

During more than a dozen hard landings and rollovers of Boeing McDonnell Douglas MD-11s in the past two decades, the U.S. National Transportation Safety Board (NTSB) is pressing for changes in training to help pilots better handle the airplane during landing.

In two safety recommendations issued in July 2011 to the U.S. Federal Aviation Administration (FAA), the NTSB called on the FAA to require Boeing to “revise its *MD-11 Flight Crew Operating Manual (FCOM)* to re-emphasize high sink rate awareness during landing, the importance of momentarily maintaining landing pitch attitude after touchdown and using proper pitch attitude and power to cushion excess sink rate in the flare, and to go around in the event of a bounced landing.”

After Boeing completes the revision, the NTSB said, all operators of MD-11s should be required to incorporate the company’s recommended procedures for bounce recognition and recovery into their own operating manuals and to teach the procedures during recurrent simulator training.

The recommendations were issued during the investigation — by the General Authority of Civil Aviation of Saudi Arabia, with the NTSB participating — of the July 27, 2010, crash of a Lufthansa Cargo MD-11F during landing at King Khalid International Airport in Riyadh. The airplane bounced twice, with a “strong pitch up after the second hard touchdown” and then strong nose-down pitch forces, the NTSB said in a letter to FAA Administrator Randy Babbitt that outlined the safety

‘Shocking’ Touchdowns

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recommendations. The fuselage broke apart, and the two pilots — the only people in the airplane — were injured, one seriously. Investigation of the accident is continuing.

The captain later told accident investigators that he considered the airplane's behavior after touchdown "shocking" and "much beyond [his] experience," the NTSB said.

Information from the flight data recorder showed that the airplane first touched down at 2.1 g — 2.1 times standard gravitational acceleration. Then the airplane bounced about 4.7 ft (1.4 m) and touched down again at 3 g.

"After the second touchdown, the aircraft reached a pitch attitude of 13 degrees, and a third touchdown, on the main gear, exceeded 4 g," the NTSB said. "Flight data indicated that

two large forward and aft control column inputs were made between the first touchdown and the third and final touchdown."

In later discussions with accident investigators, the captain said he had not expected the "strong movement of the nose" and that the airplane's pitch attitude was "higher than the maximum allowable and outside of his comfort zone."

The captain also said that, although he had been trained to maintain 7.5 degrees of pitch in recovering from a bounced landing, he had not completed Lufthansa Cargo's "bounced landing recovery procedure training," a one-time course that was developed because of the company's experience — and the experiences of other operators — with hard landings in MD-11s. The first officer had completed the

The NTSB says pilots need better training to avoid unexpected bounced landings in MD-11s.



one-time course in 2010 while he was undergoing his initial training.

During the course, pilots are taken to a simulator, where an instructor demonstrates a hard landing. The pilot trainee then takes control and “maintains 7.5 degrees of pitch and applies go-around thrust to recover,” the NTSB said.

Lufthansa Cargo’s top pilots said after the accident that the simulator course had limitations.

“The company’s MD-11 chief flight instructor stated that the simulator was limited in its ability to capture the true sensation of a bounced landing, and the head of flight operations said that, while bounced landing training was positive training, it may still be difficult for a pilot to recognize a bounce in a real aircraft,” the NTSB said.

A similar accident — the March 23, 2009, crash of a FedEx MD-11 at Narita International Airport in Japan — also remains under investigation by the Japan Transport Safety Board (JTSB). Both pilots — the only people in the airplane — were killed, and the airplane was destroyed by the crash and the subsequent fire.

The NTSB, which is participating in the accident investigation, said that information from the flight data recorder and the airport’s localizer surveillance camera showed that the airplane “bounced after touching down initially on the right main landing gear and subsequently bounced once more before the left wing ... fractured and the airplane rolled over to the left and caught fire.”

“The vertical acceleration at initial touchdown was 1.63 g, followed by acceleration as high

as 3.06 g when the airplane touched down on the nose landing gear following the last bounce.”

A JTSB interim report, released in April 2010, said that the examination of a number of operations and human performance issues — conducted in cooperation with the NTSB — included a review of MD-11 handling characteristics. The report noted that interviews had indicated that the MD-11 is faster on approach and “less forgiving than other large airplanes” and that pilots must “remain more alert on the MD-11 than on other airplanes.”¹

Seven Events in Two Years

In its safety recommendation letter, the NTSB acknowledged that it is “not uncommon for jet transport aircraft to experience a small skip or bounce during landing.” Nevertheless, the NTSB added, MD-11s have been involved in 14 such events since the aircraft entered service in 1990 (Table 1, p. 15). Of the 14 events, seven occurred in the past two years.

“The number and severity of these events raise concerns that MD-11 flight crews are not effectively trained to recognize and arrest high sink rates during landing or to properly control pitch attitude following a hard landing,” the NTSB said.

In a report on an earlier MD-11 landing accident, the NTSB noted the MD-11’s “known tendency to pitch up” after deployment of ground spoilers and suggested that “a reduction or elimination of the pitch-up tendency would simplify MD-11 landing techniques and may help prevent future MD-11 landing incidents and accidents.”²

In its July safety recommendation letter, the NTSB noted that the Boeing *MD-11 FCOM* recommends a sink rate of 2 to 4 fps during the landing flare, and that the airplanes are certified to land at maximum landing weight with a sink rate of 10 fps (600 fpm) and “an ultimate sink rate of 12.3 fps.”

The NTSB added, “Boeing defines hard landings that exceed 12.3 fps or that involve rapid derotation [lowering the nosewheel to the runway after the main gear touches down] after the initial touchdown as severe.”

The investigation is continuing into the crash of this Lufthansa Cargo MD-11F in July 2010 in Riyadh, Saudi Arabia. The fuselage broke apart after a bounced landing.



Instructions in the FCOM say, “If the aircraft should bounce, hold or re-establish a normal landing attitude and add thrust as necessary to control the rate of descent. Avoid rapid pitch rates in establishing a normal landing attitude. *Caution: Tail strikes or nosewheel structural damage can occur if large forward or aft control column movements are made prior to touchdown.*”

MD-11 Severe Hard Landings

Date	Location	Operator	Event
Apr. 30, 1993	Los Angeles	Delta Air Lines	Bounced hard landing
Aug. 19, 1994	Chicago	Alitalia	Landing bounce and porpoise
July 31, 1997	Newark	FedEx	Wing spar break and rollover
Aug. 22, 1999	Hong Kong	China Airlines	Wing spar break and rollover
May 22, 2000	Taipei, Taiwan	Eva Air	Hard landing and go around
Nov. 20, 2001	Taipei, Taiwan	Eva Air	Bounce and nose landing gear (NLG) strike
June 7, 2005	Louisville, Kentucky, U.S.	UPS	Hard NLG strike
March 23, 2009	Tokyo	FedEx	Wing spar break and rollover
June 3, 2009	Urumqi, China	China Cargo	Hard landing and tail strike
June 9, 2009	Khartoum, Sudan	Saudi Arabian Airlines	Hard landing
Sept 13, 2009	Mexico City	Lufthansa Cargo	Hard landing and NLG strike
Oct. 20, 2009	Montevideo, Uruguay	Centurion	Hard landing and main landing gear collapse
July 27, 2010	Riyadh, Saudi Arabia	Lufthansa Cargo	Hard landing and fuselage failure
Sept. 22, 2010	Kabul, Afghanistan	World Airways	Hard NLG strike

Source: U.S. National Transportation Safety Board

Timing the Flare

The NTSB said that some operators have provided specific instructions to their pilots aimed at helping them avoid high sink rates through “appropriate combinations of power and pitch” and appropriate timing of the landing flare.

As examples, the NTSB noted that:

- Lufthansa Cargo includes in its MD-11 training information a table that “guides pilots when to commence the flare based on gross weight, temperature and pressure altitude.”
- UPS information suggests that the air-speed trend vector “may be a useful tool” in determining when to begin to flare.
- FedEx, which operates more MD-11s than any other airline, tells its pilots to pay particular attention to “aural altitude calls and [the] radar altimeter.”

“Although the pilot monitoring also has a role in recognizing and responding to high sink rates — for example, calling out the sink rate and calling for a go-around — the ability to appropriately judge when to initiate the flare is a fundamental

pilot skill that is learned in training and checked periodically,” the NTSB said.

In reviewing the circumstances surrounding the events cited in Table 1, the NTSB noted that several were associated with high sink rates at touchdown. For example, the Aug. 22, 1999, accident involved a China Airlines MD-11 that developed a high sink rate before touchdown at Hong Kong International Airport. In an attempt to counteract the sink rate, the captain used “a large elevator input, resulting in destructive force on the structure at touchdown,” the NTSB said.

Of the 315 people in the airplane, three were killed, 50 were seriously injured and 153 received minor injuries, the Civil Aviation Department of Hong Kong said in its final report on the accident. The report said that investigators identified the cause of the accident as “the commander’s inability to arrest the high rate of descent existing at 50 ft radio altitude.”³

The NTSB cited the June 9, 2009, severe hard landing of a Saudi Arabian MD-11 in Khartoum, Sudan, in which the “sink rate” alert from the airplane’s enhanced ground proximity warning system sounded repeatedly, from the time the airplane descended through 100 ft

Boeing McDonnell Douglas MD-11

The McDonnell Douglas MD-11 — a derivative of the Douglas DC-10 — entered service in 1990. Boeing produced the 200th — and last — of the medium/long-range passenger/freight transports in 2001.

The MD-11 differs from the DC-10, in part, because of its two-pilot, all-digital flight deck; winglets; and redesigned tail. The MD-11 wing area is smaller — 346.33 m², including winglets, compared with the DC-10-30's 367.7 m² — and its standard maximum takeoff weight is greater — 602,555 lb (273,314 kg), compared with the DC-10's 571,983 lb (259,450 kg).

It is equipped with either three Pratt & Whitney PW4460 turbofan engines, each rated at 60,000 lb static thrust (267 kilonewtons); three Pratt & Whitney PW4462 turbofans, each rated at 62,000 lb static thrust (267 kilonewtons), or three General Electric CF6-80C2D1F turbofan engines, each rated at 61,500 lb static thrust (274 kilonewtons).

Standard fuel capacity is 40,183 gal (152,092 L) for the passenger version and 38,650 gal (146,290 L) for the freighter version and the mixed passenger/cargo version.

Maximum takeoff weight is 625,500 lb (283,727 kg) for all versions.

Maximum operating Mach number is 0.945. Maximum level speed at 31,000 ft is Mach 0.87, or 511 kt. Maximum design range with fuel reserves is 6,821 nm (12,633 km) for the passenger version, 3,867 nm (7,161 km) for the freighter and 6,717 nm (12,440 km) for the mixed version.

Source: *Jane's All the World's Aircraft*

above ground level until touchdown, which was recorded at 3.06 g.

Rapid Derotation

Rapid derotation also has been a factor in a number of MD-11 hard landing accidents, the NTSB said, citing the July 31, 1997, FedEx accident in Newark, New Jersey, U.S., in which the captain “initiated a rapid nose-down elevator input within 0.5 second following initial touchdown, resulting in a second touchdown that exceeded the airplane’s design structural limits.”⁴

In the June 7, 2005, accident involving a UPS MD-11 in Louisville, Kentucky, U.S., the pilot “moved the control column forward sharply following the initial touchdown, reducing pitch angle from 5 degrees nose up to 1 degree nose down in 1.5 seconds,” the NTSB said. The subsequent touchdown on the nosewheel was measured at 2.5 g.

As a result of its investigation of the Newark accident, the NTSB recommended in 2000 that

the FAA establish a government–industry task force to develop a pilot training tool including a syllabus for simulator training in stabilized approaches, and techniques for recognizing and recovering from high sink rates, overcontrol in pitch and premature derotation.

The FAA subsequently issued an appendix to Advisory Circular 120-71, “Standard Operating Procedures for Flight Deck Crew Members,” and Flight Standards Information Bulletins for Air Transport (FSATs) 00-08 and 00-12 to discuss stabilized approaches and reduction of approach and landing accidents.

“Despite the corrective action ... MD-11 crews continue to have difficulty in judging the flare maneuver and in making appropriate pitch and power changes after hard landings,” the NTSB said. “The frequency of MD-11 hard landing accidents suggests that generic guidance on these concepts is not sufficient or effective.”

The NTSB said that “enhanced operational guidance and recurrent training will provide near-term improvements that reduce the risk of MD-11 landing accidents,” while the board continues to identify and evaluate factors that contribute to the accidents. ➤

Notes

1. JTSB. *The Interim Report of Aircraft Accident Investigation*. <www.mlit.go.jp/jtsb/eng-air_report/N526FE.pdf>. April 16, 2010.
2. NTSB. Aircraft Accident Report NTSB/AAR-00/02, *Crash During Landing; Federal Express Inc., McDonnell Douglas MD-11, N611FE; Newark International Airport, Newark, New Jersey; July 31, 1997*.
3. Civil Aviation Department of Hong Kong. Aircraft Accident Report 1/2004, *Report on the Accident to Boeing MD11, B-150, at Hong Kong International Airport on 22 August 1999*. December 2004.
4. NTSB. Accident Report no. DCA97MA055. July 31, 1997. The flight crew and three other FedEx employees received minor injuries in the crash or while exiting the airplane through a cockpit window to escape from a fire that destroyed the airplane. The NTSB said the probable cause of the accident was the captain’s “overcontrol of the airplane during the landing and his failure to execute a go-around from a destabilized flare.”