National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: April 19, 2006

In reply refer to: R-06-3 through -6

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On Wednesday, November 3, 2004, about 12:49 p.m., eastern standard time, Washington Metropolitan Area Transit Authority (WMATA)[1] Metrorail train 703 collided with train 105 at the Woodley Park-Zoo/Adams Morgan (Woodley Park) station in Washington, D.C. Train 703 was traveling outbound on the Red-Line segment of the Metrorail system and ascending the grade between the Woodley Park and the Cleveland Park underground stations, when it rolled backwards about 2,246 feet[2] and struck train 105 at a speed of about 36 mph. Train 703 was operating as a nonrevenue train; that is, it was not carrying passengers. Train 105, a revenue train, was in the process of discharging and loading passengers at the Woodley Park 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 transported about 20 persons to local hospitals. Estimated property damages were $3,463,183.[3]

The National Transportation Safety Board determined that the probable cause of the November 3, 2004, collision between two WMATA trains at the Woodley Park station was the failure of the operator of train 703 to apply 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.

The night before the accident, the train operator went off duty about 11:00 p.m., and 9 hours later (about 8:00 a.m.) began his next shift. It took him about 30 minutes to commute each way to work and home; the 60-minute roundtrip provided him with 8 hours at home. The train operator informed investigators that he needs 8 hours of sleep to wake up feeling rested. However, realistically, there was inadequate opportunity for him to receive 8 hours of sleep after his last shift and before the start of his first shift on the day of the accident. Specifically, during

[1] WMATA is responsible for the Metrorail and Metrobus systems that serve Washington, D.C., and the surrounding suburbs in Maryland and Virginia. Although WMATA is responsible for rail and bus services, this report focuses exclusively on the Metrorail system.

[2] This estimate is based on calculations provided by WMATA.

[3] For additional information, see National Transportation Safety Board, *Collision Between Two Washington Metropolitan Area Transit Authority trains at the Woodley Park-Zoo/Adams Morgan Station in Washington, D.C., November 3, 2004*, Railroad Accident Report NTSB/RAR-06/01 (Washington, DC: NTSB, 2006).

his 9 hours off-duty time, he stated that he took about 30 minutes commuting from work to home, about 15 minutes to fall asleep after he arrived home, and a combined 75 minutes in the morning to get ready and commute to work in order to arrive 15 minutes before the start of his shift. Therefore, since the train operator arrived home at 11:30 p.m. on Tuesday night and woke up Wednesday at 6:30 a.m., he had no more than 7 hours available for him to sleep. This assumes that he fell asleep immediately after arriving home and spent little or no time eating meals and tending to family matters. The Safety Board is thus concerned that because a person, on average, needs 8 hours of sleep, allowing an operator as little as 8 hours off duty between shifts does not provide a realistic opportunity for adequate sleep.

The available time train operators have for sleep is limited by various necessities, including commuting, as well as the usual time it takes to prepare for bed, fall asleep, shower, and prepare for work the next day. Other typical needs, such as eating meals or tending to family or personal matters, further impinge on their available rest (sleep) time. In actuality, in order to have an opportunity to sleep for 8 hours, a train operator's off-duty time must be appreciably greater than 8 hours. Further, the Safety Board notes that WMATA's practice of allowing train operators to start a shift after having only 8 hours off duty conflicts with its own scientifically-based fatigue-educational material,[4] which indicates that, on average, adults physiologically require 8 hours of sleep for optimal waking performance and alertness.

The Safety Board concluded that WMATA's practice of allowing train operators to return to work after having as few as 8 hours off between shifts following prolonged tours of duty does not give train operators the opportunity to receive adequate sleep to be fully alert and to operate safely.

The Safety Board is also concerned that train operators working an extended tour of duty may not be able to obtain adequate rest before the start of their next assignment. While working an extended day may in itself be demanding,[5] it also reduces the available time off before the start of their next shift. For instance, the operator of the accident train worked an additional (overtime) shift on 9 of the 19 days in the month preceding the accident. Often, his overtime assignments occurred on several consecutive days. These extended days, typically lasting between 15 and 16 1/2 hours, began with an overtime shift starting as early as 6:23 a.m., followed by his regular shift ending at 11:00 p.m. As a result, the time off between the end of one day's tour and the start of the next day's shift was as little as 7 hours 23 minutes. So, rather than having 14 hours off between regular assignments, the extra assignment reduced the time off to 8 hours or less. Thus, prolonged tours of work on successive days reduce the opportunity for train operators to get adequate sleep.

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[4] WMATA provides fatigue awareness training, which is presented to train operator trainees during formal train operator training classes. The fatigue program, developed by the FTA, encompasses a wide range of fatigue-related issues, such as fatigue signs and symptoms (that is, lack of alertness, nodding off, slow reaction time, and micro sleeps). The material also discusses the need for train operators to achieve adequate sleep and to report to work rested before the start of their shift. Specifically, the information (accurately) details that people, on average, require about 8 hours of sleep (per day).

[5] Continuous hours of wakefulness is another factor that can affect performance and alertness. Data suggest that 16 or 17 hours of continuous wakefulness can be associated with significantly reduced performance and alertness. See National Transportation Safety Board, *Uncontrolled Collision with Terrain American International Airways Flight 808, Douglas DC-8-61, N814CK U.S. Naval Air Station Guantanamo Bay, Cuba August 18, 1993*, Aviation Accident Report NTSB/AAR-94/04 (Washington, DC: NTSB, 1994).

The Safety Board recognizes that assigning overtime shifts is not necessarily an unsafe practice. That is, the operator on the accident train could have worked the same number of assignments over the last month without jeopardizing his sleep. For instance, working an extra assignment on alternate days would provide ample opportunity for adequate rest before returning to work. Thus, train operators can safely work extra assignments if their work time is not exceedingly long and if their time off is adequate for them to receive sufficient rest before the start of their next shift. The Board notes that other transit agencies have a maximum time on duty and minimum time off practice that is similar to WMATA's.[6]

During the investigation of the January 6, 1996, accident at the Shady Grove station, the Safety Board identified employee concerns about WMATA's organizational structure, specifically, a perceived lack of communication and a sense of information isolation. These concerns were addressed by a WMATA safety review committee, which recommended that WMATA change its organizational structure to have the safety department report directly to the general manager (GM). This recommendation was subsequently adopted and implemented, and WMATA's safety department began reporting directly to the GM.

WMATA's organizational structure was not an issue in the November 3, 2004, accident at the Woodley Park station. However, following the 2004 accident, WMATA restructured its organization again, reverting back to the safety department having a disconnected responsibility and accountability reporting chain. In effect, this restructuring maneuver rescinded the direct reporting link between the safety department and the GM that had been established as result of the Shady Grove accident. In a letter to WMATA, dated March 31, 2005, the Tri-State Oversight Committee expressed concern about the transit authority's reorganization, which eliminated the safety department's direct access to the GM. This postaccident reorganization could recreate the systemic information isolation that existed within WMATA prior to the Shady Grove accident, which in turn could inhibit serious safety problems from being identified or adequately addressed.

The Federal Transit Administration (FTA) apparently believes that an effective management structure is important, and it has established that a transit system must include an organizational chart in its system safety plan along with a description of how the safety function is integrated into the rest of the transit organization. Still, the Safety Board is concerned that the more distant reporting relationship between WMATA's safety department and the GM could inhibit serious safety problems from being identified or adequately addressed.

In a life-threatening situation, such as this accident, emergency responders must be able to enter the passenger cars quickly. Passengers must also be able to evacuate the cars rapidly and safely. The Safety Board is concerned about the limited number of emergency access/egress points on Metrorail passenger cars.

The windows on Metrorail cars are not designed to open easily. WMATA's *Emergency Services Manual* provides emergency responders with general window specifications, stating that

[6] For instance, New York City Transit, Metro Transit (Minneapolis, Minnesota), and Metropolitan Atlanta Rapid Transit Authority allow as little as 8 hours off between shifts. The Southeastern Pennsylvania Transportation Authority permits scheduling operators for as many as 18 hours in 1 day.

the windows are not designed to be removed, but can be removed from the inside by taking off the inside zip strip. However, according to the General Superintendent of Rail Car Maintenance, the rubber grommet surrounding the window inside the car must be pried off with a tool, and it is not easily removed by hand.

As reported during the emergency response activities, the emergency responders had extreme difficulty removing the Metrorail car windows because the rubber grommet surrounding the outside of the window was brittle and kept tearing; and the window was stuck in its frame and could not be removed easily. They had to remove a window in the damaged portion of a car to insert imaging equipment because they did not know whether the car was still occupied by any incapacitated passengers. Fortunately, the visual and thermal imaging searches confirmed that no one was trapped in the car.

The conditions surrounding the search and rescue operations after this accident were optimal. The collision occurred within a lighted rail station while the passenger load was light. One train had no passengers, the occupied train was disembarking passengers, and the last car of the striking train was next to the platform. In addition, both the incident commander and the forward commander reported that they had attended WMATA's training for emergency responders. Despite these conditions, the limited access into the cars delayed the search of the last car. As previously stated, the center door (the emergency exit door) of car 1077 of train 703 was damaged, and debris in the car end did not permit access to search that area. Further, two other door panels that can be opened from the outside the car were in a section that was severely damaged by the collision.

The Safety Board investigated WMATA's January 13, 1982, accident at the Smithsonian interlocking in which a Metrorail train car derailed, struck the end of a reinforced concrete wall, and was severed, resulting in three fatalities. Following the investigation, the Board issued Safety Recommendation R-82-70 to WMATA.[7]

> R-82-70
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> 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.

In a letter dated October 18, 1984, WMATA expressed concern that emergency windows would create new hazards, such as an uncontrolled evacuation in tunnels or vandals opening the windows. Instead of emergency windows, WMATA installed passenger-initiated evacuation devices that allow passengers to open center doors of cars. On January 14, 1986, the Safety Board classified Safety Recommendation R-82-70 "Closed—Acceptable Alternate Action."

Although there is an emergency exit on each side of a car, passengers are instructed to exit the train from only one side during an emergency evacuation. The emergency exits are located at the center doors on each side of the car. These center doors have two panels. However,

[7] National Transportation Safety Board, *Derailment of Washington Metropolitan Area Transit Authority Train No. 410 at Smithsonian Interlocking, January 13, 1982*, Railroad Accident Report NTSB/RAR-82/06 (Washington, DC: NTSB, 1982).

only one panel can be opened using a mechanical emergency pull located next to the door. Passengers can slide the door open only if it is undamaged, and there is no debris or obstruction in the doorway path. However, passengers can also use the end bulkhead doors to exit from one car into another if the side doors are inoperative and the end doors are not damaged. In this accident, the side door panels and the end doors in the last car of train 703 could not have been used.

Emergency responders' access to the Metrorail cars is substantially limited to doors. Electrical power and a special key are required to open the door panels. In the event that third-rail power is down, an on-board battery can be used to furnish power to open the doors.

The Safety Board is concerned that the only means for emergency responders to quickly enter the cars relies on electrical power and key-controlled access. In an accident, third-rail power may be turned off and the back-up battery in the passenger car could be damaged, which would prevent the doors from operating properly. Further, although WMATA distributes access keys to fire departments in WMATA's territory, bystanders who may be on scene and willing to help cannot open doors. Therefore, the Board concluded that emergency access/egress points for WMATA's equipment do not provide adequate means for emergency responder entry or passenger evacuation.

The Safety Board also notes that passenger railroads regulated by the Federal Railroad Administration (FRA), per 49 *Code of Federal Regulations* (CFR) 238.113, are required to have a minimum of four emergency window exits on their passenger cars. However, there is no requirement for rail transit equipment to have emergency window exits.

In this accident, the last car of train 703 sustained damage that was vastly disproportionate to that sustained by the lead car of train 105. The carbody structure of car 1077 inboard of the collision posts failed, which demonstrates a fundamental flaw in the crashworthiness structural design of the 1000-series carbody. Even though the anti-climber showed indications of engagement,[8] the last railcar of train 703 telescoped and overrode the leading end of the first railcar of train 105, sustaining a catastrophic loss of approximately 34 feet of survival space in the passenger compartment. However, the collision post elements of the lead car of train 105 remained intact, and the operator's cab was not compromised.

The Woodley Park station collision scenario was not much different from that of the January 1996 collision at the Shady Grove station.[9] In that accident, the collision speed was calculated between 22 and 29 mph occurring on a 0.35-percent descending grade of straight track with the moving train telescoping 21 feet over the stopped equipment, severely compromising the occupant volume of the striking car. In the November 3, 2004, accident, the calculated speed of train 703 was 36 mph as it rolled backwards down a 3.72-percent descending grade of straight track and collided with stopped train 105 and telescoped 20 feet over it. Almost half of the passenger occupant volume of the striking car of train 703 was also severely compromised.

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[8] *Engagement* was indicated by the shear damage to the anti-climber flanges (teeth), which suggested that there was positive engagement with the anti-climber of the adjacent railcar (4018).

[9] National Transportation Safety Board, *Collision of Washington Metropolitan Area Transit Authority Train T-111 with Standing Train at Shady Grove Passenger Station, Gaithersburg, Maryland, January 6, 1996,* Railroad Accident Report NTSB/RAR-96/04 (Washington, DC: NTSB, 1996).

In WMATA's March 2002 response to the Safety Board's recommendation (R-96-37) to conduct a comprehensive evaluation of Metrorail cars and make modifications to improve their crashworthiness, WMATA stated that its consultant determined that it was neither practical nor desirable to add underframe reinforcement and that such modification possibly could result in more injuries. WMATA also stated that it would have been impractical to modify the 1000-series Metrorail cars before they are scrapped and it would be prohibitive to modify the 2000, 3000, and 4000 series when they are refurbished. As a result of this response, the Board classified Safety Recommendation R-96-37 "Closed—Acceptable Action" based on the information that WMATA's position on the existing fleet was reasonable and that the intent of the recommendation had been met.

The Safety Board concluded that the failure of the carbody (underframe) end structure of the 1000-series Metrorail cars may make them susceptible to telescoping and potentially subject to a catastrophic compromise of the occupant survival space. WMATA's evaluation, which determined that it was impractical to modify the 1000-series cars and their crashworthiness performance in collisions, in effect validates the scheduled retirement of the cars.[10] Any replacement car should be designed with crashworthiness components for absorbing maximum energy in a collision and to transmit minimum acceleration to passengers without override or telescoping, as found in the current 5000-series railcars and specified for the 6000-series cars.

Railroad and commuter passenger railcars are subject to FRA regulations and are required to have carbody structural provisions to reduce the propensity of carbody telescoping during severe end-structure collisions.[11] Conversely, the FTA has not established requirements to address structural crashworthiness provisions for passenger cars operating in transit service. Because transit passenger railroad systems operate railcars of a similar size and passenger capacity to that used by commuter train operations, which are subject to FRA crashworthiness requirements as described under 49 CFR 238, the Safety Board concluded that the failure to have minimum crashworthiness standards for preventing telescoping of rail transit cars in collisions places an unnecessary risk on passengers and crew.

The National Transportation Safety Board therefore makes the following safety recommendations to the Federal Transit Administration:

> 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. (R-06-3)
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> Assess the adequacy of the Washington Metropolitan Area Transit Authority's current organizational structure and ensure that it effectively identifies and addresses safety issues. (R-06-4)

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[10] The 1000-series cars (292 cars) are currently scheduled for retirement between 2012 and 2015. The 4000-series cars (100 cars) will begin their mid-life rehabilitation in 2012.WMATA plans to have in service during 2006 its 5000- (192 cars) and 6000- (184 cars) series Metrorail cars and have completed the rehabilitation of the 2000- (76 cars) and 3000- (288 cars) series cars.

[11] A feature as described in 49 *Code of Federal Regulations* 238.211.

Develop transit railcar design standards to provide adequate means for safe and rapid emergency responder entry and passenger evacuation. (R-06-5)

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. (R-06-6)

The Safety Board also issued safety recommendations to the Washington Metropolitan Area Transit Authority. In addition, Urgent Safety Recommendation R-04-9, previously classified "Open—Acceptable Response," was reclassified "Open—Unacceptable Response." Please refer to Safety Recommendations R-06-3 through -6 in your reply. If you need additional information, you may call (202) 314-6177.

Acting Chairman ROSENKER and Members ENGLEMAN CONNERS, HERSMAN, and HIGGINS concurred in these recommendations.

[Original Signed]

By: Mark V. Rosenker
Acting Chairman