Aviation Investigation Final Report

Location:	PROVIDENCE, Rhode Island	**Accident Number:**	NYC00LA085
Date & Time:	February 27, 2000, 21:00 Local	**Registration:**	GBDXL
Aircraft:	Boeing 747-236	**Aircraft Damage:**	None
Defining Event:		**Injuries:**	1 Serious, 11 Minor, 371 None
Flight Conducted Under:	Part 129: Foreign		

Analysis

The airplane was in cruise flight when it began a descent from flight level 350. At the same time, the flight engineer was reconfiguring the airplane's electrical system from a Category III landing to a Category I landing. When the flight engineer closed the "number one bus-tie-breaker," the airplane experienced an uncommanded pitch-up, accompanied by numerous momentary instrument failures. Twelve occupants were injured. The airplane was utilizing the "A" autopilot system, which remained engaged. The pilot disconnected the autopilot, leveled the airplane, re-engaged the autopilot, and continued to an uneventful landing. During a ferry flight, maintenance personnel were able to duplicate a "sudden pitch-up" while using the airplane's "B" autopilot system, and closing the "number two bus-tie-breaker." Additionally, the flight crew reported that the airplane "felt light in pitch." Examination of data obtained from the flight data recorder and optical quick access recorder revealed an electrical discontinuity around the time of the pitch-up. An inspection of the airplane revealed that the number 1 and 2, elevator feel computer pitot connections were capped. Review of the airplane's maintenance history revealed that the airplane had recently undergone an "inter 2 check" at a British Airways maintenance facility. During that time, maintenance personnel disconnected the pitot connections to the elevator feel computer in order to perform pitot static system checks. The effect of the disconnected pitot-static lines on the elevator feel computer would have resulted in a more extreme travel of the elevator control surface. The calculated expected autopilot elevator authority for the accident flight was about 4 degrees. The estimated actual elevator deflection during the accident sequence was 6.87 degrees nose up, and 6.97 degrees nose down. Review of the Boeing basic airplane maintenance manual section that detailed the pitot-static system checks revealed a test to confirm that the elevator feel computer was reconnected and functioned. The test was not present the maintenance manual utilized by British Airways, which was provided by Boeing. The source of the pitch-up command to the autopilot was not determined; however, when the autopilot system was properly configured, the pitch-up characteristics were not objectionable and within expected values.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this accident to be: Maintenance personnel's failure to reconnect the pitot connections to the elevator feel computer which resulted in an elevator control surface deflection which was outside of the normal autopilot elevator authority. The uncommanded autopilot input to the elevator control surface resulted from an undetermined electrical source. A factor in this accident was that the section of the 747 Maintenance Manuel utilized by company maintenance personnel did not contain an "elevator feel light test."

Findings

Occurrence #1: AIRFRAME/COMPONENT/SYSTEM FAILURE/MALFUNCTION
Phase of Operation: DESCENT - NORMAL

Findings
1. ELECTRICAL SYSTEM - UNDETERMINED
2. (C) MAINTENANCE - IMPROPER - COMPANY MAINTENANCE PERSONNEL
3. (F) CONDITION(S)/STEP(S) NOT LISTED - MANUFACTURER
4. AUTOPILOT/FLIGHT DIRECTOR - UNCOMMANDED

Factual Information

On February 27, 2000, about 2100 Eastern Standard Time, a Boeing 747-236, G-BDXL, operated by British Airways, PLC., as flight 179, experienced an in-flight upset during a descent in the vicinity of Providence, Rhode Island. Three flight crewmembers, 14 flight attendants, and 354 passengers were not injured. One passenger received serious injures, while 10 passengers and 1 flight attendant sustained minor injures. Instrument meteorological conditions prevailed and an instrument flight rules flight plan had been filed for the flight that departed London-Heathrow Airport (LHR), England, United Kingdom, destined for the John F. Kennedy International Airport (JFK), Jamaica, New York. The scheduled international flight was conducted under 14 CFR Part 129.

In an interview with a Federal Aviation Administration (FAA) Inspector, the flight crew reported that the fasten seat belt sign was "off," and the airplane's electrical system was configured for a Category III (CAT III) landing, when they began a descent from "flight level 350." At the same time, the flight engineer began to reconfigure the airplane's electrical system for a Category I (CAT I) landing, due to an improvement in landing visibility. When the flight engineer closed the "number one bus-tie-breaker," the airplane's pitch changed from 2-degrees nose-down, to about 5-degrees nose-up. The airplane was utilizing the "A" autopilot system, which remained engaged. The pilot disconnected the autopilot, leveled the airplane, re-engaged the autopilot, and then continued a normal descent. The airplane landed at JFK without further incident. Additionally, the pilot reported that the pitch-up was accompanied by numerous momentary instrument failures, and the effect was very similar to the electrical changeover that is experienced on the ground when the airplane's electrical system supply changes from ground power to aircraft power.

Examination of the airplane's autopilot and electrical system performed by maintenance personnel at JFK did not reveal any discrepancies.

The accident airplane was equipped with a Penny & Giles flight data recorder (FDR), and an optical quick access recorder (OQAR). The data from the recorders was downloaded by British Airways, and provided to the Safety Board. Examination of both the FDR and the OQAR information revealed an electrical discontinuity around the time of the event.

According to British Airways, on the evening of February 29, the accident airplane was flown on a non-revenue flight back to LHR.

During the flight to LHR, maintenance personnel were able to duplicate a "sudden pitch-up" while using the airplane's "B" autopilot system, and closing the "number two bus-tie-breaker." Additionally, the flight crew reported that the airplane "felt light in pitch."

A subsequent inspection of the airplane revealed that the number 1 and 2, "elevator feel computer" pitot connections were capped. Review of the airplane's maintenance history revealed that the airplane underwent an "inter 2 check" at a British Airways maintenance facility between February 5 and 23, 2000. According to a British Airways quality inspection report, during the time of the inter 2 check, the pitot connections to the elevator feel computer were disconnected by maintenance personnel in order to perform pitot static system checks "in-accordance-with (IAW) the [airplane] Maintenance Manual [Chapter] 34-11-00." A functional check of the feel computer was not performed before the airplane was returned to service.

Review of the Boeing basic 747 Maintenance Manual Chapter 34-11-00, Pitot-Static Adjustment/Test, revealed an "Elevator Feel Light Test" and the following note:

"The following test must be performed to ensure that auxiliary pitot systems No. 1 and 2, which were disconnected prior to system leakage test, are properly reconnected...."

British Airways utilized a customized version of the 747 Maintenance Manual, which was provided by Boeing. Review of the maintenance manual chapter 34-11-00, Pitot-Static Adjustment/Test revealed that the customized section did not contain the requirement for an elevator feel light test. The section did specify that a "leak check" be performed after the pitot-static lines are reconnected. A representative from Boeing stated that if the pitot-static connections to the elevator feel computer were left disconnected and capped, then a "leak check" would not identify an unconnected elevator feel computer, provided that the caps were pressure tight.

The Boeing representative also stated that Boeing intends to publish a revised customized 747 Maintenance Manual for British Airways, which will include an elevator feel light test in Chapter 34-11-00. Additionally, Boeing will revise the customized maintenance manuals for four other 747 operators.

Boeing provided information on the effect of disconnected pitot-static lines on the elevator feel computer.

According to Boeing, the elevator control system required artificial feel forces that were provided by a combination of mechanical and hydraulic springs contained in the feel unit. The feel computer programs hydraulic pressure to the feel unit actuators as a function of pitot pressure and stabilizer position. With the lines disconnected, the feel computer would react as if the airspeed is low and thus the feel unit forces would be less than expected. The autopilot reacts against artificial feel forces to regulate the deflection of the elevator surface. If the artificial feel forces were low, the autopilot command would cause greater than normal elevator deflection, resulting in a larger upset of the airplane than would normally be encountered.

Boeing calculated that the normal autopilot elevator authority for the flight conditions at the time of the accident should have been about 4 degrees. The estimated actual elevator

deflection during the accident sequence was 6.87 degrees nose up, and 6.97 degrees nose down.

British Airways reported they were able to duplicate the pitch-up during two test flights, using two other 747-200 airplanes; however, the magnitude of the elevator movement experienced during the test flights remained within the autopilot elevator authority.

Subsequently, British Airways instituted the following modified bus-tie-breaker (BTB) re-engagement procedure:

"In flight, when it is necessary to CLOSE a BTB, the autopilot must be disconnected prior to selecting CLOSE on the BTB. The autopilot may be reselected once normal conditions are confirmed. In addition, when closing the BTB, possible short term flight instrument failures may occur."

The Boeing Operations Manual for the airplane, stated:

"When the No. 1 and No. 2 Bus Tie OPEN lights illuminate due to triple channel operation, reclose BTBs during accomplishment of the AFTER LANDING PROCEDURE or when in stabilized flight."

The Boeing Flight Crew Training Manual for the airplane, Automatic Flight, Go-Around section included the note:

"The automatic bus isolation system will reclose the DC isolation relays when any A/P [autopilot] disengages, however, bus tie breakers 1 and 2 will not reclose automatically. The bus tie breakers do not have auto-paralleling circuits and when placed to CLOSE will connect the bus regardless of phase relationship. Closing of the bus tie breakers during certain out of phase conditions may cause a voltage fluctuation. While these voltage fluctuations are within system tolerance, momentary airplane instrumentation instability could occur...."

At the time of the accident, British Airways operated 16 Boeing 747-200 airplanes that were modified by a supplemental type certificate to allow for a modified flight management computer (FMC) interface with the autopilot. The modification incorporated a Honeywell FMC, and a Honeywell data adapter unit. The modified British Airways 747-200 airplanes had been in use since 1984. According to Boeing and Honeywell, there were no other known 747-200 aircraft that were modified to this configuration.

British Airways reported they were in the process of "retiring" their 747-200 airplanes and expect to have all of their 747-200 airplanes out of service by April of 2002. The airplanes are being sold to a leasing company that intends to utilize the airplanes as freighters.

Thirty two operators of "classic 747" aircraft were surveyed with regards to the procedures their flight crews used when they reconfigured from a CAT III approach to a CAT I approach.

They were also asked to report any uncommanded aircraft motions as a result of electrical system reconfigurations. Twenty-one operators responded to the survey.

Of the twenty one operators which responded, 6 operators reported they performed CAT III approaches, of which, 4 operators stated they waited until after landing to reconfigure the BTBs and 2 operators published procedures for closing the BTBs after a missed approach. None of the respondents reported uncommanded aircraft motion as a result of BTB manipulation.

The source of the pitch-up command to the autopilot, which was experienced during the accident and test flights, was not determined; however, when the autopilot system was properly configured, the pitch-up characteristics were not objectionable and within expected values.

Pilot Information

Certificate:	Airline transport	**Age:**	47,Male
Airplane Rating(s):	Multi-engine land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	Airplane multi-engine; Instrument airplane	**Toxicology Performed:**	No
Medical Certification:	Class 1 Valid Medical--w/ waivers/lim	**Last FAA Medical Exam:**	September 28, 1999
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	
Flight Time:	13200 hours (Total, all aircraft), 4600 hours (Pilot In Command, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Make:	Boeing	**Registration:**	GBDXL
Model/Series:	747-236 747-236	**Aircraft Category:**	Airplane
Year of Manufacture:		**Amateur Built:**	
Airworthiness Certificate:	Transport	**Serial Number:**	22305
Landing Gear Type:	Retractable - Tricycle	**Seats:**	394
Date/Type of Last Inspection:	February 23, 2000 Continuous airworthiness	**Certified Max Gross Wt.:**	820000 lbs
Time Since Last Inspection:	59 Hrs	**Engines:**	4 Turbo fan
Airframe Total Time:	648 Hrs	**Engine Manufacturer:**	Rolls-Royce
ELT:	Not installed	**Engine Model/Series:**	RB211-524D4
Registered Owner:	BRITISH AIRWAYS, PLC.	**Rated Power:**	52810 Lbs thrust
Operator:		**Operating Certificate(s) Held:**	None
Operator Does Business As:		**Operator Designator Code:**	

Meteorological Information and Flight Plan

Conditions at Accident Site:	Instrument (IMC)	**Condition of Light:**	Night/dark
Observation Facility, Elevation:		**Distance from Accident Site:**	
Observation Time:		**Direction from Accident Site:**	
Lowest Cloud Condition:	Unknown	**Visibility**	
Lowest Ceiling:	Unknown	**Visibility (RVR):**	
Wind Speed/Gusts:	/	**Turbulence Type Forecast/Actual:**	/
Wind Direction:	0°	**Turbulence Severity Forecast/Actual:**	/
Altimeter Setting:		**Temperature/Dew Point:**	
Precipitation and Obscuration:			
Departure Point:	LONDON (LHR)	**Type of Flight Plan Filed:**	IFR
Destination:	JAMAICA (JFK)	**Type of Clearance:**	IFR
Departure Time:		**Type of Airspace:**	Class A

Airport Information

Airport:		**Runway Surface Type:**	
Airport Elevation:		**Runway Surface Condition:**	
Runway Used:	0	**IFR Approach:**	
Runway Length/Width:		**VFR Approach/Landing:**	

Wreckage and Impact Information

Crew Injuries:	1 Minor, 17 None	**Aircraft Damage:**	None
Passenger Injuries:	1 Serious, 10 Minor, 354 None	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	1 Serious, 11 Minor, 371 None	**Latitude, Longitude:**	

Administrative Information

Investigator In Charge (IIC):	Schiada, Luke
Additional Participating Persons:	MIKE CARTELLI; GARDEN CITY , NY SIMON LIE; SEATTLE , WA MARTIN BUZZARD; LONDON GREG NIECIECKI; PHOENIX , AZ
Original Publish Date:	September 27, 2001
Last Revision Date:	
Investigation Class:	Class
Note:	
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=48707