National Transportation Safety Board

Washington, D. C. 20594

Safety Recommendation

Log 2089

Date: September 30, 1988

In reply refer to: A-88-131 through -133

Honorable T. Allan McArtor
Administrator
Federal Aviation Administration
Washington, D.C. 20591

On May 9, 1988, a British Airways Boeing 747-136 airplane experienced an in-flight structural failure of the outboard track of the left inboard flap (No. 3 flap track--a structure to support and guide the flap) while on final approach to Chicago O'Hare International Airport, Chicago, Illinois. The Safety Board's continuing investigation revealed that the captain was flying a coupled autopilot approach and had selected 30° flaps at 1,500 feet above ground level (agl) for the final landing configuration. At 1,200 feet agl, approximately 30 seconds after final flap selection, a "large bump" was felt followed by a severe left yaw and moderate left roll which the autopilot was unable to control. The captain disengaged the autopilot, regained control of the aircraft, and manually flew the approach to an uneventful landing. There were no injuries to the 18 crewmembers or 286 passengers. The aircraft sustained extensive structural damage to the left inboard flaps, the two inboard spoilers, the spoiler support beam, the flap track attachment point on the aft wing spar, and various upper and lower wing surface panels. In addition, a puncture in the fuselage was found above and behind the aft entry door. The flap track was fractured completely just aft of the forward attachment point. At the rear attachment point, the inboard bolt failed, and the outboard bolt was bent outward 45°.

A postaccident metallurgical examination of the failed flap track was conducted by the Materials Laboratory Division, Bureau of Technology, National Transportation Safety Board, with assistance from Boeing Materials Technology Laboratory. This metallurgical examination concluded that the origin of the final fracture was a 0.174-inch-long stress corrosion crack which initiated in a corrosion pit in the outboard flange of the most forward outboard fail-safe bar bolt hole (the No. 1 bolt hole).

On September 12, 1988, the Air Accidents Investigation Branch (AAIB) of the Ministry of Transport, United Kingdom, notified the Safety Board of another occurrence of an in-flight failure of the outboard track of the right inboard flap (No. 6 flap track) on a British Airways Boeing 747-100 during a landing approach to London Heathrow Airport, London, England. The flap track failure occurred during

final approach at approximately 600 feet and shortly after the 30°-flap position was selected by the flightcrew. The airplane yawed to the right; the yaw was corrected by the captain with aileron and rudder, and an uneventful landing was made.

The AAIB, British Airways, and Boeing Commercial Airplane Company (Boeing) personnel on the scene found that the No. 6 flap track had fractured completely in the vicinity of the forward bolt holes and that the aft section of the track was displaced downward about 1.5 inches. Significant additional structural damage was noted to the fore flap, spoilers, spoiler support beam, and several fixed panels.

Inspection of the flap track fracture by AAIB and Boeing metallurgists indicated that the separation had initiated at the most forward fail-safe bar bolt hole (No. 1 bolt hole) in the outboard flange of the track and had propagated upward through the flange and aft in the track web. The fracture terminated in the vicinity of the No. 7 bolt hole in the inboard flange of the track. Initial examination of the fracture initiation area at the No. 1 outboard bolt hole revealed heavy corrosion on the fracture faces and corrosion pitting in the bolt hole bore. The initial fracture mode has been established as a 0.175-inch-long preexisting stress corrosion crack emanating from a corrosion pit in the hole bore and subsequently extending in overstress until separation of the track.

After this flap track fracture, British Airways began an inspection of the flap tracks on its Boeing 747-100 fleet by removing eight randomly selected bolts from the tracks and visually inspecting the bores for evidence of cracking and corrosion. Corrosion pitting was found in four of the eight bolt holes examined. Also, an ultrasonic inspection of one track revealed an 0.08-inch crack radiating out of the No. 4 bolt hole bore which was confirmed by magnetic inspection after removal of the bolt. The track had been inspected ultrasonically 10 flight cycles before this inspection with no indication of a crack.

In both the May 9 and September 12 accidents, the failed flap tracks were an early production design incorporated in the first 239 B-747s, and the tracks have a documented history of cracks attributed to fatigue, stress corrosion, and corrosion pitting at the fail-safe bar fastener holes. Since October 1972, 23 operators have reported 85 cases of cracks found during inspection of early production flap tracks, 22 of which have been specific to the tracks on the inboard flaps (No. 3, 4, 5, and 6). In addition to the two cases discussed herein, there has been one previous occurrence of an in-flight failure of this model track at the No. 1 bolt hole.[1] The Safety Board report on this occurrence listed corrosion and fatigue in the bolt bore as the probable cause.

This early production flap track has been the subject of Federal Aviation Administration (FAA) Airworthiness Directives (AD) 84-19-02 and 76-03-06 and Boeing Safety Bulletins (SB) 747-57A2229 and 747-57-2146 which prescribe the frequency and methodology of inspection to detect cracks before failure. The flap track in the Chicago accident airplane had been inspected visually for cracks in accordance with all applicable ADs and SBs 145 flight cycles before it failed, and it was not due to be reinspected for another 155 flight cycles. Total flight cycles on the failed track were 16,381.

[1]For more detailed information, read Brief of Accident Report No. 5119 (attached).

As a result of the Chicago accident investigation, Boeing revised and reissued SB 747-57A2229 (Rev. 5). The new SB incorporated a 300-flight recurrent ultrasonic inspection for cracks on the Nos. 3, 4, 5, and 6 flap tracks in addition to the previously prescribed visual inspection of these tracks. The accident airplane at Heathrow had been inspected ultrasonically 152 flights before the incident per SB 747-57A2229 (Rev. 5). This latest revision of the SB has been incorporated subsequently in full into AD 88-16-03, effective August 15, 1988. As a terminating action to the repetitive inspections, the SB specifies replacement of the early production flap tracks with the current production tracks that are stronger and more durable. The current production flap track is designed with an increased web and flange thickness and raised bosses on the lower forward chords at the fail-safe bar fastener holes. This design change provided a stronger, more durable flap track and was incorporated in 1971.

To address the issue of continuing airworthiness in the face of corrosion pitting and stress corrosion, the Safety Board believes that these early production flap tracks should be replaced with the current production tracks and that these new tracks should be incorporated into the Boeing 747 Supplemental Structural Inspection Program to monitor the adequacy of the design changes and to establish a baseline for continued inspections. In the interim, early and recurrent magnified visual or other nondestructive inspection of the bolt hole bores should be required to detect corrosion pitting and cracks in the bores. Because of the unpredictability of stress corrosion crack propagation, the Safety Board believes that inspection of the inboard flap track bolt hole bores should be accomplished within 20 flight cycles of any previous inspection of tracks for cracks.

Consideration also should be given to restrict operation of the affected B-747 airplanes to 25° of flap extension unless there is an operational safety consideration necessitating 30° of flap extension. The reduction of the stress on the inboard flap tracks is significant with the reduction of flap setting from 30° to 25°. Boeing analysis shows a 15 percent reduction of the loading at the flap track forward fuse pin with an attendant increase of fatigue life of 43 percent by reducing approach flap extension by this 5°. Use of the 25°-flap setting requires a slightly increased approach attitude and an increase of about 8 knots to V_{ref} (reference speed). Increase in runway required at this reduced flap setting is approximately 800 feet.

The recent failures of these flap tracks clearly indicate that the present visual and ultrasonic inspections of the flap tracks on the inboard flaps are not adequate for detecting a critical crack of such small magnitude and that the common initial factor in the three in-flight failures has been corrosion pitting in the bolt hole bores. The Safety Board is very concerned that there is a potential for catastrophic structural failure on the 239 aircraft in the world fleet configured with these early production flap tracks. The Safety Board also believes that early detection of the pitting in the bolt hole bores will preclude subsequent cracking and failure of the tracks.

Therefore, as a result of its investigation, the National Transportation Safety Board recommends that the Federal Aviation Administration:

> For Boeing 747 airplanes with the early production flap tracks, require a magnified visual or other nondestructive inspection, within 20 flight cycles of any previous inspection, of the forward bolt hole bores of the inboard flap tracks for corrosion pitting and cracks using damage tolerance criteria devised by Boeing, and establish periodic inspection

intervals for the bolt hole bores consistent with early detection of corrosion pitting in the bores. (Class I, Urgent Action) (A-88-131)

Issue an Air Carrier Operations Bulletin to advise all operators of Boeing 747 airplanes configured with the early production flap tracks of the advantages of operating these airplanes with a maximum of 25°-flap extension. (Class I, Urgent Action) (A-88-132)

Require prompt replacement of all early production flap tracks on inboard and outboard flaps on Boeing 747 airplanes with new production tracks, and include these new tracks in the Boeing 747 Supplemental Structural Inspection Program. (Class II, Priority Action) (A-88-133)

By: James L. Kolstad
Acting Chairman

National Transportation Safety Board
Washington, D.C. 20594

Brief of Incident

File No. - 5119 6/11/84 SAN FRANCISCO,CA A/C Reg. No. N4712U Time (Lcl) - 2130 PDT

----Basic Information----
Type Operating Certificate-AIR CARRIER - FLAG/DOMESTIC
Name of Carrier -UNITED AIRLINES
Type of Operation -SCHEDULED,DOMESTIC,PASSENGER
Flight Conducted Under -14 CFR 121
Incident Occurred During -APPROACH

Aircraft Damage
MINOR
Fire
NONE

	Injuries			
	Fatal	Serious	Minor	None
Crew	0	0	0	3
Pass	0	0	0	1

----Aircraft Information----
Make/Model - BOEING 747-122
Landing Gear - TRICYCLE-RETRACTABLE
Max Gross Wt - 775000
No. of Seats - 429

Eng Make/Model - P&W JT9D-3
Number Engines - 4
Engine Type - TURBOFAN
Rated Power - UNK/NR

ELT Installed/Activated - YES/NO
Stall Warning System - YES

----Environment/Operations Information----
Weather Data
Wx Briefing - UNK/NR
Method - UNK/NR
Completeness - UNK/NR
Basic Weather - VMC
Wind Dir/Speed- 280/025 KTS
Visibility - 15.0 SM
Lowest Sky/Clouds - CLEAR
Lowest Ceiling - NONE
Obstructions to Vision- NONE
Precipitation - NONE
Condition of Light - DUSK

Itinerary
Last Departure Point
HONOLULU,HI
Destination
SAN FRANCISCO,CA

ATC/Airspace
Type of Flight Plan - IFR
Type of Clearance - IFR
Type Apch/Lnds - FULL STOP

Airport Proximity
OFF AIRPORT/STRIP

Airport Data
Runway Ident - N/A
Runway Lth/Wid - N/A
Runway Surface - N/A
Runway Status - N/A

----Personnel Information----
Pilot-In-Command
Certificate(s)/Rating(s)
ATP
ME LAND

Age - 59
Biennial Flight Review
Current - YES
Months Since - UNK/NR
Aircraft Type - UNK/NR

Medical Certificate - VALID MEDICAL-WAIVERS/LIMIT
Flight Time (Hours)
Total - 31140
Make/Model- UNK/NR
Instrument- UNK/NR
Multi-Eng - UNK/NR
Last 24 Hrs - UNK/NR
Last 30 Days- UNK/NR
Last 90 Days- UNK/NR
Rotorcraft - UNK/NR

Instrument Rating(s) - AIRPLANE

----Narrative----
JUST INSIDE THE OUTER MARKER, A *LOUD BANG* WAS HEARD & LEFT AILERON INPUT WAS NEEDED TO CONTROL ACFT HEADING. THE LANDING WAS MADE WITHOUT INCIDENT UNTIL THE FLAPS WERE RAISED WHILE TAXIING & THE FLT ENGINEER REPORTED A #4 HYDRAULIC SYSTEM FAILURE. THE CAPT LOST BRAKES AND HAD TO UTILIZE STANDBY BRAKES. AT THIS TIME A SPLIT FLAP INDICATION WAS OBSERVED. INSPECTION REVEALED FLAP TRACK FRACTURED APRX 6 INCHES AFT OF THE FORWARD ATTACH POINT. THE FRACTURE INITIATED ON OUTBOARD FLANGE #1 BOLTHOLE WALL BECAUSE OF FITTING CORROSION. A PORTION OF THE FORE FLAP & A SMALL WING PANEL SEPARATED FROM THE ACFT. DURING FLAP RETRACTION AFTER LANDING, THE TRANSMISSION BALL NUT JAMMED. THE DRIVE TORQUE TUBE FRACTURED AT THIS TIME AND THE BROKEN END OF THE ROTATING TORQUE TUBE DAMAGED HYDRAULIC LINES, CAUSING A LOSS OF HYDRAULIC FLUID. AN ALERT SERVICE BULLETIN WAS ISSUED BY BOEING AFTER THIS INCIDENT & UNITED AIRLINES INITIATED A FLEET WIDE INSPECTION.

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Occurrence #1 AIRFRAME/COMPONENT/SYSTEM FAILURE/MALFUNCTION
Phase of Operation APPROACH

Finding(s)
1. FLIGHT CONTROL,FLAP ATTACHMENT - CORRODED
2. FLIGHT CONTROL,FLAP ATTACHMENT - FATIGUE
3. HYDRAULIC SYSTEM,LINE - LEAK
4. LANDING GEAR,NORMAL BRAKE SYSTEM - INOPERATIVE

----Probable Cause----

The National Transportation Safety Board determines that the Probable Cause(s) of this incident is/are finding(s) 1,2