NATIONAL TRANSPORTATION SAFETY BOARD
Public Meeting of July 27, 2010
(Information subject to editing)

Collision of Two Washington Metropolitan Area Transit Authority Metrorail Trains Near Fort Totten Station, Washington, D.C. June 22, 2009 Railroad Accident Report NTSB/RAR-10/02

This is a synopsis from the Safety Board's report and does not include the Board's rationale for the conclusions, probable cause, and safety recommendations. Safety Board staff is currently making final revisions to the report from which the attached conclusions and safety recommendations have been extracted. The final report and pertinent safety recommendation letters will be distributed to recommendation recipients as soon as possible. The attached information is subject to further review and editing.

EXECUTIVE SUMMARY

On Monday, June 22, 2009, about 4:58 p.m., eastern daylight time, inbound Washington Metropolitan Area Transit Authority (WMATA) Metrorail train 112 struck the rear of stopped inbound Metrorail train 214. The accident occurred on aboveground track on the Metrorail Red Line near the Fort Totten station in Washington, D.C. 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. Damage to train equipment was estimated to be $12 million.

CONCLUSIONS

1. The following were neither causal nor contributory to the accident: weather, training and qualifications of the train operators, fatigue, use of alcohol or illegal drugs by the train operators, track structure and rail integrity, and condition and performance of train mechanical equipment.

2. The operator's decision to operate train 214 (the struck train) in manual mode during the evening rush hour period was in violation of Metro rules, but track circuit B2-304 was failing to detect trains, regardless of whether they were operating in manual or automatic mode.

3. Because train 214, which was being operated in manual mode, was traveling at a much slower speed than the authorized speed commands it was receiving, train 214 stopped completely within the faulty B2-304 track circuit when its detection was lost and it received a 0 mph speed command.

4. Because of the design of the Washington Metropolitan Area Transit Authority (WMATA) operations control center information management system and the high number of track circuit failure alarms routinely generated by that system, operations control center controllers could not have been expected to be aware of the impending collision or to warn either train operator.

5. Considering the challenges of the recovery operations, the emergency response was well coordinated and effectively managed.

6. The Metrorail automatic train control system stopped detecting the presence of train 214 (the struck train) in track circuit B2-304, which caused train 214 to stop and also allowed speed commands to be transmitted to train 112 (the striking train) until the collision.

7. Even though the operator of train 112 activated emergency braking before the collision, there was not enough time, once train 214 came into full view, to stop the train and avoid a collision.

8. On the day of the accident, parasitic oscillation in the track circuit modules for track circuit B2-304 was creating a spurious signal that mimicked a valid track circuit signal, thus causing the track circuit to fail to detect the presence of train 214.

9. Spurious signals had been causing the track circuit modules for track circuit B2-304 to erroneously indicate that the track circuit was vacant from the time the track circuit transmitter power was increased after the impedance bond was replaced on June 17, 2009, until the accident 5 days later.

10. Train operators did not report problems with track circuit B2-304 before the accident because reductions in speed commands to maintain train separation, or even momentary losses of all speed commands, were common during train operations.

11. The track circuit modules did not function safely as part of a fail-safe train control system because GRS/Alstom did not provide a maintenance plan that would detect anomalies in the track circuit signal, such as parasitic oscillation, over the modules' service life and prevent these anomalies from being interpreted as valid track circuit signals.

12. Some of the General Railway Signal Company (GRS) track circuit modules in use on the WMATA Metrorail system continue to exhibit parasitic oscillation, and the presence of this oscillation presents an unacceptable risk to Metrorail users.

13. As shown by the fact that (1) the GRS modules in the accident track circuit B2-304 consistently exhibited parasitic oscillation in on-scene and laboratory testing regardless of the type of impedance bond or simulated load used, (2) numerous other Metrorail track circuits that used all GRS components were found to have parasitic oscillation similar to the oscillation found at Fort Totten, and (3) numerous other track circuits with components made by different manufacturers showed no evidence of such oscillation, this accident did not result from WMATA's use of Union Switch & Signal impedance bonds with GRS track circuit modules.

14. The change in transmitter power level necessitated by the installation of a Union Switch & Signal impedance bond in track circuit B2-304 was within the design parameters of the equipment and would not have resulted in a failure of train detection in the absence of parasitic oscillation within the GRS track circuit modules.

15. WMATA failed to institutionalize and employ systemwide the enhanced track circuit verification test developed following the 2005 Rosslyn near-collisions, and this test procedure, had it been formally implemented, would have been sufficient to identify track circuits that could fail in the manner of those at Rosslyn and Fort Totten.

16. If proper shunt placements had been used, as required by WMATA's procedures, to verify track circuit B2-304 either immediately after the new impedance bond was installed on June 17, 2009, or when the track circuit was tested the following day, the work crews would have been able to determine that the track circuit was failing to detect trains, and actions could have been taken to resolve the problem and prevent the accident.

17. A technician following the manufacturer-provided GRS track circuit module maintenance procedures would not have detected the spurious signals that caused track circuit B2-304 to fail in an unsafe manner.

18. WMATA Metrorail automatic train control test procedure T163, developed since this accident, will permit technicians to detect the presence of parasitic oscillation like that found in the failed track circuit modules at Fort Totten; however, unless these procedures are carried out on a periodic basis, an unsafe condition may persist for some time before being discovered and corrected.

19. A comprehensive safety analysis of an automatic train control system must consider all foreseeable system failures that may result in a loss of train separation, including failures in train detection caused by track circuit failures.

20. WMATA did not effectively distribute technical bulletins and safety information to its automatic train control technicians nor did it ensure that the information was received, understood, and properly acted upon by those technicians.

21. WMATA failed to recognize that the near-collisions at Rosslyn in 2005 represented an unacceptable hazard that had not been considered in the fail-safe design of the automatic train control system, and WMATA failed to communicate that hazard to the affected divisions in the organization for resolution.

22. The Metrorail maintenance communication line system—a system that was in disrepair and was apparently no longer needed by WMATA—could allow unanticipated signal paths that could degrade the integrity, and thus the safety, of the Metrorail automatic train control system.

23. As revealed by postaccident testing, the cables serving the impedance bonds for track circuit B2-304 did not meet proposed WMATA Metrorail standards for insulation resistance, and although this did not cause or contribute to the accident, such

deficiencies, if undetected and uncorrected, could undermine the safety of the Metrorail train control system.

24. The structure of the Federal Transit Administration'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.

25. The results of this investigation, as well as the Federal Transit Administration's audit of the Tri-State Oversight Committee and WMATA, determined that the Tri-State Oversight Committee has been ineffective in providing proper safety oversight of and lacks the necessary authority to properly oversee the WMATA Metrorail system.

26. The results of this investigation and the findings and recommendations contained in the Federal Transit Administration's March 4, 2010, Final Audit Report of its 2009 safety audit of the Tri-State Oversight Committee and WMATA, if implemented, will enhance WMATA Metrorail passenger and employee safety.

27. The low priority that WMATA Metrorail managers placed on addressing malfunctions in the train control system before the accident likely influenced the inadequate response to such malfunctions by automatic train control technicians, operations control center controllers, and train operators.

28. The steps that WMATA has taken since the Fort Totten accident, such as improving and increasing the use of the loss-of-shunt software tool for identifying track circuit malfunctions, will contribute to improving the safety of the system.

29. The safety of transit rail operations would be improved by periodic transit agency review of recorded operational data and non-punitive safety reports, which have been demonstrated to be effective tools for identifying safety problems in other modes of transportation.

30. Based on the results of this investigation and the Federal Transit Administration's recent safety audit, WMATA was not adequately assessing the severity of hazardous risk associated with identified anomalies in its automatic train control system.

31. The WMATA Board of Directors did not exercise oversight responsibility for the system safety of the WMATA system.

32. Before the accident, the WMATA Board of Directors did not seek adequate information about, nor did it demonstrate adequate oversight to address, the number of open corrective action plans from previous Tri-State Oversight Committee and Federal Transit Administration safety audits of WMATA.

33. Before the accident, the position of chief safety officer lacked the necessary resources and authority within the organizational structure of WMATA to adequately identify and address system safety issues, ensure the distribution of safety-critical information throughout the organization, or manage the system safety program plan as required by 49 *Code of Federal Regulations* Part 659.

34. 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.

35. Previous attempts at non-regulatory oversight failed to compel WMATA to maintain the organizational structure necessary to ensure effective identification and communication of safety-critical information throughout its Metrorail operations.

36. The FTA's lack of toxicological specimen authority prevents transit agencies from collecting pertinent information for determining the circumstances of transit accidents.

37. The structural design of the 1000-series railcars offers little occupant protection against a catastrophic loss of occupant survival space in a collision, and the continued use of these cars in revenue service constitutes an unacceptable risk to WMATA Metrorail users.

38. WMATA's practice of bellying the 1000-series cars does not provide appreciable crashworthiness benefits and is not an acceptable substitute for removing the cars from service.

39. The lack of onboard event recording capability on the striking train prevented a definitive determination of train performance, the status of the onboard systems, and the operator's actions before the collision.

40. Because WMATA does not have a program to monitor the performance of onboard event recorders or to ensure that they are functioning properly, these devices cannot be relied upon by WMATA to provide data that can be used for accident investigations or for equipment or operations monitoring and maintenance.

PROBABLE CAUSE

The National Transportation Safety Board determines that the probable cause of the June 22, 2009, collision of Washington Metropolitan Area Transit Authority (WMATA) Metrorail train 112 with the rear of standing train 214 near the Fort Totten station 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.

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 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 previous accidents to exhibit poor crashworthiness.

RECOMMENDATIONS

As a result of its investigation of this accident, the National Transportation Safety Board makes the following safety recommendations.

New Recommendations

As a result of its investigation of this accident, the National Transportation Safety Board makes the following safety recommendations.

To the U.S. Department of Transportation:

1. 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.

To the Federal Transit Administration:

2. 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.

3. Seek authority similar to FRA regulations (49 CFR 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.

To the Tri-State Oversight Committee:

4. Work with WMATA 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 WMATA.

To the Board of Directors, Washington Metropolitan Area Transit Authority:

5. Elevate the safety oversight role of the WMATA 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.

To Washington Metropolitan Area Transit Authority:

6. Because of the susceptibility to pulse-type parasitic oscillation that can cause a loss of train detection by the Generation 2 GRS audio frequency track circuit modules, establish a program to permanently remove from service all of these modules within the Metrorail system.

7. 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. 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.

9. Completely remove the unnecessary Metrorail wayside maintenance communication system to eliminate its potential for interfering with the proper functioning of the train control system.

10. 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.

11. Based on the findings of the safety analysis recommended in the previous recommendation, incorporate the design, operational, and maintenance controls necessary to address potential failures in the automatic train control system.

12. Implement cable insulation resistance testing as part of Metrorail's periodic maintenance program.

13. 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 WMATA.

14. 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.

15. 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.

16. 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.

17. Develop a formal process by which the General Manager and managers responsible for WMATA 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.

18. 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.

19. Ensure that the lead married-pair car set of each train is equipped with an operating onboard event recorder.

20. Develop and implement a program to monitor the performance of onboard event recorders and ensure they are functioning properly.

To Alstom Signaling Inc.:

21. Develop and implement periodic inspection and maintenance guidelines for use by WMATA and other rail transit operators and railroads equipped with GRS audio frequency track circuit modules and assist them in identifying and removing from service all modules that exhibit pulse-type parasitic oscillation in order to ensure the vitality and integrity of the automatic train control system.

22. Conduct a comprehensive safety analysis of your audio frequency track circuit modules to evaluate all foreseeable failure modes that could cause a loss of train detection over the service life of the modules, including parasitic oscillation, and work with your customers to address these failure modes.

To Massachusetts Bay Transportation Authority, Southeastern Pennsylvania Transportation Authority, Greater Cleveland Regional Transit Authority, Metropolitan Atlanta Regional Transportation Authority, Los Angeles County Metropolitan Transportation Authority, and Chicago Transit Authority:

23. Work with Alstom Signaling Inc. to establish periodic inspection and maintenance procedures to examine all GRS audio frequency track circuit modules to identify and remove from service any modules that exhibit pulse-type parasitic oscillation.

Previously Issued Recommendations

As a result of this accident investigation, the National Transportation Safety Board previously issued the following safety recommendations:

To the Federal Transit Administration:

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. (R-09-7 Urgent) (Currently classified "Open—Acceptable Response.")

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. (R-09-17 Urgent) (Classified "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. (R-09-18 Urgent) (Classified "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. (R-09-19) (Currently classified "Open—Acceptable Response.")

To the Federal Railroad Administration:

Advise all railroads 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. (R-09-20 Urgent) (Classified "Closed—Acceptable Action."

Require all railroads 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. (R-09-21 Urgent) (Currently classified "Open—Acceptable Response.")

Require all railroads 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. (R-09-22) (Currently classified "Open—Acceptable Response.")

To Washington Metropolitan Area Transit Authority:

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. (R-09-6 Urgent) (Currently classified "Open—Acceptable Response.")

Develop a program to periodically determine that electronic components in your train control system are performing within design tolerances. (R-09-16) (Currently classified "Open—Initial Response Received.")

Previously Issued Recommendations Reclassified in This Report

To Washington Metropolitan Area Transit Authority:

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). (R-09-15 Urgent)

Urgent Safety Recommendation R-09-15, previously classified "Open—Acceptable Response," is reclassified "Closed—Superseded."

To Alstom Signaling Inc.:

Assist the WMATA, and other rail transit operators and railroads that use your audio frequency track circuit equipment, in examining their train control systems for susceptibility to parasitic oscillations and spurious-

signals capable of exploiting unintended signal paths, and implementing measures to eliminate those adverse conditions that could affect the safe performance of their train control systems. (R-09-23 Urgent)

Urgent Safety Recommendation R-09-23, previously classified "Open—Acceptable Response," is reclassified "Closed—Superseded."