



Hard Landing Results in Destruction of Freighter

Inadequate crosswind-landing technique by the pilot flying and inadequate monitoring by the pilot not flying were cited in the collapse of the Boeing MD-10's right main landing gear on touchdown.

FSF Editorial Staff

About 1226 local time Dec. 18, 2003, a Boeing MD-10-10F operated by FedEx as Flight 647 veered off the right side of the runway after the right main landing gear collapsed on touchdown at Memphis (Tennessee, U.S.) International Airport. The first officer and a nonrevenue passenger received minor injuries during the evacuation. The captain and four nonrevenue passengers were not injured. The airplane was destroyed by the post-impact fire.

The U.S. National Transportation Safety Board (NTSB) said, in its final report, that the probable causes of the accident were “the first officer’s failure to properly apply crosswind landing techniques to align the airplane with the runway centerline and to properly arrest the airplane’s descent rate (flare) before the airplane touched down; and the captain’s failure to adequately monitor the first officer’s performance and command or initiate corrective action during the final approach and landing.”

The captain, 59, had approximately 21,000 flight hours, including 2,602 flight hours as an MD-11/MD-10 flight crewmember. He held type ratings in the Cessna Citation 500 and MD-11. (The report said that a pilot with an MD-11 type rating is qualified to fly an MD-10 after completing MD-10 differences training. The captain had completed MD-10 differences training in October 2000.) He had been a pilot for Flying Tiger Airlines for 11 years when the company merged with FedEx in 1989.

The first officer, 44, had approximately 15,000 flight hours, including 1,918 flight hours as an MD-11/MD-10 flight crewmember. She held type ratings in the de Havilland



Canada Dash 8, Fokker F27 and MD-11. She had completed MD-10 differences training in February 2003. She had been a Dash 8 captain for Mesaba Airlines before being hired by FedEx in 1996.

“A review of the first officer’s employment, flight and training records revealed that two of her [Dash 8] captain proficiency check rides (on April 7 and 13, 1994, while she was employed by Mesaba Airlines) were unsatisfactory,” the report said. “According to Mesaba Airlines, the check airman who conducted both proficiency check rides indicated that the unsatisfactory results were because of ‘generally poor airmanship.’”

A U.S. Federal Aviation Administration (FAA) inspector who observed the first officer’s check ride on April 13, 1994, required that she be re-examined for her airline transport pilot (ATP) certificate. The first officer completed the re-examination on May 15, 1994.

The report said that the first officer failed an MD-11 proficiency check ride on Oct. 26, 1999. After receiving additional training, she completed the check ride on Oct. 29, 1999.

“The records also indicated that on Oct. 17, 2001, the first officer failed another MD-11 proficiency check ride,” the report said. “After additional training, she satisfactorily completed a proficiency check ride on Oct. 19, 2001.”

The accident occurred on the last day of a scheduled four-day trip that included a line check of the first officer by the captain, a FedEx check airman.

“FedEx required this line check because the first officer was a flight crewmember involved in an altitude deviation that occurred shortly after departing [from London,] England, in November 2003,” the report said.

The altitude deviation occurred when air traffic control (ATC) told the crew to climb to and maintain Flight Level (FL) 230 (approximately 23,000 feet). The first officer and the captain of that flight believed that they had been cleared to FL 330. The airplane was near FL 260 when ATC told the crew to descend to FL 230.

“As a result of this excursion, the first officer and the captain [of the altitude-deviation flight] were required to complete a company-mandated requalification simulator proficiency check and a line check,” the report said. “The first officer successfully completed the requalification simulator proficiency check on Nov. 20, 2003.”

During the 12 months preceding the accident, the first officer frequently had been on reserve duty. She had flown about 61 hours and conducted, as the pilot flying, seven landings — six in MD-11s and one in an MD-10 — during the 90 days preceding the accident.

FedEx pilots and check airmen told investigators that differences in flight characteristics and handling qualities between the two airplanes are minimal (see “Boeing MD-10-10F”).

“The significant flight control inputs that are needed when landing either an MD-11 or MD-10 in strong, gusty crosswind conditions (such as those encountered during the accident flight) would render any subtle differences in handling characteristics between the airplane negligible,” the report said.

Boeing MD-10-10F

The Boeing Co. converted 60 McDonnell Douglas DC-10-10s to MD-10-10F freighters for Federal Express Corp. (FedEx). The conversion included retrofit of an advanced-technology flight deck that accommodates two flight crewmembers and provides commonality with the FedEx MD-11 fleet. Boeing delivered the first MD-10-10F to FedEx in 2000.

Introduced in 1970, the DC-10-10 was the first model in the DC-10 series of long-range, high-capacity transport airplanes and was designed to be flown by three flight crewmembers. The airplane is powered by three General Electric CF6-6D or CF6-6D1 turbofan engines, each rated at 40,000 pounds (18,144 kilograms) thrust.

The MD-11, a derivative of the DC-10, has a digital flight deck designed for two pilots, winglets and a redesigned tail incorporating fuel-trim tanks. The airplane is powered by three Pratt & Whitney PW4460 turbofan engines, each rated at 60,000 pounds (27,216 kilograms) thrust. ♦

Sources: U.S. National Transportation Safety Board and *Jane's All the World's Aircraft*

The nonrevenue passengers on the accident flight were off-duty FedEx pilots. A DC-10 captain occupied the flight deck jump seat; the other passengers — two DC-10 first officers, an MD-11 first officer and a DC-10 flight engineer — occupied courier seats aft of the flight deck.

The airplane departed from Oakland, California, U.S., at 0832 (Memphis time; 0632 Oakland time).

The cockpit voice recorder (CVR) recorded numerous sounds of the first officer clearing her throat and coughing, and a conversation between the captain and the jump seat passenger about the first officer's health. The conversation, recorded from a cockpit area microphone, began about 1056.

“She was coughing like crazy the other day,” the captain said. “I think she's got pneumonia.”

“She's going to make us sick,” the jump seat passenger said.

“I think so, too,” the captain said. “It's a three-leg line check [to requalify]. I think she would have [stayed home] if it hadn't been [for] so much scrutiny on this line check.”

The first officer told investigators that she felt fine during the accident flight and was not taking any medication.

“She stated that she was not sick, and there is no evidence that this (the coughing/clearing her throat) adversely affected the flight or her performance,” the report said.

At 1145, the first officer briefed the captain on arrival procedures and approach procedures for Runway 27 and Runway 36L at the Memphis airport. The pilots also discussed the use of Runway 36R as a backup.

At 1156, the captain told the first officer, “I need to see a stable approach at a thousand feet. If, for some reason, we're not stable, go around. All right?”

The first officer said, “Yep. No problem there.”

The captain said, “But we don't have ... a lot of gas, so ... be stable.”

“Got it,” the first officer said. “Here we go.”

During descent, the captain listened to the automatic terminal information service (ATIS) broadcast, which said that winds were from 320 degrees at 16 knots with gusts to 22 knots, visibility was about 10 statute miles (16 kilometers), a broken ceiling was at 4,300 feet and wind shear advisories were in effect for the airport.

The captain repeated the wind information and told the first officer that the winds were more favorable to a landing on Runway 36L or Runway 36R than to a landing on Runway 27.

The first officer said that she was “still fairly unfamiliar with Memphis” and wanted to configure the airplane for approach earlier than normal.

The captain said, “Do what you want.” He then briefed the first officer about typical approach-and-landing procedures at the airport.

Soon after conducting the “In Range” checklist, the crew was told by Memphis Approach Control that they should expect clearance to land on Runway 36L. The controller told the crew to descend to 8,000 feet.

At 1211, the controller told the crew to reduce airspeed to 210 knots and to descend to 6,000 feet. Soon thereafter, the first officer called “two ten [knots]” and told the captain to extend the slats. The airplane was in level flight at 6,000 feet at 1214 when the first officer called for 15 degrees of flap.

The controller told the crew to descend to 5,000 feet and to expect clearance to land on Runway 36R, which was 9,000 feet (2,745 meters) long and 150 feet (46 meters) wide. The captain programmed the flight management system for an approach and landing on Runway 36R.

The crew was conducting the “Approach” checklist at 1216, when the controller told them to reduce airspeed to 190 knots, to turn left to a heading of 020 degrees and to intercept the instrument landing system (ILS) localizer for Runway 36R.

At 1219, the captain told the first officer that the localizer course-deviation indicators were “alive” (i.e., beginning to center) and that the airplane was 18 nautical miles (33 kilometers) from touchdown.

The controller told the crew to reduce airspeed to 170 knots and issued a wake-turbulence advisory for an Airbus airplane that was 6.5 nautical miles (12.0 kilometers) ahead on the approach. The captain told the controller that they were looking for the Airbus.

The first officer called for 22 degrees of flap. The captain said, “Flaps twenty-two. I got an Airbus right here and another one out there [that] looks like [it is] about level with us.”

The controller told the crew to descend to 2,000 feet.

At 1220, the captain told the first officer that the airplane was established on the localizer course. “We’re not yet cleared for the approach,” he said.

At 1221, the captain told the controller that they had the airport in sight. The controller cleared the crew to conduct a visual approach to Runway 36R and told them to maintain 170 knots until crossing the MAGEE intersection and to establish radio communication with the airport control tower.

The captain told the first officer that MAGEE was 5.5 nautical miles (10.2 kilometers) ahead.

The tower controller cleared the crew to land and told them that they were no. 2 to land, following the Airbus on a two-nautical-mile (four-kilometer) final to Runway 36R. The controller issued a wake-turbulence advisory for the Airbus and a wind shear alert: “Gain and loss of ten [knots] short final runway three six right.”

At 1222, the captain said, “How about four extra knots? I don’t like to add extra speed; but, you know, three or four knots can make a lot of difference if you’re bumping around back and forth.”

The first officer said, “Good enough. Let’s go with landing gear down [and] ‘Before Landing’ checklist, please. Glideslope [indicators are] alive.”

The captain said, “Spoilers are armed. The gear is down, and three green. Flaps are twenty-two. Flaps to go. ... There’s MAGEE.”

Soon after the first officer called for 35 degrees of flap at 1223, the airplane’s central aural warning system (CAWS) issued a “tail wind shear” alert. The airplane was 1,460 feet above ground level (AGL).

The pilots told investigators that they continued the approach because they observed no airspeed excursions during the brief CAWS wind shear alert.

The report said that no other wind shear alerts were generated during the remainder of the flight and that a review by the Massachusetts Institute of Technology Lincoln Laboratory of flight data recorder (FDR) data, Doppler weather radar data and terminal-winds data indicated that there was no horizontal wind shear or other hazardous wind conditions near the runway when the accident occurred.

The Lincoln Laboratory review indicated that the tail wind shear warning issued by the CAWS at 1223 likely was generated by buoyancy waves — “parcels of air that oscillate, rising and falling between slightly above the boundary layer to near the surface,” the report said. “Buoyancy waves, which often occur in a gusting wind environment, may have existed from just above the ground to about 4,800 feet AGL at the time of the accident.”

The report said that less than 15 knots of wind shear was associated with the buoyancy waves and that the wind shear was not significant. The crew’s decision to continue the approach was “appropriate and consistent with FedEx’s wind shear policies,” the report said.

After the CAWS called out 1,000 feet radio altitude at 1224:27, the captain told the first officer that the approach was stable. “We have a nine-thousand-foot runway,” he said. “And we land at a hundred and forty-six.”

At 1224:52, the first officer told the captain that she was disengaging the autopilot. The first officer did not disengage the autothrottles.

At 1225:02, the captain said, "Checklist is complete. You're cleared to land."

Studies conducted in a flight simulator after the accident indicated that the control wheel neared full travel to the left and right several times during the approach, and that the first officer applied left aileron and right rudder to align the fuselage with the runway centerline when the airplane was 140 feet AGL to 130 feet AGL.

"These normal crosswind landing control inputs were only momentary," the report said. "As the airplane descended below 100 feet [AGL], the aileron and rudder control inputs were neutralized and remained neutral until the airplane touched down."

Weather conditions recorded by the automated surface observing system (ASOS) at the time included winds from 320 degrees at 21 knots with gusts to 26 knots. The airplane began to drift right after the first officer neutralized the flight controls. The report said that the flight simulator studies showed that the drift was "markedly notable from both pilots' seats as the airplane descended through about 60 feet."

Investigators estimated that the airplane's landing weight was 358,450 pounds (162,593 kilograms), including about 110,600 pounds (50,168 kilograms) of cargo — none of which was hazardous material — and about 20,300 pounds (9,208 kilograms) of fuel.

The airplane's descent rate during the 20 seconds preceding touchdown and during the touchdown at 1225:53 was 12.5 feet per second (750 feet per minute). FDR data indicated that the airplane's pitch attitude was not increased before touchdown (i.e., the airplane was not flared for landing).

"The first officer did not properly apply control wheel [inputs] and rudder inputs to align the airplane with the runway centerline or apply appropriate back pressure on the control column to arrest the airplane's rate of descent before touchdown," the report said. "As a result, the airplane touched down extremely hard while still in a crab."

The report said that investigators (including representatives of FedEx and the Air Line Pilots Association, International) who viewed the flight simulator studies said that "there were clear indications that aspects of the approach needed correcting and that the captain should have taken corrective actions when these indications became apparent."

The report said, "The captain should have verbally prompted flight control actions, commanded a go-around or taken control of the airplane for a go-around or landing."

Tire marks on the runway indicated that the airplane was yawed about 5.4 degrees left of the runway heading and that the flight deck was about 20 feet (six meters) right of the runway centerline when the airplane touched down on the left main landing gear about 564 feet (172 meters) from the approach end of the runway.

The report said that the landing gear on the MD-10-10 at maximum landing weight (375,000 pounds [170,100 kilograms]) were designed to absorb energy generated by a touchdown with a descent rate of 10 feet per second (600 feet per minute).

"In addition, ... the main landing gear is designed to be capable of absorbing reserve energy that is equivalent to a maximum airplane descent rate of 12 feet per second (720 feet per minute) when landing at the maximum airplane design landing weight," the report said.

The descent rate was 14.5 feet per second (870 feet per minute) when the right main landing gear touched down about 613 feet (187 meters) from the approach end of the runway and 45 feet (14 meters) right of the runway centerline.

"The excessive vertical [forces] and lateral forces on the right main landing gear during the landing exceeded those that the gear was designed to withstand and resulted in the fracture of the outer cylinder and the collapse of the right main landing gear," the report said.

The airframe struck the runway about 2,891 feet (882 meters) from the touchdown point. As the airplane began to veer off the side of the runway at 1226:25, the captain said, "Here we go."

At 1226:30, the airplane came to a stop in the grass about 155 feet (47 meters) right of Runway 36R and 5,979 feet (1,824 meters) from the approach end of the runway.

"The right main landing gear assembly collapsed, and the airplane was supported by its nose landing gear, left main landing gear and the lower surface of the right wing," the report said.

The captain told the controller that seven people were aboard the airplane. The report said that although control tower personnel alerted aircraft rescue and fire fighting (ARFF) personnel about the accident, they did not tell them the number of people aboard the airplane.

"Controllers should recognize the importance of relaying all available pertinent information, including airplane-occupant information, to [ARFF] personnel to assist them in ARFF efforts and decision making," the report said.

All the occupants exited the airplane through flight deck window exits. The report said that several occupants "showed poor judgment and exposed themselves to unnecessary risk" when they delayed their evacuation while throwing personal baggage from the burning airplane.



The left side of the fuselage and the left wing received minimal damage by the impact and fire. (Photo: U.S. National Transportation Safety Board)

The first officer received friction burns to both hands while sliding down the evacuation tape (a thin ribbon of reinforced synthetic material deployed through the flight deck window). The jump seat passenger received a shoulder injury when he fell to the ground after relinquishing his grip on the evacuation tape.

Before exiting through the flight deck window, one passenger opened the left front (L1) door. He told investigators that the slide/raft deployed but did not inflate, and that when he pulled the manual inflation handle, the slide/raft inflated, separated from the L1 doorsill and dropped beneath the airplane. The report said that the passenger mistakenly had pulled both the manual inflation handle and the slide/raft disengage handle.

The report said that the hands-on emergency-procedures training provided to flight crewmembers by FedEx was inadequate. The emergency exit door/slide device used during initial training and recurrent training did not have a manual inflation handle or a manual disengage handle. Pilots observed a video presentation on the use of the manual inflation handle, but “this method of training does not adequately provide crewmembers with the skills required to operate the door/slide,” the report said.

The report said that the guidance on flight crew emergency-procedures training provided by FAA to its principal operations inspectors (POIs) was inadequate.

“The guidance, contained in FAA Order 8400.10, *Air Transportation Aviation Inspector’s Handbook*, includes a more detailed description of the emergency exit–training requirements for cabin crew than for flight crew, including the requirement to pull the manual inflation handle,” the report said.

The POI assigned to FedEx told investigators that he interpreted the handbook guidance to mean that flight crewmembers were not required to pull the manual inflation handle during training. The report said that U.S. Federal Aviation Regulations

(FARs) Part 121.417 requires cabin crewmembers and flight crewmembers to pull the manual inflation handle during training.

ARFF personnel in three vehicles operated by the Memphis Fire Department (MFD) for the airport authority (the Memphis–Shelby County Airport Authority) responded to the accident. The MFD station was west of, and near the end of, Runway 36C. The MFD ARFF personnel arrived at the accident site about 1228.

ARFF personnel in two vehicles operated by the Rural/Metro Fire Department (RMFD) for FedEx also responded. The RMFD station was in the FedEx complex at the extreme northern end of the airport. Airport tower controllers told investigators that RMFD ARFF vehicles normally operate within the FedEx complex and were not considered as primary emergency responders. The report said that a letter of agreement among FAA, the airport authority and MFD did not specify emergency-response procedures for RMFD ARFF personnel.

At 1228, the RMFD ARFF personnel requested clearance from the ground controller to proceed from the FedEx complex to the accident site and were told to hold short of Runway 27 because of landing traffic. (Runway 09/27 is north of the three parallel 18/36 runways.) The report said that the delay was not necessary.

“A review of recorded radar data showed that, at that time, the arriving airplane was about 2.5 [nautical] miles [4.6 kilometers] east of the end of Runway 27,” the report said.

After the arriving airplane landed, the ground controller cleared the crews of two other airplanes to taxi the airplanes across the runway. The controller then cleared the RMFD ARFF personnel to taxi across the runway and proceed to the accident site. The report said that RMFD ARFF personnel arrived at the accident site several minutes after the MFD ARFF personnel.

The main body of fire was under control within 10 minutes to 15 minutes of the arrival of the MFD ARFF personnel and was extinguished completely by 1322.

The report said that in January 2004, FedEx implemented an enhanced oversight program (EOP) to identify pilots who have demonstrated performance deficiencies during training and to conduct additional oversight of the pilots, including two annual line checks of first officers and an additional annual line check of captains. (Normally, captains receive one annual line check; first officers do not receive an annual line check.)

“Additionally, the EOP board, which is made up of company training and flight standards directors, meets monthly to review recent events and discuss identified pilots’ case histories,” the report said. “This increased level of monitoring a pilot’s performance helps the company determine if deficient performance demonstrated during a check ride is indicative of

the pilot's overall performance. If FedEx's EOP had been in effect when the first officer failed her check rides in 1999 and/or 2001, she would certainly have received additional company scrutiny and training."

At the time the accident report was adopted (May 2005), FedEx was the only FARs Part 121 air carrier that had an EOP or a similar proactive program.

Based on the findings of the accident investigation, NTSB made the following recommendations to FAA:

- "Require all [FARs] Part 121 air carrier operators to establish programs for flight crewmembers who have demonstrated performance deficiencies or experienced failures in the training environment that would require a review of their whole performance history at the company and administer additional oversight and training to ensure that performance deficiencies are address and corrected. (A-05-014);
- "Amend the emergency exit-training information contained in the flight crew and cabin crew sections in [FAA] Order 8400.10 ... to make the emergency exit-door/slide training described in the flight crew section as comprehensive as the cabin crew emergency-training section of the [POI] handbook. (A-05-015);
- "Verify that all [FARs] Part 121 operator's emergency door/slide trainers are configured to accurately represent

the actual airplane exit-door/slide and that their flight crew emergency exit door/slide training provides the intended hands-on emergency-procedures training as described in [Part] 121.417, to include pulling the manual inflation handle. (A-05-016);

- "Inform all [ATC] control tower controllers of the circumstances of this accident, including the need to ensure that [ARFF] vehicles are not delayed without good cause when en route to an emergency and the need to relay the number of airplane occupants to ARFF responders. (A-05-017); [and,]
- "In cooperation with the Memphis/Shelby County Airport Authority and [MFD], modify the Nov. 1, 2001, letter of agreement titled 'Airport Emergency Procedures' to fully describe the protocol to be used for emergency responses, including [RMFD ARFF] equipment and personnel. (A-05-018)."

[At press time, FAA had not responded to the recommendations.]♦

[FSF editorial note: This article, except where noted, is based on U.S. National Transportation Safety Board Aircraft Accident Report NTSB/AAR-05/01, *Hard Landing, Gear Collapse, Federal Express Flight 647, Boeing MD-10-10F, N364FE, Memphis, Tennessee, December 18, 2003*. The 109-page report contains illustrations and appendixes.]

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