMATA issued a memorandum dated February 27, 2015, detailing third-rail jumper cable installation.
- Review of ground fault detectors on third-rail circuit breakers. WMATA issued a memorandum dated February 27, 2015, detailing third-rail circuit breaker improvements.

- Operational analysis of running trains at 45 mph in the core with limited acceleration. On March 2, 2015, WMATA completed an operational analysis of running trains at 45 mph in the core with limited acceleration.
- Provide report on installing zoned smoke detectors using emergency trip station (ETS) boxes for location and transmitting of information, also investigate use of wireless smoke detectors. On February 27, 2015, WMATA completed a report on installing zoned smoke detectors using ETS boxes for location and transmitting of information; also investigate use of wireless smoke detectors.

On April 17, 2015, WMATA issued the following additional early action items:

- Tunnel lighting maintenance program to replace every light and light fixture cover in tunnels. WMATA stated it would take approximately four years to complete all 88,044 light fixtures in the entire system, using two six-person crews. WMATA issued a memorandum outlining the tunnel light replacement project which provided a tentative schedule for the work. The project is ongoing.
- Establishing a dedicated maintenance crew to clean tunnel walkways of any debris or retired equipment left behind in the underground portions of the system that may obstruct non-designated passageways for rail personnel or emergency responders.
- Begin reviewing protocols for responding to alarms in the rail operations control center. The goal is to reduce superfluous alarms and segregate "critical" from "non-critical" alarms. Final implementation of new protocols will be subject to receiving the American Public Transportation Association peer review report next month to ensure alignment with their recommendations.
- Implementing a quality audit of the ventilation system testing. This shall include development of the document "PLNT 1000" which will specifically outline periodic critical safety testing apart from regular preventive maintenance activities. This insures self-regulatory compliance to maintenance and testing practices which address "life safety" issues. WMATA completed the revised testing and inspection plan for ventilation systems, a revision date of September 28, 2015, was provided.

In April 2015, the North American Transit Services Association (NATSA), a subsidiary of the American Public Transportation Association, conducted a peer review of WMATA (NATSA 2015). The review looked at ventilation procedures, ventilation equipment and sizing, training, and the use of drills as areas where improvements might be made to speed response and coordination within the ROCC and with emergency responders. In its report NATSA issued recommendations based on its findings. Major areas where changes are recommended include the following:

- Infrastructure
- ROCC operations

- ROCC staffing, training, and organization
- Rules and procedures
- Safety oversight and communication
- Emergency response

Two areas with particular emphasis were ROCC training and restructuring rule books to develop predefined responses for ventilation operations so that better decisions can be made during emergencies.

The report listed the following key results:

- Assess fan equipment performance and develop a plan to incrementally through prioritization of risk improve ventilation capability
- Enhance and expand training including use of emergency drills and checklist
- Develop improved procedures for fan operations in emergencies
- Adhere to proper radio communication procedures ensuring accuracy and integrity
- Examine the added risk of second train presence in the affected zone
- Define more specifically the state of operations in the ROCC, distinguishing between normal operation, high-tempo activity, and emergency operation, noting the changes in operating procedures, the person in charge and how the stated is declared and communicated

Most recently, on March 14, 2016, the WMATA informed the NTSB of an arcing event earlier that day at the McPherson Square station in Washington, DC, and invited the NTSB to view some of the damaged electrical components. NTSB staff viewed surveillance video of the McPherson Square station platform, photographs of the incident location, and components that had been removed from the incident location. NTSB staff who viewed the evidence indicated that the damage to the traction power electrical components was similar to that of the L'Enfant Plaza accident. One cable connector assembly was entirely consumed, and portions of the cables had been consumed. Additionally, a portion of third rail cover board was consumed, which was similar to the third rail cover damage in the L'Enfant Plaza accident. Surveillance video showing smoke filling the McPherson Square station also was similar to what occurred at the L'Enfant Plaza platform. It is not clear, however, what mechanism initiated the arcing event at McPherson Square. To improve our understanding of the McPherson Square incident, the NTSB has sent WMATA a list of questions about its 24-hour-long systemwide emergency inspections, which started on March 16. The questions focus on the nature of the inspections and what was discovered during the inspections.

5.2 Federal Transit Administration

On June 17, 2015, the FTA released a report detailing the results of a safety management inspection (SMI) conducted on the WMATA system. The FTA SMI was in response to concerns about WMATA's safety performance. The SMI report identified organizational deficiencies and operational concerns that continue to limit WMATA's effectiveness in recognizing and resolving safety issues and hazards. As a result of the SMI, the FTA issued 44 safety findings in eight categories. (See table 2.)

Table 2. Summary of Federal Transit Administration safety management inspection findings.

Finding Category	Number of Findings and Required Actions
Inadequate Rail Operations Control Center Staffing and Procedures	14 Findings 21 Required Actions
Ineffective Training, Operational Testing and Rules Compliance Programs	8 Findings 22 Required Actions
Insufficient Track Time for Maintenance	4 Findings 4 Required Actions
System-wide Maintenance Issues	7 Findings 7 Required Actions
Fire/Life Safety and Emergency Preparedness	2 Findings 7 Required Actions
Condition and Performance of Tunnel Ventilation System	3 Findings 4 Required Actions
Performance of Information Management Technology	4 Findings 8 Required Actions
Outstanding Items from Previous FTA Audits and Reviews	2 Findings 5 Required Actions
Total	**44 Findings** **78 Required Actions**

After the FTA SMI, the FTA issued Safety Directive 15-1 (FTA 2015b). The directive noted that during calendar year 2014, the number of fire and smoke events requiring suppression on the WMATA rail system almost doubled from 15 in 2013 to 29 by the end of December 2014. Like the NTSB investigators, the FTA SMI team found safety lapses in the ROCC related to training and certification of control operators. WMATA was given 30 days to respond to the FTA's safety directive, to provide additional information for consideration, and to propose any equivalent alternate actions. WMATA responded to the FTA findings with corrective actions; the current status of all corrective actions are open, with estimated completion dates ranging from December 2015 to September 2019.

Following the January L'Enfant Plaza accident, the NTSB issued the following urgent safety recommendation to the FTA:

R-15-7 (Urgent)

> Audit all rail transit agencies that have subway tunnel environments to assess (1) the state of good repair of tunnel ventilation systems, (2) written emergency procedures for fire and smoke events, (3) training programs to ensure compliance with these procedures, and (4) verify that rail transit agencies are applying industry best standards, such as NFPA 130, *Standard for Fixed Guideway Transit and Passenger Rail System*s, in maintenance procedures and emergency procedures.

In response to this recommendation, the FTA directed all SSOAs with jurisdiction over the 25 rail transit agencies with subway tunnels to conduct audits to assess and inspect tunnel ventilation systems and related issues.

The NTSB urgent Safety Recommendations R-15-31 and -32, issued on October 26, 2015, recommended that the DOT seek an amendment to 45 USC § 1104(3) to list WMATA as a commuter authority, thus authorizing the FRA to exercise regulatory oversight of WMATA and the DOT decision to direct the FTA to conduct direct oversight of WMATA. In response, the FTA issued Safety Directive 16-1, which outlines how the FTA will exercise leadership over the TOC as part of the FTA's direct oversight of the safety of the WMATA rail system (FTA 2016). In the fall of 2015, the FTA declared the TOC as deficient and began direct safety oversight of WMATA.

5.3 District of Columbia Fire and Emergency Medical Services

After the January L'Enfant Plaza accident, FEMS implemented an emergency access railcar door refamiliarization program for its firefighting crews, emphasizing that the correct (center side) emergency access door process was to be used.

FEMS has acquired a portable PSRS repeater used to bridge communication gaps in large buildings or underground spaces such as WMATA stations and tunnels. The system allows emergency responders to use their portable radios as normal. FEMS also has improved its radio voice quality testing program, which includes testing all underground spaces weekly using an industry-standard voice quality evaluation system. This testing is supplemented by voice quality testing to be performed by WMATA personnel and by sampling and measurement of radio system operating parameters conducted by radio technicians. FEMS expects that these actions will help identify communication system problems before the radio system is needed in support of an emergency response.

5.4 Secretary of US Department of Transportation

The secretary of transportation responded to the NTSB's Safety Recommendations R-15-31 and -32 on October 9, 2015, acknowledging that the TOC lacked sufficient resources,

technical capacity, and enforcement authority to provide the level of oversight needed to ensure safety at WMATA. However, he disagreed with the NTSB recommendation to transfer safety oversight of the WMATA rail system to the FRA, citing the enhanced authority of the SSOAs and the authority for the FTA to assume the safety oversight in the absence of an effective SSOA. The secretary stated in his letter that the FTA would begin increased oversight and would "directly enforce and investigate the safety oversight of WMATA." He also said that the expanded authority would include orders and directives pursuant to Title 49 USC § 5329(f) and (g), would require WMATA to spend federal funds to address safety deficiencies, and would amend the corrective action plan to include previous notices of deficiencies, the implementation of which would be overseen directly by the FTA with the TOC's assistance. The FTA oversight of WMATA was to include unannounced facility inspections. The secretary said that the higher level of oversight would be maintained by the FTA "until a compliant and capable SSOA is established to replace the TOC."

The NTSB responded to the secretary of transportation on February 19, 2016, reclassifying Safety Recommendations R-15-31 and -32 "Open—Unacceptable Response." The NTSB was concerned that while the FTA was tasked with the assumption of the authority of the SSOA, the FTA had very limited ability to effectively oversee WMATA. The FTA had no prior experience in direct safety oversight or as a SSOA, had limited staff to carry out the function, and did not have the authority to levy civil or individual penalties in response to safety deficiencies. The NTSB learned that legislation enabling the creation of a fully functional SSOA for WMATA was going to be delayed until at least 2017, and the FTA's temporary SSOA authority would likely exist longer than anticipated.

The NTSB was not alone in its concern. On December 2, 2015, the DOT Office of the Inspector General announced the initiation of an audit of the FTA's safety oversight program and its assumption of WMATA rail safety oversight, stating in a memorandum to the acting administrator of the FTA that, "FTA may face significant challenges in carrying out these new responsibilities. Accordingly, we are initiating an audit of FTA's enhanced oversight role."

The NTSB responded that although Congress passed the FAST Act granting new authority to the FTA including the authority to exercise direct safety oversight of rail transit agencies when necessary to correct safety deficiencies, and the authority to withhold not more than 25 percent of the Section 5307 financial assistance funds from recipients for noncompliance with safety regulations, it did not believe that these additional authorities address the concerns that it highlighted in the safety recommendations. The NTSB stated that there are many uncertainties associated with the proposed FTA approach to WMATA oversight. The NTSB recommendations for WMATA to be ruled a commuter authority and for the FRA to assume oversight responsibility for WMATA rail transit would eliminate those uncertainties because the FRA was an experienced regulatory safety oversight agency.

6. Conclusions

6.1 Findings

1. Electrical arc tracking was aided by the presence of contaminants and moisture on third rail cables and inside cable connector assemblies.

2. The Washington Metropolitan Area Transit Authority's third rail electrical power cable systems are susceptible to electrical arc tracking at improperly constructed power cable connector assemblies, which can lead to short circuits that can generate fire and smoke in tunnels.

3. The electrical short circuit initiated from either the consumed or the damaged cable connector assembly.

4. Intrusion of water at the electrical arcing site contributed to the severity of the accident.

5. The electrical arcing that resulted in the consumption of the cables that were resting against the tunnel wall was the origin of the smoke at the accident location.

6. Including leak inspections with WMATA tunnel structural inspections was not effective in identifying leaks.

7. The Washington Metropolitan Area Transit Authority tunnel repair program was not effective in mitigating recurring water intrusion like that found in the southbound Yellow Line tunnel.

8. Water intrusion into the Yellow Line tunnel south of L'Enfant Plaza predated the adjacent construction of the Wharf project, and therefore the construction was not a factor in the initiation of the electrical arcing.

9. The Washington Metropolitan Area Transit Authority did not have a written procedure for operating ventilation fans in response to smoke and fire events in a tunnel.

10. The Washington Metropolitan Area Transit Authority did not have effective training on the proper operation of tunnel ventilation fans.

11. The Washington Metropolitan Area Transit Authority failed to address the capacity problems of the ventilation system that were identified by engineering studies.

12. Had the maintenance procedures in place at the time of the accident been followed correctly, the fault in the remote control of the fans could have been identified and corrected during the scheduled monthly inspection.

13. The conditions discovered after the accident—the inability to execute remote commands to the tunnel ventilation system, the tripped overload breakers, the defective remote terminal unit card, and the deficient automatic transfer switch, automatic voltage regulator, and

motor control center—resulted from the Washington Metropolitan Area Transit Authority's inadequate maintenance.

14. The Washington Metropolitan Area Transit Authority did not comply with its ventilation fan inspection and maintenance procedures.

15. The Washington Metropolitan Area Transit Authority was not following its tunnel-washing and insulator-cleaning procedure.

16. At the time of the accident the Washington Metropolitan Area Transit Authority did not have a procedure for train operators to follow that would immediately shut down the ventilation systems on all the railcars in a train.

17. When the operator of train 302 shut down the ventilation system, only the ventilation system on the leading railcar shut down immediately, and the ventilation systems of all the other railcars remained operational.

18. The requirement for a train operator to receive permission from the Rail Operations Control Center to shut down the ventilation systems on a train, and the lack of a procedure for shutting down all the ventilation systems on a train from the lead railcar, contributed to the smoke entering the railcars in train 302.

19. The Rail Operations Control Center supervisor failed to ensure that the emergency procedures contained in Standard Operating Procedure #6 were followed by the control operators.

20. Had the Washington Metropolitan Area Transit Authority followed its standard operating procedures and stopped all trains at the first report of smoke, train 302 would not have been trapped in the smoke-filled tunnel.

21. The Washington Metropolitan Area Transit Authority put passengers at risk by routinely using trains with revenue passengers to investigate reports of smoke or fire

22. The Rail Operations Control Center supervisor failed to ensure that all trains in both directions were stopped after smoke was reported, which was inconsistent with the Washington Metropolitan Area Transit Authority standard operating procedure.

23. Rail Operations Control Center supervisors and control operators were not proficient in executing emergency response procedures.

24. Public Service Radio System communication problems were identified but not remediated before the accident.

25. The Washington Metropolitan Area Transit Authority's radio-testing procedure in place at the time of the accident was insufficient to identify Public Service Radio System communication problems in a timely manner.

26. Communications between the District of Columbia Fire and Emergency Medical Services Department (FEMS) liaison in the Rail Operations Control Center and the FEMS incident commander were delayed and inefficient.

27. The District of Columbia Office of Unified Communications' call processing delayed the emergency response to the accident.

28. Without line identification and direction signage at tunnel entrances and in tunnels, emergency response personnel may have difficulty navigating, which may delay their response efforts.

29. The lack of emergency lighting in the tunnel and the conduit and junction boxes on the tunnel wall above the walkway were safety hazards to passengers evacuating through the tunnel.

30. The lack of safety standards or regulation addressing emergency evacuation routes, including design and lighting, led to obstructed and poorly illuminated walkways at the Washington Metropolitan Area Transit Authority that increased the risk of injury to people evacuating train 302 in the Yellow Line tunnel.

31. The lack of formal training criteria for the battalion fire chief position may pose unnecessary risk with respect to incidents requiring the incident command process.

32. The incident commander had not been effectively trained in the skills and practices of the incident command process.

33. The incident commander should have elevated the incident response to a Unified Command structure.

34. In the initial phase of the emergency response, the incident commander did not take appropriate immediate action to provide emergency assistance to passengers on train 302.

35. Quarterly emergency response drills, particularly those in tunnels, would better prepare the Washington Metropolitan Area Transit Authority (WMATA) and local emergency response agencies to respond to emergencies on the WMATA system.

36. The District of Columbia Fire and Emergency Medical Services Department was unprepared to respond to a mass casualty event in the Washington Metropolitan Area Transit Authority's underground system.

37. The Washington Metropolitan Area Transit Authority missed the opportunity to improve its emergency response and procedures by not conducting an after-action review of its emergency response to the accident.

38. Despite its new authorities under the Fixing America's Surface Transportation Act, the Federal Transit Administration still lacks sufficient authority, expertise, and resources to assume temporary, direct safety oversight of rail transit agencies.

39. The structure of the Tri-State Oversight Committee (TOC) Executive Committee and its failure to effectively guide the TOC reduced the ability of the TOC to execute efficient and effective safety oversight of the Washington Metropolitan Area Transit Authority.

40. The projected establishment of the Metro Safety Commission will be delayed by the required legislation.

41. The Washington Metropolitan Area Transit Authority has not effectively used past safety investigations and studies to make lasting changes that become incorporated in its organizational safety culture.

42. Although the Washington Metropolitan Area Transit Authority has taken steps to improve its organizational safety since the 2009 Fort Totten accident, significant safety management deficiencies still exist within the organization.

43. Had the Washington Metropolitan Area Transit Authority effectively used its existing quality assurance program, it would have identified problems such as missing sealing sleeves and procedure noncompliance.

6.2 Probable Cause

The National Transportation Safety Board determines that the probable cause of the Washington Metropolitan Area Transit Authority (WMATA) L'Enfant Plaza station electrical arcing and smoke accident was a prolonged short circuit that consumed power system components resulting from the WMATA's ineffective inspection and maintenance practices. The ineffective practices persisted as the result of (1) the failure of WMATA senior management to proactively assess and mitigate foreseeable safety risks, and (2) the inadequate safety oversight by the Tri-State Oversight Committee and the Federal Transit Administration. Contributing to the accident were WMATA's failure to follow established procedures and the District of Columbia Fire and Emergency Medical Services Department's being unprepared to respond to a mass casualty event on the WMATA underground system.

7. Recommendations

7.1 New Recommendations

To the Federal Transit Administration:

Issue regulatory standards for tunnel infrastructure inspection, maintenance, and repair, incorporating applicable industry consensus standards into those standards. (R-16-01)

Issue regulatory safety standards for emergency egress in tunnel environments. (R-16-02)

To the mayor of the District of Columbia:

Convene an independent panel of experts to (1) assess the District of Columbia Fire and Emergency Medical Services Department's preparedness to respond to mass casualty events in the Washington Metropolitan Area Transit Authority (WMATA) underground system, (2) identify and make recommendations to improve this preparedness, and (3) share the findings of that assessment with the other local jurisdictions with WMATA underground systems. (R-16-03)

To the District of Columbia Office of Unified Communications:

Audit your public service answering point (PSAP) to validate compliance with the standards published by the National Emergency Number Association or another similar standards organization. The audit should (1) determine the average length of time that call takers use to process an emergency call and dispatch emergency service and (2) compare those results with those of other comparable PSAPs. (R-16-04)

Upon completion of action satisfying Safety Recommendation R-16-04, develop call-processing standards for the public service answering point (PSAP) to ensure that 911 calls are processed in accordance with those of other comparable PSAPs. (R-16-05)

Train call takers for the public service answering point on the standards developed in Safety Recommendation R-16-05 and include the standards in recurrent training. (R-16-06)

To the District of Columbia Fire and Emergency Medical Services Department:

Implement measures to train all command officers who will serve in the role of incident commander in the skills and practices of National Incident Management System incident command and unified command processes. This training should include regular refresher training. (R-16-07)

To the Washington Metropolitan Area Transit Authority:

Review and revise your tunnel inspection, maintenance, and repair procedures to mitigate water intrusion into tunnels. (R-16-08)

When the revision of tunnel inspection, maintenance, and repair procedures recommended in Safety Recommendation R-16-08 has been completed, train maintenance employees on the new procedures, and ensure that the procedures are implemented. (R-16-09)

Improve the capacity of tunnel ventilation fans to conform to the requirements of National Fire Protection Association (NFPA) 130. (R-16-10)

Develop location-specific emergency ventilation configurations based on engineering studies of the Washington Metropolitan Area Transit Authority tunnel ventilation system. (R-16-11)

Develop and implement procedures for actions to be taken by Rail Operations Control Center personnel when smoke detectors alarm. (R-16-12)

Once action to address Safety Recommendation R-16-12 is completed, train all Rail Operations Control Center personnel on the new procedures for responding to smoke alarms. This training should include regular refresher training. (R-16-13)

Incorporate smoke alarms in periodic emergency drills and exercises. (R-16-14)

Include in your efficiency testing program (rules compliance testing program) a specific test to ensure appropriate emergency actions are taken by Rail Operations Control Center supervisors and control operators in response to an alarm. (R-16-15)

Install and maintain a system that will detect the presence and location of fire and smoke throughout the Washington Metropolitan Area Transit Authority tunnel and station network. (R-16-16)

Develop procedures for regular testing of all smoke detectors. (R-16-17)

Conduct a risk assessment before any preventive maintenance program is initiated, changed, or discontinued. (R-16-18)

Ensure that all train operators are trained and regularly tested on the appropriate procedure for emergency shutdown of railcar ventilation. (R-16-19)

Incorporate a specific test in your efficiency testing program to ensure that train operators understand the procedure for emergency shutdown of railcar ventilation. (R-16-20)

Revise Standard Operating Procedure #6 to clarify which trains should be stopped until the source of smoke is identified. (R-16-21)

Revise your standard operating procedures to require that (1) suitably trained, qualified, and properly equipped personnel investigate reports of wayside fire or smoke and (2) these reports are not investigated using trains with revenue passengers. (R-16-22)

Review and revise as necessary your Rail Operations Control Center emergency response procedures for smoke and fire. (R-16-23)

Retrain Rail Operations Control Center supervisors on all standard operating procedures for emergencies. (R-16-24)

Develop and incorporate a comprehensive program for training Rail Operations Control Center control operators in emergency response procedures including regular refresher training. (R-16-25)

Conduct regular emergency response drills and develop a program to test the efficiency of the Rail Operations Control Center to ensure that standard operating procedures are properly followed during emergencies. (R-16-26)

Install line identification and direction signage at tunnel entrances and inside tunnels. (R-16-27)

Implement a regular schedule for the inspection and removal of obstructions from safety walkways and track-bed floors to ensure safe passageways for passengers to use during a tunnel evacuation. (R-16-28)

Conduct emergency response drills with local emergency response agencies in accordance with National Fire Protection Association (NFPA) 130, document lessons learned, and develop and implement additional procedures as necessary to effectively respond to emergencies. (R-16-29)

Revise your standard operating procedures to require that an after-action review be conducted of all emergency responses to events with passenger or employee fatalities, and publish the results, including both the successes and the potential deficiencies of your responses, to help ensure that deficiencies are appropriately remediated. (R-16-30)

Review and revise your quality assurance program to ensure that regular quality assurance audits are included to identify and correct any elements of procedural noncompliance. (R-16-31)

7.2 Previously Issued Recommendations

To the US Department of Transportation:

Seek an amendment to Title 45 United States Code Section 1104(3) to list the Washington Metropolitan Area Transit Authority as a commuter authority, thus authorizing the Federal Railroad Administration to exercise regulatory oversight of the Washington Metropolitan Area Transit Authority's rail system. (R-15-31, Urgent)

After Title 45 United States Code Section 1104(3) is amended to include the Washington Metropolitan Area Transit Authority, direct the Administrator of the

Federal Railroad Administration to develop and implement a plan to transition the oversight of the Washington Metropolitan Area Transit Authority's rail system to the Federal Railroad Administration within 6 months. (R-15-32, Urgent)

Safety Recommendations R-15-31 and -32 are classified "Open—Unacceptable Response."

To the Federal Transit Administration:

Audit all rail transit agencies that have subway tunnel environments to assess (1) the state of good repair of tunnel ventilation systems, (2) written emergency procedures for fire and smoke events, (3) training programs to ensure compliance with these procedures, and (4) verify that rail transit agencies are applying industry best standards, such as NFPA 130, Standard for Fixed Guideway Transit and Passenger Rail Systems, in maintenance procedures and emergency procedures. (R-15-7, Urgent)

Safety Recommendation R-15-7 is classified "Open—Acceptable Response."

To the American Public Transportation Association:

Inform your members of the circumstances of this accident and the risks posed by inadequate written procedures for ventilation processes during smoke and fire events in a tunnel environment. Urge your members to assess their procedures for verifying consistency with industry best practices, such as those outlined in the National Fire Protection Association's NFPA 130, *Standard for Fixed Guideway Transit and Passenger Rail Systems*. (R-15-11, Urgent)

Urge your members to conduct regular training exercises that use written ventilation procedures to provide ample opportunities for employees and emergency responders to practice those procedures. (R-15-12, Urgent)

Safety Recommendations R-15-11 and -12 are classified "Closed—Acceptable Action."

To the Washington Metropolitan Transit Authority:

Assess your subway tunnel ventilation system to verify the state of good repair and compliance with industry best practices and standards, such as those outlined in the National Fire Protection Association's NFPA 130, Standard for Fixed Guideway Transit and Passenger Rail Systems. (R-15-8, Urgent)

Develop and implement detailed written tunnel ventilation procedures for operations control center staff that take into account the probable source location of smoke and fire, the location of the train, the best evacuation route, and unique infrastructure features; these procedures should be based on the most effective strategy for fan direction and activation to limit passengers' exposure to smoke. (R-15-9, Urgent)

As part of the implementation of the procedures developed in response to Safety Recommendation R-15-009, incorporate the use of the procedures into your ongoing training and exercise programs and ensure that operations control center staff and emergency responders have ample opportunities to learn and practice activating ventilation fans. (R-15-10, Urgent)

Promptly develop and implement a program to ensure that all power cable connector assemblies are properly constructed and installed in accordance with your engineering design specifications, including the weather tight seals that prevent intrusion by contaminants and moisture. (R-15-25)

Safety Recommendations R-15-8, -9, -10, and -25 are classified "Open—Acceptable Response."

BY THE NATIONAL TRANSPORTATION SAFETY BOARD

CHRISTOPHER A. HART
Chairman

ROBERT L. SUMWALT
Member

T. BELLA DINH-ZARR
Vice Chairman

EARL F. WEENER
Member

Adopted: May 3, 2016

Chairman Hart, Vice Chairman Dinh-Zarr, and Member Weener filed the following concurring statements.

Board Member Statements

Chairman Christopher A. Hart filed the following concurring statement on May 10, 2016.

I concur in the findings, probable cause, and recommendations in this report, and I would like to comment further on our probable cause, which lists safety issues that are both internal and external to WMATA.

WMATA's Failure to Assess and Mitigate Safety Risks. The internal issue is about WMATA's safety culture. When we investigated WMATA's tragic 2009 Fort Totten accident, we saw no manifestation of a safety culture—no safety committees, no safety reports to the Board, no apparent emphasis on safety anywhere. On further reflection, it occurred to me that we should not have been surprised. When WMATA introduced rail service in the 1970s, there was publicity to the effect that the track geometry and the advanced automation were designed to ensure that WMATA trains could never collide. Not only has this claim of collision impossibility been shown by tragic experience to be woefully incorrect, but it had unintended consequences.

The woefully incorrect part is obvious. A prediction that a given bad outcome is impossible, e.g., "This ship can't sink," usually proves to be wrong sooner or later (and is itself an indicator of a defective safety culture). The unintended consequences, however, are not so obvious. The belief that trains cannot collide predictably and foreseeably led to the attitude that it doesn't really matter what anyone at WMATA does because nothing can go wrong. That type of attitude clearly undermines the development of safety culture, and even feeds the belief that there is no need for a safety culture. Despite the untruth of the assertion that trains could not collide, it created an attitude of not needing a safety culture that spilled over into other things that could (and did) go wrong, such as fatalities to roadway workers, derailments, and, as occurred near L'Enfant Plaza, serious electrical issues.

WMATA has made progress since 2009 at developing a safety culture in an environment in which a safety culture was thought for decades to be unnecessary, but it still has a long way to go. I am encouraged by the new management, and my hope is that in the course of redirecting WMATA toward having a robust safety culture, management will fully engage labor, as opposed to trying to force safety culture unilaterally from above.

Our investigators did not determine that labor-management relations were an issue with regard to this arcing event, but our general investigation experience over the years has revealed that adversarial labor-management relations can be a major safety issue. If labor is not on board with the safety culture that they ultimately have to implement in their daily activities, that safety culture will not be sustainable. Moreover, when management and labor work together in major issues such as developing a safety culture, the result can be a win-win because management sees that labor wants, and knows how, to make things better, and labor sees that management values labor's input toward developing a better process. As the US commercial aviation industry has so successfully demonstrated, everyone who is involved in a problem should be involved in developing the solution.

Inadequate External Safety Oversight. The external issue is about the safety oversight of WMATA. We have seen from our accident investigation experience over the years that no matter how good an organization's safety culture is, external safety oversight provides an additional independent review that can make it better.

Until recently, the FTA has been the only agency within the DOT that did not have safety authority or responsibility. Instead, safety oversight of mass transit properties has generally been by state agencies. When we saw from our investigation of WMATA's Fort Totten accident in 2009 that its "state" safety oversight—by three jurisdictions, Maryland, Virginia, and the District of Columbia—was ineffective, we recommended that the FTA be given safety authority and responsibility.

Congress did that, and in so doing it elected to take advantage of the many state regulatory processes that are already in place by giving the FTA safety authority that operates through the states. This type of regulatory oversight structure was not unprecedented—similar oversight has been in place for decades in other transportation modes, such as motor carriers and pipelines. In those situations, however, only one state was involved. While only one state is involved in overseeing most mass transit properties, a few mass transit properties are under oversight by two states. WMATA is unique in being the only mass transit property in the United States that has oversight by three jurisdictions; and unfortunately, those three jurisdictions have not yet shown that they can work together effectively to oversee WMATA's safety. That is why we recommended, in our investigation of this accident, that safety regulation of WMATA be undertaken by the FRA, which operates directly rather than through the states.

Our recommendation was not intended to suggest that the three jurisdictions cannot work together; to the contrary, they may eventually be able to do that effectively. Our concern was how to obtain the needed safety oversight of WMATA now, without having to wait several years, and without having to depend upon the FTA to fill in for those several years despite its lack of required standards, lack of inspectors to determine if those standards are being met, and lack of authority to enforce against WMATA and its individual employees if the standards are not met.

Our objective is immediate and effective safety oversight of WMATA, but we have no "pride of authorship." If the DOT can accomplish that objective other than through our recommended choice of the FRA, we would be the first to applaud.

With a robust internal safety culture and effective safety oversight, WMATA can become one of the safest, most effective, and most efficient mass transit systems in the United States. The millions of daily riders in our nation's capital region deserve nothing less.

Members Sumwalt and Weener joined in this statement.

Vice Chairman T. Bella Dinh-Zarr filed the following concurring statement on May 11, 2016.

I concur with the findings, probable cause, and recommendations in this investigative report on the WMATA L'Enfant Plaza accident. I commend the staff on their excellent work and submit this concurring statement.

This accident highlights the NTSB's longstanding concerns regarding the safety of the WMATA system as well as oversight of WMATA by the FTA and the TOC. Every year, millions of people take WMATA for trips to work, school, home, or other destinations. The advantages of efficient mass transit cannot be overstated. But unquestionably, mass transit also must be safe. We should remember that mass transit is a very safe form of transportation, but accidents, like the one at L'Enfant Plaza, erode the public's confidence and it is the NTSB's responsibility to make safety recommendations so that lasting changes can be made to prevent more deaths and injuries, as well as to restore trust in public transportation.

I believe the key safety issue in this investigation is our urgent recommendation to the DOT regarding WMATA oversight (R-15-31). If we want WMATA to have a safety culture that will prevent future accidents, we must give WMATA the proper tools through effective oversight. On September 30, 2015, the Board issued an urgent recommendation to the DOT secretary urging him to seek legislation to declare WMATA a commuter authority, thus moving oversight of WMATA to the FRA. The Board issued this recommendation because we saw that our specific recommendations to WMATA have resulted in temporary fixes to the transit agency because the TOC and FTA both lacked the authority to provide sufficient safety oversight. Three years after the passage of MAP-21, the FTA has enacted only basic rulemakings; others will be years in the making. We have 40 years, 13 accident investigations, and 100+ safety recommendations worth of data to back up R-15-31. Only with proper oversight and mandated regulatory standards, which can be enforced, will WMATA's safety culture begin to improve.

In this report, the majority of our 24 new recommendations call upon WMATA to "review and revise" its policies and procedures and "develop and implement" procedures where none exist. Yet at the Board meeting, we learned that WMATA's safety standards are developed by WMATA itself. WMATA can change those standards at any time, without approval of any regulatory agency. The FRA has the ability to fine or decertify individuals in safety-sensitive positions who violate regulatory requirements, whereas the FTA does not. If the FRA were the regulator over WMATA, the FRA (not WMATA) would set the standards for inspections. In the absence of specific regulations for WMATA to follow, it seems that once again we call on WMATA to self-regulate. As our prior investigations show, this self-regulation has been ineffective for the past 40 years. However, it is our responsibility as an investigative safety agency to continue to make recommendations to try to improve safety. These recommendations, if followed, would improve safety at WMATA. And given the current oversight choice by the DOT, we must make these 24 new recommendations despite the fact that many of these recommendations would be unnecessary if the DOT had asked Congress to add five words to Title 45 of the United States Code in Section 1104, subsection 3, to make WMATA a commuter authority, rather than seeking additional authority for the FTA as part of the FAST Act. Despite the new provisions under the FAST Act, the FTA still lacks the robust inspection, oversight, regulatory, and enforcement authority that already exists at the FRA. Currently, there is a clear

difference between FRA and FTA oversight, a difference that has a direct effect on the long-term safety of WMATA.

Based upon what we have seen in this investigation and the previous 12 NTSB investigations into WMATA, I believe R-15-31 was both bold and necessary. Moreover, I strongly believe that this recommendation has the potential to lead to meaningful and lasting safety changes within the WMATA system.

Members Sumwalt and Weener joined in this statement.

Member Earl F. Weener filed the following concurring statement on May 10, 2016.

I concur with the recommendations put forth in this report, but I am concerned that they may not adequately address the problems at the heart of WMATA's dysfunction. The NTSB has made numerous similar recommendations over the years, encouraging WMATA to improve various safety practices and policies. While generally compliant, at least in the short-term, WMATA has remained resistant to long-term, organization-wide change. Improvements have been made, but most come as a result of an incident or accident and do not constitute a proactive approach to safety. In other words, WMATA has adopted a Whack-A-Mole approach to safety, opting to act swiftly only when a new crisis becomes apparent. Despite its history of reactive implementation of incident-specific safety improvements, WMATA has failed to prioritize safety in its daily operations and lacks a positive safety culture consistent with industry best practices and a strong and controlling safety management system.

I concur with the conclusion that FRA oversight of WMATA is a critical step in improving organizational safety. For example, a strong confidential close call reporting system is a necessary part of a sound safety culture. In 2013, WMATA created its own in-house version of a confidential close call reporting system. While the system launched by WMATA is a positive step, this model collects and keeps information regarding close calls only within the walls of the organization. The FRA, in the alternative, maintains the industry-wide Confidential Close Call Reporting System (C3RS) which collects close-call details from multiple organizations. An industry-wide model is superior because it allows for better use of collected data and a clearer picture of needed improvements. The FTA does not maintain an industry-wide C3RS. This is yet another reason why FRA oversight of WMATA is superior to the current, temporary FTA oversight.

Several of our recommendations ask WMATA to create new policies and procedures. While strong policies and sound procedures are important, they are meaningless without reliable compliance. Disregarded procedures do nothing to prevent disasters or mitigate accidents when they occur. WMATA must find a way to ensure procedural compliance. I agree that recurring training and, in particular, frequent, realistic emergency drills can help with compliance. Intentional noncompliance is an entirely different and pernicious problem. Training alone will not address it. WMATA must implement a series of new controls on the front lines of operations. These controls should be effective in detecting intentional noncompliance and capable of imposing swift, meaningful penalties for such behavior. Equally as important are efforts to engage all WMATA employees in the prioritization of safety in daily operations and the adoption of a positive safety culture. Real change will depend on front-line employees and line managers working together with WMATA's top management to make hard decisions. Top leadership alone cannot, in my opinion, succeed in the massive transformation necessary to safeguard the commuters entrusted to WMATA.

Clearly, WMATA must undergo a metamorphosis over the coming months if it hopes to overcome its internal struggles and regain the trust of the commuting public through long-term safe performance. Only through the adoption and utilization of safety management systems and the organization-wide promotion of a strong safety culture will this be possible. Moreover, it is clearer today than when our urgent Safety Recommendation R-15-31 was issued that FRA oversight is the key component to sustaining any progress or positive changes WMATA

achieves. Short-term accomplishments will be meaningless to any additional victims of future accidents, while long-term success may serve as some balm to those who have suffered due to previous safety failures. It is my hope that WMATA finally learns the lessons of its past and fully embraces the recommendations in this report.

Chairman Hart and Member Sumwalt joined in this statement.

Appendix A. Investigation

The National Transportation Safety Board (NTSB) was notified of the accident on January 12, 2015. NTSB investigators were launched from the headquarters office in Washington, DC, and from field offices around the United States. The NTSB's investigation focused on all aspects of the accident, including signal and train control, operations, track, mechanical issues, survival factors, civil engineering/state of good repair, fire science, event recorders, video evidence, communications, and safety culture/oversight issues.

Parties to the investigation were the Federal Transit Administration; the Bureau of Alcohol, Tobacco, Firearms and Explosives; the District of Columbia Fire and Emergency Medical Services Department; the District of Columbia Metropolitan Police Department; the District of Columbia Office of Unified Communications, the Tri-State Oversight Committee; Washington Metropolitan Area Transit Authority, the Amalgamated Transit Union, and the International Fire Fighters Association.

After the accident, an investigative hearing on this accident was held at NTSB headquarters in Washington, DC, on June 23–24, 2015. Chairman Christopher A. Hart chaired the hearing.

Appendix B. Accident Timeline

Time (p.m.)	Activity
3:04:54	Smoke detector at drain/pump station L-1 activates
3:06:40	L'Enfant Plaza south tie-breaker circuit trips and remains open
3:07:21	Train Operator (Train 508 North) reports smoke in the L'Enfant Plaza Interlocking
3:13:29	Train 302, lead car, enters L'Enfant Plaza station
3:13:50	Train 302 stops at L'Enfant Plaza platform, at normal berthing location; services the platform
3:14:25	Train 302 begins to depart L'Enfant Plaza station, en route to Pentagon station
3:15:15	Train 302, under Train Operator control, is stopped by Operator and unable to proceed due to heavy smoke ahead
3:15:24	MTP officer, badge 549, who is on board Train 302, which had just entered the tunnel leaving the L'Enfant Plaza station, reported [to MTP Communications] that there is a fire on board the train, that they are stuck on the train that had just left the L'Enfant Plaza station, that patrons (passengers) were being moved to the back [of the railcar or train], that there is smoke in the tunnel, and that they need immediate assistance.
3:15:33	Train 510 arrives at Archives station; services the platform
3:15:45 ~	The OCC Liaison of WMATA Office of Emergency Management, who was on duty in the ROCC at that time, heard the MTP Officer's transmission (from Train 302, at 3:15:24) over the MTP radio and verbally passed the information to the ROCC train controller personnel (see 3:15:57 event)
3:15:52	Train 510 departs Archives station en route to L'Enfant Plaza station
3:15:57	A ROCC controller makes a radio call (on the Yellow Line train operations frequency): "There's smoke, heavy smoke, low visibility."
3:16:09	ROCC sends emergency exhaust command to L'Enfant station under-platform ventilation fan # 2
3:16:32	ROCC sends emergency exhaust command to L'Enfant station under-platform ventilation fan # 1
3:16:35	Train Operator (Train 302) keyed down [deactivated] south controlling cab.
3:16:37	MTP officer, badge 549, who had made a prior report [radio transmission timestamp 3:15:24], further advised [MTP Communications]; that they had just departed L'Enfant Plaza and are still in the tunnel, and that they are trying to get the [train] operator to move [the train] back away from the fire because of a smoke situation.
3:17:03	Smoke was clearly visible toward the center of the [upper level] south portal, moving north. Smoke was whitish-grey and increasing in density. The intensity of the smoke progressively increased over the ensuing three minutes.
3:17:17	Train 302 Operator radio call to ROCC: "Central Control, 302, track 2 leaving L'Enfant Plaza. We have heavy smoke in the tunnel. I have Transit Police on board trying to either get the train back the train back to ... I need ... I'm going to have to get back to ..."
3:17:31	Track switch [turnout] of Track 2 (designated in WMATA Track Chart Sheet TC-L-1 as Turnout 7), in interlock / crossover immediately south of L'Enfant Plaza station, changes position from Pentagon (Yellow Line) alignment to Waterfront (Green Line) alignment

Time (p.m.)	Activity
3:17:33	ROCC radio call to Train 302 Operator: “Negative, sir. That's a negative. Negative, sir.”
3:17:38	ROCC radio call to Train 510 (which is in the tunnel, north of L’Enfant Plaza station): “510, stop the train, 510. 510, stop the train”, which is followed by “510, stop the train, 510. 510, I need you to stop the train. 510, stop.”
3:17:45 ~	Train 510 comes to a stop in the tunnel (north of L’Enfant Plaza station)
3:18:15	ROCC radio call to Train 510 “Train 510; confirm you stopped the train, 510. 510, confirm you stopped the train”, which is immediately followed by a response from the Train 510 Operator, advising ROCC that the Train 510 is stopped.
3:18:15	ROCC radio call to Train 302: the Operator is requested to advise ROCC [further] when he arrives at the aft end of his train (in preparation to making a reverse move).
3:18:30	OUC receives a 911 call (from a construction site), reporting smoke coming from a Metro Vent [shaft] located at 9th and Water St, SW. Call concludes at 3:21:05; call duration 2:35 (min:sec). (DC-FEMS Incident F150006378)
3:18:45	Train 302 Operator keyed up [activated] north controlling cab
3:18:50	Train 302 Operator radio call to ROCC, advises that he has “reversed ends.” (he had arrived at the cab at the opposite end of his train)
3:18:54	ROCC radio call to Train 302: advises Operator to “stand by”
3:19:56	ROCC radio call to Train 302 Operator: “I need you to stand by, sir, stand by. We'll get back to you momentarily.”
3:19:58	Whitish-brown smoke was entering the platform area at a rapid rate; visibility had reduced to about 20 feet [as observed in one of the station security cameras]. Shortly thereafter, passengers waiting on the station platforms commenced to self-evacuate the station in large numbers at a fairly rapid pace.
3:20:57	Train 302 Operator radio call to ROCC: “There's smoke coming in the train. Passengers are complaining of smoke inhalation. I need that block to the platform.”
3:20:59	ROCC receives indication of Fire Alarm 1 active [smoke alarm activation at L’Enfant Plaza station]
3:21:13	ROCC instructs Train 302 operator to drop the EV circuit breaker
3:22:10	ROCC radio call to Train 510: “Train 510, you may service L'Enfant Plaza (indiscernible), 510, in L'Enfant …” [inquiring if that train has serviced the station]
3:22:27	Train 302 Operator radio call to ROCC: “Need that update. I need to move the train back ….” ROCC responds “All right. Give me one minute 302, give me one minute. Give permission to block no closer than 10 feet of F0346 signal red, 302, stand by.”
3:22:32	OUC dispatches the first of several units of DC-FEMS (unit E13) to the site of a report of smoke coming from a Metro Vent [shaft] at 9th and Water St, SW, which was in response to the call received by OUC at 3:18:30 (DC-FEMS Incident F150006378)
3:22:34	OUC receives a call placed by WMATA, describing a “heavy smoke” condition at L’Enfant Plaza station upper level [platform], requesting a DC-FEMS response to that location. Call concludes at 3:24:15; call duration 1:41. (DC-FEMS Incident F150006381)
3:22:41	ROCC radio call to Train 510: “I need you to service L'Enfant Plaza, 510.” Train 510 responds “We are moving”

Time (p.m.)	Activity
3:22:42	Train 510 proceeds forward (in response to radio call order of ROCC)
3:22:47	ROCC gives permission for Train 302 to reverse and stop short of the F0346 signal.
3:22:48	A ROCC controller makes a radio call (on the Yellow Line train operations frequency): "… At this time, all operators, we're having a major situation with the smoke in the tunnel between L'Enfant Plaza and Pentagon, tracks 1 and 2. We have a situation 307 …."
3:23:18	Train 510, lead car, pulls into L'Enfant Plaza station
3:23:29	Train 510 makes an initial stop at the platform in L'Enfant Plaza station
3:23:34	Train 510 slowly resumes forward movement along the platform in L'Enfant Plaza station
3:23:47	Train 510 makes another stop at the platform in L'Enfant Plaza station, after moving about one-half a car length since the initial stop
3:24:02	Train 510 slowly resumes forward movement along the track in L'Enfant Plaza station
3:24:13	Train 510, in its continued forward movement along the track in L'Enfant Plaza station, now observed [by a station security camera] being 'directed' by a MTP officer, who was walking along the platform approximately adjacent to the train operator's cab window. (testimony was received that the MTP officer, using his flashlight, was providing visual guidance assistance to the Train Operator [in the forward movement of the train], who was unable to see the track in front of the train)
3:24:24	Train 510, after having moved about 150 feet since the second stop in the station [at 3:23:47], comes to a complete stop at the platform in L'Enfant Plaza station, with no further movement. (testimony was received that the train was stopped at that point because the MTP officer was unable to see the track beyond that point) The lead end of the lead railcar was later measured to be about 105 feet from the south of end of that platform.
3:24:28	ROCC sends emergency exhaust command to Fan Shaft FL-1 (south of arcing event)
3:24:45	MTP official, Cruiser 71 becomes the MTP On-Scene Commander at the L'Enfant Plaza station. The Command Post location is not given at this time. RTRA is still servicing trains, and Cruiser 71 requests that they stop. The MTP dispatcher acknowledges the request.
3:25:50	First responding unit [fire apparatus] of DC-FEMS (Truck 10) arrives at Metro Fan [shaft] located at 9th and Water St, SW (DC-FEMS Incident F150006378).
3:25:54	Train 510 (lead railcar) front-most, side door at the platform opens, passengers began to exit the car; center door remains closed.
3:26:20	Train 510 is " keyed down" [deactivated] at the platform in L'Enfant Plaza station
3:26:31	Baker 26 advises that they are trying to off-load Train 510, which just came into the L'Enfant Plaza station.
3:26:53	OUC dispatches units of DC-FEMS to L'Enfant Plaza station, which was in response to the call received by OUC at 3:22:34 (DC-FEMS Incident F150006381). This dispatch included a request for BC2 (the DC-FEMS command officer who became the Incident Commander) to respond to the scene.
3:27:45	BC2 is en route to the scene

Time (p.m.)	Activity
3:31:12	First responding unit [fire apparatus] of DC-FEMS (Rescue 1) arrives at L'Enfant Plaza station (DC-FEMS Incident F150006381). Additional responding units arrive at the scene shortly thereafter.
3:32:01	Train 302 operator advises ROCC that passengers are self-evacuating
3:32:30	Train 302 brake pipe pressure switch opened
3:38:57	BC 2 arrives at the L'Enfant Plaza station (DC-FEMS Incident F150006381). Travel time was 10:12 (min:sec).
3:39:05	The Incident Commander assumed Incident Command
3:40 ~	The MTP Chief, who intended to become the MTP on-scene incident commander (and thus principal emergency coordinator for WMATA with DC-FEMS), attempts to inform the Incident Commander about train 302 that was stopped in the tunnel with passengers that thus required an immediate evacuation.
3:40:21	ROCC receives tripped indication for third rail electrical power on both [upper level] tracks at L'Enfant Plaza station
3:43:16	BC1 to Command advises Metro OCC that tactical response team should be in the station and a DC Fire unit tripped emergency trip station and shut down power to train that they were trying to move out.
3:43:42	BC2 (Incident Command) requests a 2nd alarm at the L'Enfant Plaza scene
3:49:34	ROCC sends command to trip breaker 68 (tie breaker circuit)
3:49:45	ROCC sends command to trip breaker 32 (south of arcing location)
3:49:55	ROCC sends command to trip breaker 69 (tie breaker circuit)
3:50:11	ROCC sends command to trip breaker 11 (south of arcing location)
3:50:23	ROCC sends command to trip breaker 34 (south of arcing location)
3:50 ~	Firefighters (personnel of Rescue 1) arrive at last railcar of Train 302
3:50:58	"RS1 driver advises Command that units are having trouble with their radios. They have a yellow line outbound train with smoke inside the tunnels and individuals complaining of trouble breathing on the train." [this communication, from a firefighter of Rescue 1 to Command, indicates that personnel of Rescue 1 had arrived at the last railcar of Train, and that individuals on the train were complaining of trouble breathing]
3:51:15	Command 2 advises firefighters (personnel of Rescue 1) at last railcar of Train 302 to proceed with sending train evacuees toward the L'Enfant Plaza station platform
3:51 ~	Firefighters (personnel of Rescue 1) commence evacuation of occupants in last railcar of Train 302, which is immediately followed by evacuation of occupants in the remaining railcars of the train
3:51:31	The train operator of train 302 reports [to ROCC] that the MTP began evacuating all personnel wayside
3:53:20	Train 302 occupants (evacuees) were first observed to be exiting the tunnel portal (Track 2), en route 'topside' (street level)

Time (p.m.)	Activity
3:55:44	Dispatch of DC-FEMS resources in response to a “mass casualty incident” Box Alarm at the L’Enfant Plaza station (a quantity of ambulances / medical support personnel would be directed to the scene) (DC-FEMS Incident F150006400)
3:56 ~	Approximate time of arrival ‘topside’ (at street level, station entrance) of the first of the Train 302 occupants (evacuees) after departing L’Enfant Plaza station
3:57:31	MAB3 [mobile ambulance bus] dispatched, is en route to the scene
3:58:16	ROCC confirms to DC-FEMS Command that 3rd rail power is down from L’Enfant Plaza to Waterfront, and from L’Enfant Plaza to Portal Bridge
16:03:34	The DC-FEMS command officer at the Fan Shaft scene advises Command that two persons had exited from the Fan shaft at that location
16:17:59	The first DC-FEMS [medical response] unit, responding to the “mass casualty incident” Box Alarm, arrived at the scene (DC-FEMS Incident F150006400)
16:27:42	Recon team (of DC-FEMS) advises Ops 2 that all civilians have been removed from the train at this time. Smoke conditions are clear in the tunnel.
16:33:45	The last of the Train 302 occupants (evacuees) were observed exiting the tunnel portal (Track 2), en route ‘topside’ (street level) Total evacuee count: 380
17:09:53	Departure of initial DC-FEMS ambulance (patient transport) from the accident scene, en route to the hospital
17:48:47	Departure of final DC-FEMS ambulance (patient transport) from the accident scene, en route to the hospital
18:42:54	Command 2 is terminated (Incident Command ceases on-scene operations)

Appendix C. Rail Rapid Transit Accidents Investigated by the NTSB Since 1967

#	Accident Date	NTSB Investigation Report Title	Injuries	Fatalities
1	01/12/2015	Washington Metropolitan Area Transit Authority Smoke and Electrical Arcing Accident in Washington, DC (note – in process)	91	1
2	03/24/2014	Chicago Transit Authority Train Collides with Bumping Post and Escalator at O'Hare Station	34	0
3	10/19/2013	Bay Area Rapid Transit Train 963 Struck Roadway Workers	0	2
4	09/30/2013	Collision of Two Chicago Transit Authority Trains	34	0
5	05/08/2011	Collision of Port Authority Trans-Hudson Train with Bumping Post at Hoboken Station	32	0
6	07/20/2010	Collision between Two Miami-Dade Transit Metromovers	16	0
7	02/12/2010	Washington Metropolitan Area Transit Authority Derailment	3	0
8	01/26/2010	Washington Metropolitan Area Transit Authority Hi-Rail Maintenance Vehicle Strikes Two Wayside Workers Near the Rockville Station	0	2
9	11/29/2009	Washington Metropolitan Area Transit Authority Rear-end collision	3	0
10	07/18/2009	Collision of Two Municipal Transportation Agency Light Rail Vehicles	48	0
11	06/22/2009	Collision of Two Washington Metropolitan Area Transit Authority Metrorail Trains Near Fort Totten Station	52	9
12	05/08/2009	Collision of Two Massachusetts Bay Transportation Authority Light Rail Passenger Trains	68	0
13	11/28/2008	Miami International Airport, Automated People Mover Train Collision with Passenger Terminal Wall	6	0
14	05/28/2008	Derailment of Chicago Transit Authority Passenger Cars on Elevated Track	14	0
15	05/28/2008	Collision Between Two Massachusetts Bay Transportation Authority Green Line Trains	8	1
16	01/07/2007	Derailment of Washington Metropolitan Area Transit Authority Train near the Mt. Vernon Square Station	23	0
17	11/30/2006	Washington Metropolitan Area Transit Authority Train Strikes Wayside Workers Near Eisenhower Avenue Station	0	2
18	07/11/2006	Derailment of Chicago Transit Authority Train Number 220 Between Clark/Lake and Grand/Milwaukee Stations	152	0
19	05/14/2006	Washington Metropolitan Area Transit Authority Train Strikes Wayside Worker Near Dupont Circle Station	0	1
20	11/03/2004	Collision Between Two Washington Metropolitan Area Transit Authority Trains at the Woodley Park-Zoo/Adams Morgan Station	20	0
21	02/03/2004	Collision of Two Chicago Transit Authority Trains	42	0
22	09/27/2002	Derailment of AirTrain	0	1
23	02/26/2002	Chicago Transit Authority Green Line train run 2, Train/Worker Incident at Tower 18	2	0
24 **25**	06/17/2001 08/03/2001	Two Rear-End Collisions Involving Chicago Transit Authority Rapid Transit Trains at Chicago, Illinois – NTSB-SIR-01-02	21 116	0 0
26	04/10/2000	Metropolitan Atlanta Rapid Transit Authority (MARTA), Unscheduled train 166 striking bucket of self-propelled lift containing two contract workers at MARTA Lenox rail transit station	0	2
27	02/25/2000	Metropolitan Atlanta Rapid Transit Authority (MARTA) train 103, striking technicians fouling the track near MARTA Avondale Station	1	1

#	Accident Date	NTSB Investigation Report Title	Injuries	Fatalities
28	11/12/1999	WMATA Train No. 154 Struck Passenger, Silver Spring, MD – ATL00FR002 – 47846	0	1
29	06/08/1998	SFMUNI K Line Train LRV 1243 Struck the Rear-end of Standing SFMUNI N Line Train LRV-2 1403A Van Ness Station in San Francisco, CA – LAX98FR010	7	0
30	05/22/1998	SEPTA Streetcar 9055 Struck the Rear End of Standing Streetcar 9053 at 69th St and Elmwood Ave. in Philadelphia, PA – ATL98FR017 – 43250	4	0
31	05/04/1998	Derailment, Massachusetts Bay Transportation Authority	4	0
32	02/3/1998	NYCTA Train No 2 collision with rear of standing Train Number 4 in Bronx, NY– ATL98FR007 – 51682	2	0
33	11/20/1997	New York City Metropolitan Transportation Authority Train 804-G Struck the Rear of Standing Train 723-R in Queens, NY – ATL98FR005 – 1541	100	0
34	10/28/1997	Washington Metropolitan Area Transit Authority Passenger Fatality in Silver Spring, MD – ATL98FR003 –1539	0	1
35	06/03/1997	Grade Crossing/Derailment, Dallas Area Rapid Transit	20	0
36	07/25/1996	Metropolitan Atlanta Rapid Transit Authority Run-Away Train Derailment, Stone Mountain, GA – ATL96FR020 – 1507	1	0
37	04/26/1997	SFMUNI L Line train Derailed on Ocean Avenue in San Francisco, CA LAX08FR007 – 1716	0	0
38	04/24/1997	Employee Fatality, Southeastern Pennsylvania Transportation Authority	0	1
39	01/30/1997	Employee Fatality, Massachusetts Bay Transportation Authority, Ruggles Street Station	0	1
40	06/1/1996	Metropolitan Atlanta Rapid Transit Authority Derailment, Atlanta, GA – ATL96FR018 – 1505	16	0
41	03/11/1996	Light-Rail Vehicle Rear-End Collision, Southeastern Pennsylvania Transportation Authority	89	0
42	01/06/1996	Collision of Washington Metropolitan Area Transit Authority Train T-111 with Standing Train at Shady Grove Passenger Station	0	1
43	02/09/1995	Collision and Derailment of Two Subway Trains Metropolitan Transportation Authority New York City Transit	15	0
44	08/28/1991	New York City Transit Authority Derailment at Union Square Station	98	5
45	07/02/1991	Rear-end Collision Involving Two Greater Cleveland Regional Transit Authority Trains Near the West 98th Street Station	15	0
46	03/10/1989	Rear-end collision of two New York City Transit Authority Trains, 103rd Street Station	41	0
47	07/10/1985	Rear-End Collision of Two Greater Cleveland Regional Transit Authority Red Line Rapid Transit Trains near the 98th Street Station	50	0
48	06/26/1985	Rear End Collision of Metro-Dade Transportation Administration Trains Nos. 172-171 and 141-142	16	0
49	05/15/1985	Derailment of New York City Transit Authority Subway Train, Dekalb Avenue Station	56	0
50	08/17/1984	Rear End Collision of Two Chicago Transit Authority Trains near the Montrose Avenue Station	49	1
51	03/17/1984	Derailment of New York City Transit Authority Subway Train in the Joralemon Street Tunnel	19	0
52	01/13/1982	Derailment of Washington Metropolitan Area Transit Authority Train No. 410 at Smithsonian Interlocking	25	3
53	07/03/1981	Rear End Collision of New York City Transit Authority Subway Trains 142NL and 132NL	140	1
54	01/17/1979	Bay Area Rapid Transit Fire on Train No. 117 and Evacuation of Passengers While in the Transbay Tube	56	1
55	12/12/1978	Derailment of New York City Transit Authority Subway Train	22	0

#	Accident Date	NTSB Investigation Report Title	Injuries	Fatalities
56	02/10/1978	Collision of Port Authority of Allegheny County Trolley Car No. 1790 and Bus No. 2413	37	4
57	07/08/1977	Head On Collision of Two Greater Cleveland Regional Transit Authority Trains	60	0
58	02/04/1977	Rear End Collision of Two Chicago Transit Authority Trains	266	11
59	08/18/1976	Rear End Collision of Two Greater Cleveland Regional Transit Authority Trains	22	0
60	01/09/1976	Chicago Transit Authority Collision of Trains No. 104 and No. 315 at Addison Street Station	341	1
61	08/01/1975	Rear End Collision of Three Massachusetts Bay Transportation Authority Trains	154	0
62	08/11/1973	Collision of the State-of-the-Art Transit Cars with a Standing Car, High Speed Ground Test Center	0	1

Appendix D. NTSB Safety Recommendations Issued to the FTA and UMTA

Number	Status	Safety Recommendation	Issued	Closed
TO UMTA				
R-71-015	Closed—Acceptable Action	Require that all rail rapid transit applications for capital improvement, demonstration, and research and development grants include a system safety plan for the project for which funds are being requested. This plan might include, but not be limited to, such items as: (a) a description of the safety organization and its position inthe total organization. (b) identification of the tasks to be accomplished by the safety organization. (c) the technical methods to be used for accomplishment of these tasks. (d) a schedule for task completion, keyed to major program milestones. (e) a description of the output from the safety effort. (f) the methods for applying this output to identify the hazards, to evaluate the risks, and to determine the alternatives to assumption of these risks. (g) the document to be developed.	6/17/1971	9/10/1976
R-71-016	Closed—Acceptable Action	Evaluate comparatively the system safety plans submitted by applicants for rail rapid transit funding assistance, and employ such evaluations as a partial basis for selecting applicant to be funded. In addition, develop, or obtain through cooperation with other agencies, a permanent system safety engineering capability to evaluate the safety plan of each project for which funds are requested.	6/17/1971	9/10/1976
R-71-017	Closed—Recon-sidered	Include safety considerations in its study of the feasibility of providing federal assistance to help defray operating costs of mass transportation companies, insofar as rail rapid transit is concerned.	6/17/1971	12/11/1974
R-71-018	Closed—Acceptable Action	Undertake a study of selected rail rapid transit systems in the planning stage to determine the feasibility of separating passengers from tracks, in the underground and above-ground stations.	6/17/1971	6/21/1982
R-71-021	Closed—Acceptable Action	In cooperation with the Federal Railroad Administration, provide a continuing review of the study now underway involving the effects of vandalism and assault on rail rapid transit vehicles and passengers. This review should include scrutiny of existing laws and regulations to determine their adequacy, with recommendations for appropriate federal action.	6/17/1971	12/11/1974
R-71-022	Closed—No Longer Applicable	With the Federal Highway Administration, Department of Housing and Urban Development, and Urban Mass Transportation Administration: Cooperatively evaluate highway planning in urban areas with regard to accommodation of rail rapid transit lines, and establish criteria for joint corridor accommodation of rail rapid transit lines, and establish criteria, and establish and criteria for proper and safey accommodation of such lines.	6/17/1971	11/17/1975

Number	Status	Safety Recommendation	Issued	Closed
TO UMTA				
R-73-015	Closed—Acceptable Action	The following areas be included in specifications for the 15 additional highliner cars to be funded by the Urban Mass Transportation Administration: Design specifications to require that all weld designs in the center sill area and in the underframe at ends of cars comply with specified current recommendations of engineering practices, and that single bevel welds not be employed.	4/11/1973	12/11/1974
R-73-016	Closed—Acceptable Action	The following areas be included in specifications for the 15 additional highliner cars to be funded by the Urban Mass Transportation Administration: Design specifications to require that welds, or other fasterners which join side walls to roof, develop a high proportion of the strength of the parent metal.	4/11/1973	12/11/1974
R-73-017	Closed—Acceptable Action	The following areas be included in specifications for the 15 additional highliner cars to be funded by the Urban Mass Transportation Administration: Design specifications to ensure that the collision posts resist more adequately the impact loads which are likely to be applied by crash forces generally along the axis of the car. The design should not permit such impact loads to produce, torque, or lateral beding when applied at the logical points by an end to end collision. Collision posts and other structures should be designed to resist torque and bending efficently.	4/11/1973	12/11/1974
R-73-018	Closed—Acceptable Action	Require specific statements of intended capability of cars to resist low-speed collision damage in specifications for newly designed cars which are candidates for federal capital grants. Such specifications should be coordinated with injury resistance specifications which may arise from current funded research.	4/11/1974	12/11/1974
R-73-031	Closed—Acceptable Action	With the Federal Highway Administration: Initiate research to develop the technical approaches to crash worthiness in light-weight passenger cars for use in commuter or rail rapid-transit operations. These approaches should include crash testing as part of the design and development function for new equipment.	6/28/1973	12/11/1974
R-73-033	Closed—Acceptable Action	Formalize and publish requirements for safety plans to be prepared by transit authorities seeking grants, and fully implement a policy which requires assurance that these plans will be submitted as a condition to releasing funds. This safety plan requirement was recommended to UMTA by the Safety Board in June 1971.	8/8/1973	9/10/1976
R-74-016	Closed—Acceptable Action	Establish safety goals or criteria within the detail specifications for development projects similar to the [State-of-the-Art Car] program so that attainment of crashworthiness and systems safety can be objectively determined.	5/7/1974	9/10/1976
R-74-017	Closed—No Longer Applicable	Review the “detail specification for state-of-the-art car” and identify for all prospective users those areas of functional performance in which the specification does not actually require attainment of the full state of the art or in which the state of the art was not attained.	5/7/1974	9/10/1976
R-74-018	Closed—Acceptable Action	Conduct a systematic review to identify incompatibilities between the [State-of-the-Art Cars] (SOAC’s) and each different system upon which they are to be used, and assure compatibility before SOAC’s are introduced on operating transit systems.	5/7/1974	9/10/1976

Number	Status	Safety Recommendation	Issued	Closed
TO UMTA				
R-74-019	Closed—Acceptable Action	Review the specific operating procedures, rules, and facilities in use at the transit test track of the HSGTC. If the track is to be operated on the "secure pathway" theory, then all possibile violations of security should be examined. Resultant corrections should insure that specific safety functions are assigned to a specific individual and that all safety functions assigned to each individual are listed at one place in the operating rules and identified as that individual's responsibilities.	5/7/1974	6/20/1975
R-74-020	Closed—Acceptable Action	With the Federal Railroad Administration: explore various technical approaches to crashworthiness of rail transit cars, such as determining means of preventing override during crashes of similar cars and investigating the use of plastic deformation as a means of absorbing crash energy. Those technical approaches which appear practicable should be crash tested to insure that override would not occur and that a stated collapse cusioning effect will result as intended.	5/7/1974	6/21/1982
R-74-021	Closed—Acceptable Alternate Action	With the Federal Railroad Administration: review past escapes of motormen and engineers from operating compartments of rail transit and commuter cars during crash situations in order to establish design requirements and definite procedures for an operator's escape during impending crashes. Take action to ensure that these requirements and procedures are put into effect by the transit and railroad industries.	5/7/1974	6/21/1982
R-78-052	Closed—Acceptable Action	Inform operators of trolley car systems of the details of the Pittsburgh accident and, where applicable, have them disable the car feature that makes it possible to operate track switches by use of the power pedal.	9/20/1978	3/31/1981
R-79-054	Closed—Unaccep-table Action	Promulgate regulations establishing minimum fire safety standards for the design and construction of rapid transit vehicles.	8/31/1979	6/21/1982
R-79-055	Closed—Acceptable Action	Establish overview of Bay Area Rapid Transit District procedures to ensure that the emergency deficiencies noted in this investigation received appropriate remedial action.	8/2/1979	11/27/1979
R-79-062	Closed—Acceptable Alternate Action	Require those rapid transit systems that depend on oncoupling damaged cars from trains for the evacuation of passengers to redesign and modify car uncoupling circuitry to provide train operators with a positive means of uncoupling from within the cars in the event of an electrical short or other malfunction in the control circuit.	8/31/1979	2/28/1989
R-79-063	Closed—Acceptable Alternate Action	Require those rapid transit systems that depend on oncoupling damaged cars from trains for the evacuation of passengers to establish training programs in emergency procedures for train operators and crewmembers to insure that they thoroughly understand the method used to uncouple cars.	8/31/1979	2/28/1989
R-80-048	Closed—Acceptable Alternate Action	Require other rapid transit operations to establish adequate mutual emergency notification procedures in instances where rapid transit trains operate in close proximity to an operational railroad line.	10/24/1980	2/28/1989

Number	Status	Safety Recommendation	Issued	Closed
TO UMTA				
R-81-003	Closed—Unacceptable Action	In cooperation with rail rapid transit authorities and local fire officials, immediately survey the facilities, communication systems, fire safety and other emergency equipment, and emergency plans of existing rail rapid transit systems to determine their capability for evacuation of passengers under various operational and passenger load conditions.	2/11/1981	2/28/1989
R-81-004	Closed—Acceptable Action	Establish procedures to consult organizations, such as the United States Fire Administration, the International Association of Fire Chiefs, the International Association of Fire Fighters, the National Fire Protection Association, and employee unions, as appropriate, in addition to the American Public Transit Association and individual transit properties, in developing federal guidelines for car and tunnel designs, safety equipment requirements, training programs (inclouding emergency response) and other appropriate safety areas.	2/11/1981	3/30/1982
R-81-005	Closed—Acceptable Action	Make appropriate organizational changes to provide for more direct consideration of safety issues in the formulation of the administration's rail rapid transit policies and priorities.	2/11/1981	9/19/1983
R-81-006	Closed—Unacceptable Action	Establish, on a priority basis, federal guidelines for the elimination or minimization of combustible and toxic gas and smoke-generating materials in existing rail rapid transit cars. Wherever possible, adherence to these guidelines should be made mandatory as a condition of federal financial assistance.	2/11/1981	2/28/1989
R-81-007	Closed—Unacceptable Action	In cooperation with rail rapid transit authorities and a local fire officials, assess the need for modification or retrofit of existing rail rapid transit cars to reduce the potential for the exposure of combustible or toxic materials to fire.	2/11/1989	2/28/1989
R-81-008	Closed—Acceptable Action	Include in federal financial assistance to rail rapid transit systems an ability to provide funding for acquisition of emergency equipment and for periodic inspection, maintenance, and testing of such equipment after it is installed.	2/11/1989	9/19/1983
R-81-009	Closed—Unacceptable Action	Develop and publish for public comment a comprehensive, 5-year safety program plan for increased safety oversight of new rail rapid transit systems as they are developed and for improving the safety of existing systems.	2/11/1989	2/28/1989
R-81-010	Closed—Unacceptable Action	Develop and publish for public comment a comprehensive, 5-year plan for rail rapid transit safety research and development.	2/11/1989	2/28/1989
R-81-011	Closed—Unacceptable Action	Establish a process, based upon testing and evaluation in accordance with such criteria as the administration shall establish, for the certification or identification of specific products and materials used in the construction of rail rapid transit cars as meeting minimum safety standards or guidelines, and provide this information to rail rapid transit authorities on a regular basis.	2/11/1989	2/28/1989
R-81-012	Closed—Acceptable Alternate Action	Develop and publish for public comment a formal plan for the review, evaluation, and certification of rail rapid transit system safety plans.	2/11/1989	1/11/1985

Number	Status	Safety Recommendation	Issued	Closed
TO UMTA				
R-81-013	Closed—Acceptable Alternate Action	Establish a fire safety research and testing program to assess the combustibility and toxic gas and smoke generation of materials used in the construction of rail rapid transit cars and to evaluate the fire safety of rail rapid transit cars through full-scale testing.	2/11/1989	8/10/1993
R-81-014	Closed—Acceptable Action	Offer to assist and cooperate with the United States Fire Administration in its development of a national training curriculum for fire service personnel involved in the administration of fire protection on rail rapid transit systems.	2/11/1989	3/30/1982
R-81-015	Closed—Acceptable Action	Develop federal guidelines for training programs for rail rapid transit employees, to include actual performance, under simulated conditions, of the duties they may be required to perform in the event of a fire or other emergency.	2/11/1989	7/30/1986
R-81-016	Closed—Acceptable Action	Conduct research to determine the most effective means of informing rail rapid transit passengers of the actions to be taken in the event of an emergency the location of emergency equipment, and the means of operating vehicle exit doors, and promulgate federal guidelines.	2/11/1989	7/30/1986
R-81-017	Closed—Acceptable Action	Study and evaluate the need for fire suppression systems on new rail rapid transit vehicles and conduct research and development, and develop and promulgate federal guidelines if so indicated..	2/11/1989	6/21/1990
R-81-018	Closed—Unacceptable Action	Require rail rapid transit authorities to have a formal, continuing process for incuding local fire and emergency medical service officials in reviews of fire and life safety considerations during system planning, design, construction, and operation.	2/11/1989	2/28/1989
R-81-019	Closed—Acceptable Action	Include local fire and emergency response services in onsite reviews performed by the administration of new and existing rail rapid transit systems.	2/11/1989	3/30/1982
R-81-020	Closed—Unacceptable Action	Until such time as comprehensive, formal safety standards have been established for rail rapid transit, publish an annual report assessing the degree of conformance or nonconformance of rail rapid transit systems with each federal safety guideline established by the administration.	2/11/1989	1/11/1985
R-81-118	Closed—Unacceptable Action	Establish procedures to monitor, evaluate, and assure that approved plans to correct unsafe conditions are carried out by transit authorities and that no changes in the plans are approved or made without adequate evaluation.	12/30/1981	9/19/1983
R-86-034	Closed—Acceptable Action/ Superseded	Require that all employees involved in a rail rapid transit accident with a fatality, injury, or property damage be tested in a timely manner for alcohol and drugs. (Superseded by R-91-33 through -36)	8/13/1986	8/6/1991
R-86-035	Closed—Acceptable Action/ Superseded	Require rail rapid transit systems to screen for drug and alcohol abuse all prospective and transferred employees prior to employment in safety-sensitive positions. (Superseded by R-91-33 through -36)	8/13/1986	8/6/1991
R-86-036	Closed—Acceptable Action/ Superseded	Require rail rapid transit systems to institute procedures and information systems to inform employees of the deleterious effects on work performance of some over-the-counter and prescription drugs on work performance. (Superseded by R-91-33 through -36)	8/13/1986	8/6/1991

Number	Status	Safety Recommendation	Issued	Closed
TO UMTA				
R-86-037	Closed—Acceptable Action/ Superseded	Require the removal of employees from safety-sensitive positions if the rail rapid transit medical department determines that the employees' use of a prescription drug will affect their work performance. (Superseded by R-91-33 through R-91-36)	8/13/1986	8/6/1991
R-86-038	Closed—Acceptable Action/ Superseded	Encourage the creation of effective employee assistance programs to detect and treat substance abuse among rail rapid transit employees in safety-sensitive positions. (Superseded by R-91-33 through -36)	8/13/1986	8/6/1991
R-86-039	Closed—No Longer Applicable	Require that rail rapid transit companies equip with operable radios all trains operating in revenue service.	8/13/1986	12/18/1990
R-86-040	Closed—No Longer Applicable	Develop and promulgate a uniform code of radio operating rules and procedures for use by the rail rapid transit industry.	8/13/1986	12/18/1990
R-88-038	Closed—Unacceptable Action	Require periodic medical examinations, including alcohol and drug screening, for rail rapid transit employees in safety-sensitive positions.	8/9/1988	12/20/1988
R-91-033	Closed—Acceptable Action	Document and evaluate the effectiveness of existing state oversight activities of rail rapid transit transit safety and develop guidelines for use by state and local governments that address the critical element of an effective oversight program.	8/6/1991	4/16/1996
R-91-034	Closed—Acceptable Action	Monitor safety oversight programs implemented by the state and local governments to determine that the elements of an effective program are in place, that adequate financial resources are available, and that the mechanism through which the oversight is being accomplished is appropriate given the nature of the particular transit system.	8/6/1991	4/16/1996
R-91-035	Closed—Acceptable Action	Use your funding authority to ensure independent and effective safety oversight for UMTA-funded projects and UMTA-assisted systems.	8/6/1991	4/16/1996
R-91-036	Closed—Acceptable Action	Develop an accident/incident reporting form for rail rapid transit systems that distinguishes between passenger and employee injuries and fatalities and require transit systems to file these reporting forms periodically. Publish this information and exposure rate data for each system annually. Regularly analyze the data to determine trends in accidents and injuries.	8/6/1991	7/12/1995

Number	Status	Safety Recommendation	Issued	Closed
TO THE FTA				
R-93-025	Closed—Acceptable Action	Cooperate with the Federal Railroad Administration to study the feasibility of providing car body corner post structures on all self-propelled passenger cars and control cab locomotives to afford occupant protection during corner collisions.	1/7/1994	1/11/2000
R-96-020	Closed—Acceptable Action	In cooperation with the American Public Transit Association, develop a fatigue educational awareness program and distribute it to transit agencies to use in their fitness-for-duty training for supervisors and employees involved in safety-sensitive acitvities.	9/11/1996	1/11/2000
R-96-046	Closed—Acceptable Action	Develop, with the assistance of the Amercian Public Transit Association, guidelines for monitoring/recording devices that capture critical performance and event data for rapid rail transit cars and urge transit agencies to install these devices on new and rehabilitated cars.	11/14/1996	1/6/1999
R-97-022	Closed—Acceptable Action	Revise the grant application process to require a comprehensive failure modes and effects analyses, including a human factors analysis, be provided for all federally funded transit projects that are directly related to the transport of passengers.	8/28/1997	9/26/2001
R-97-023	Closed—No Longer Applicable	Cooperate with the Federal Railroad Administration for requiring, in the interim of a positive train separation control system being available, the installation of cab signals, automatic train stop, automatic train control, or other similar redundant systems for all trains where commuter and intercity passenger railroads operate.	8/28/1997	10/29/2001
R-97-024	Closed—No Longer Applicable	Cooperate with the Federal Railroad Administration for requiring the implementation of positive train separation control systems for all trains where commuter and intercity passenger railroads operate.	8/28/1997	4/2/1998
R-97-025	Closed—Recon-sidered	Cooperate with CSX Transportation Inc. in the development and installation of a positive train separation control where Maryland rail commuter equipment operates on CSX Transportation Inc. tracks.	8/28/1997	4/2/1998
R-00-005	Closed—Acceptable Alternate Action	Establish, with assistance from experts on the effects of pharmacological agents on human performance and alertness, procedures or criteria by which transit vehicle operators who medically require substances not on the US Dept. of Transportation's list of approved medications may be allowed, when appropriate, to use those medications when operating transit vehicles.	1/13/2000	1/24/2005
R-00-006	Closed—Acceptable Action	Develop, then periodically publish, an easy-to-understand source of information for transit vehicle operators on the hazards of using specific medications when operating transit vehicles.	1/13/2000	1/24/2005
R-00-007	Closed—Acceptable Action	Establish and implement an educational program targeting transit vehicle operators that, at a minimum, ensures that all operators are aware of the source of information described in R-00-6 regarding the hazards of using specific medications when operating transit vehicles.	1/13/2000	1/24/2005

Number	Status	Safety Recommendation	Issued	Closed
TO THE FTA				
R-00-008	Closed—Acceptable Action	Establish, in coordination with the US Department of Transportation, the Federal Motor Carrier Safety Administration, the Federal Railroad Administration, and the US Coast Guard, comprehensive toxicological testing requirements for an appropriate sample of fatal highway, railroad, transit, and marine accidents to ensure the identification of the role played by common prescription and over-the-counter medications. Review and analyze the results of such testing at intervals not to exceed every 5 years.	1/13/2000	6/19/2013
R-01-025	Closed—Acceptable Action	the Federal Transit Administration: Authorize and encourage rail transit systems to require their employees in safety-sensitive positions to inform the rail transit system about their use of prescription and over-the-counter medications so that the rail transit system can have qualified medical personnel determine the medication's potential effects on employee performance.	1/23/2002	4/14/2004
R-02-018	Closed—Acceptable Alternate Action	Adopt the American Public Transportation Association manual that contains updated language on auditing the effectiveness of operating rules compliance programs, and simultaneously modify 49 Code of Federal Regulations Part 659 so that the Part always references the current American Public Transportation Association manual.	9/26/2002	6/21/2005
R-02-019	Closed—Unacceptable Action	Require that new or rehabilitated vehicles funded by Federal Transit Administration grants be equipped with event recorders meeting Institute of Electrical and Electronics Engineers Standard 1482.1 for rail transit vehicle event recorders.	9/26/2002	8/29/2008
R-06-003	Open—Acceptable Response	Require transit agencies, through the system safety program and hazard management process if necessary, to ensure that the time off between daily tours of duty, including regular and overtime assignments, allows train operators to obtain at least 8 hours of uninterrupted sleep.	4/19/2006	
R-06-004	Closed—Acceptable Action	Assess the adequacy of the Washington Metropolitan Area Transit Authority's current organizational structure and ensure that it effectively identifies and addresses safety issues.	4/19/2006	10/5/2007
R-06-005	Closed—Acceptable Action	Develop transit railcar design standards to provide adequate means for safe and rapid emergency responder entry and passenger evacuation.	4/19/2006	6/19/2003
R-06-006	Open—Acceptable Response	Develop minimum crashworthiness standards to prevent the telescoping of transit railcars in collisions and establish a timetable for removing equipment that cannot be modified to meet the new standards.	4/19/2006	
R-07-009	Closed—Acceptable Response	Modify your program to ensure that State safety oversight agencies take action to prompt rail transit agencies to correct all safety deficiencies that are identified as a result of oversight inspections and safety reviews, regardless of whether those deficiencies are labeled as findings, observations, or some other term.	10/26/2007	6/22/2010
R-07-010	Closed—Acceptable Action	Develop and implement an action plan, including provisions for technical and financial resources as necessary, to enhance the effectiveness of State safety oversight programs to identify safety deficiencies and to ensure that those deficiencies are corrected.	10/26/2007	6/22/2010

Number	Status	Safety Recommendation	Issued	Closed
TO THE FTA				
R-07-011	Closed—Acceptable Action	Schedule the Chicago Transit Authority as a priority for receiving the maintenance oversight workshop and the training course to be developed for track inspectors and supervisors that will address the unique demands of track inspection in the rail transit environment.	10/26/2007	6/22/2010
R-07-012	Closed—Acceptable Action	Inform all rail transit agencies about the circumstances of the July 11, 2006, Chicago Transit Authority subway accident and urge them to examine and improve, as necessary, their ability to communicate with passengers and perform emergency evacuations from their tunnel systems, including the ability to (1) identify the exact location of a train, (2) locate a specific call box, and (3) remove smoke from their tunnel systems.	10/26/2007	6/22/2010
R-09-007 (Urgent)	Open—Acceptable Response	Advise all rail transit operators that have train control systems capable of monitoring train movements to determine whether their systems have adequate safety redundancy if losses in train detection occur. If a system is susceptible to single point failures, urge and verify that corrective action is taken to add redundancy by evaluating track occupancy data on a real-time basis to automatically generate alerts and speed restrictions to prevent train collisions.	7/31/2009	
R-09-008	Closed—Unacceptable Action/Superseded	Facilitate the development and implementation of positive train control systems for rail transit systems nationwide. (Superseded by Safety Recommendation R-15-22)	7/23/2009	5/11/2015
R-09-009	Open—Acceptable Response	Develop and disseminate guidance for operators, transit authorities, and physicians regarding the identification and treatment of individuals at high risk for obstructive sleep apnea and other sleep disorders.	7/23/2009	
R-09-017 (Urgent)	Closed—Acceptable Action	Advise all rail transit operators that use audio frequency track circuits in their train control systems that postaccident testing following the June 22, 2009, collision between two rail transit trains near the Fort Totten station in Washington, D.C., identified that a spurious signal generated in a track circuit module transmitter by parasitic oscillation propagated from the transmitter through a metal rack to an adjacent track circuit module receiver, and through a shared power source, thus establishing an unintended signal path. The spurious signal mimicked a valid track circuit signal, bypassed the rails, and was sensed by the module receiver so that the ability of the track circuit to detect the train was lost.	9/22/2009	4/27/2010
R-09-018 (Urgent)	Closed—Acceptable Action	Advise all rail transit operators that use audio frequency track circuits in their train control systems to examine track circuits that may be susceptible to parasitic oscillation and spurious signals capable of exploiting unintended signal paths and eliminate those adverse conditions that could affect the safe performance of their train control systems. This work should be conducted in coordination with their signal and train control equipment manufacturers.	9/22/2009	4/27/2010

Number	Status	Safety Recommendation	Issued	Closed
TO THE FTA				
R-09-019	Closed—Acceptable Action	Advise all rail transit operators that use audio frequency track circuits in their train control systems to develop a program to periodically determine that electronic components in their train control systems are performing within design tolerances.	9/22/2009	5/18/2011
R-10-004	Closed—Acceptable Action	Facilitate the development of non-punitive safety reporting programs at all transit agencies to collect reports from employees in all divisions within their agencies and to have their safety departments; representatives of their operations, maintenance, and engineering departments; and representatives of labor organizations regularly review these reports and share the results of those reviews across all divisions of their agencies.	8/10/2010	6/19/2013
R-10-005	Open—Acceptable Response	Seek authority similar to Federal Railroad Administration regulations (Title 49 Code of Federal Regulations 219.207) to require that transit agencies obtain toxicological specimens from covered transit employees and contractors who are fatally injured as a result of an on-duty accident.	8/10/2010	
R-12-032	Closed—Acceptable Action	Notify all rail transit agencies regarding the circumstances of the January 26, 2010, accident near Rockville Metro Station and urge them to evaluate their roadway worker protection programs and procedures to ensure that they adequately and effectively address appropriate training, communication, maintenance-vehicle movement authorities, flagging procedures, rules compliance, and the sharing of a work area by multiple work crews.	6/1/2012	8/1/2012
R-12-033	Open—Acceptable Response	Advise all state safety oversight agencies of the circumstances of the January 26, 2010, accident near Rockville Metro Station and urge them to audit the roadway worker protection programs and the procedures of all rail transit operations in their states to ensure that they adequately and effectively address appropriate training, communication, maintenance-vehicle movement authorities, flagging procedures, rules compliance, and the sharing of a work area by multiple work crews.	6/1/2012	
R-12-034	Open—Acceptable Response	Issue guidelines to advise transit agencies and state oversight agencies on how to effectively implement, oversee, and audit the requirements of 49 Code of Federal Regulations Section 659.19(r) using industry best practices, industry voluntary standards, and appropriate elements from 49 Code of Federal RegulationsPart214, Subpart C—Roadway Worker Protection.	6/1/2012	
R-12-035	Open—Acceptable Response	Emphasize the effective implementation and oversight of 49 Code of Federal Regulations Section 659.19(r) as part of your safety oversight program audits.	6/1/2012	
R-13-001	Closed—Acceptable Response	In coordination with the Federal Railroad Administration: evaluate the best practices outlined in the Federal Railroad Administration's Safety Advisory 2002-01, and issue an updated safety advisory to all rail transit agencies that (1) advises them of the circumstances of the Miami, Florida; Madison, Illinois; and Niles, Michigan, accidents involving signal system maintenance procedures and (2) highlights the importance of adhering to the specified industry best practices regarding the use of jumper wires.	3/8/2013	9/6/2013

Number	Status	Safety Recommendation	Issued	Closed
TO THE FTA				
R-13-002	Closed—Acceptable Action	Instruct state safety oversight agencies to audit all rail transit agency procedures and maintenance oversight programs regarding the use of jumper wires to ensure they incorporate the current best industry practices outinled in the revised Safety Advisory recommended in Safety Recommendatoin R-13-1 and that transit procedures comply with Title 49 Code of Federal Regulations sections 236.4 and 234.209.	3/8/2013	9/6/2013
R-13-036 (Urgent)	Closed—Acceptable Action	Issue a safety advisory to all rail transit properties asking them to review their operating and maintenance procedures for stored unoccupied cars to ensure the propulsion and brake systems are left in a condition that would not facilitate unintended movement and that redundant means of stopping unintended rail car movements, such as wheel chocks and/or a derails are used.	10/4/2013	3/18/2014
R-13-039 (Urgent)	Open—Acceptable Response	Issue a directiveto all transit properties requiring redundant protection for roadway workers, such as positive train control, secondary warning devices, or shunting.	12/19/2013	
R-13-040 (Urgent)	Open—Acceptable Response	Issue a directive to require all transit properties to review their wayside worker rules and procedures and revise them as necessary to eliminate any authorization that depends solely on the roadway worker to provide protection from trains and moving equipment.	12/19/2013	
R-14-036	Open—Acceptable Response	Require initial and recurring training for roadway workers in hazard recognition and mitigation. Such training should include recognition and mitigation of the hazards of tasks being performed by coworkers.	10/22/2014	
R-14-037	Open—Acceptable Response	Include union participation in accident investigations similar to that allowed by the Occupational Safety and Health Administration. Seek authority from Congress to allow such participation, if necessary.	10/22/2014	
R-14-038	Open—Acceptable Response	With assistance from the Federal Railroad Administration and the Occupational Safety and Health Administration, establish roadway worker protection rules, including requirements for job briefings.	10/22/2014	
R-14-039	Open—Acceptable Response	Once the action specified in Safety Recommendation R-14-38 is completed, update the state safety oversight program to ensure that rail transit systems are meeting the safety requirements for roadway workers.	10/22/2014	
R-14-040	Open—Acceptable Response	Establish a national inspection program that specifically includes roadway worker activities.	10/22/2014	
R-14-041	Open—Acceptable Response	Revise Title 49 *Code of Federal Regulations* (CFR) Part 659 to require all federally funded rail transit properties to comply with 29 CFR Parts 1904, 1910, and 1926.	10/22/2014	
R-14-042	Open—Acceptable Response	Establish an agreement with the Occupational Safety and Health Administration to collaborate on any investigation of the fatality of an on-duty rail transit employee.	10/22/2014	
R-14-043	Open—Acceptable Response	Establish a committee for rail transit, similar to the Fatality Analysis of Maintenance-of-Way Employees and Signalmen Committee, that includes participation from interested parties, analyzes all rail transit employee fatalities, and makes recommendations that, when implemented, will prevent future accidents.	10/22/2014	

Number	Status	Safety Recommendation	Issued	Closed
TO THE FTA				
R-15-007 (Urgent)	Open—Acceptable Response	Audit all rail transit agencies that have subway tunnel environments to assess (1) the state of good repair of tunnel ventilation systems, (2) written emergency procedures for fire and smoke events, (3) training programs to ensure compliance with these procedures, and (4) verify that rail transit agencies are applying industry best standards, such as NFPA130,®Standard for Fixed Guideway Transit and Passenger Rail Systems,® in maintenance procedures and emergency procedures.	2/11/2015	
R-15-018	Open—Initial Response Received	Develop a work scheduling program for rail transit agencies that incorporates fatigue science—such as validated biomathematical models of fatigue—and provides for the management of personnel fatigue risks, and implement the program through the state safety oversight program.	5/13/2015	
R-15-019	Open—Initial Response Received	Establish (through the state safety oversight program) scientifically based hours-of-service regulations that set limits on hours of service, provide predictable work and rest schedules, and consider circadian rhythms and human sleep and rest requirements.	5/13/2015	
R-15-020	Open—Initial Response Received	Identify the necessary training and certification needs for work schedulers in the rail transit industry and require the transit agencies—through the state safety oversight program—to provide additional training or certification for their work schedulers.	5/13/2015	
R-15-021	Open—Initial Response Received	Require (through the state safety oversight program) rail transit employees who develop work schedules to complete initial and recurrent training based on current fatigue science to identify and mitigate work schedule risks that contribute to operator fatigue.	5/13/2015	
R-15-022	Open—Unacceptable Response	Require rail transit agencies to implement transmission-based train control systems that prevent train collisions. (Supersedes Safety Recommendation R-09-008)	5/13/2015	
R-15-023	Open—Initial Response Received	Require that new or rehabilitated rail transit vehicles be equipped with event recorders meeting Institute of Electrical and Electronics Engineers Standard 1482.1 for rail transit vehicle event recorders.	5/13/2015	

Appendix E. NTSB Safety Recommendations Issued to the US DOT addressing Rail Transit Safety

Number	Status	Safety Recommendation	Issued	Closed
R-78-010	Closed—Unacceptable Action	Develop oversight capability to insure that the safety of rail rapid transit systems will be regulated and enforced by a responsibility state or federal agency. Within the Department of Transportation, accountability for the oversight should be assigned to the Administration that controls federal grants to aid rail rapid transit.	2/24/1978	01/12/1987
R-81-001	Closed—Reconsidered	Propose legislation to explicitly authorize the Secretary of Transportation to regulate the safety of rail rapid transit systems which receive federal financial assistance. Such legislation should include the authority to establish federal minimum safety standards, to enforce compliance, to conduct inspections, to conduct investigations of accidents and incidents, and such other general powers and duties as are necessary to provide for effective safety oversight.	2/11/1981	10/1/1982
R-81-002	Closed—Reconsidered	Pending the enactment of legislation conferring direct regulatory authority, require the Urban Mass Transportation Administration to establish federal guidelines for equipment and operations, to aggressively utilize existing grant programs and investigative authority to promote conformance with federal guidelines, and to conduct a program of substantially increased safety oversight of federal assisted rail rapid transit systems.	2/11/1981	7/28/1986
R-81-117	Closed—No Longer Applicable	Propose legislation to amend section 107 of the National Mass Transportation Assistance Act of 1974 to substitute, for the Secretary's authority to investigate unsafe conditions in federally funded mass transit systems, the authority to investigate any mass transit accident or incident in such systems, or any condition which affects or could affect the safety of passengers.	12/20/1981	3/11/1985
R-10-003	Closed—Acceptable Action	Continue to seek the authority to provide safety oversight of rail fixed guideway transportation systems, including the ability to promulgate and enforce safety regulations and minimum requirements governing operations, track and equipment, and signal and train control systems.	8/10/2010	12/26/2012
R-15-031 (Urgent)	Open—Unacceptable Response	Seek an amendment to Title 45 *United States Code* Section 1104(3) to list the Washington Metropolitan Area Transit Authority as a commuter authority, thus authorizing the Federal Railroad Administration to exercise regulatory oversight of the Washington Metropolitan Area Transit Authority's rail system.	9/30/2015	
R-15-032 (Urgent)	Open—Unacceptable Response	After Title 45 *United States Code* Section 1104(3) is amended to include the Washington Metropolitan Area Transit Authority, direct the Administrator of the Federal Railroad Administration to develop and implement a plan to transition the oversight of the Washington Metropolitan Area Transit Authority's rail system to the Federal Railroad Administration within 6 months.	9/30/2015	

Appendix F. NTSB Safety Recommendations Issued to WMATA

Number	Status	Safety Recommendation	Issued	Closed
R-70-018	Closed—Acceptable Action	Develop the capability within its organization for system safety engineering and apply system safety principles to all aspects of the proposed Metro system to identify, assess, and correct those deficiencies identified by the analysis.	8/12/1970	11/17/1975
R-76-042	Closed—Acceptable Action	Prohibit trains with inoperative automatic train control or cab signals from departing a terminal for main track operation.	8/1/1976	7/6/1978
R-76-043	Closed—Acceptable Action	Develop a procedure to discharge passengers and remove trains from service immediately if they develop automatic train control problems or cab signal problems while en route.	8/1/1976	9/14/1978
R-76-044	Closed—Acceptable Action	Insure that communication facilities are adequate for dependable operational control and that proper procedures are in effect to provide emergency warnings and instructions.	8/1/1976	7/6/1978
R-82-008	Closed—Acceptable Action	Modify its operating rules and standard operating procedures to require the establishment of an absolute block whenever it is necessary to operate a train in other than in the fully automatic mode.	3/19/1982	2/19/1985
R-82-009	Closed—Acceptable Action	Include in its operating rules a requirement that whenever it is necessary to operate a train manually, the Operations Control Center will not permit the train to proceed into the block to the next station as long as that block is occupied by another train. If there is an interlocking between the stations, require that the absolute block between the stations will apply to both main tracks unless the Operations Control Center has an oscilloscope indication that all crossover switches are aligned for main track movement.	3/19/82	2/19/85
R-82-010	Closed—Acceptable Action	Include in its operating rules a requirement that train operators report to the Operations Control Center whenever they are unable to operate in the fully automatic mode, and enforce the operating rules requiring authorization by the Operations Control Center to change operating modes.	3/19/82	8/13/84
R-82-011	Closed—Acceptable Action	Include in its operating rules a requirement that that before a manually operated train is permitted to enter a block containing an interlocking, the Operations Control Center must instruct the train's operator as to the intended route for the train and receive proper acknowledgement from the operator.	3/19/82	2/19/85
R-82-012	Closed—Acceptable Action	Modify its operating rules to prohibit the reverse movement of a train within interlocking limits until it has been established that no derailment has occurred, that switches are aligned, and that there are no conflicting train movements.	3/19/1982	7/8/1983
R-82-013	Closed—Acceptable Action	Improve the maintenance and redundancy of the communications equipment in the Operations Control Center and of "hot line" intercoms between the Operations Control Center and the other Washington Metropolitan Area Transit Authority command centers to provide continuous communications between all centers.	3/19/1982	7/8/1983

Number	Status	Safety Recommendation	Issued	Closed
R-82-014	Closed—Acceptable Action	Provide radio communicating capability for the Operations Control Center that is commensurate with peak radio traffic demands of the expanding Washington Metropolitan Area Transit Authority rail system.	3/19/1982	7/8/1983
R-82-015	Closed—Acceptable Action	Upgrade the training given to rail transportation supervisors and assign them the necessary authority to effectively supervise train operations and correctly deal with the full range of operating situations.	3/19/1982	1/14/1986
R-82-016	Closed—Acceptable Action	Implement a program of mandatory periodic instruction and examination on the combined book of operating rules and standard operating procedures, including emergency train evacuation procedures, for all rail supervisors and train operators.	3/19/1982	2/19/1985
R-82-017	Closed—Acceptable Action	Amend its standard operating procedures to require the Operations Control Center (1) to require that, whenever a train emergency which requires evacuation is known to exist at a location between stations, all third-rail power circuits between the emergency location and the stations on each side of that location be deenergized as soon as all other trains have cleared the area, and (2) to direct the nearest qualified rail employee to begin the timely evacuation of passengers from the train.	3/19/1982	2/19/1985
R-82-018	Closed—Acceptable Action	Implement a continuing program to educate passengers on the procedures to be followed when it is necessary to evacuate a disabled train.	3/19/1982	1/14/1986
R-82-055	Closed—Acceptable Action	Immediately implement an indepth continuing program for controllers and their superiors in the Metrorail Operations Control Center which includes instruction in the rules, procedures, and fundamentals of rail transit operations; familiarization with all Metrorail operations; radio protocol; and peridic testing and certification by a professional training specialist who is knowledgeable in rail transit operations.	10/15/1982	11/14/1986
R-82-056	Closed—Acceptable Action	Establish a Training Department for Metrorail that is accountable to top WMATA management and is staffed by professional specialists in this field.	10/15/1982	8/13/1984
R-82-057	Closed—Acceptable Action	Evaluate the quality of the curriculum, instruction, training aids, and periodic certification process of the present Metrorail train operators' training course, and implement necessary improvements.	10/15/1982	1/14/1986
R-82-058	Closed—Unacceptable Action	Modify the overspeed control on the Metrorail cars to enforce speed commands of the Automatic Train Protection subsystem to and including zero miles per hour.	10/15/1982	8/13/1984
R-82-059	Closed—Unacceptable Action	Change the identification numbers of its interlockings and interlocking signals to eliminate possible misunderstandings which could result in a train improperly passing a restricting signal.	10/15/1982	7/8/1983
R-82-060	Closed—Acceptable Action	Require the Metrorail Operations Control Center personnel, rail transportation supervisors, and train operators to refer to all signals by their complete and proper designation.	10/15/1982	7/8/1983
R-82-061	Closed—Acceptable Action	Require that the Metrorail Operations Control Center personnel and transportation supervisors understand and implement provisions of Standard Operating Procedure No. 15 for the establishment of an absolute block when there is a failure in the Automatic Train Control system.	10/15/1982	7/8/1983

Number	Status	Safety Recommendation	Issued	Closed
R-82-062	Closed—Acceptable Action	Include in Metrorail operating rules a definition of restricted speed. Establish and require that all employees involved in the operation of trains understand and abide by the maximum allowable speed for trains being operated through an interlocking with inoperative track circuits.	10/15/1982	8/13/1984
R-82-063	Closed—Acceptable Action	Eliminate the practice of issuing verbal instructions to the Metrorail Operations Control Center personnel which modify or amend operating rules and standard operating procedures.	10/15/1982	7/8/1983
R-82-064	Closed—Acceptable Action	Modify the automated alert system to segregate the "serious" physical plant-related Type 1 visual alarms from the less serious train-oriented Type 2 alarms, and to provide an audible indication of a Type 1 alarm which must be manually acknowledged.	10/15/1982	8/13/1984
R-82-065	Closed—Acceptable Action	Require that Type 1 automated alert alarms be immediately reported by the Operations Control Center to Maintenance Control for corrective action.	10/15/1982	7/8/1983
R-82-066	Closed—Acceptable Action	Require that maintenance forces inspect switch machine fusetrons while making their regular preventive maintenance inspections of the control system apparatus.	10/15/1982	2/19/1985
R-82-067	Closed—Acceptable Action	Provide train operators with some type of self-contained radios which will function in the event that auxiliary and emergency car power sources are lost.	10/15/1982	8/13/1984
R-82-068	Closed—Acceptable Action	Arrange for a comprehensive review of its Metrorail safety program and of its rules and procedures by a peer review board of the American Public Transit Association.	10/15/1982	7/8/1983
R-82-069	Closed—Acceptable Action	Provide all Metrorail Operations Control Center controllers and their supervisors with clear instructions that all automatic reclosing circuit breakers for the traction power sections in the affected area must be commanded open prior to the commencement of an evacuation of a train.	10/15/1982	7/8/1983
R-82-070	Closed—Acceptable Alternate Action	Require the installation of an adequate number of marked emergency escape windows on all new Metrorail cars and implement a program to similarly retrofit existing cars.	10/15/1982	1/14/1986
R-82-071	Closed—Unacceptable Action	Equip each Metrorail car with an adequate number of self-contained, battery-powered emergency lights which will automatically illuminate the car interior in the event the car's auxiliary and emergency power is lost.	10/15/1982	2/19/1985
R-82-072	Closed—Acceptable Alternate Action	Post emergency information inside Metrorail cars at locations near the doors regarding the location and method of operation of the manual emergency door handle.	10/15/1982	1/14/1986
R-82-073	Closed—Unacceptable Action	Retrofit existing Metrorail cars with derailment detector devices which will apply the brakes in emergency when a car wheel leaves the rail. Require that all new cars be so equipped.	10/15/82	2/19/1985
R-82-074	Closed—Acceptable Action	Maintain the carborne monitors on existing Metrorail cars and require their installation on cars presently on order. Acquire the necessary equipment to read the monitor tapes.	10/15/1982	6/10/1991
R-82-075	Closed—Acceptable Alternate Action	Provide a portable radio, compatible with the Metrorail communication system, at each station kiosk for dedicated use by fire/rescue personnel.	10/15/1982	8/13/1984

Number	Status	Safety Recommendation	Issued	Closed
R-82-076	Closed—Acceptable Action	Expedite the completion of its underground communication system.	10/15/1982	8/13/1984
R-82-077	Closed—Acceptable Action	In conjunction with the District of Columbia Fire Department, expand the scope and frequency of the Disaster Crash Simulations and include hospitals and fire/rcscue units from surrounding jurisdictions.	10/15/1982	8/13/1984
R-87-059	Closed—Acceptable Action	Raise the intrusion detection warning system to a uniform height above the top of the CSX Corporation rail beds.	12/9/1987	3/19/1991
R-87-060	Closed—Acceptable Action	Modify the existing intrusion detection warning system to ensure that the signal system on the Metro tracks and the CSX Corporation tracks automatically display stop indications for all trains when an intrusion is detected.	12/9/1987	3/19/1991
R-88-015	Closed—Unaccep-table Action	Until permanent solutions to joint corridor occupancy are implemented and their safety effectiveness is assessed, develop and implement a plan to control the access of Washington Metropolitan Area Transit Authority (WMATA) transit trains and CSX Transportation (CSXT) freight trains into the common transportation corrodor where WMATA trackage lies between the two tracks of CSXT so that CSXT freight trains and WMATA transit trains do not simultaneously occupy this corridor.	5/13/1988	3/19/1991
R-96-026	Closed—Acceptable Action	Analyze the braking performance under low-adhesion condtions of all railcar series in the Metrorail fleet. Take the measures necessary to ensure compatibility between the cars' braking performance and the automatic train control system block design.	11/14/1996	2/4/2002
R-96-027	Closed—Acceptable Action	Discontinue the use of the non-vital and non-fail-safe automatic train supervision (ATS) subsystem to perform safety-critical functions, and make it impossible for trains to default to a higher speed when a lower speed is required to ensure safe operation.	11/14/1996	8/18/1997
R-96-028	Closed—Acceptable Action	Establish management controls to ensure that changes to Metrorail operating policy are properly evaluated before adoption and that any such changes that may constitute a change in operating rules are (1) made in compliance with formal rule-change procedures, and (2) fully coordinated with all appropriate Washington Metropolitan Area Transit Authority technical and administrative branches and divisions.	11/14/1996	2/4/2002
R-96-029	Closed—Acceptable Action	Establish, document, and enforce a maximum authorized speed for every route segment on the Metrorail system. Ensure that these speeds are made known to all Metrorail personnel who hold safety-sensitive positions.	11/14/1996	5/28/2002
R-96-030	Closed—Acceptable Action	Develop a formal operating rule that governs the placement of standby gap trains at Metrorail terminals or other locations. This rule should clearly state that gap trains will not be stored on the inbound track.	11/14/1996	2/4/2002

Number	Status	Safety Recommendation	Issued	Closed
R-96-031	Closed—Acceptable Action	Develop and implement a formal, comprehensive, recurrent training and qualification program for Operations Control Center controllers that includes, at a minimum, decisionmaking, instruction and testing on Washington Metropolitan Area Transit Authority rules, policies, operational procedures, emergency procedures, emergency preparedness and notification (including the minimum information to be provided to emergency dispatchers); Metrorail signal and control systems; and the physical characteristics of the Metrorail system, to include requirements that controllers be qualified on the physical characteristics of the route segments for which they are responsible.	11/14/1996	2/4/2002
R-96-032	Closed—Acceptable Action	Develop and implement procedures for Operations Control Center controllers that (1) provide for active monitoring of both the automated control system and revenue train operation, (2) permit standardized interventions at the onset of recognition of potential automated system failures as well as direct hazards to individual trains, and (3) include unambiguous, clear guidelines for recognizing emergency operating situations requiring the stopping of trains.	11/14/1996	2/4/2002
R-96-033	Closed—Acceptable Action	Discontinue the practice of using oral instructions to convey standard operating procedures or to notify Metrorail personnel of new or revised rules, policies, or operating practices.	11/14/1996	8/18/1997
R-96-034	Closed—Acceptable Action	Develop and implement procedures to ensure that Metrorail operations personnel receive all bulletins, special orders, memoranda, or notices related to their responsibilities. These procedures should include a mechanism by which these personnel must sign or initial a document to signify that they have received, read, and understood any guidance intended for them.	11/14/1996	8/18/1997
R-96-035	Closed—Acceptable Action	Implement policies and procedures that provide a means for train operators to develop and maintain proficiency in manual train operation.	11/14/1996	8/19/1997
R-96-036	Closed—Acceptable Action	Conduct a detailed investigation and analysis to determine the cause of the approximately 400 station or platform overruns experienced across the Metrorail system each year, and take the measures necessary to improve train stopping accuracy and to eliminate station overruns.	11/14/1996	2/4/2002
R-96-037	Closed—Acceptable Action	Undertake, with the assistance of qualified engineering support, a comprehensive evaluation of the design and design specifications of all series of Metrorail cars with respect to resisting carbody telescoping and providing better passenger protection, and make the necessary modifications, such as incorporating underframe bracing or similar features, to improve the crashworthiness of cars in the current and/or future Metrorail fleet.	11/14/1996	5/28/2002
R-96-038	Closed—Superseded	Establish and administer a comprehensive educational program to alert employees to the potential adverse effects on performance that may arise from the use of prescribed and over-the counter medications. (Superseded by R-01-26 and -27)	11/14/1996	5/28/2002

Number	Status	Safety Recommendation	Issued	Closed
R-96-039	Closed—Acceptable Action	Finalize the specifications for a new advanced-technology carborne monitoring system and, once that is complete, retrofit existing Metrorail cars with the monitordrecorders during rehabilitation and require that all new Metrorail cars be equipped with the devices.	11/14/1996	5/28/2002
R-96-040	Closed—Acceptable Action	Coordinate with emergency service providers in all jurisdictions served by the Metrorail system to determine what information should be provided during an initial emergency notification, and amend the *Metrorail Safety Rules and Procedures Handbook* or standard operating procedures as needed to reflect these requirements.	11/14/1996	2/4/2002
R-96-041	Closed—Acceptable Alternate Action	Amend Washington Metropolitan Area 'Transit Authority standard operating procedures to require that in Metrorail emergencies in which rescue workers must be summoned to the scene or in which the possibility of passenger evacuation exists, all train traffic be diverted from that location as soon as possible and all third-rail circuits in the emergency area, including those on adjacent tracks, be deenergized as soon as trains have left the vicinity.	11/14/1996	8/18/1997
R-96-042	Closed—Acceptable Action	Develop a mechanism to provide emergency rescue personnel responding to an accident anywhere on the Metrorail system with easily accessible information about third-rail circuitry. Such a mechanism could include or consist of posting schematics or third-rail circuit diagrams on all blue light boxes and fences adjacent to interlockings.	11/14/1996	2/4/2002
R-96-043	Closed—Acceptable Action	Implement a program of regularly scheduled operational testing of systems used to remotely trip third-rail circuit breakers from Operations Control Center command consoles.	11/14/1996	8/18/1997
R-96-044	Closed—Acceptable Action	Increase the frequency of command and control exercises conducted ,jointly between the Washington Metropolitan Area Transit Authority and the emergency rescue services of all jurisdictions served by the Metrorail system.	11/14/1996	8/18/1997
R-96-045	Closed—Acceptable Action	Coordinate with and assist fire and rescue service providers of ail ,jurisdictions served by the Metrorail system in the procurement and distribution of sufficient quantities of warning strobe and alarm devices (WSADs) or similar protective devices to ensure that all rescue stations that may respond to a Metrorail accident are equipped to monitor the status of third-rail power in an accident area that includes one or more interlockings.	11/14/1996	2/4/2002
R-01-026	Open — Acceptable Response	Require employees in safety-sensitive positions to inform their supervisors when they are using prescription or over-the-counter medications so that qualified medical personnel may determine the medication's potential effects on employee performance, and train the employees about their responsibilities under the policy.	1/23/2002	
R-01-027	Open — Acceptable Response	Ensure that your fatigue educational awareness program includes the risks posed by sleeping disorders, the indicators and symptoms of such disorders, and the available means of detecting and treating them.	1/23/2002	
R-04-009 (Urgent)	Closed—Acceptable Action	Immediately revise the directions to train operators contained in your memorandums of November 7 and 9, 2004, to include specific written instructions for identifying and responding to an emergency rollback situation, and provide training to operators on the procedures to follow if such a rollback event occurs.	11/22/2004	6/20/2006

Number	Status	Safety Recommendation	Issued	Closed
R-06-001	Closed—Acceptable Action	Equip, as soon as possible, all existing and future train equipment with rollback protection for trains operated in the manual mode.	4/19/2006	5/23/2013
R-06-002	Closed—Unacceptable Action	Either accelerate retirement of Rohr-built railcars, or if those railcars are not retired but instead rehabilitated, then the Rohr-built passenger railcars should incorporate a retrofit of crashworthiness collision protection that is comparable to the 6000-series railcars.	4/19/2006	10/5/2007
R-07-023	Closed—Acceptable Action	Develop a standard for maximum allowable wheel roughness and develop and implement post-wheel-truing procedures to meet that standard.	12/20/2007	10/3/2008
R-07-024	Closed—Acceptable Action	Implement quality assurance procedures to ensure accurate wheel truing, including the regular alignment and indexing of cutting heads on wheel milling machines.	12/20/2007	6/27/2013
R-07-025	Closed—Acceptable Action	Establish procedures to ensure that there is appropriate coordination between all departments responsible for car maintenance and engineering design to ensure that problematic issues are identified, examined, and resolved before new equipment is ordered.	12/20/2007	10/23/2013
R-07-026	Closed—Acceptable Action	Establish a process, including a single point of responsibility, to prompt timely evaluation and action on proposed safety improvements that are identified as a result of accident and derailment investigations and related research projects.	12/20/2007	10/23/2013
R-07-027	Closed—Acceptable Alternate Action	Establish written procedures for rail lubrication that include close coordination between the operating and track engineering departments to ensure timely and appropriate rail lubrication is applied in normal and single-track operations.	12/20/2007	10/23/2013
R-07-028	Closed—Acceptable Action	Expedite and complete by 2009 the replacement of all No. 8 standard turnouts with guarded turnouts on main track.	12/20/2007	5/23/2013
R-08-001	Closed—Acceptable Action	Review your *Metrorail Safety Rules and Procedures Handbook* and revise it as necessary to create additional layers of protection for wayside workers, including: Adding requirements for wayside pre-work job briefings to ensure that all workers are informed of their duties, of their respective roles in work crew safety, and of the areas that are to be used to stay clear of trains. Requiring that when train operators request permission to either enter a main track, or when a train is turned for a return trip, the train operators along the affected lines must acknowledge receipt of the updated radio announcement from the control center regarding wayside workers. Establishing procedures to be used for members of a work crew to acknowledge a lookout's warning that a train is approaching on a particular track from a particular direction before a lookout gives an all clear signal to a train.	1/30/2008	10/23/2013
R-08-002	Closed—Acceptable Action	Establish a systematic program for frequent unannounced checks of employee compliance with Metrorail operating and safety rules and procedures.	1/30/2008	11/13/2012
R-08-003	Closed—Acceptable Action	Perform periodic hazard analyses on the deficiencies identified by unannounced checks of employee compliance in response to Safety Recommendation R-08-02, and use the results to revise Metrorail training curricula or enforcement activities, as necessary, to improve employee compliance with operating and safety rules and procedures.	1/30/2008	11/13/2012

Number	Status	Safety Recommendation	Issued	Closed
R-08-004	Open—Acceptable Response	Promptly implement appropriate technology that will automatically alert wayside workers of approaching trains and will automatically alert train operators when approaching areas with workers on or near the tracks.	1/30/2008	
R-09-006 (Urgent)	Closed—Acceptable Action	Take action to enhance the safety redundancy of your train control system by evaluating track occupancy data on a real-time basis in order to detect losses in track occupancy and automatically generate alerts. Alerts should prompt actions that include immediately stopping train movements or implementing appropriate speed restrictions to prevent collisions.	7/13/2009	7/19/2012
R-09-010	Open—Acceptable Response	Review your medical history and physical examination forms and modify them as necessary to ensure that they elicit specific information about any previous diagnosis of obstructive sleep apnea or other sleep disorders and about the presence of specific risk factors for such disorders.	7/23/2009	
R-09-011	Open—Acceptable Response	Establish a program to identify operators who are at high risk for obstructive sleep apnea or other sleep disorders and require that such operators be appropriately evaluated and treated.	7/23/2009	
R-09-015 (Urgent)	Closed—Superseded	Examine track circuits within your system that may be susceptible to parasitic oscillation and spurious signals capable of exploiting unintended signal paths, and eliminate those adverse conditions that could affect the safe performance of your train control system. This work should be conducted in coordination with your signal and train control equipment manufacturer(s). (Superseded by R-10-8)	9/22/2009	8/10/2010
R-09-016	Closed—Acceptable Action	Develop a program to periodically determine that electronic components in your train control system are performing within design tolerances.	9/22/2009	1/21/2014
R-10-007	Closed—Acceptable Action	Elevate the safety oversight role of the Washington Metropolitan Area Transit Authority Board of Directors by (1) developing a policy statement to explicitly and publicly assume the responsibility for continual oversight of system safety, (2) implementing processes to exercise oversight of system safety, including appropriate proactive performance metrics, and (3) evaluating actions taken in response to National Transportation Safety Board and Federal Transit Administration recommendations, as well as the status of open corrective action plans and the results of audits conducted by the Tri-State Oversight Committee.	8/10/2010	3/17/2011
R-10-008	Closed—Acceptable Action	Because of the susceptibility to pulse-type parasitic oscillation that can cause a loss of train detection by the Generation 2 General Railway Signal Company audio frequency track circuit modules, establish a program to permanently remove from service all of these modules within the Metrorail system.	8/10/2010	7/19/2012
R-10-009	Closed—Acceptable Action	Establish periodic inspection and maintenance procedures to examine all audio frequency track circuit modules within the Metrorail system to identify and remove from service any modules that exhibit pulse-type parasitic oscillation.	8/10/2010	4/5/2011

Number	Status	Safety Recommendation	Issued	Closed
R-10-010	Closed—Acceptable Action	Review the process by which Metrorail technical bulletins and other safety information are provided to employees and revise that process as necessary to ensure that (1) employees have received the information intended for them, (2) employees understand the actions to be taken in response to the information, and (3) employees take the appropriate actions.	8/10/2010	6/27/2013
R-10-011	Closed—Acceptable Action	Completely remove the unnecessary Metrorail wayside maintenance communication system to eliminate its potential for interfering with the proper functioning of the train control system.	8/10/2010	10/23/2013
R-10-012	Closed—Acceptable Action	Conduct a comprehensive safety analysis of the Metrorail automatic train control system to evaluate all foreseeable failures of this system that could result in a loss of train separation, and work with your train control equipment manufacturers to address in that analysis all potential failure modes that could cause a loss of train detection, including parasitic oscillation, cable faults and placement, and corrugated rail.	8/10/2010	6/25/2014
R-10-013	Closed—Acceptable Action	Based on the findings of the safety analysis recommended in R-10-12 incorporate the design, operational, and maintenance controls necessary to address potential failures in the automatic train control system.	8/10/2010	6/25/2014
R-10-014	Closed—Acceptable Action	Implement cable insulation resistance testing as part of Metrorail's periodic maintenance program.	8/10/2010	7/19/2012
R-10-015	Closed—Acceptable Action	Work with the Tri-State Oversight Committee to satisfactorily address the recommendations contained in the Federal Transit Administration's March 4, 2010, final report of its audit of the Tri-State Oversight Committee and the Washington Metropolitan Area Transit Authority.	8/10/2010	7/19/2012
R-10-016	Closed—Acceptable Action	Require that your safety department; representatives of the operations, maintenance, and engineering departments; and representatives of labor organizations regularly review recorded operational data from Metrorail train onboard recorders and the Advanced Information Management system to identify safety issues and trends and share the results across all divisions of your organization.	8/10/2010	11/20/2014
R-10-017	Closed—Acceptable Action	Develop and implement a non-punitive safety reporting program to collect reports from employees in all divisions within your organization, and ensure that the safety department; representatives of the operations, maintenance, and engineering departments; and representatives of labor organizations regularly review these reports and share the results of those reviews across all divisions of your organization.	8/10/2010	6/24/2014
R-10-018	Closed—Acceptable Action	Review the Hazard Identification and Resolution Matrix process in your system safety program plan to ensure that safety-critical systems such as the automatic train control system and its subsystem components are assigned appropriate levels of risk in light of the issues identified in this accident.	8/10/2010	7/19/2012

Number	Status	Safety Recommendation	Issued	Closed
R-10-019	Closed—Acceptable Action	Develop a formal process by which the general manager and managers responsible for Washington Metropolitan Area Transit Authority operations, maintenance, and engineering will periodically review, in collaboration with the chief safety officer, all safety audits and open corrective action plans, and modify policy, identify and commit resources, and initiate any other action necessary to ensure that the plans are adequately addressed and closed within the required time frame.	8/110/2010	4/5/2011
R-10-020	Open—Acceptable Response	Remove all 1000-series railcars as soon as possible and replace them with cars that have crashworthiness collision protection at least comparable to the 6000-series railcars	8/10/2010	
R-10-021	Open—Acceptable Response	Ensure that the lead married-pair car set of each train is equipped with an operating onboard event recorder.	8/10/2010	
R-10-022	Open—Acceptable Response	Develop and implement a program to monitor the performance of onboard event recorders and ensure they are functioning properly.	8/10/2010	
R-15-008 (Urgent)	Open—Acceptable Response	Assess your subway tunnel ventilation system to verify the state of good repair and compliance with industry best practices and standards, such as those outlined in the National Fire Protection Association's NFPA130,®Standard for Fixed Guideway Transit and Passenger Rail Systems.®	2/11/2015	
R-15-009 (Urgent)	Open—Acceptable Response	Develop and implement detailed written tunnel ventilation procedures for operations control center staff that take into account the probable source location of smoke and fire, the location of the train, the best evacuation route, and unique infrastructure features; these procedures should be based on the most effective strategy for fan direction and activation to limit passengers' exposure to smoke.	2/11/2015	
R-15-010 (Urgent)	Open—Acceptable Response	As part of the implementation of the procedures developed in response to Safety Recommendation R-15-009, incorporate the use of the procedures into your ongoing training and exercise programs and ensure that operations control center staff and emergency responders have ample opportunities to learn and practice activating ventilation fans.	2/11/2015	
R-15-025	Open—Acceptable Response	Promptly develop and implement a program to ensure that all power cable connector assemblies are properly constructed and installed in accordance with your engineering design specifications, including the weather tight seals that prevent intrusion by contaminants and moisture.	6/8/2015	

Appendix G. WMATA SOP #6 – Fire and Smoke on the Roadway

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
STANDARD OPERATING PROCEDURES

SOP # 6 FIRE AND SMOKE ON THE ROADWAY

6.1 PURPOSE

The purpose of this Standard Operating Procedure is to define responsibilities and procedures for WMATA personnel in the event of Fire and Smoke being reported on the Roadway.

6.2 SCOPE

This SOP is applicable to all WMATA personnel actively working in or riding on the Metrorail system.

6.3 DEFINITIONS

None

6.4 RESPONSIBILITIES

6.4.1 The ROCC Supervisors shall be responsible for supervising and coordinating response activities in accordance with this SOP.

6.4.2 The ROCC Supervisors shall be responsible for all notifications in accordance with this SOP.

6.4.3 All employees shall be guided by SOP # 1A when responding to emergencies.

6.4.4 Train Operators shall be responsible for following all sections of this SOP. In addition, train operators shall notify ROCC and adhere to SOP 4A if an indication exists that customers have entered the Roadway.

6.5 PROCEDURES

Procedure #	Content
6.5.1	Train Operator's Procedures when Observing Fire or Smoke on the Roadway
6.5.2	ROCC Supervisor's Procedures when Fire or Smoke is Reported in the Tunnel
6.5.3	ROCC Supervisor's Procedures when Heavy Smoke is Reported in the Tunnel
6.5.4	ROCC Supervisor's Procedures when Light Smoke (no Visible Fire) is Reported in the Tunnel

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
STANDARD OPERATING PROCEDURES

Procedure #	Content
6.5.5	ROCC Supervisor's Procedures when Arching, Glowing or Haze (Light Smoke) coming from a Third Rail Insulator is Reported
6.5.6	ROCC Supervisor's Procedures when a Fire is Reported in an Above Ground Location
6.5.7	ROCC Supervisor's Procedures when Smoke is Reported in an Above Ground Location

6.5.1 Train Operator's Procedures when Observing Fire or Smoke on the Roadway:

Stop their train if possible before reaching the fire or smoke and immediately notify Rail Operations Control Center (ROCC).

6.5.2 ROCC Supervisor's Procedures when Fire or Smoke is Reported in the Tunnel:

6.5.2.1 Stop all trains in both directions.

6.5.2.2 If the Train Operator reporting the fire was able to stop in approach of the fire, the ROCC Supervisor shall instruct the Train Operator to reverse ends and proceed to the next station.

6.5.2.3 If the Train Operator was not able to stop in approach of the fire, the ROCC Supervisor shall:

6.5.2.3.1 Ensure the track and station platform ahead are clear and third rail power is energized.

6.5.2.3.2 Instruct the Train Operator to turn off the train's Environmental System and continue on to the next station.

6.5.2.3.3 Notify the Fire Department and summon assistance.

6.5.2.3.4 Jointly assess the resolution of the situation over the conference line.

6.5.2.3.5 Request permission from the Fire Department to start single-track operations.

6.5.3 ROCC Supervisor's Procedures when Heavy Smoke is Reported in the Tunnel:

6.5.3.1 Stop all trains in both directions.

6.5.3.2 If the Train Operator reporting the heavy smoke was able to stop in approach of the smoke, the ROCC Supervisor shall instruct the Train Operator to reverse ends and proceed to the next station.

6.5.3.3 If the Train Operator was not able to stop in approach of the heavy smoke, the ROCC Supervisor shall:

6.5.3.3.1 Ensure the track and station platform ahead are clear and third rail power is energized.

6.5.3.3.2 Instruct the Train Operator to turn off the train's Environmental System and continue on to the next station.

6.5.3.3.3 Notify the Fire Department and summon assistance.

6.5.3.3.4 Jointly assess the resolution of the situation over the conference line.

6.5.3.3.5 Request permission from the Fire Department to start single-track operations.

6.5.4 ROCC Supervisor's Procedures when Light Smoke (no Visible Fire) is Reported in the Tunnel:

6.5.4.1 Instruct the Train Operator reporting the light smoke to turn off the train's Environmental System and continue to the next station.

6.5.4.2 Stop trains in both directions. Instruct trains in the area that are not in a station to turn off the train's Environmental System, continue to the next station and hold there.

6.5.4.3 Notify the Fire Department and jointly assess the resolution of the situation over the conference line.

6.5.4.4 Off-load the train following the train reporting the smoke and instruct the Train Operator to proceed to the area, assess the situation and report findings to the ROCC Supervisor.

6.5.4.5 If fire is observed, instruct the Train Operator reporting the fire to reverse ends and proceed to the next station. On the conference line, request the Fire Department to respond.

6.5.4.6 Request permission from the Fire Department to start single-track operations.

6.5.5 ROCC Supervisor's Procedures when Arching, Glowing or Haze (Light Smoke) coming from a Third Rail Insulator is Reported:

6.5.5.1 If the Train Operator reporting the arcing, glowing or haze involving a Third Rail Insulator was able to stop in approach of the insulator, the ROCC Supervisor shall instruct the Train Operator to reverse ends and proceed to the next station.

6.5.5.2 If the Train Operator was not able to stop in approach of the arcing, glowing or haze involving an insulator, the ROCC Supervisor shall:

6.5.5.2.1 Ensure the track and station platform ahead are clear and third rail power is energized.

6.5.5.2.2 Instruct the Train Operator to turn off the train's Environmental System and continue on to the next station.

6.5.5.2.3 Notify the Fire Department, jointly assess the resolution of the situation over the conference line and provide the following information:

6.5.5.2.3.1 The nature of the problem insulator glowing, arcing or producing a light haze.

6.5.5.2.3.2 The Chain Marker location.

6.5.5.2.3.3 Nearest station to the incident scene, and;

6.5.5.2.3.4 Estimated Time of Arrival (ETA) of Metro personnel responding to the scene.

6.5.5.2.4 Coordinate a meeting point for the On Scene Commanders from the Fire Department and Metro personnel.

6.5.5.2.5 Remove third rail power on the affected track.

6.5.5.2.6 Dispatch qualified personnel to investigate and/or remove the insulator.

6.5.5.2.7 Begin a single-track operation on the opposite track.

6.5.5.2.8 Check with personnel responding to the location to see if they advise it is safe to proceed with removal of the insulator.

6.5.5.2.9 Keep the Fire Department updated on the status of the removal of the insulator.

6.5.5.2.10 If third rail power has been removed, it shall be restored after the Rail Operations Supervisor at the scene has notified the ROCC Supervisor that the fire has been extinguished, the smoke has subsided and;

6.5.5.2.10.1 The senior Fire Department official has cleared the scene of Fire Department personnel and authorized the system to be placed back in operation.

6.5.5.2.10.2 All other public agency personnel have left the scene and;

6.5.5.2.10.3 Remaining employees are clear and have been alerted that power will be restored.

6.5.5.2.11 The ROCC Supervisor shall restore third rail power in accordance with SOP # 2.

6.5.6 ROCC Supervisor's Procedures when a Fire is Reported in an Above Ground Location:

6.5.6.1 Stop trains in both directions. Instruct trains in the area that are not in a station to turn off the train's Environmental System and continue to the next station.

6.5.6.2 Notify the Fire Department and jointly assess the resolution of the situation over the conference line.

6.5.6.3 Off-load the train following the train reporting smoke or fire; instruct the Train Operator to proceed to an area where the reported fire or smoke can be seen and assess the situation.

6.5.6.4 If fire cannot be extinguished quickly (without difficulty), instruct the Train Operator to reverse ends and proceed to the next station. On the conference line, request the Fire Department to respond.

6.5.7 ROCC Supervisor's Procedures when Smoke is Reported in an Above Ground Location:

6.5.7.1 Instruct the Train Operator reporting the smoke to turn off the train's Environmental System and continue to the next station.

6.5.7.2 Stop trains in both directions. Instruct Train Operators of trains in the area that are not in a station to turn off the train's Environmental System and continue to the next station and hold there.

6.5.7.3 Notify the Fire Department and jointly assess the resolution of the situation over the conference line.

6.5.7.4 Off-load the train following the train reporting smoke or fire; instruct the Train Operator to proceed to an area where the reported fire or smoke can be seen and assess the situation.

6.5.7.5 If the fire cannot be extinguished quickly (without difficulty), instruct the Train Operator attempting to extinguish the fire to reverse ends and proceed to the next station. On the conference line, request the Fire Department to respond.

6.6 REFERENCES

6.6.1 SOP # 1A

6.6.2 SOP # 2

6.6.3 SOP # 4A

Appendix H. NTSB September 30, 2015, Letter to the US Department of Transportation

National Transportation Safety Board
Washington, DC 20594

Safety Recommendation

Date: September 30, 2015

In reply refer to: R-15-31 and -32 (Urgent)

The Honorable Anthony Foxx
Secretary of Transportation
US Department of Transportation
Washington, DC 20590

The National Transportation Safety Board (NTSB) urges the US Department of Transportation (DOT) to take action on the urgent safety recommendations issued in this letter. These recommendations address the continued failure of the Tri-State Oversight Committee (TOC) to provide effective safety oversight of the Washington Metropolitan Area Transit Authority (WMATA). These recommendations are derived from our ongoing investigation of the WMATA Metrorail smoke and arcing accident at the L'Enfant Plaza station on January 12, 2015, and from other events indicating inadequate oversight of WMATA. Facts supporting these recommendations are discussed below.

Background

On Monday, January 12, 2015, about 3:15 p.m. eastern standard time, WMATA Metrorail Yellow Line train 302 stopped after encountering an accumulation of heavy smoke while traveling southbound in a tunnel between the L'Enfant Plaza station and the Potomac River bridge in the District of Columbia.

About 400 passengers were on board the six-car passenger train at the time of the accident. Some passengers self-evacuated from the train, while others were assisted by emergency responders. The smoke originated from an arcing event near the third rail about 2,000 feet south of the L'Enfant Plaza station. Smoke filled the L'Enfant Plaza station causing an evacuation of the station. District of Columbia Fire and Emergency Management Services reported that 86 people were treated and transported from the scene; another 9 passengers self-transported to medical facilities. There was one passenger fatality.

On Tuesday, June 23, 2015, the NTSB convened a 2-day investigative hearing to gather additional factual information for the ongoing investigation of the accident. The investigative hearing focused on the following areas:

- State of WMATA's infrastructure
- Emergency response efforts
- WMATA's organizational culture
- Federal Transit Administration (FTA) and TOC efforts for public transportation safety

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Rail Transit Operations

Rail transit operations are an inherently local activity, and the FTA has limited responsibility for the safety of rail transit operations. In the Intermodal Surface Transportation Efficiency Act of 1991, Congress directed the FTA to establish the State Safety Oversight (SSO) program; this program went into effect in 1997. Under this program, states are responsible for the safety of the rail fixed guideway systems within their borders. Each state is required to establish a state safety oversight agency (SSOA) that sets requirements for rail transit safety and monitors the performance of rail transit agencies in accordance with those requirements. The FTA established minimum requirements for the safety programs that the state agencies implement and oversees the efforts of the state agencies in carrying out the programs.

Since the establishment of the SSO program, the NTSB has investigated serious accidents involving rail transit systems; several of these accidents involved WMATA.[1] Many of the accident investigations identified inadequate oversight and regulation. In general, the NTSB investigations of WMATA found that although safety program plans were in place, they were not effectively implemented and overseen. In the NTSB's investigation of the June 22, 2009, WMATA accident near the Fort Totten station, we called for increased regulatory oversight of rail transit properties and recommended that the DOT seek the authority to provide safety oversight of rail fixed guideway transportation systems, including the ability to promulgate and enforce safety regulations and minimum requirements governing operations, track and equipment, and signal train control systems.

On July 6, 2012, the President signed into law the Moving Ahead for Progress in the 21st Century Act (MAP-21), Pub. L. 112-141, with an effective date of October 2, 2012. MAP-21 made a number of fundamental changes to the statutes that authorize the federal transit programs in Title 49 *United States Code* (*USC*) Chapter 53. The Public Transportation Safety Program requires the Secretary of Transportation to create and implement a national public transportation safety plan to improve the safety of all public transportation systems that receive funding from the FTA. The statute requires the contents of this plan to include the following:

1. Safety performance criteria for all modes of public transportation
2. Definition of the term "state of good repair"
3. Minimum safety performance standards for public transportation vehicles used in revenue operations that
    a. do not apply to rolling stock otherwise regulated by the Secretary or any other federal agency
    b. to the extent practicable, take into consideration
        i. relevant recommendations of the National Transportation Safety Board
        ii. recommendations of, and best practices standards developed by, the public transportation industry

[1] See, for example, NTSB accident reports: RAR-82-06, RAR-96-04, RAR-06-01, RAR-07-03, RAR-10-02, RAR-12-04, RAB-08-01, RAB-08-02, RAB-12-04, RAB-12-05, and DCA15FR004 preliminary report *Washington Metropolitan Area Transit Authority Arcing/Smoke Event with Passenger Evacuation, L'Enfant Plaza Station, Washington, DC, January 12, 2015.*

4. A public transportation safety certification training program

The FTA is still in the process of implementing the requirements of MAP-21. During the NTSB's June 23–24, 2015, investigative hearing into the WMATA L'Enfant Plaza accident, the FTA Associate Administrator for Transit Safety and Oversight was questioned about the implementation of the requirements of MAP-21. The Associate Administrator testified that the FTA's current rulemaking would include the elements stated above; however, he provided no specific timeline for completion of the rulemaking.[2]

Until the rail transit safety rulemaking called for by MAP-21 is complete, Title 49 *Code of Federal Regulations (CFR)* Part 659 (Rail Fixed Guideway Systems; State Safety Oversight) remains in effect, and SSOAs will continue using this regulation to conduct safety oversight. Although the FTA is responsible for overseeing the work of the SSOAs and for partially funding rail transit agencies through grants, it has a very small staff to regulate, audit, investigate, and administer the SSO program.

There are 32 SSOAs overseeing 50 rail transit systems.[3] The level of expertise within each SSOA, the methods used to assure safety, and the agencies' resources vary and are not necessarily commensurate with the amount of rail transit activity for which each agency is responsible. Of the 50 rail transit systems, 3 operate in multiple states and cross state boundaries:

- WMATA – District of Columbia, Maryland, and Virginia
- Port Authority Transit Corporation (PATCO) – Pennsylvania and New Jersey
- Metro Transit-St. Louis (MetroLink) – Missouri and Illinois

The three SSOAs for transit agencies that operate across state boundaries face the challenges of managing oversight authorities and responsibilities among different jurisdictions under separate bureaucracies. A 2006 report by the Government Accountability Office stated that although the oversight programs of MetroLink and PATCO appeared to be working well, WMATA's oversight program "experienced difficulty obtaining funding, responding to FTA information requests, and ensuring audit findings are addressed."[4]

WMATA

WMATA is unique in that it is the only rail transit agency in the country with an SSOA made up of representatives from three jurisdictions (Maryland, Virginia, and the District of Columbia); it is the Tri-State Oversight Committee (TOC). The TOC was established in 1997 by a memorandum of understanding (MOU) between the Virginia Department of Rail and Public

[2] We note that the August 2015 *Report on DOT Significant Rulemakings* states that the FTA rulemaking on the Public Transportation Safety Program indicates that a draft notice of proposed rulemaking (NPRM) had not yet been sent to the Office of Management and Budget and projects the publication date of the NPRM to be October 21, 2015.

[3] Federal Transit Administration, *State Safety Oversight (SSO) Program Annual Report for 2005* (Washington, DC: US Department of Transportation, Federal Transit Administration, 2005). http://www.fta.dot.gov/TSO/12537_12950.htm, accessed August 31, 2015.

[4] Government Accountability Office, *RAIL TRANSIT: Additional Federal Leadership Would Enhance FTA's State Safety Oversight* (Washington, DC: Government Accountability Office, 2006). http://www.gao.gov/products/GAO-06-821, accessed August 31, 2015.

Transportation (VDRPT) and the Departments of Transportation of Maryland (MDOT) and the District of Columbia (DCDOT). Amended in 2008 and again in 2010, the MOU specifies that the TOC be composed of six representatives, two from each of those agencies. The secretaries of transportation for the State of Maryland and the Commonwealth of Virginia and the director of transportation for the District of Columbia select their respective members. The MOU specifies that TOC members must select a chair and a vice chair who serve in those capacities for 2 years. At the end of the 2-year term, the vice chair becomes the chair, and a new vice chair is selected by the TOC members.

As the designated SSOA for WMATA, the TOC is required to develop and adopt a System Safety Program Standard, a document that establishes the relationship between the oversight agency and the rail transit agency and that specifies the requirements that the rail transit agency must follow.[5] The program standard must include requirements for safety practices to reduce the likelihood of unintentional events that may lead to death, injury, or property damage and security practices to reduce intentional wrongful or criminal acts or terrorist activities. The TOC does not conduct independent inspections of equipment, infrastructure, or operations as part of its safety oversight activities.[6] The TOC has no regulatory or enforcement authority, such as the ability to initiate or levy civil penalties. It must rely on WMATA to respond appropriately and in a timely manner to any safety concern, finding, or recommendation the TOC makes.

Under the requirements of MAP-21, the FTA must certify oversight agencies, and, as a result of certification, an SSOA can receive federal grant money. To gain certification, an SSOA must show the FTA that it is financially independent of the rail transit system it oversees, it has adequate authority to oversee those systems, and it has adequate resources to hire appropriate staff. In 2013, the TOC received notification from the FTA that it did not meet MAP-21 certification requirements. Until the TOC is certified, it is not eligible for FTA SSOA funding grants. The FTA's concerns with the TOC focused on the TOC's effectiveness as a legal organizational model for overseeing WMATA. The following is a summary of issues cited by the FTA that led to the TOC's not receiving certification:[7]

1. The TOC is a committee created by MOU between the VDRPT, MDOT, and DCDOT.
2. Beyond the MOU, the TOC has no enabling legislation, administrative code, or set of regulations that each jurisdiction has adopted to enforce safety provisions for WMATA.
3. As a committee created by MOU, the TOC is not a legal agency of any state but it is a "working group" responsible for implementing the FTA's existing SSO program requirements (49 *CFR* Part 659).
4. As a committee, not a legal agency of a state, the TOC cannot hire staff, establish qualifications or training requirements, promulgate or enforce legislation or regulations, issue contracts, or take independent action.
5. As specified in the MOU, each jurisdiction (VDRPT, MDOT, and DCDOT) contributes one full-time and one part-time staff member to serve on the TOC. The jurisdictions appoint these members based on their own preferences and considerations. As a result,

[5] Title 49 *CFR* 659.15, System Safety Program Standard.
[6] TOC Program Standards and Procedures, Exhibit F3, January, 2011. NTSB Docket, DCA15FR004.
[7] FTA GAP Analysis for the TOC with Attachments, Exhibit F1, October 2013. NTSB Docket, DCA15FR004.

the TOC has no uniform standards or qualifications for its members and no standard terms for employees.

6. TOC members are not managed and directed by the TOC but instead by their home jurisdictions. As a result, they can be moved or directed to support other safety or oversight activities in those home jurisdictions. For example, FTA SSO audits have found that MDOT and DCDOT both move their TOC members around to support other oversight programs (MDOT's program for the Maryland Transportation Administration) or agency safety obligations (engineering and construction of the DC Streetcar program).
7. The TOC chair position rotates every 2 years from jurisdiction to jurisdiction. This continual change in leadership exacerbates challenges for both TOC staff and WMATA in maintaining continuity and building expertise.
8. The TOC's members report up through the management and decision-making structures of the three separate jurisdictions. This situation makes it difficult for TOC members in the field to take expedient or independent action and to build consensus with each other regarding safety issues at WMATA. Findings, concerns, and approvals sometimes must move up the management structures of all three jurisdictions and back down to staff before any action can be taken.
9. All three jurisdictions have their own funding and political relationships with WMATA, with the counties serviced by WMATA, with the WMATA Board, and with each other.
    a. The director of DCDOT serves as a member of the WMATA Board
    b. All three jurisdictions have joint projects with WMATA
    c. All three jurisdictions provide subsidies and funding to WMATA

In a February 26, 2014, letter to the Secretary of Transportation, Governor McAuliffe (Virginia), then Governor O'Malley (Maryland), and then Mayor Grey of the District of Columbia authorized what they described as an actionable step to establish an independent state oversight agency that would conform to MAP-21. In doing so they proposed the Metro Safety Commission (MSC), an independent organization that would assume the responsibilities of the TOC. The letter offers no detail, but it references a White Paper, *Optimizing State Safety Oversight of the WMATA Metro Rail System*, prepared by their respective jurisdictions.

The White Paper includes a discussion of the inherent barriers that the structure and function of the TOC pose for effective implementation of the SSO program.[8] The paper describes the different jurisdictions' ideal SSO program for the oversight of WMATA and proposes actions necessary to achieve that ideal. It proposes to carry out this effort in two phases, acknowledging the time-consuming procedures and negotiations that would be required. Phase one is the creation of a strengthened Interim TOC Oversight Program, and phase two is either the legal creation of an MSC or federal oversight of WMATA's safety oversight functions.[9]

[8] Tri-State Oversight Committee Oversight Program White Paper, *Optimizing State Safety Oversight of the WMATA Metro Rail System* (The District of Columbia, Maryland, and Virginia: 2010).

[9] MAP-21 does not provide for direct federal safety oversight, and this alternative approach will not be pursued.

The White Paper proposes specific board membership, director, staff, facility, and funding requirements for the MSC. It includes discussion of the need for legal independence and authority for the MSC to conduct and enforce safety oversight of WMATA. However, the paper includes no details about establishing legal authority in a way that overcomes the multijurisdiction problems faced by the current TOC. Finally, it concedes that phase two will entail actions that will "consume years" to create. In the paper, the authors admit other challenges such as resources; legislation at the local, state, and federal levels; and budgetary constraints of all three jurisdictions that may further limit progress in achieving a robust safety oversight program. According to the TOC chairman, the earliest the MSC would come into existence is 2019.[10]

Discussion

The NTSB is concerned about the ongoing challenges to effective safety oversight of WMATA. The TOC's current approach to assuring safety of WMATA consists of audits, reviewing required WMATA safety plans, following up on reported accidents and incidents, and corrective action plans developed in response to audit findings or accident investigations. MAP-21 was enacted to create a national public transportation safety plan to improve safety of all public modes of transportation. It calls for an increased level of independent oversight of rail transit agencies. MAP-21 requires the establishment of safety performance criteria and performance standards, which serve as the foundation of a safety management system (SMS). The FTA Associate Administrator testified during the NTSB investigative hearing on the L'Enfant Plaza accident that MAP-21 is very similar to the current 49 *CFR* Part 659, stating, "It just has a higher bar of what's required for the state safety oversight agencies."

Testimony given at the investigative hearing demonstrated that although both the TOC and WMATA have made progress since the 2009 Fort Totten accident, significant safety, oversight, and organizational issues still exist in both agencies. The TOC has only three full-time employees, and each employee is paid by and accountable to a different jurisdiction: Maryland, Virginia, or the District of Columbia. The TOC has no offices; the TOC staff participates in audits but has not conducted a single investigation into any accident or incident, because all investigations have been delegated to WMATA; and the TOC has no enforcement authority.[11]

FTA enforcement authority will not change significantly under MAP-21. Because the FTA's safety authority primarily relies on SSOAs, it does not wield the same regulatory enforcement tools to compel safety compliance that are available to other agencies such as the Federal Railroad Administration (FRA). The FTA envisions using an SMS approach to implement the National Public Transportation Safety Plan that systemically and proactively identifies the factors that contribute to unsafe events and prevents or minimizes the likelihood of their occurrence.[12] The NTSB agrees that an SMS is a critical component of assuring organizational safety, and we look forward to increased oversight under MAP-21. However, neither MAP-21 nor 49 *CFR* Part 659 provides regulatory enforcement tools to compel compliance that are available to other agencies such as the FRA. Title 49 *CFR* Part 659 provides no authority for the FTA to conduct inspections of rail transit agencies, and although MAP-21 does include some additional authorities for the FTA, the only FTA enforcement tool is to

[10] TOC Plan for Transition to MSC, Exhibit F14, March 9, 2015, NTSB Docket, DCA15FR004.
[11] Title 49 *CFR* Part 659 authorizes an SSOA to delegate accident investigations to the transit agency.
[12] *Federal Register* 78, no. 192 (October 3, 2013): 61254.

withhold funds or require funds to be spent to correct a safety deficiency.[13] According to the FTA,

> safety oversight reviews would focus on the overall safety performance of an entire organization and effective implementation of the methods for identifying and evaluating safety risks and to mitigate exposure to those risks, instead of relying solely on strict compliance with regulatory requirements or technical standards.[14]

The infrastructure complexities of WMATA's system are comparable to those of commuter rail systems that are currently regulated by the FRA. The FRA exercises jurisdiction over all commuter services, as defined in 45 *USC* Section 1104(4), as provided by "commuter author[ities]" specifically enumerated in 45 *USC* 1104(3), including the Port Authority Trans-Hudson Corporation (PATH).[15]

PATH operates a 13.8-mile rapid transit system between New Jersey and New York. About one-half of the track is below ground level. Over 1,248 train movements per day carry about 244,000 passengers 5 days per week. Four major terminals and nine intermediate stations serve the closed system. PATH has 10 different speed limits ranging from 8 mph to 55 mph; the average speed over the system is about 20 mph. The FRA's authority to regulate this system is derived from 45 *USC* Section 1104(3), which means PATH is subject to FRA safety enforcement and oversight. PATH is a rail transit system similar to WMATA.

The FRA has established and developed robust inspection, oversight, regulatory, and enforcement authority and conducts regular safety compliance inspections of railroads. Title 49 *CFR* Part 209 describes the procedures used by the FRA in its enforcement of federal railroad safety statutes and regulations. According to appendix A to Part 209, those statutes include the Federal Railroad Safety Act of 1970 and a group of statutes enacted before 1970 referred to as the "older safety statutes." Other statutes include the Rail Safety Improvement Act of 1988, which raised the maximum civil penalties available under railroad safety laws and made individuals liable for willful violations of those laws.

The FRA administers and enforces the federal laws and related regulations designed to promote safety on railroads and exercises jurisdiction over all areas of railroad safety, such as track maintenance, inspection standards, equipment standards, and operating practices. It also administers and enforces regulations enacted under railroad safety legislation for locomotives, signals, safety appliances, power brakes, hours of service, transportation of explosives and other dangerous articles, and the reporting and investigation of railroad accidents. Railroad and related industry equipment, facilities, and records are inspected, and required reports are reviewed.

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[13] A proposed rule to establish a framework for the US Department of Transportation's authority, delegated to the FTA administrator, to monitor, oversee, and enforce safety in public transportation is at *Federal Register* 80, no. 157 (August 14, 2015): 48794.

[14] *Federal Register* 78, no. 192 (October 3, 2013): 61255.

[15] Title 45 *USC* Section 1104(3) designates the following entities as "commuter author[ities]": Metropolitan Transportation Authority, the Connecticut Department of Transportation, the Maryland Department of Transportation, the Southeastern Pennsylvania Transportation Authority, the New Jersey Transit Corporation, the Massachusetts Bay Transportation Authority, and any entity created by one or more such agencies for the purpose of operating, or contracting for the operation of, commuter service.

The FRA issues and enforces railroad safety regulations, administers railroad financial assistance programs, conducts research and development in support of improved railroad safety and national rail transportation policy, provides for the rehabilitation of Northeast Corridor rail passenger service, and consolidates government support of rail transportation activities. FRA inspectors document noncompliance on inspection reports. The FRA has several tools available when inspectors find that railroads are noncompliant with applicable regulations. It can issue civil penalties, individual liability penalties, compliance orders, and emergency orders. In contrast, the FTA and the TOC do not have such tools.

The FRA fulfills its mission through safety compliance inspections, audits, and accident investigations. Annually the FRA develops a National Inspection Plan (NIP).[16] The NIP is intended to reduce accidents by providing guidance to each FRA regional office on how inspectors in each of the five FRA disciplines—track, operating practices, motive power and equipment, signal and train control, and hazardous materials—should divide their work by railroad and state. Under this approach, the FRA uses data models to focus its inspectors' efforts in places deemed likely to have safety problems. The FRA headquarters uses accident, inspection, and other data to specify, by inspection discipline, numeric goals for the level of inspection activity to allocate to each railroad, by state. FRA regional administrators may adjust these goals for their respective regions based on local knowledge and emerging issues to allow regions to respond to new and/or unexpected events such as major accidents. The FRA monitors how the regions are meeting their inspection goals on an annual basis, and the regions are required to submit reports on any missed NIP goals. Furthermore, the FRA investigates all safety complaints from individuals, state and federal agencies, and railroads and their employees.

The FRA enforces the federal railroad safety regulations and laws with about 400 federal safety inspectors whose efforts are supplemented by about 165 state inspectors from states that participate in the FRA's State Inspection Program. Both Maryland and Virginia participate in the FRA's program. The state programs are important supplements to the NIP established by the FRA. The state inspectors coordinate with federal inspectors while monitoring the safety practices of each railroad company operating in the states. State inspectors are certified by the FRA. As states participating in the FRA state program, Maryland employs three FRA-qualified inspectors and Virginia employs six FRA-qualified inspectors. The role of the FRA-qualified inspectors is to inspect operating practices, motive power and equipment, and track and structures.

Another recent event illustrates the value that FRA oversight could bring to WMATA. On August 6, 2015, WMATA Metrorail train 412, a nonrevenue employee train, derailed on approach to the D02 (Smithsonian) Interlocking on track 2. Three of the six cars in the consist derailed. The derailed cars had not reached the switch points of the interlocking. WMATA's investigation into the derailment revealed that on July 9, 2015, a WMATA track geometry vehicle performed track measurement inspections on the Orange line of the Metrorail system through the area where the train derailed. This inspection identified a gage defect of 58.09 inches at chain marker D2-22+41 between the Federal Triangle station and the Smithsonian station, the

[16] The new National Rail Safety Action Plan was developed in response to a 2004 DOT Office of the Inspector General recommendation that the FRA develop a comprehensive program to use available data to focus inspection activities.

area where train 412 derailed. This gage exceeded WMATA's maximum gage standard of 57.75 inches, a condition often referred to as wide gage.

Track gage is the spacing of the rails measured between the inner faces of the load-bearing rails. Wide gage impedes the wheel-rail interface, and derailment is likely. WMATA policy requires immediately removing the track from service because of wide gage, as identified on July 9, 2015, until repairs are completed.[17] WMATA confirmed both the wide gage at the subsequent point of derailment and that this out-of-service track condition remained between July 9, 2015, and the August 6, 2015, derailment. For 27 days this gage defect remained in the track while WMATA continued to run revenue service trains over the track, with no reduction in speed or other mitigation.

FRA inspectors enforce the requirements set forth as Track Safety Standards in 49 *CFR* Part 213 in addition to operating practices and equipment safety standards for railroad operations. Track gage must be maintained within prescribed limits, or the track must be removed from service or the maximum track speed must be reduced.

Crosstie and wide gage defects are the second leading cause of derailments across the nation's railroads. The identification of track geometry defects during routine inspections is complex. Track geometry test vehicles using computerized tools enhance track inspections. FRA inspectors conduct ride-alongs on railroad-operated geometry cars. FRA inspectors monitor the data collected and observe remedial actions taken when defective conditions are identified. The FRA also operates its own geometry test vehicles under the Automated Track Inspection Program (ATIP). On an ATIP survey, an FRA inspector has the authority to stop the vehicle and objectively verify the defective conditions measured.

The role of FRA inspectors may vary depending on operational requirements. The FRA model includes data integrity oversight. Additionally, assurance of proper protection and remedial action are included. In many circumstances, after verification, the FRA may recommend a civil penalty assessment on the railroad if it is determined that the defective condition put railroad employees or the general public at risk.

With FRA oversight in place, the wide gage noted on July 9, 2015, would have required the track to be removed from service. Operations could have continued only after a designated person determined that operations could safely continue. Any operation also would be subject to limiting conditions specified by such person and at a maximum speed of 15 mph for a period of no longer than 30 days.[18]

Under the current safety oversight structure, the TOC does not have the authority to levy penalties or stop Metrorail revenue service for a track gage problem such as the one that existed for 27 days near the Smithsonian station and resulted in the derailment. Further, the only FTA enforcement action allowed under MAP-21 is withholding funds or directing funds to correct safety conditions.

[17] WMATA 1000 Track Maintenance and Inspection Manual.
[18] Title 49 *CFR* Part 213.

Conclusion

Regulatory assurance of compliance with standards and direct inspection and enforcement authority provides an increased measure of safety across all modes of transportation. The TOC currently does not have the authority, the expertise, or the resources to provide assurance of compliance. The TOC does not have a standardized set of regulations to draw upon. The TOC cannot issue civil penalties, individual liability penalties, compliance orders, or emergency orders nor can it conduct independent inspections.

The NTSB has initiated 11 investigations on the WMATA rail system over the past 33 years. In total, these accidents and incidents have resulted in 18 fatalities. Many of the NTSB investigations determined that WMATA's inadequate management of its operation contributed to the events, and based on the repeated and ongoing deficiencies identified during its investigations of accidents and incidents involving WMATA, the NTSB concludes that the TOC cannot perform effective safety oversight of the WMATA rail system. Based on testimony from representatives of the TOC and the FTA during the NTSB's June 23, 2015, investigative hearing on the January 12, 2015, WMATA Metrorail accident, the NTSB further concludes that neither the regulatory changes the FTA can make as a result of MAP-21 nor the proposed creation of a Metro Safety Commission will likely resolve the deficiencies identified in safety oversight of WMATA.

The FRA has an established state inspection program whereby states can participate in regulatory oversight. The District of Columbia, the State of Maryland, and the Commonwealth of Virginia, through the FRA's state inspection program, could remain involved in safety oversight of WMATA.

Without adequate oversight, accidents and incidents will continue to place the riders of the WMATA system at risk. The NTSB therefore proposes that the DOT seek the authorization under 45 *USC* Section 1104 to classify WMATA as a commuter authority, thus placing WMATA under the regulatory authority of the FRA.

The Congress is currently working on a surface transportation bill to reauthorize the DOT's surface transportation administrations, including the FRA and the FTA. This provides an opportunity to revise 45 *USC* Section 1104(3) to list WMATA as a commuter authority, thus placing WMATA under FRA regulatory oversight.

Therefore, the NTSB makes the following urgent safety recommendations to the US Department of Transportation:

> Seek an amendment to Title 45 *United States Code* Section 1104(3) to list the Washington Metropolitan Area Transit Authority as a commuter authority, thus authorizing the Federal Railroad Administration to exercise regulatory oversight of the Washington Metropolitan Area Transit Authority's rail system. (R-15-31) (Urgent)

After Title 45 *United States Code* Section 1104(3) is amended to include the Washington Metropolitan Area Transit Authority, direct the Administrator of the Federal Railroad Administration to develop and implement a plan to transition the oversight of the Washington Metropolitan Area Transit Authority's rail system to the Federal Railroad Administration within 6 months. (R-15-32) (Urgent)

Chairman HART, Vice Chairman DINH-ZARR, and Members SUMWALT and WEENER concurred in these recommendations.

We are vitally interested in these recommendations because they are designed to prevent accidents and save lives. We would appreciate receiving a response from you within 30 days detailing the actions you have taken or intend to take to implement them. When replying, please refer to the safety recommendations by number. We encourage you to submit your response electronically to correspondence@ntsb.gov.

[Original Signed]

By: Christopher A. Hart,
Chairman

Appendix I. October 9, 2015, Letter from the Secretary of Transportation to the NTSB

201500988

THE SECRETARY OF TRANSPORTATION
WASHINGTON, DC 20590

October 9, 2015

The Honorable Christopher A. Hart
Chairman
National Transportation Safety Board
490 L'Enfant Plaza East, SW
Washington, DC 20594

Dear Chairman Hart:

This correspondence is in response to Urgent Safety Recommendation R-15-31 and 32 issued by the National Transportation Safety Board (NTSB) on September 30, 2015. The NTSB issued these recommendations as part of its ongoing investigation of the smoke and arcing accident at the Washington Metropolitan Area Transit Authority (WMATA) Metrorail's L'Enfant Plaza station on January 12, 2015, as well as other events indicating inadequate safety oversight of WMATA.

We take every recommendation of the NTSB seriously, including how quickly we can implement an urgent recommendation. In this case, we agree on the problem identified by NTSB, but believe there is a faster, more effective way to address it.

NTSB is recommending that the U.S. Department of Transportation (DOT) seek a legislative change from Congress to transfer responsibility for oversight of WMATA's transit rail operations to the Federal Railroad Administration (FRA) from the Tri-State Oversight Committee (TOC), which is currently responsible for safety oversight of Metrorail, but lacks sufficient resources, technical capacity, and enforcement authority to provide the level of oversight that is needed. We agree that the TOC, as currently established, is ineffective. We disagree, however, that the best, most urgent and most effective solution is to transfer safety oversight of WMATA's rail transit system to the Federal Railroad Administration.

Through the Moving Ahead for Progress in the 21st Century Act (MAP-21) legislation, Congress provided the Federal Transit Administration (FTA) with greatly enhanced, independent safety oversight authority, which augments the enhanced authority of State Safety Oversight Agencies (SSOA), and if necessary, allows FTA to assume those same authorities in the absence of an effective SSO agency. FTA has the capability to assert this authority and, at my direction, will do so immediately.

This increased oversight means that FTA will now directly enforce and investigate the safety oversight of WMATA Metrorail until the District of Columbia, Maryland, and Virginia establish a fully functioning and capable SSOA. This expanded FTA enforcement effort will: include orders and directives pursuant to 49 U.S.C. § 5329(f) and (g); require WMATA to spend Federal funds to address safety deficiencies; and amend the Corrective Acton Plan (CAP) to include previous TOC notices of deficiencies, the implementation of which will be overseen directly by FTA with assistance from the TOC.

The FTA investigation efforts will include unannounced facility inspections and issuance of directives as necessary to address safety deficiencies. The FTA will also coordinate a robust level of funding from existing resources to carry out enhanced oversight.

The FTA will maintain this higher level of oversight until a compliant and capable SSOA is established to replace the TOC. WMATA must also immediately hire a capable General Manager who is able to correct the course at the transit agency and aggressively manage the implementation of the Corrective Action Plan, which has been approved by the FTA. The urgency of having accountable leadership at the helm of WMATA cannot be overstated. Daily operations of WMATA will continue to be run by WMATA and must be responsive to the FTA as it assumes direct leadership of safety oversight from the TOC. We believe this approach accomplishes the same goals as the NTSB's urgent recommendations, albeit with greater speed and within the responsible agency.

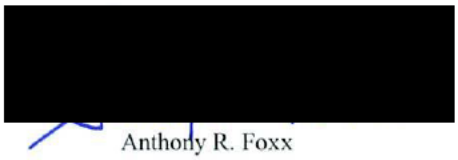
The FTA has already taken many direct oversight actions this year, as can be seen on the FTA website at http://www.fta.dot.gov/, and this would continue and intensify that effort. The FTA recently conducted a comprehensive safety management inspection of WMATA Metrorail and Metrobus that made 54 safety findings, including 44 related to Metrorail. As a result, FTA issued a Safety Directive outlining 91 required actions that WMATA must take to improve safety, including 78 specifically for Metrorail. FTA approved last month and is now actively tracking and monitoring the implementation of the CAP that WMATA developed to address these issues. The FTA also audited the TOC and came to many of the same conclusions as the NTSB did about its shortcomings.

By contrast, the NTSB recommendation shifts oversight from one agency to another one, creating confusion and a greater risk of slowing down improvements. More practically, WMATA does not have an understanding or familiarity with FRA regulations, and separating their rail and bus oversight into different regulatory structures would confuse and likely delay safety improvements. Because FTA has the authority under existing law, I am directing FTA to exert federal safety oversight over WMATA Metrorail and to use every reasonable aspect of its other authorities to address this situation.

Under the law, FTA can direct safety activities of the SSOAs as well as the transit agencies. To address the safety concerns of WMATA, FTA has already conducted a Safety Management Inspection and issued a Safety Directive requiring WMATA to take a series of corrective measures. The law provides grant funding to increase the resources available to carry out these new requirements, and a timeline by which they must be achieved.

Clearly, more needs to be done to ensure that there is sufficient safety oversight of WMATA until a MAP-21-compliant SSO regime is in place. The TOC has submitted a plan to achieve compliance, but it is not achievable in the short term. The approach we have outlined will allow for a ramping up of oversight of WMATA to a level consistent with what would be in place once a fully MAP-21-compliant SSOA is established. Therefore, it is essential that the District of Columbia, Maryland, and Virginia proceed with all due haste to establish a fully compliant SSOA. The DOT will engage with the State and Federal officials from the region to expedite the required steps to replace the TOC with a fully functioning, sufficiently resourced SSO organization. Until a fully capable SSO is in place, the FTA will lead all oversight, inspection, and enforcement activities over WMATA.

Sincerely,



Anthony R. Foxx

Appendix J. Comparison of Federal Transit Administration and Federal Railroad Administration Authority

	FTA	FRA
Regulatory Authority	The FTA's authority to regulate rail transit properties is limited. The FTA sets the standards for the state oversight agencies and partially funds certified agencies through grants.	The FRA's authority to regulate railroads comes from legislation based on the Commerce Clause in the US Constitution.
Safety Regulation and Minimum Safety Standards	The FTA has published no safety standards or regulations. The FTA's proposed National Public Transportation Safety Plan cites references. MAP-21 provides for the FTA to establish minimum vehicle standards in the National Public Transportation Safety Plan; however, a guidance document will not have the force of law. The FAST Act gives the FTA authority to issue minimum safety standards other than vehicle safety standards through the rulemaking process. The FTA has proposed no rules to establish minimum safety standards.	Title 49 *Code of Federal Regulations* (*CFR*) Parts 200–299 set forth minimum safety standards for the following: Part 213 - Track safety standards Part 214 -Railroad workplace safety Part 217 - Railroad operating rules Part 218 - Railroad operating practices Part 219 - Control of alcohol and drug use Part 220 - Railroad communications Part 221 - Rear end marking devices for passenger, commuter, and freight trains Part 223 - Safety glazing standards for locomotives, passenger cars, and cabooses Part 225 - railroad accident/incident reports classification and investigations Part 227 - Occupational noise exposure Part 228 - Hours of service of railroad employees, record keeping and reporting, sleeping quarters Part 229 - Railroad locomotive safety standards Part 231 - Railroad safety appliance standards Part 232 - Brake system safety standards for freight and other nonpassenger trains and equipment; end of train devices Part 233 - Signal system requirements Part 235 - Instructions governing applications for approval of a discontinuance or material modification of a signal system Part 236 - Rules, standards, and instructions governing the installation, inspection, maintenance, and repair of signal and train control systems, devices, and appliances Part 237 - Bridge safety standards

	FTA	FRA
Safety Regulation and Minimum Safety Standards, continued		Part 238 - Passenger equipment safety standards Part 239 - Passenger train emergency preparedness Part 240 - Qualification and certification of locomotive engineers Part 242 - Qualification and certification of conductors
Safety Oversight Regulations	Title 49 *CFR* Part 655 establishes programs to be implemented by employers that receive financial assistance from the FTA, and by contractors of those employers, that are designed to help prevent accidents, injuries, and fatalities resulting from the misuse of alcohol and use of prohibited drugs by employees who perform safety-sensitive functions. Part 659 - Rail Fixed Guideway Systems, State Safety Oversight. This part implements 49 USC 5330 by requiring a state to oversee the safety and security of rail fixed guideway systems through a designated oversight agency. NOTE: This regulation is repealed effective April 16, 2019 (3 years after issuance of 49 *CFR* Part 674). Title 49 *CFR* Part 670 - (Notice of Proposed Rulemaking (NPRM), *FR* 80, no. 157 (August 14, 2015): 48794) Proposed Public Transportation Safety Program as required by MAP-21, Pub. L. 112-141 (2012) and 49 USC 5329, adopting safety management systems as the basis for the program. This NPRM established the framework for the secretary's authority delegated to the FTA administrator to monitor, oversee, and enforce safety in the public transportation industry. Title 49 *CFR* Part 672 - Final rule for interim safety certification training provisions as the initial regulatory training requirements for public transportation industry personnel responsible for safety oversight of public transportation systems, *FR* 80, no. 39 (February 27, 2015): 10619. Another NPRM was published on December 3, 2015, proposing the adoption of the interim safety certification training provision as the final rule for the Public Transportation Safety Certification Training Program: *FR* 80, no. 232 (December 3, 2015): 75639.	Federal Railroad Safety Act of 1970, 45 United States Code (USC) 421, 431–441, as amended by the Rail Safety Improvement Act of 1988, and authority from 49 App. USC 16559e (49 *CFR* 1.49 (c), (d), (f), and (g). [42 *Federal Register* (FR) 56742, October 28, 1977, as amended at 53 FR 52920, December 29, 1988; 54 FR 42905, October 18, 1989]

	FTA	FRA
Safety Oversight Regulations, continued	49 CFR Part 673 (NPRM- *FR* 81, no 24, (February 5, 2016): 6344)[a] The proposed rule for Public Transportation Agency Safety Plans established the requirements for the adoption of Safety Management Systems (SMS) principles and methods; the development, certification, and update of Public Transportation Agency Safety Plans and required elements and approval process of those plans; and the coordination of Public Transportation Agency Safety Plan elements with other FTA programs and proposed rules, as specified in 49 U.S.C. 5329. The FTA published its intent to issue the National Public Transportation Safety Plan as a guidance document on February 5, 2017, FR vol. 81, no 24, 6344.	
Oversight Resources	The FTA has a very small staff to regulate, audit, investigate, and administer the state safety oversight program. The FTA currently uses qualified inspectors from other DOT agencies (primarily the FRA) to perform audits and inspections of WMATA.	The FRA enforces the federal rail safety regulations and laws with about 400 trained and qualified federal safety inspectors whose efforts are supplemented by about 165 state inspectors from states that participate in the FRA's State Inspection Program. Both Maryland and Virginia have participating railroad inspection programs.
Safety Compliance	The FTA is limited in compliance tools. The primary tool available is the withholding of funds. They have no enforcement authority to levy civil penalties, individual liability penalties, compliance orders or emergency orders. It must rely on the agency, in this case WMATA, to respond appropriately and timely to any safety concern, finding or recommendation.	The FRA has several tools available to use when inspectors find that railroads are not in compliance with applicable regulations. The FRA can issue civil penalties, individual liability penalties, compliance orders, special notice for repair, and emergency orders.
Safety Data	The FTA maintains the National Transit Database (NTD), which was established by Congress to be the nation's primary source for information and statistics on the transit systems of the United States. Recipients or beneficiaries of grants from the FTA under the Urbanized Area Formula Program (§5307) or Other than Urbanized Area (Rural) Formula Program (§5311) are required by statute to submit data to the NTD. More than 660 transit providers in urbanized areas currently report to the NTD through the Internet-based reporting system. Each year, NTD performance data are used to apportion more than $5 billion of FTA funds to transit agencies in urbanized areas. Annual NTD reports summarizing transit service and safety data are submitted to Congress.	The FRA is a data-driven agency. Regulations, Safety Advisories, and Emergency Orders are based on facts and research using statistical methods and modeling. The FRA collects and analyzes data from the railroads and converts this information into meaningful statistical tables, charts, and reports that can be found on the FRA Safety Data site. In addition to railroad reported accidents and incidents, the FRA continuously monitors the occurrence of train accidents and incidents and investigates serious events to determine their cause and compliance with existing safety laws and regulations. Detailed information on FRA investigations is available on the FRA website.

[a]MAP-21, Pub. L. 112-141, July 6, 2012; FAST Act, Pub. L. 114-94, December 4, 2015; USC 5329.

	FTA	FRA
Research and Development	The FTA undertakes nationally significant research, development, demonstration, deployment, and evaluation projects to improve public transportation services.	The FRA's research and development (R&D) mission is to ensure the safe, efficient, and reliable movement of people and goods by rail through basic and applied research and development of innovations and solutions. Safety is the DOT's primary strategic goal and thus the principal driver of the FRA's R&D program. The FRA's R&D program also contributes to other DOT strategic goals because safety-focused projects typically yield solutions toward the state of good repair, economic competitiveness, and environmental sustainability goals. The R&D program also has an important role to play in workforce development. The FRA's R&D program is founded on an understanding of safety risks in the industry. Hazard identification and risk analysis allows the FRA to identify opportunities to reduce the likelihood of accidents and incidents and to limit the consequences of hazardous events should they occur. Key strategies include stakeholder engagement and partnerships with other researchers such as the Association of American Railroads, prioritization of projects, and conducting research through cost-effective procurement.

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