False GPWS warning and airframe damage, McDonnell Douglas MD-11, June 3, 2002

Micro-summary: **This MD-11 experienced damage to the left elevator while executing a GPWS escape maneuver.**

Event Date: **2002-06-03 at 1600 UTC**

Investigative Body: **National Transportation Safety Board (NTSB), USA**

Investigative Body's Web Site: **http://www.ntsb.gov/**

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National Transportation Safety Board

FACTUAL REPORT AVIATION

NTSB ID: DCA02MA039	Aircraft Registration Number: N588FE
Occurrence Date: 06/03/2002	Most Critical Injury: None
Occurrence Type: Accident	Investigated By: NTSB

Location/Time

Nearest City/Place	State	Zip Code	Local Time	Time Zone
Subic Bay			1600	UTC

Airport Proximity: Off Airport/Airstrip	Distance From Landing Facility:	Direction From Airport:

Aircraft Information Summary

Aircraft Manufacturer	Model/Series	Type of Aircraft
McDonnell Douglas	MD-11	Airplane

Sightseeing Flight: No

Air Medical Transport Flight: No

Narrative

Brief narrative statement of facts, conditions and circumstances pertinent to the accident/incident:

HISTORY OF FLIGHT

On June 3, 2002, about 1600 hours Universal Coordinated Time (UTC), a McDonnell Douglas MD-11, registration N588FE, operating as Federal Express cargo flight 5181, experienced structural damage to the left elevator during an abrupt maneuver while descending to land at the Subic Bay International Airport, Subic Bay, Philippines. The abrupt maneuver was initiated by the flight crew in response to a ground proximity warning system (GPWS) alert that occurred as the airplane was encountering heavy precipitation at an altitude of about 9,800 feet above mean sea level. The airplane landed uneventfully at the Subic Bay International Airport and both flight crewmembers, the sole occupants, were not injured. Night and instrument meteorological conditions prevailed at the time of the accident. The flight had departed from Kuala Lumpur, Malaysia, and was destined for Subic Bay. Under the provisions of Annex 13 to the Convention on International Civil Aviation, the investigation was delegated to the U.S. National Transportation Safety Board (NTSB) by the Air Transportation Office (ATO), Department of Transportation and Communications, Republic of the Philippines.

The flight crew stated that they performed the GPWS escape maneuver as per the Federal Express procedure, and the warning subsided. They also stated that they had no problems with aircraft handling after the escape maneuver. This information is consistent with information from the digital flight data recorder (DFDR). The DFDR data indicate that the maximum recorded pitch of the airplane during the escape maneuver was 22.5 degrees nose up, and the maximum recorded g-force was 2.2 g's. In addition, the radio altitude signals for both altimeters indicated an abrupt drop to below 1,000 feet at the time of the GPWS "Pull-up" warning. The false radio altitude lasted for approximately two minutes. There were also several stall warnings during the maneuver and recovery.

Information recorded at the time of the escape maneuver from the 2-hour cockpit voice recorder (CVR) was overwritten; the CVR recording began during final approach to Subic Bay, after the GPWS warning.

PERSONNEL INFORMATION

The captain, age 56, was acting as the pilot-not-flying on the accident flight. The captain held type ratings in the MD-11, Boeing B727 and Douglas DC-10. The captain reported that he had 13,537 hours of total flight time, including 8,643 hours in type. The captain's first class medical certificate was issued on January 3, 2002 with no limitations or waivers.

The first officer, age 48, was acting as the pilot flying on the accident flight. The first officer held a type rating in the MD-11. The first officer reported that he had 7,096 hours of total flight time, including 4,188 hours in type. The first officer's first class medical certificate was issued on May 20, 2002 with no limitations or waivers.

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NTSB ID: DCA02MA039

Occurrence Date: 06/03/2002

Occurrence Type: Accident

Narrative (Continued)

METEOROLOGICAL INFORMATION

The weather at the Subic Bay International Airport at 1600 hours UTC was reported as wind variable at 3 knots, rain with broken skies at 1,800 feet AGL and overcast skies at 8,000 AGL, 4 miles visibility, temperature 75 degrees Fahrenheit, dew point 73 degrees Fahrenheit and altimeter 29.89 inches of Mercury.

WRECKAGE INFORMATION

Post-flight inspection of the airplane revealed that the outboard portion of the left elevator, including the balance weight, was partially separated from the rest of the elevator. A 12 to 18 inch section of the elevator was missing. The right elevator appeared undamaged and underwent a detailed examination to confirm that it was undamaged.

RESEARCH AND TESTING

According to Boeing, elevator damage to DC-10 and MD-11 airplanes can occur due to the dynamic response of the elevator when it is driven by the separated flow from the wing that results from a maneuver beyond the stall buffet boundary. During these events, the outboard elevators respond in their first torsion mode of about 10 cycles per second. The elevator horn balance weight contributes to this effect. The DC-10 and MD-11 elevators are equipped with an outboard damper to reduce the horn balance response, but this can be overcome by forces that occur when the stall buffet boundary is exceeded.

Analysis of the DFDR from this accident revealed that the airplane's design aerodynamic stall buffet boundary was exceeded during the abrupt GPWS pull-up maneuver.

The airplane was equipped with an upgraded Allied Signal enhanced GPWS and two upgraded Rockwell Collins LRA-700 radio altimeters. The enhanced GPWS receives inputs from two radio altimeters instead of just one, like the previous model, and is capable of sensing false radio altimeter tracking in airplanes like the MD-11, assuming that at least one of the radio altimeters is providing accurate data.

The radio altimeters, model LRA-700, P/N 622-4542-222, were tested by Rockwell Collins in Melbourne, Florida, on August 22, 2002. The no. 1 radio altimeter, S/N 4133, had no fault data logged. The no. 2 radio altimeter, S/N 4130, had faults logged from two previous legs. Both faults were internal faults listed as "lra-1 transceiver" and occurred prior to the incident flight. There were no faults listed for the incident flight. Both units passed the normal operation, return to service (with the exception of the 2500-foot sensitivity test), and temperature testing with no anomalies noted. The Melbourne facility lacked the support equipment to perform the 2500-foot altitude test so Rockwell Collins in Forth Worth, Texas, performed the remaining testing. Both units were tested and showed a sensitivity of 125 dB at the 2500-foot altitude. These measurements were within limits.

Both radio altimeters had been modified by Boeing service bulletin (SB), MD11-34-094. The SB modified the sensitivity of the LRA-700 altimeters in an attempt to reduce the frequency of false warnings during heavy precipitation. The modified altimeters were identified with a -222 part number, and their sensitivity was decreased by 6 dB per the SB.

The enhanced GPWS unit, P/N 965-0976-003-212-212, S/N 3930, was tested by AlliedSignal in Redmond, Washington. The GPWS unit passed the full Acceptance Test Plan with no anomalies noted. There was no examination of the antennae or the attaching hardware for the radio altimeter and the GPWS unit.

According to representatives of Federal Express, the airplane also had incorporated a Global

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Narrative (Continued)

Positioning System (GPS) multi-mode receiver, but the receiver was not interfaced with the GPWS. When interfaced, this unit provides an altitude that is derived from the global positioning system (GPS) and a terrain database. The altitude is used as a reasonableness test for the radio altimeters.

ADDITIONAL INFORMATION

Previous Federal Express Elevator Damage Occurrence

A similar accident involving a Federal Express MD-11 occurred on June 30, 1999, when, on an approach to Acquino International Airport in the Philippines, the airplane experienced a GPWS "terrain-terrain" alert while descending through 9,500 feet in heavy precipitation. The pilot executed a GPWS escape maneuver, which resulted in similar damage to the elevators. The left outboard elevator and balance weight was completely separated from the rest of the elevator. The right elevator sustained substantially less damage. The airplane landed safely.

The airplane had a previous model GPWS unit that was capable of only accepting inputs from one radio altimeter. The airplane also had two previous model radio altimeters prior to a Boeing service bulletin that desensitized them.

According to Rockwell Collins, radio altimeters are susceptible to false warning due to reflectivity from ice crystals, heavy precipitation, or aircraft that fly underneath the airplane. The altimeters are designed to be sensitive and accurate enough for the auto-land mode, while minimizing false warnings.

History of DC-10 and MD-11 In-flight Elevator Damage.

According to information presented by Boeing in the 1999 GPWS incident and a previous NTSB investigation of a China Airlines MD-11 in-flight turbulence encounter in 1991 (NTSB/AAR-94/02), the damage found on this Federal Express airplane was similar to damage found on other MD-11s that experienced aerodynamic stall buffet.

In similar instances involving high-altitude upsets, damage to MD-11 elevators occurred with no reported loss of control. In the China Airlines incident report, the Safety Board concluded that the elevator buffet damage in that incident and previous incidents was caused by overstress but did not create an unsafe condition. In the 1999 GPWS incident, the captain stated that she had no indication after the escape maneuver that the elevators were damaged, and that the airplane's flight characteristics were "not irregular."

Integration of Global Positioning System with GPWS.

Prior to this accident, Boeing developed and released Service Bulletin MD11-34-116, allowing operators to install two GPS multi-mode receivers in place of the Instrument Landing System (ILS) receivers. Honeywell then developed Supplemental Type Certificate (STC) ST00536SE to allow the GPS information to be inputted into the GPWS computers to provide a reasonableness test for the altitude reported by the radio altimeters. The accident airplane had the GPS multi-mode receivers installed on February 8, 2002 but these receivers were not linked to the GPWS computer. As a result of this accident and other operational considerations at Federal Express, all MD-11s in the FedEx fleet have had the necessary equipment installed and the connections made to allow the GPS information to be used by the GPWS computer as of December 6, 2003.

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Occurrence Type: Accident

Landing Facility/Approach Information

Airport Name	Airport ID:	Airport Elevation	Runway Used	Runway Length	Runway Width
Subic Bay International	RPLB	Ft. MSL	NA		

Runway Surface Type:

Runway Surface Condition:

Type Instrument Approach: VOR/DME

VFR Approach/Landing: Unknown

Aircraft Information

Aircraft Manufacturer	Model/Series	Serial Number
McDonnell Douglas	MD-11	48490

Airworthiness Certificate(s): Transport

Landing Gear Type: Retractable - Tricycle

Homebuilt Aircraft?	Number of Seats:	Certified Max Gross Wt.	Number of Engines:
No	6	630500 LBS	3

Engine Type:	Engine Manufacturer:	Model/Series:	Rated Power:
Turbo Fan	General Electric	CF6-8C2D1F	62000 LBS

- Aircraft Inspection Information

Type of Last Inspection	Date of Last Inspection	Time Since Last Inspection	Airframe Total Time
Continuous Airworthiness	05/2002	115 Hours	35753 Hours

- Emergency Locator Transmitter (ELT) Information

ELT Installed?	ELT Operated?	ELT Aided in Locating Accident Site?
No	No	No

Owner/Operator Information

Registered Aircraft Owner	Street Address	City	State	Zip Code
FEDERAL EXPRESS CORP		Memphis	TN	

Operator of Aircraft	Street Address	City	State	Zip Code
FEDERAL EXPRESS CORP		Memphis	TN	

Operator Does Business As:

Operator Designator Code: FDEA

- Type of U.S. Certificate(s) Held:

Air Carrier Operating Certificate(s): Flag Carrier/Domestic

Operating Certificate:

Operator Certificate:

Regulation Flight Conducted Under: Part 121: Air Carrier

Type of Flight Operation Conducted: Non-scheduled; International; Cargo

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FACTUAL REPORT AVIATION

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Occurrence Date: 06/03/2002

Occurrence Type: Accident

First Pilot Information

Name	City	State	Date of Birth	Age
On File	On File	On File	On File	56

Sex: M | Seat Occupied: Left | Principal Profession: Civilian Pilot | Certificate Number: On File

Certificate(s): Airline Transport

Airplane Rating(s): Multi-engine Land

Rotorcraft/Glider/LTA: None

Instrument Rating(s): Airplane

Instructor Rating(s): None

Type Rating/Endorsement for Accident/Incident Aircraft? Yes | Current Biennial Flight Review? 05/2002

Medical Cert.: Class 1 | Medical Cert. Status: Valid Medical--no waivers/lim. | Date of Last Medical Exam: 01/2002

- Flight Time Matrix	All A/C	This Make and Model	Airplane Single Engine	Airplane Mult-Engine	Night	Instrument Actual	Instrument Simulated	Rotorcraft	Glider	Lighter Than Air
Total Time	15537	8643		13537						
Pilot In Command(PIC)	11628	8487		11672						
Instructor										
Last 90 Days	150	150		150						
Last 30 Days	58	58		58						
Last 24 Hours	7	7		7						

Seatbelt Used? Yes | Shoulder Harness Used? Yes | Toxicology Performed? No | Second Pilot? Yes

Flight Plan/Itinerary

Type of Flight Plan Filed: IFR

Departure Point	State	Airport Identifier	Departure Time	Time Zone
Kuala Lumpur		WMKK	1319	UTC

Destination	State	Airport Identifier
Subic Bay		RPLB

Type of Clearance: IFR

Type of Airspace: Unknown

Weather Information

Source of Briefing: Company

Method of Briefing: Aircraft Radio; In Person; Telephone; Teletype

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Occurrence Date: 06/03/2002

Occurrence Type: Accident

Weather Information

WOF ID	Observation Time	Time Zone	WOF Elevation	WOF Distance From Accident Site	Direction From Accident Site
RPLB			Ft. MSL	NM	Deg. Mag.

Sky/Lowest Cloud Condition: Clear Ft. AGL

Condition of Light: Night/Dark

Lowest Ceiling: Broken 1800 Ft. AGL

Visibility: 1 SM

Altimeter: 29.88 "Hg

Temperature: 24 °C

Dew Point: 22 °C

Wind Direction: Variable

Density Altitude: Ft.

Wind Speed: 3

Gusts:

Weather Condtions at Accident Site: Instrument Conditions

Visibility (RVR): Ft.

Visibility (RVV) SM

Intensity of Precipitation: Moderate

Restrictions to Visibility:

Type of Precipitation: Rain

Accident Information

Aircraft Damage: Substantial

Aircraft Fire: None

Aircraft Explosion None

Classification: U.S. Registered/Foreign Soil

- Injury Summary Matrix	Fatal	Serious	Minor	None	TOTAL
First Pilot				1	1
Second Pilot				1	1
Student Pilot					
Flight Instructor					
Check Pilot					
Flight Engineer					
Cabin Attendants					
Other Crew					
Passengers					
- TOTAL ABOARD -				2	2
Other Ground	0	0	0		0
- GRAND TOTAL -	0	0	0	2	2

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Occurrence Date: 06/03/2002

Occurrence Type: Accident

Administrative Information

Investigator-In-Charge (IIC)

Jeffrey B. Guzzetti

Additional Persons Participating in This Accident/Incident Investigation:

William Steelhammer
Boeing Commercial Airplane Company
Long Beach, CA

Matt Duke
Federal Express, Inc.
Memphis, TN

Michael Bender
Air Line Pilots Association
Memphis, TN

Roger Southgate
Rockwell Collins
Grand Rapids, MI