Aviation Investigation Final Report

Location:	Diyarbakir, Other Foreign	**Incident Number:**	ENG09IA011
Date & Time:	June 14, 2009, 18:17 UTC	**Registration:**	TC-TLA
Aircraft:	Boeing 737	**Aircraft Damage:**	None
Defining Event:	Flight control sys malf/fail	**Injuries:**	2 Minor
Flight Conducted Under:	Non-U.S., commercial		

Analysis

The Boeing 737-400 airplane experienced an uncommanded pitch up event at 20 feet radio altitude during landing. The flight crew reacted to the uncommanded pitch-up event by adjusting the stabilizer trim position, attempting to move the elevator control columns forward, disengaging the autothrottle, and executing a go-around. The airplane subsequently landed without incident and both crewmembers sustained minor injuries that were incurred during the go around.

Post-incident inspection of the elevator Power Control Units (PCUs) revealed that the left elevator PCU input control arm assembly was jammed by a piece of Foreign Object Debris (FOD) in a position that offset the control arm in a downward direction. With the control arm deflected in this direction and with hydraulic pressure on, the left PCU moved the elevators to a position that pitched the airplane nose up independent of pilot input. An assessment of information obtained from the FDR regarding the functional characteristics of the airplane's pitch control system indicates that the elevator control system was fully functional and operated as designed during previous flights and up until the uncommanded pitch event occurred. According to Boeing, a jam in either the left or right PCU input control arm assembly could result in the loss of manual control of both elevator PCUs under hydraulic-powered operation. The flight crew's immediate actions of exerting constant and excessive force on the control columns and executing a go-around at low altitude following the jam resulted in recovery of airplane pitch control despite high control forces.

Metallurgical analysis revealed that the FOD had the same dimensions and material composition as the metal rollers that are contained in a DAS10-26B1-502 bearing, which is

installed in only two locations in the aft elevator control system; the right and left ends of the elevator upper output torque tube crank assembly. Post-incident inspections of the airplane's elevator system components located within the area of the tail cone also revealed that the left hand elevator upper torque tube output crank bearing/sleeve was completely intact with all rollers present. Examination of the maintenance records revealed that the left elevator upper torque tube output crank bearing/sleeve assembly had been replaced in January 2009 to correct an elevator freeplay discrepancy on the incident airplane. However, based on the available information, it could not be determined whether the metal rollers were left behind following the maintenance work performed in January 2009 or were present before the work was performed.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this incident to be: An uncommanded elevator surface deflection as a result of a left elevator PCU input arm assembly jam due to FOD lodged between the input arm assembly and the PCU housing. The FOD was a roller element from an elevator upper torque tube output crank bearing, but how or when the roller element liberated from its bearing assembly could not be determined.

Contributing to the survivability of this incident was the flight crew's immediate actions in response to the elevator control system jam.

Findings

Aircraft	Elevator control system - Malfunction
Environmental issues	Debris/dirt/foreign object - Effect on equipment
Aircraft	Elevator control system - Incorrect service/maintenance
Aircraft	Elevator control system - Design

Factual Information

History of Flight

Landing-flare/touchdown	Flight control sys malf/fail (Defining event)

HISTORY OF FLIGHT:

On June 14, 2009, about 1817 UTC, a Boeing 737-400 (737), registration number TC-TLA, operated as Tailwind Airlines flight OHY036, experienced an uncommanded pitch up event at 20 feet radio altitude (RA) during the landing flare at Diyarbakir Airport in southeast Turkey. The flight crew performed a go-around and was able to control the pitch with significant column force, full nose down stabilizer trim, and thrust. A second approach and uneventful landing were made. The scheduled commercial passenger flight was operated by Tailwind Airlines on a wet lease to Onur Airlines from Istanbul to Diyarbakir (DIY).

According to the pilot report, the flight crew reported that, “during final approach to runway 34 for DIY at 20 feet RA without any command, the aircraft rapidly moved to an extreme nose up position of approximately 30 degrees”.

Information provided by the flight data recorder (FDR) indicates that on approach, the airplane was on a heading of about 140 degrees at an indicated airspeed of approximately 145 knots. The airplane was configured for landing, with the autothrottles on, autopilot off and the flaps positioned to a setting of 30. At a radio altitude of about 20 feet, with the pilot holding back pressure on the column for flare, there was an uncommanded continued displacement of both elevators resulting in the airplane's pitch attitude increasing from about four degrees to about forty degrees within approximately 14 seconds. The flight crew reacted immediately to the unexpected pitch-up by adjusting the stabilizer trim position to its full airplane nose down position (0 units) and by attempting to move the elevator control columns forward. The crew then executed a go-around.

Information from the FDR indicates that once the flight crew was able to re-establish minimal control over the pitching tendency, they turned off the hydraulic power to the flight controls. This action removed the hydraulic pressure from both elevator PCUs resulting in both elevators deflecting to their neutral (zero hinge moment or float) position. Because the stabilizer was positioned full nose down, the airplane’s pitch attitude rapidly changed from a positive five degrees to approximately negative five degrees. The flight crew immediately restored hydraulic power and the airplane continued to demonstrate significant pitch up tendencies. The flight crew controlled the airplane through the use of full nose down stabilizer, thrust, roll and significant pilot effort by both crewmembers on their respective columns. A second approach and landing was successfully made.

INJURIES TO PERSONS:

Both crewmembers sustained and reported injuries. No other injuries were reported among the passengers or the cabin crew.

DAMAGE TO AIRCRAFT:

None.

OTHER DAMAGE:

None.

PERSONNEL INFORMATION:

None.

AIRCRAFT INFORMATION:

The incident airplane was a Boeing 737-400 airplane equipped with CFM56 engines.

The Boeing 737-400 elevator control system provides primary pitch control of the airplane using two elevators that are hydraulically powered with manual reversion available in the event of a loss of hydraulics. This control system is activated by fore and aft motion of the captain's and first officer's control columns, which are connected via a torque tube with a forward cable control quadrant mounted at each end. Elevator control cables are routed from the quadrants aftwards and attach to a pair of elevator control quadrants, which are mounted on the lower elevator input torque tube. This tube is mechanically connected, via linkages, to each of the two power control unit (PCU) input control arm assemblies. When rotated, the lower torque tube input arm assembly provides a simultaneous command to each PCU to extend or retract. The two PCUs operate in unison and are powered by separate hydraulic systems, the left unit from hydraulic system “A” pressure and the right unit from hydraulic system "B" pressure. The output rod of each PCU is connected to the upper torque tube, which is directly linked by pushrods to each elevator. Failure of either hydraulic system will render one PCU inoperable. The remaining unit will then drive both elevators through the full range of travel. In the event of dual hydraulic failure, a manual reversion mode will allow the elevators to be driven directly through the mechanical control system. Aerodynamic elevator tabs are provided to assist elevator movement.

The incident airplane was equipped with two Parker Aerospace part number (P/N) 65-44761-21 elevator PCUs. According to the airplane’s flight and maintenance log, an inspection of the elevator PCUs was conducted after the incident flight. The inspection revealed that the left side elevator PCUs control input arm assembly was jammed in a position commanding retraction of the PCU’s piston. A piece of foreign object debris (FOD) was found positioned in

the gap between the left side elevator PCU control input arm assembly and its control stop; the roller was oriented with its axis parallel to the axis of the input arm assembly. In this position, the FOD prevented the input arm assembly from returning to its neutral (null) position. The operator dislodged and removed the FOD from the PCU and performed a functional test on the elevator control system. The functional test demonstrated that the elevator system was operational and fully functional per all maintenance requirements. Inspection also revealed a second piece of FOD at the bottom of the tail cone near the drain hole mostly buried in debris. Tailwind Airlines submitted both pieces of FOD to Boeing for metallurgical analysis.

Tailwind Airlines leased the incident airplane, from the International Lease Finance Corporation (ILFC) on February 20, 2009. Prior to this time, the airplane was operated under United States registry to a US-based operator and had been since its delivery in 1993.

In January 2009, AAR Aircraft Services (Oklahoma) performed a scheduled maintenance check ("C" check) on the airplane prior to re-registration for operation in Turkey. The Safety Board examined the maintenance work performed at AAR Aircraft Services during the airplane's "C check" to determine if any work was completed on the elevator control system. Part of the check involved inspecting the amount of elevator control surface free play and performing maintenance as necessary. According to AAR Aircraft Services paperwork (a non-routine form), the left hand elevator failed the free play check; the free play of the control surface movement exceeded the tolerance specified in the Aircraft Maintenance Manual. To correct this discrepancy, AAR replaced the following components on the left hand (LH) elevator control system: elevator mast arm fitting bearing, elevator upper torque tube output crank bearing/sleeve, and control rod bushings. The elevator control surface free play was re-checked and passed per AMM specifications.

A review of the non-routine form by the FAA revealed that AAR Aircraft Services referenced an incorrect document for the removal and replacement of the elevator upper torque tube output crank bearing/sleeve. AAR Aircraft Services agreed with the FAA's findings that the reference was incorrect, but were confident that the bearing/sleeve was replaced per the correct maintenance document. A follow-up review of AAR Aircraft Services by the FAA found no additional discrepancies with the maintenance documents reference for completed maintenance tasks. A review of the non-routine form by the NTSB revealed that an AAR Aircraft Services mechanic replaced the left elevator upper torque tube output crank bearing/sleeve and that an AAR Aircraft Services inspector inspected and approved the work.

METEOROLOGICAL INFORMATION:

None.

AIDS TO NAVIGATION:

None.

COMMUNICATIONS:

None.

AERODROME INFORMATION:

None.

FLIGHT RECORDERS.

On January 7, 2010, the Safety Board's Vehicle Recorder Division received an electronic file from the aircraft manufacturer, Boeing. The file was a download from the FDR on board the event aircraft and contained over 31 hours of data.

MEDICAL AND PATHOLOGICAL INFORMATION:

None.

FIRE:

None.

TESTS AND RESEARCH:

The Boeing Material and Process Technology (M&PT) group identified the two FOD items found in the left side PCU and in the tailcone area provided by the operator as having the same dimensions and metallurgical composition as the rollers installed into a DAS10-26B1-502 bearing. The DAS10-26B1-502 bearing is installed in the elevator upper output torque tube crank assembly. Energy Dispersive X-Ray Spectroscopy (EDS) results showed that both parts are made of 52100 low alloy steel. The length of the FOD and non-FOD parts was 0.1988" and 0.1989", respectively. The diameters of both parts were narrowest in the middle and widest at the ends, and ranged from 0.1371" to 0.1441 for the part removed from the PCU, and 0.1371" to 0.1442" for the part found in the tailcone area.

The system "A" elevator PCU was removed from the airplane and sent to the Boeing M&PT group for examination. The examination of the elevator PCU was held to specifically review and reenact how a bearing roller trapped between the PCU arm and its housing could cause the reported incident. This reenactment was performed with another individual roller taken from a like bearing. The reenactment showed that if a roller (from a bearing) became lodged between the PCUs arm and body as on the event PCU, it could offset the control input arm in a downward direction. With the control arm deflected to the downward position and with hydraulic pressure on system A, the PCU would be actuated to raise the elevator or pitch the airplane up. This closely agreed with the FDR recorded elevator trailing edge up movement rate during the event flight landing flare just prior to the commanded go-around.

Boeing conducted a post-incident examination of the airplane's elevator system components located within the area of the tail cone with specific focus on the left elevator upper torque tube output crank bearing. The inspection revealed that the bearing/sleeve appeared new, in good condition and completely intact (all bearings present). Both elevator PCUs and their associated components (input linkages, external summing levers, input rods) were inspected and found intact and mechanically connected to their respective attachment points via attachment hardware.

ORGANIZATIONAL AND MANAGEMENT INFORMATION:

None

ADDITIONAL INFORMATION:

The Boeing 737-100/-200 series airplanes were certified in 1967. A significant model change was introduced with the advent of the B737-300, which incorporated a new engine variant (CFM-56) and updated flight deck displays and avionics. The B737-300, -400 and-500 series airplanes were type certificated during the 1984-1990 period (November 14, 1984; September 2, 1988; and February 12, 1990, respectively). The Type Certificate Data Sheet (A16WE) shows that the unchanged areas of the 737-300/-400/-500 flight control system carry the same certification basis as the 737-100/-200 airplanes. The main transport category rules for the 737-100/-200 and 737-300/-400/-500 airplane flight control systems were 14 Code of Federal Regulations (CFR) 25.695 and 25.1309. The design of the pitch control system on the 737-300/-400/-500 airplanes is essentially unchanged from the 737-100/-200 airplanes.

When the 737-100/-200 airplanes were certified, the FARs did not specifically require consideration of a single point failure mode (such as a single PCU rate jam) as long as the failure mode was considered extremely remote. The FARs have been modified since then, and the current certification regulations cover this area in 14 CFR 25.671, "Control Systems, General" which states the following in part:
(C) The airplane must be shown by analysis, tests, or both, to be capable of continued safe flight and landing after any of the following failures or jamming in the flight control system and surfaces (including trim, lift, drag, and feel systems), within the normal flight envelope, without requiring exceptional piloting skill or strength.
(3) Any jam in a control position normally encountered during takeoff, climb, cruise, normal turns, descent, and landing unless the jam is shown to be extremely improbable, or can be alleviated. A runaway of a flight control to an adverse position and jam must be accounted for if such runaway and subsequent jamming is not extremely improbable.

Information

Certificate:	**Age:**
Airplane Rating(s):	**Seat Occupied:**
Other Aircraft Rating(s):	**Restraint Used:**
Instrument Rating(s):	**Second Pilot Present:**
Instructor Rating(s):	**Toxicology Performed:**
Medical Certification:	**Last FAA Medical Exam:**
Occupational Pilot:	**Last Flight Review or Equivalent:**
Flight Time:	

Aircraft and Owner/Operator Information

Aircraft Make:	Boeing	**Registration:**	TC-TLA
Model/Series:	737 4Q8	**Aircraft Category:**	Airplane
Year of Manufacture:		**Amateur Built:**	
Airworthiness Certificate:	Normal; Transport	**Serial Number:**	25107
Landing Gear Type:	Retractable - Tricycle	**Seats:**	144
Date/Type of Last Inspection:		**Certified Max Gross Wt.:**	
Time Since Last Inspection:		**Engines:**	2 Turbo fan
Airframe Total Time:		**Engine Manufacturer:**	CFM
ELT:	Not installed	**Engine Model/Series:**	56
Registered Owner:	Tailwinds Airlines	**Rated Power:**	
Operator:	Tailwinds Airlines	**Operating Certificate(s) Held:**	Foreign air carrier (129)

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Not reported
Observation Facility, Elevation:		**Distance from Accident Site:**	
Observation Time:		**Direction from Accident Site:**	
Lowest Cloud Condition:	Unknown	**Visibility**	
Lowest Ceiling:		**Visibility (RVR):**	
Wind Speed/Gusts:	/	**Turbulence Type Forecast/Actual:**	/
Wind Direction:		**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:		**Temperature/Dew Point:**	
Precipitation and Obscuration:			
Departure Point:	ISTANBUL (IST)	**Type of Flight Plan Filed:**	Unknown
Destination:	Diyarbakir (DIY)	**Type of Clearance:**	Unknown
Departure Time:		**Type of Airspace:**	Unknown

Airport Information

Airport:	Diyarbakir Airport LTCC	**Runway Surface Type:**	
Airport Elevation:		**Runway Surface Condition:**	
Runway Used:		**IFR Approach:**	Unknown
Runway Length/Width:		**VFR Approach/Landing:**	Unknown

Wreckage and Impact Information

Crew Injuries:	2 Minor	**Aircraft Damage:**	None
Passenger Injuries:		**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	2 Minor	**Latitude, Longitude:**	37.892619,40.199837

Administrative Information

Investigator In Charge (IIC):	Hauf, Michael
Additional Participating Persons:	
Original Publish Date:	September 27, 2010
Last Revision Date:	July 8, 2024
Investigation Class:	Class
Note:	
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=74596