National Transportation Safety Board
Washington, D.C. 20594

Railroad Accident Brief

Accident No.:	DCA-10-FR-005
Location:	Miami, Florida
Date:	July 20, 2010
Time:	5:39 p.m. eastern daylight time[1]
Railroad:	Miami-Dade Transit Metromover
Property Damage:	$406,691
Fatalities:	0
Injuries:	16 minor
Type of Accident:	Collision between two Metromover cars

The Accident

On July 20, 2010, about 5:39 p.m., eastern daylight time, an inbound[2] Miami-Dade Transit (MDT) Metromover,[3] traveling about 10 mph along a fixed guideway,[4] struck the trailing end of another Metromover. The struck Metromover was stopped at Brickell Station near downtown Miami, Florida. There were a total of 45 passengers on board the two Metromovers. These Metromovers operate in a fully automatic mode without human operators. Sixteen passengers incurred minor injuries and were transported to, treated by, and released from local hospitals. At the time of the accident, weather conditions were clear, with winds of 20 mph and a temperature of 87° F. Total damages were estimated at $406,691.

MDT Metromover Equipment Description

The MDT Metromovers involved in this accident were built by Bombardier—Automated People Movers (Bombardier) and delivered in 2008. There are 29 cars in the MDT Metromover fleet.

[1] All times in this brief are eastern daylight time.

[2] *Inbound* refers to Metromovers operating toward downtown Miami, while *outbound* refers to Metromovers operating away from downtown Miami.

[3] MDT Metromovers are automated people movers (APM) that operate as single cars to carry passengers along a grade-separated mass transit system serving downtown Miami and the Brickell, Park West, and Omni areas of Dade County.

[4] A fixed guideway system is defined by Title 49 *Code of Federal Regulations* (CFR) Part 659 as any light, heavy, or rapid rail system, monorail, inclined plane, funicular, trolley, or automated guideway.

The Metromovers are 39 feet 8 inches long, 112 inches wide, and 133 inches high, with a wheelbase of 20 feet. Each car weighs 32,000 pounds. The Metromovers have a maximum speed of 33 mph and carry a maximum of 95 passengers (8 seated and 87 standing).

The Metromovers are propelled by two 300-volt d.c. traction motors. Power is provided through an electrified rail located along a center guide rail and contacted by four collector shoe assemblies (two at each end of the car) beneath the Metromover. Each collector assembly consists of five spring-loaded contact arms that are fitted with replaceable copper-graphite shoes. Braking is provided by dynamic and pneumatic air-over-spring friction brakes.

Metromover movements are controlled remotely by an automatic train control (ATC) system from the MDT central control facility. Antennas mounted on the Metromovers and positioned along the guideway make ATC systems possible and allow for communication between the Metromover and central control.

System Overview

The MDT Metromover system consists of two parallel concrete guideways that are used for movement in opposing directions. The Metromover system is controlled by an ATC system which can handle up to 21 Metromovers simultaneously. During peak daily operations, 21 Metromovers are in service; 2 Metromovers remain on standby; and the remaining 6 Metromovers are in storage, repair, or out of service.

Rail Traffic Controllers (RTC)[5] located in downtown Miami at the MDT central control office monitor the ATC system and respond to maintenance and troubleshooting events as needed.

Metromovers ride on rubber tires and have guide wheels underneath that straddle an I-beam[6] guide rail that centers the Metromovers along the guideway. The power rails and signal rails are positioned along the I-beam guide rail. Using two signal rails, Metromovers receive speed commands for movement authority. A zero speed command stops or prevents a Metromover from moving. In addition, the signal rails are divided into discrete blocks (track circuits) to provide location information to the ATC system when shunted by the signal collector assembly on a Metromover.

Accident Sequence

The accident occurred on the MDT Metromover system at Brickell Station, which is located at the south end of the system (see figure 1). Brickell Station is about 1 mile south of downtown Miami. The accident involved a collision of the leading end of Metromover No. 38 with the trailing end of Metromover No. 32, which was stopped at Brickell Station (see figure 2). Both Metromovers were in service, transporting passengers on the Brickell Outer Loop and the Downtown Inner and Outer Loops.

[5] Three RTCs monitored the MDT Metromover system: one concentrated on operations, the second focused on power distribution, and the third performed oversight of communications and other tasks.

[6] An *I-beam* is a steel joist or girder with a cross-sectional shape similar to the letter "I"; that is, short flanges top and bottom joined in their midsections by a longer straight beam.

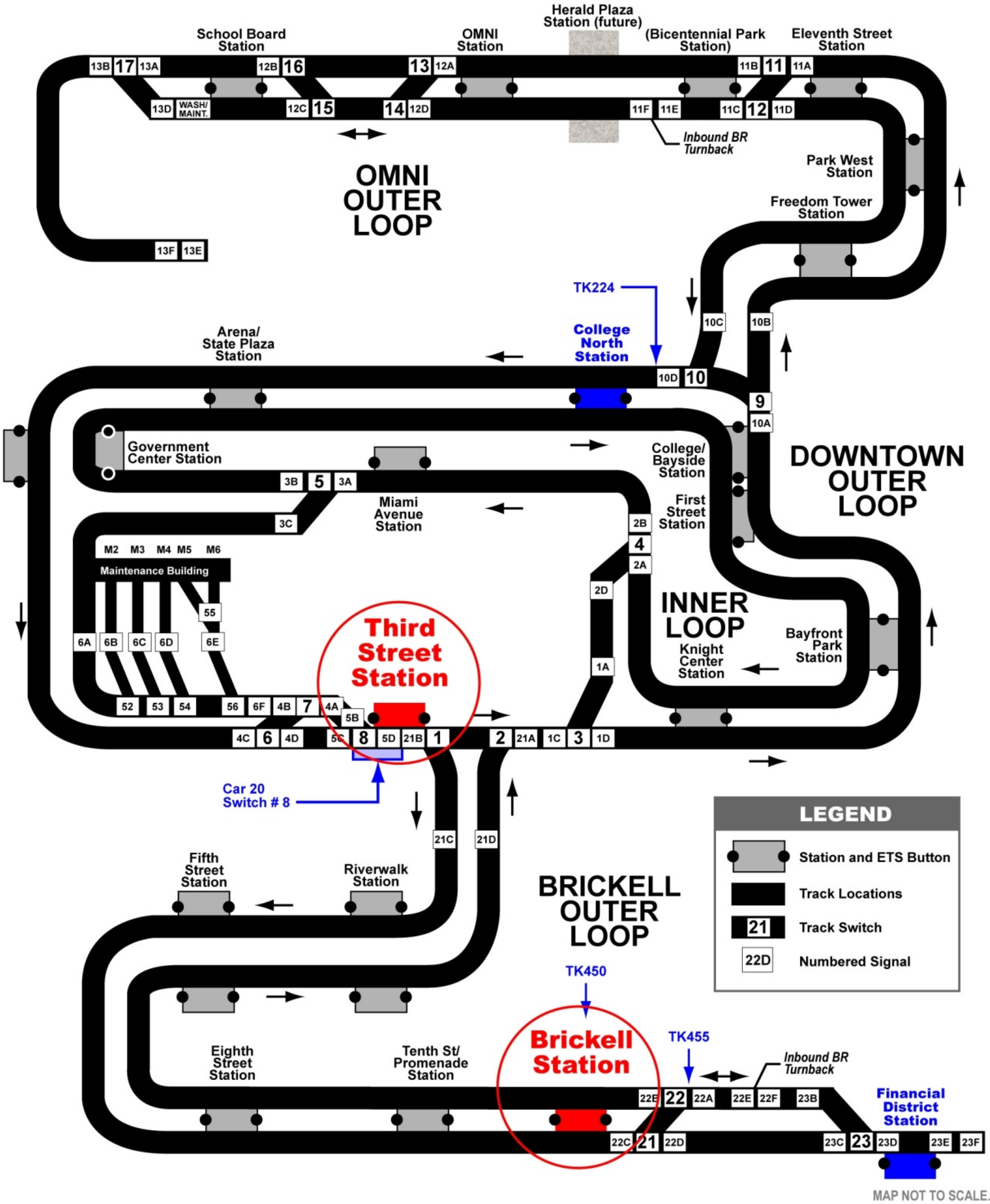

Figure 1. Map of MDT Metromover system, showing the track circuits and stations, as well as switch and train locations applicable to the accident.

Figure 2. Photograph of Metromover No. 32 (lower left/foreground) and Metromover No. 38 (upper right/ background) at Brickell Station following the accident.

While the NTSB investigation found that Metromover No. 38 struck the trailing end of Metromover No. 32, it also determined that the accident actually resulted from a chain of events concerning two other Metromovers. The following information lists the four Metromovers involved in the investigation and briefly describes the role of each in the events leading up to the accident:

- Metromover No. 35 - initially damaged the signal rail due to a guide wheel dropping from its spindle.
- Metromover No. 32 - passed over the signal rail damaged by Metromover No. 35, incurring signal rail damage and loss of power.
- Metromover No. 20 - moved from the maintenance facility to replace Metromover No. 35, triggering system alarms which alerted RTCs of abnormal activity on the signal rail.
- Metromover No. 38 - collided with the trailing end of Metromover No. 32.

Metromover No. 35

On July 20, 2010 at 4:43 p.m., the ATC system detected a false occupancy[7] alarm on track circuit (TK) 224, which was located on the Downtown Outer Loop. Metromover No. 35 was operating over TK 224, and the ATC system associated the false occupancy alarm with that

[7] A false occupancy is the simulated occupancy of a track circuit not caused by shunting of the block (circuit) by a Metromover.

APM.[8] However, the ATC system did not stop Metromover No. 35; rather, it continued to operate away from the Downtown Outer Loop to the Brickell Outer Loop at a normal operational speed.

About 4:50 p.m., an RTC dispatched a maintenance crew to investigate the false occupancy alarm on TK 224. The crew found and repaired a malfunctioning circuit. Once the circuit was repaired, the false occupancy alarm was reset (cleared) in the ATC system and Metromover No. 35 continued to move into the Brickell Outer Loop. However, since the ATC system no longer detected Metromover No. 35 in TK 224, a system-generated multiplex (MUX) computer shutdown[9] occurred.

About 5:00 p.m., with the MUX computer shutdown still in effect, Metromover No. 35 generated a "door-fail-to-open" alarm in the ATC system. An RTC instructed a Metromover recovery technician (MRT) to recover Metromover No. 35. The MRT boarded Metromover No. 35 at Brickell Station.

About 5:15 p.m., the RTC performed a MUX shutdown reset procedure[10] to restore system operations. In this procedure, two RTCs reset the controlling computer system. One of the RTCs enters information in a computer terminal while the other RTC manually resets the actual RTC unit electrical system control panel, also known as a console. This process involves moving behind a large piece of equipment, inserting a key, and physically pressing the appropriate buttons. The required steps involved in the MUX shutdown reset procedure, as used by RTCs at MDT, are as follows:

1. Determine the identity and location of the specific Metromover that caused the MUX computer shutdown.

2. Account for all Metromovers on the route affected by the MUX computer shutdown. The RTC may review a hard-copy log or computer listing of the operating Metromovers. If a Metromover is unaccounted [for], the RTC must perform a visual identification, either with closed-circuit cameras or with a dispatched MRT or security officer.

3. Once all Metromovers are identified and located, a reset command is entered into the system and the reset button on the back of the RTC console is toggled manually.

Around 5:17 p.m., the MRT advised the RTC that Metromover No. 35 had generated another alarm (that is, a "flat tire" alarm). The MRT reset the alarm and, then, coordinated with the RTC to remove Metromover No. 35 from service. The MRT and the RTC planned to take Metromover No. 35 to the maintenance building, place it in storage for repair, and put a replacement Metromover into service. As discussed later in this report, Metromover No. 20 was used as the replacement car.

[8] An RTC referred to this condition as a stranded train identification or "stranded ID."

[9] A MUX computer shutdown is a safety feature of the ATC system that causes a loss of track signal on the loop and safely stops all Metromovers until the MUX is reset.

[10] *Miami Metromover System Operations Procedures Manual*, effective January 1, 1995.

About 5:23 p.m., the MRT arrived at the maintenance building after manually operating Metromover No. 35 from Brickell Station. At that time, neither the MRT nor the RTC realized that Metromover No. 35 had lost a guide wheel. The guide wheel spindle that is, axle) remained intact and in place, but without an attached guide wheel, the spindle damaged the signal rail along the guideway. Damage to the signal rail was found along the entire route of Metromover No. 35, from the Downtown Outer Loop, through Brickell Station, to the maintenance building.

Metromover No. 32

Metromover No. 32 was the first APM to follow behind Metromover No. 35 from the Downtown Outer Loop to Brickell Station. Due to the damage to the signal rail caused by Metromover No. 35, the collector shoes[11] on Metromover No. 32 were damaged and, consequentially it lost contact and speed command communications from the ATC system. When this occurred, Metromover No. 32 stopped short in Brickell Station and lost its identification in the ATC system.

At 5:32 p.m., the ATC system detected a track occupancy dropout[12] alarm due to the identity of Metromover No. 32 dropping out of the ATC system. This led to another automatic MUX computer shutdown, which halted all of the Metromovers.

Metromover No. 20

The MUX computer shutdown at 5:32 p.m. was followed 3 seconds later by a false occupancy alarm at Switch No. 8 (see figure 1), located near the maintenance facility. The ATC system attributed the false occupancy alarm to Metromover No. 20. The RTC knew that Metromover No. 20 was being staged for service as a replacement for Metromover No. 35 and made the false assumption that Metromover No. 20 had moved across Switch No. 8 from the maintenance facility, thereby causing the false occupancy. More significantly, the RTC incorrectly assumed that the movement of Metromover No. 20 caused the active MUX computer shutdown; although the false occupancy alarm occurred shortly after the MUX computer shutdown. The RTC saw only a message about Metromover No. 20 on the ATC system console screen and, consequently, dispatched a maintenance technician to troubleshoot the failure.

About 5:33 p.m., in an effort to restore service on the system, two RTCs completed a MUX shutdown reset procedure. Based on interviews conducted during the NTSB investigation, the RTCs said they followed standard procedure: one RTC typed in a “reset” command on his computer terminal, while a second RTC walked behind the control console and pressed a “reset” button. These actions allowed the system to resume operations, including Metromover movements.

About 5:34 p.m., about a minute following the MUX shutdown reset, several additional ATC system alarms activated: false occupancy, track occupancy drop out, and inbound Brickell

[11] *Collector shoes* consist of copper graphite plates that contact the signal rail. They are contained in collector assemblies on the underside of a Metromover. A physical connection between the collector shoes and the signal rail provides speed commands to the Metromover, as well as identifies the location of Metromovers to the ATC system.

[12] A *track occupancy dropout* occurs when the circuit loses the signal of the ATC system that is occupied by Metromovers or equipment.

alarms. The alarms occurred because the restarted ATC system could not detect Metromover No. 32, which had remained standing short of Brickell Station and unidentified due to the loss of its signal rail contact. Nevertheless, the RTCs remained focused on resolving what they believed to be a problem at Switch No. 8 with Metromover No. 20.

Metromover No. 38

At 5:37 p.m., the RTCs removed power from the track to the Third Street Station to allow a maintenance crew to troubleshoot the problem at Switch No. 8. Meanwhile, operations resumed on the rest of the system, and some Metromover movements occurred. In particular, Metromover No. 38, which was traveling behind Metromover No. 32, was routed to Brickell Station.

At 5:39 p.m., Metromover No. 38 entered Brickell Station, where it collided with the trailing end of standing Metromover No. 32. The doors on both trains opened, and the passengers exited the APMs. The collision damaged the couplers of both Metromovers; however, the car bodies of the Metromovers were not damaged.

Emergency Response

At 5:41 p.m., an MDT contract security operator (employed by 50 State Security Service, Inc.) working in the control center contacted the Miami-Dade Fire Rescue Department, which dispatched a rescue crew and notified the Miami-Dade Police Department.

According to records from the Miami-Dade Fire Rescue Department, Engine No. 4 arrived at Brickell Station at 5:45 p.m. Other units, including American Response Ambulance, arrived shortly afterward to transport injured passengers to University of Miami Hospital, Jackson Memorial Hospital, and Mercy Hospital, where they were treated for minor injuries and released. There were no reported difficulties or impediments to the emergency response services provided in response to the accident.

MDT Metromover MUX Shutdown Reset Procedure

One of the actions performed immediately before the collision was a MUX shutdown reset. In interviews conducted during the NTSB investigation, the RTCs described the MUX shutdown reset procedure and claimed they understood it. Moreover, they indicated they thought the MUX computer shutdown was caused by the alarm at Switch No.8. However, this statement implies the RTCs did not try to account for all Metromovers, contradicting Step #2 of the MUX shutdown reset procedure, as found in the *Miami Metromover System Operations Procedures Manual* and described in the section on Metromover No. 35. Instead, the RTCs simply restarted the ATC system operations by entering the reset command and then pressing the reset button on the electrical system control panel. Had the RTC's fully followed the official MUX shutdown reset procedures after the guide wheel failed and damaged the signal rail, they would have discovered the disabled Metromover No. 32 at Brickell Station and the collision would have been prevented.

MDT Metromover Safety Audits

MDT Metromover management personnel completed 19 safety audits during 2010 prior to the collision. The audits only verified the correct use of radios and did not cover ATC system or MUX shutdown reset procedures. Out of these audits, 14 were performed by the chief rail traffic controller and the remaining 5 by other MDT Metromover managers.

In a letter dated February 5, 2010, MDT outlined a requirement of a minimum of one documented safety audit per week. The assistant director for rail services was to oversee that the audits were being performed. However, he did not take the necessary steps to do so. Since only 14 of these audits were recorded during the first 29 weeks of 2010, the safety audit requirement was not fulfilled.

Damage Estimates

Total damage costs were estimated at $406,691. Estimates of damage costs were $140,160 to Metromover Nos. 32 and 38, $109,211 to the power and signal rails, and $157,320 to the vehicle hub assemblies.

Postaccident Inspections

Following the accident, Metromover No. 35 was inspected at the Maintenance Building. The inspection revealed that the forward guide tire assembly had failed and that the guide wheel hub and tire were missing from the Metromover.

The guide wheel hub and tire, along with some internal components, were recovered from the right-of-way near Knight Center Station, on the downtown loop. The guide wheel hub and tire were intact but damaged (see figure 3).

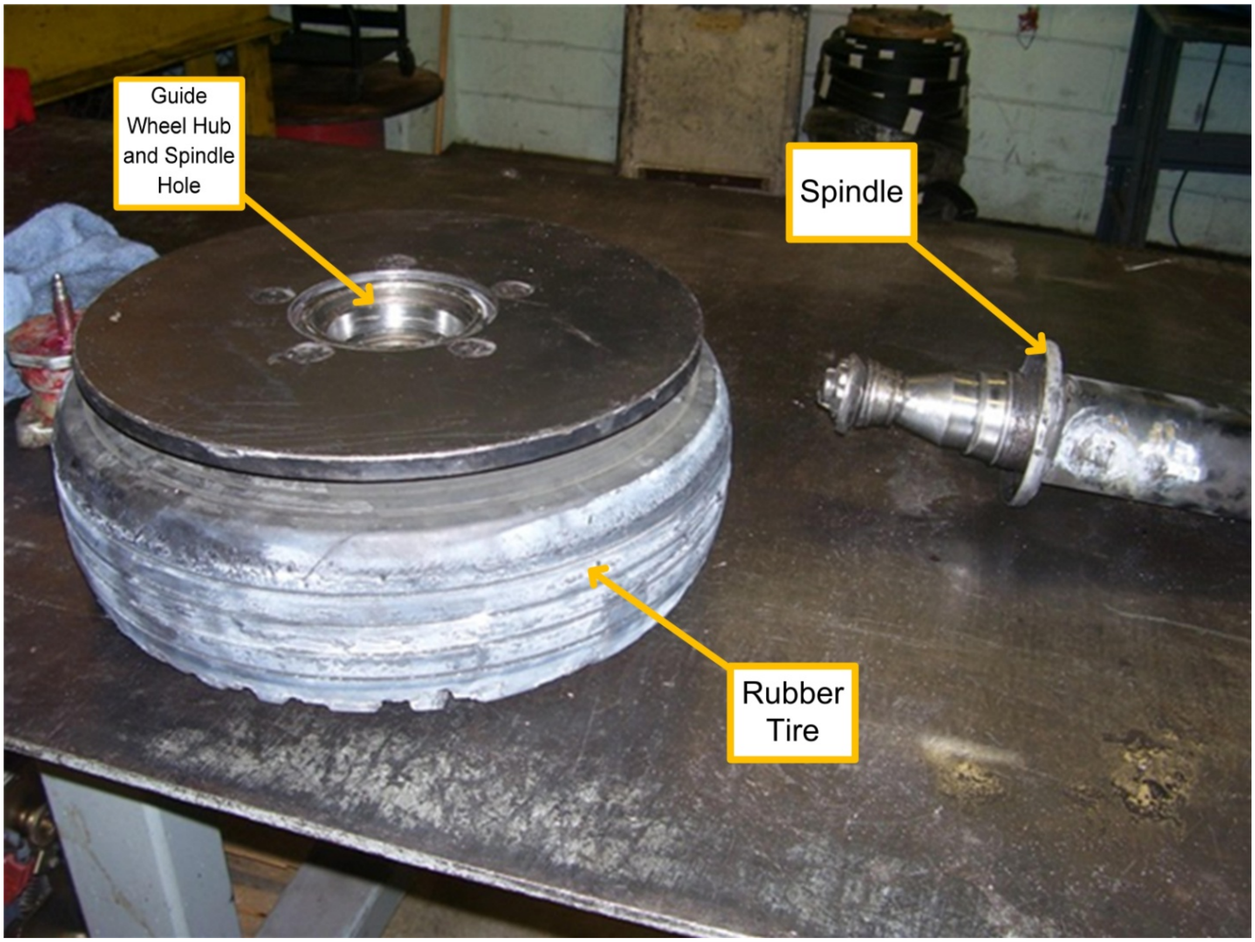

Figure 3. Photograph of the guide wheel of Metromover No. 35.

The spindle hole of the guide wheel hub had increased due to excessive wear, which allowed the guide wheel hub and tire to separate from the Metromover. Additionally, the guide wheel spindle bearing failed. Upon inspection, no lubrication was found in the spindle bearing or in the spindle hole. Further inspection revealed a fracture around the entire circumference of the guide wheel hub. The fracture surface did not show signs of abrasion. Independent laboratory testing confirmed that the hub material did not meet specifications.

MDT records indicate that, prior to service on the morning of the accident, Metromover No. 35 received its daily inspection, as required. No defects were noted during this inspection, which included the guide wheel, and a MDT Metromover supervisor signed the inspection form on July 21, 2010. The hub odometer mileage was recorded on the inspection form[13] as 79,900 miles, which is consistent with the mileage of the other metromovers. Metromover No. 35 made at least one cycle of the system during the time the guide wheel assembly was failing, as evidenced by damage to the signal rail.

[13] Metromover Preventive Maintenance Work Order P.M. 400-REV. C. Daily Vehicle Preventive Maintenance, July 21, 2010.

During the postaccident inspection, it was noted that the guideway infrastructure had been damaged by Metromover No. 35. The inspection also revealed that Metromover No. 32 sustained damage to its signal collector assembly, which disabled the location identification and speed command capabilities of the ATC system. This damage appeared consistent with contact with the guideway infrastructure.

This guide wheel hub failure is consistent with that of another guide wheel hub that failed on another MDT Metromover in April 2010, which was discovered during a daily inspection. Subsequent to the July 20, 2010, accident, Bombardier disclosed that the hub that had failed in April 2010 had been subjected to outside laboratory examination and also did not meet Bombardier specifications.

Bombardier representatives stated that the investigation of the guide wheel hub that failed in April 2010 was ongoing at the time of the July 2010 accident; therefore, at that time, Bombardier had not shared the preliminary findings with MDT or any other organizations that had purchased similar cars or replacement hubs.

Postaccident Actions

Miami-Dade Transit

Following the July 20, 2010, accident, MDT enhanced the safety of its MUX computer shutdown and MUX shutdown reset procedures. In addition, MDT improved its management oversight and equipment procedures:

- MDT no longer uses two-piece hubs on the Metromover vehicle guide wheel assemblies. According to MDT, all Metromovers have been equipped with guide wheel assemblies that have a one-piece hub design. After cars have been in service for a minimum of 5 hours, MDT technicians take daily temperature readings of the guide wheel hub bearings to detect overheating.
- MDT has reviewed the guide wheel assembly procedure with all Metromover technicians.
- MDT has developed and implemented annual refresher training of the MUX shutdown reset procedure.
- MDT has revised the MUX computer shutdown procedure and verifies compliance by testing the MUX feature daily during nonpassenger-service hours. MDT has also improved its recordkeeping by requiring each RTC to verify procedures have been followed and to detail the accountability of vehicles prior to resetting the MUX and restoring service.
- MDT conducts weekly radio communication audits with RTCs and Metromover maintenance personnel to verify and improve communications and to verify compliance with and effectiveness of procedures.
- MDT requires all Metromover RTCs to receive Metromover familiarization training. This training class was developed to improve the understanding of the Metromover system, including its vehicle, guideway, and maintenance building characteristics.

- MDT relocated the general superintendent, rail transportation office to the control center to improve oversight and procedural accountability.

Bombardier—Automated People Movers

Since the July 20, 2010, accident, Bombardier has made and continues to make changes to specified requirements and procurement notes that include requalification of suppliers by first article inspection.

Probable Cause

The National Transportation Safety Board determines that the probable cause of the accident was the Miami-Dade Transit rail traffic controllers' decision to restart automated train operations without accounting for the location of all Metromovers following a safety shutdown after the signal rail had been damaged by a defective Metromover guide wheel. Contributing to the accident was inadequate oversight by Miami-Dade Transit.

Approved: August 2, 2012