



National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: August 10, 2010

In reply refer to: R-10-23 and -24

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The National Transportation Safety Board (NTSB) is an independent federal agency charged by Congress with investigating transportation accidents, determining their probable cause, and making recommendations to prevent similar accidents from occurring. We are providing the following information to urge your organization to take action on the safety recommendations in this letter. The NTSB is vitally interested in these recommendations because they are designed to prevent accidents and save lives.

The recommendations are derived from the NTSB's investigation of the June 22, 2009, collision of two Washington Metropolitan Area Transit Authority (WMATA) Metrorail trains near the Fort Totten station and are consistent with the evidence we found and the analysis we performed. As a result of this investigation, the NTSB has issued 23 safety recommendations, 2 of which are addressed to Alstom Signaling Inc. (Alstom). Information supporting these recommendations is discussed below. The NTSB would appreciate a response from you within 90 days addressing the actions you have taken or intend to take to implement our recommendations.

On Monday, June 22, 2009, about 4:58 p.m., eastern daylight time, inbound 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 telescope¹ 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

¹ *Telescoping* occurs when a railcar body breaches the end structure of another carbody and passes into the structure of that carbody.

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.²

The NTSB determined that the probable cause of the June 22, 2009, collision of 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 a previous accident to exhibit poor crashworthiness.

The collision occurred within a 738-foot-long track circuit designated B2-304, located about 1/2 mile north of the Fort Totten station. Postaccident examination of the equipment revealed that the track relay for track circuit B2-304 was out of correspondence with the physical location of the accident trains. That is, the track relay was energized (indicating a vacant track circuit) even though both accident trains were still occupying the block and shunting the track circuit.

Postaccident testing conducted by the NTSB detected signal coupling between the General Railway Signal Company (GRS) automatic train protection track circuit transmitter and receiver modules that contributed to energizing the B2-304 track relay (indicating "vacant") while the track circuit was actually occupied. This testing identified parasitic oscillation generated by the power output transistors of the track-circuit transmitter. This oscillation produced a spurious track-circuit signal that was picked up by the track-circuit receiver and interpreted as the nonshunted signal coming from the receiver impedance bond. The parasitic oscillation was generated by the transmitter module and coupled through the heat sinks and through the rack and module structures to other modules that shared the same power source and rack.

On September 22, 2009, the NTSB issued the following safety recommendation to Alstom:

² See *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 (Washington, DC: National Transportation Safety Board, 2010) on the NTSB website at <<http://ntsb.gov/publictn/2010/RAR1002.pdf>>.

Assist the Washington Metropolitan Area Transit Authority, 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)

The manufacturer-recommended maintenance schedule for the GRS track circuit modules used by WMATA outlines a series of tests involving the measurement of average and peak-to-peak voltage levels and certain operating frequencies. These measurements are designed to ensure that the track circuit transmitter and receiver modules are operating at reasonable power and sensitivity levels and within published frequency tolerances. This maintenance schedule does not specify the measurement of detailed signal waveform parameters, such as total harmonic distortion and spectral frequency distribution, that would have revealed the presence of parasitic oscillation.

Only one procedure calls for the use of an oscilloscope capable of detailed signal waveform measurement. This procedure only calls for simple peak-to-peak voltage measurement and sets no minimum vertical bandwidth requirement on the oscilloscope to be used. Most important, the recommended maintenance contains no discussion of tests designed to determine the presence of spurious signals that could mimic a valid track circuit signal. The NTSB concludes that 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.

On June 26, 2010, Alstom informed the NTSB that it was continuing to evaluate strategies for mitigating the pulse-type parasitic oscillation found in the Generation 2 GRS modules at Fort Totten. Alstom also told the NTSB that it had contacted other transit agencies known to be using Generation 2 GRS modules and that it had done limited testing at each site to identify modules exhibiting behavior similar to the modules at Fort Totten. Alstom has also developed a new procedure and test equipment that the company says it will use to test all the known Generation 2 GRS modules currently in service across the country. Although the NTSB welcomes this effort, it believes that in addition to one-time testing, rail transit operators that use GRS audio frequency track circuit equipment should be provided with maintenance guidelines that ensure that the automatic train control system is properly maintained over time. The NTSB therefore recommends that Alstom 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.

In May 2010, the NTSB contacted several transit agencies that use GRS audio frequency track circuit modules similar to those used by WMATA. Some of those agencies told the NTSB that they have asked Alstom to provide them with guidelines to test for parasitic oscillation so that such tests can be incorporated into their track circuit inspection and maintenance programs. They also reported that Alstom had not responded to their requests; however, Alstom notified the NTSB on June 26, 2010, that “Alstom is in the process of arranging site visits to all of its

customers using Generation 2 modules to test and document the condition of all the identified track circuits.” Therefore, the NTSB is issuing the following safety recommendation to the six other rail transit agencies³ that use GRS audio frequency track circuit modules:

Work with Alstom Signaling Inc. to establish periodic inspection and maintenance procedures to examine all General Railway Signal Company audio frequency track circuit modules to identify and remove from service any modules that exhibit pulse-type parasitic oscillation. (R-10-25)

The investigation found that parasitic oscillation was not unique to track circuit B2-304. The power amplifier circuits used in Metrorail’s GRS track circuit modules are of the emitter-follower type, which are known to be prone to oscillate. Parasitic oscillation is a known potential problem with any amplifier circuit, which could result in the generation of unwanted additional signals, along with the intended amplified output signal. Alstom has informed the NTSB that, before the accident, the manufacturer was aware of previous instances of continuous parasitic oscillation, but the oscillations had never been known to affect train detection and were considered harmless. The parasitic oscillation encountered at Fort Totten, however, was a pulse-type oscillation of sufficient amplitude and of the correct frequency to mimic the coded track occupancy signal being returned from the rails. The investigation found no evidence that the modules were tested for this type of parasitic oscillation at the time they were manufactured or installed. The WMATA train control system has exhibited failure modes that were not considered in the original design. These failure modes include parasitic oscillation, corrugated rail, and cable faults. The fail-safe design of WMATA’s train control system was compromised when the track circuit modules failed to detect the presence of trains.

The NTSB concludes that 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. The NTSB therefore recommends that Alstom conduct a comprehensive safety analysis of its 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 its customers to address these failure modes.

Therefore, the National Transportation Safety Board makes the following safety recommendations to Alstom Signaling Inc.:

Develop and implement periodic inspection and maintenance guidelines for use by the Washington Metropolitan Area Transit Authority and other rail transit operators and railroads equipped with General Railway Signal Company 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. (R-10-23)

³ 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.

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. (R-10-24)

The National Transportation Safety Board has also reclassified the following safety recommendation previously issued to Alstom Signaling Inc.:

Assist the Washington Metropolitan Area Transit Authority, 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” by Safety Recommendation R-10-23, issued to Alstom Signaling Inc., and Safety Recommendation R-10-25, issued to the six other transit agencies that use GRS audio frequency track circuit modules.

The NTSB also issued safety recommendations to the U.S. Department of Transportation, the Federal Transit Administration, the Tri-State Oversight Committee, the Washington Metropolitan Area Transit Authority Board of Directors, the Washington Metropolitan Area Transit Authority, the Massachusetts Bay Transportation Authority, the Southeastern Pennsylvania Transportation Authority, the Greater Cleveland Regional Transit Authority, the Metropolitan Atlanta Regional Transportation Authority, the Los Angeles County Metropolitan Transportation Authority, and the Chicago Transit Authority.

In response to the recommendations in this letter, please refer to Safety Recommendations R-10-23 and -24. If you would like to submit your response electronically rather than in hard copy, you may send it to the following e-mail address: correspondence@ntsb.gov. If your response includes attachments that exceed 5 megabytes, please e-mail us asking for instructions on how to use our secure mailbox procedures. To avoid confusion, please use only one method of submission (that is, do not submit both an electronic copy and a hard copy of the same response letter).

Chairman HERSMAN, Vice Chairman HART, and Members SUMWALT, WEENER, and ROSEKIND concurred in these recommendations.

[Original Signed]

By: Deborah A.P. Hersman
Chairman