In-flight flap separation, Boeing 767-232, March 27, 1997

Micro-summary: **This Boeing 767 lost an 18-foot section of flap on approach.**

Event Date: **1997-03-27 at 845 CST**

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

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

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2. Readers are advised that each report is a glimpse of events at specific points in time. While broad themes permeate the causal events leading up to crashes, and we can learn from those, the specific regulatory and technological environments can and do change. ***Your company's flight operations manual is the final authority as to the safe operation of your aircraft!***

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National Transportation Safety Board

FACTUAL REPORT AVIATION

NTSB ID: FTW97IA144	Aircraft Registration Number: N105DA
Occurrence Date: 03/27/1997	Most Critical Injury: None
Occurrence Type: Incident	Investigated By: NTSB

Location/Time

Nearest City/Place	State	Zip Code	Local Time	Time Zone	
DFW AIRPORT	TX	75261	0845	CST	

Airport Proximity: Off Airport/Airstrip	Distance From Landing Facility: 10	Direction From Airport: 45

Aircraft Information Summary

Aircraft Manufacturer	Model/Series	Type of Aircraft
Boeing	767-232	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 March 27, 1997, approximately 0845 central standard time, a section of the right outboard flap separated from a Boeing 767-232, N105DA, during the airplane's approach to the Dallas/Fort Worth International Airport (DFW), Texas. The airplane was being operated by Delta Air Lines, Inc., under Title 14 CFR Part 121, as scheduled domestic passenger flight 691, from Orlando, Florida, to DFW. After making a flyby of the tower to allow controllers to view the extent of the damage, the flightcrew landed the airplane without further incident. There were no injuries to the 189 passengers or the 9 crewmembers aboard the airplane. The separated flap section came to rest in an open field in Carrollton, Texas, and there were no injuries to ground personnel.

In a written statement provided to the NTSB investigator-in-charge (IIC), the captain of flight 691 reported that the takeoff and departure from Orlando were "routine, as were all aspects of the enroute phase of the flight." During the descent for landing on runway 17C at DFW, with the spoilers fully deployed and the flaps extended to 5 degrees, the first officer, who was the pilot flying, called for 15 degrees of flaps. The captain set the flaps at 15 degrees, and "a few moments later [he] felt a strong jolt." He noted that the first officer was using "a significant amount of left aileron" and had disengaged the autopilot and retracted the spoilers. The captain stated that "despite the unusual control inputs required, [the first officer] had the aircraft under control." He further stated that "there were no cockpit indications of a spoiler or flap problem."

According to the captain, a few seconds after the event, he received an intercom communication from the mid-station flight attendant reporting that a portion of the right wing had separated. He informed air traffic control that the flight was experiencing a problem and requested a flyby of the tower. Following a low pass "between 1,000 and 1,500 feet MSL" along the centerline of Runway 17L, the tower controller informed the flight that there was "something sticking up from [the] right wing." The captain declared an emergency and requested a visual approach to the longest available runway. The flight was cleared to land on runway 17R, and the approach was flown at "180 KIAS" (knots indicated airspeed), at which speed "the aircraft was controllable and stable." Following the landing, which the captain characterized as "flat and smooth," the flight "taxied in and shut down without further problems."

DAMAGE TO AIRCRAFT

Examination of the airplane by FAA inspectors and Delta maintenance personnel revealed that approximately 18 feet of the right outboard flap had separated from the trailing edge of the right wing. The inboard and outboard flap carriage assemblies remained affixed to the wing, and the outboard 14 feet of the flap remained attached to the outboard flap carriage support beam. Collateral damage included separation of the trailing edge of the #9 spoiler and damage to the

National Transportation Safety Board

FACTUAL REPORT
AVIATION

NTSB ID: FTW97IA144

Occurrence Date: 03/27/1997

Occurrence Type: Incident

Narrative (Continued)

trailing edge of the #12 spoiler.

The separated section of the flap, which was recovered from an open field approximately 10 miles northeast of DFW, extended from the inboard flap edge at Wing Butt Line (WBL) 355 to approximately 1 foot inboard of the outboard flap carriage support beam at WBL 622. Further examination of the separated section revealed that the six bolts which fastened the lower surface of the flap to the inboard flap carriage support beam at WBL 456 had fractured. The lower pieces of the bolts (threaded portions) and the nuts used to secure the bolts were not recovered. The upper piece of each fractured bolt (head and shank portion) was found protruding through its respective attaching hole in the lower surface of the separated flap section. Portions of the fracture surfaces on three of the four aft bolts displayed dark discoloration. The fracture surfaces on the two forward bolts and the other aft bolt were unremarkable. All six of the bolts were removed, and at the request of the NTSB IIC, delivered by Delta to the NTSB Materials Laboratory, Washington, DC, for metallurgical examination.

AIRCRAFT INFORMATION

N105DA, a Boeing 767-232, serial number 22217, was manufactured on January 8, 1983. The airplane had accumulated 45,577 hours and 22,155 flight cycles at the time of the incident. According to Delta safety personnel, the airplane's maintenance records did not indicate any removal of the right outboard flap from the wing since Delta accepted delivery of the airplane from Boeing on January 19, 1983.

In response to questions raised by the IIC regarding recurring inspection procedures, a Boeing representative stated that a visual inspection of the outboard flap attachment bolts was "called out at "C" check intervals," specifically a visual inspection at "1C" checks and a detailed visual inspection at "4C" checks. The representative further stated that "there was no routine maintenance called out to check the bolt torque."

The most recent "1C" check of the airplane was performed on October 22, 1996, at an airframe total time of 44,167 hours (1,410 hours before the incident). On February 15, 1997, at an airframe total time of 45,294 hours (283 hours before the incident), the airplane underwent a service check. The last maintenance inspection performed prior to the incident was a layover check on March 26, 1997. (Delta accomplishes "C" checks, service checks, and layover checks at intervals of 4,000 hours, 400 hours, and once per day, respectively.) According to a Delta representative, both the layover check and the service check provided for a visual inspection of the wings, and both checks required inspection of the flaps for general condition and security. No discrepancies with the right outboard flap were noted during the performance of these three inspections.

FLIGHT RECORDERS

The cockpit voice recorder (CVR) was not readout. At the request of the NTSB IIC, the Digital Flight Data Recorder (DFDR) was readout by Delta, and a file containing the raw data was sent to the Safety Board's laboratory in Washington, DC, for evaluation. For details of the DFDR evaluation refer to the Flight Data Recorder Factual Report. The recorded parameters included left and right trailing edge flap positions, left and right inboard aileron positions, and left and right outboard aileron positions. The recorded parameters did not include spoiler position or control wheel position.

The tabular data indicated that the flaps reached 15 degrees extension at FDR subframe reference number 8916. Flap separation occurred 1 minute 54 seconds later, between FDR subframe reference numbers 9030 and 9031, when the airplane was at an altitude of approximately 5,000 feet MSL and an airspeed of 208 knots. During the next 11 seconds (9031 to 9042), the airplane rolled right to a maximum roll angle of 15.12 degrees right wing low and then returned to a wings level attitude.

Narrative (Continued)

Prior to flap separation, the right and left inboard ailerons were deflected to -10 and -8 degrees respectively. (With reference to aileron positions, negative numbers indicate trailing edge down deflection.) The inboard ailerons droop 10 degrees when the flaps are extended beyond 5 degrees. The deflection limits for the inboard ailerons are +20 and -20 degrees. Immediately after flap separation, the right inboard aileron deflected to and maintained -20 degrees, its maximum down limit. The left inboard aileron initially deflected to +13.5 degrees and then varied from +10 to +16 degrees before stabilizing around +14 degrees.

Prior to flap separation, the right and left outboard ailerons were deflected to +2 and 0 degrees respectively. The deflection limits for the outboard ailerons are +30 and -15 degrees. Immediately after flap separation, the right outboard aileron deflected to and remained approximately -10 degrees. The left outboard aileron initially deflected to +16 degrees and then varied from +13 to +19 degrees before stabilizing around +17 degrees.

According to graphical data provided by Boeing, the stabilized aileron positions recorded by the DFDR corresponded to a control wheel position of 30 to 35 degrees left. The control wheel deflection limits are 65 degrees left or right.

During a telephone interview, Boeing engineering personnel reported that the DFDR samples each aileron control surface position at 2 second intervals, alternating every second between left and right wings, giving an effective sample interval of 1 second. They further reported that the DFDR receives primary control surface position inputs from the same source as the Engine Indication and Crew Alerting System (EICAS) control surface position display. The EICAS display incorporates a 1 second time lag, only showing a control surface movement if the control surface remains deflected for at least 1 full second. Therefore, rapid control inputs and the corresponding control surface movements are not shown on the EICAS display or captured by the DFDR.

TESTS AND RESEARCH

Examination of the six fractured bolts in the NTSB Materials Laboratory revealed that the four aft bolts displayed fatigue propagation through 2%, 8%, 30%, and 35%, respectively, of their fracture surfaces. The fracture areas beyond the fatigue regions on the four aft bolts and the entire fracture surfaces on the two forward bolts contained features typical of overstress separation.

All six bolts contained a circumferential thread relief shoulder that was located between the threads and the non-threaded shank. Three of the four aft bolts exhibited thread contact marks on the thread relief shoulder, as if the thread relief shoulder was making contact with the threads of an attachment nut. All six bolts displayed fretting damage on the shank. For a detailed description of the metallurgical findings refer to the Metallurgist's Factual Report.

The NTSB metallurgist noted that the measured grip lengths of the four aft bolts did not correspond to the grip lengths of the bolts specified in the Boeing installation drawing for the outboard trailing edge flap (Drawing No. 113T13000.) Additionally, review of the figure, entitled "Flap Instl - Outbd TE," on pages 0-14 of the Boeing 767 Illustrated Parts Catalog (IPC) 27-51-21-01, by the IIC established that the IPC called out a specific grip length bolt for each of the six flap carriage support beam bolts.

In response to questions raised by the IIC regarding grip lengths of bolts, a Boeing representative stated that "the assembly and installation diagrams give the factory authority to vary the bolt grip lengths to accommodate the various shim requirements." The representative further stated that "the shims are required to achieve proper fit and fair of the flap with the rest of the wing surface. Therefore, the shim thickness and bolt grip lengths will be different for every airplane."

The instructions contained in the Boeing 767 Airplane Maintenance Manual (AMM) 27-51-20, pages

National Transportation Safety Board

FACTUAL REPORT

AVIATION

NTSB ID: FTW97IA144

Occurrence Date: 03/27/1997

Occurrence Type: Incident

Narrative (Continued)

402-411 and 417-426, for installation of the outboard flaps were reviewed by the IIC. The procedure for achieving proper fit and fair of the flap directed the mechanic to adjust the shims to change the position of the flap. No mention was made in the AMM of the need to adjust bolt grip length in conjunction with the addition or removal of shims in order to ensure proper installation. (In November 1997, the AMM was revised, and a note was added to page 419, which stated, "make sure the bolts have the correct grip length.")

ADDITIONAL INFORMATION

On April 1, 1997, Boeing issued Alert Service Bulletin 767-27A0151 calling for an inspection of the outboard flap attachment bolts on Boeing 767 airplanes with more than 25,000 hours or 10,000 flight cycles. Revision 1 to the service bulletin, which made corrections to the original, was issued on April 2, 1997. On the same day, the FAA issued Telegraphic Airworthiness Directive (AD) T97-08-51, applicable to "all model 767 series airplanes," mandating "an inspection to check the bolt torque, bolt length, and type of all bolts of both hinge fittings on the left- and right-hand outboard trailing edge flaps," in accordance with the Boeing service bulletin.

On April 10, 1997, Boeing issued Revision 2 to the service bulletin. This revision added a note to the accomplishment instructions stating, in part:

Due to shimming requirements, the nominal stack-up of shims at the forward and aft locations may vary plus or minus 0.25 inches. During bolt installations adjust the bolt grip length plus or minus 4 grip lengths from the nominal grip length specified in IPC 27-51-21 as required to ensure proper installation.

On June 15, 1997, Boeing sent a message to "all Boeing 767 operators" containing the following fleet summary of the results from accomplishment of the service bulletin:

Number of airplanes reported: 212 (848 joints, 5088 bolts) Joints with loose bolts: 176 (176/848 = 21%) Bolts too long/short: 138 (138/5088 = 2.8%) Airplanes with bolt type different from drawing: 10 Fatigue cracked bolt: 6 (on 3 aircraft) Bolts fractured on retorqueing: 5 Cracked nuts (also of wrong type): 5 Missing radius filler: 1

The message stated that the above results included "several airplanes that were inspected with less than 10,000 flight cycles or 25,000 flight hours." It further stated that based on the data, Boeing intended to revise the service bulletin by lowering the threshold for initial inspection to 5,000 flight cycles or 12,500 flight hours. On July 7, 1997, Revision 3 to the service bulletin, which incorporated this change, was issued.

In correspondence with Safety Board staff, Boeing has indicated that it intends to issue a new service bulletin on the outboard flap attachment bolts in the second quarter of 1998, which "will define terminating action and recommend periodic checks."

The six fractured bolts were released to Delta on June 18, 1997.

National Transportation Safety Board

FACTUAL REPORT AVIATION

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Landing Facility/Approach Information

Airport Name	Airport ID:	Airport Elevation	Runway Used	Runway Length	Runway Width
DALLAS-FT. WORTH INTL	DFW	603 Ft. MSL	17R	13400	200

Runway Surface Type: Concrete

Runway Surface Condition: Dry

Type Instrument Approach: Visual

VFR Approach/Landing: Full Stop

Aircraft Information

Aircraft Manufacturer	Model/Series	Serial Number
Boeing	767-232	22217

Airworthiness Certificate(s): Transport

Landing Gear Type: Retractable - Tricycle

Homebuilt Aircraft?	Number of Seats:	Certified Max Gross Wt.	Number of Engines:
No	207	335000 LBS	2

Engine Type:	Engine Manufacturer:	Model/Series:	Rated Power:
Turbo Fan	GE	CF6-A2	48670 LBS

- Aircraft Inspection Information

Type of Last Inspection	Date of Last Inspection	Time Since Last Inspection	Airframe Total Time
Continuous Airworthiness	02/1997	283 Hours	45577 Hours

- Emergency Locator Transmitter (ELT) Information

ELT Installed?	ELT Operated?	ELT Aided in Locating Accident Site?

Owner/Operator Information

Registered Aircraft Owner	Street Address	City	State	Zip Code
DELTA AIR LINES, INC.	1030 DELTA BLVD.	ATLANTA	GA	30320

Operator of Aircraft	Street Address	City	State	Zip Code
Same as Reg'd Aircraft Owner	Same as Reg'd Aircraft Owner			

Operator Does Business As:

Operator Designator Code: DALA

- 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: Scheduled; Domestic; Passenger Only

National Transportation Safety Board

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First Pilot Information

Name	City	State	Date of Birth	Age
On File	On File	On File	On File	55

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

Certificate(s): Airline Transport; Commercial; Flight Engineer

Airplane Rating(s): Multi-engine Land; Single-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?

Medical Cert.: Class 1 | Medical Cert. Status: Valid Medical--w/ waivers/lim. | Date of Last Medical Exam: 02/1997

- 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	15000									
Pilot In Command(PIC)										
Instructor										
Last 90 Days	150	150								
Last 30 Days										
Last 24 Hours										

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
ORLANDO	FL	MCO	0000	

Destination	State	Airport Identifier
Same as Accident/Incident Location		DFW

Type of Clearance: IFR

Type of Airspace: Class B

Weather Information

Source of Briefing:

Method of Briefing:

National Transportation Safety Board

FACTUAL REPORT AVIATION

NTSB ID: FTW97IA144

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Occurrence Type: Incident

Weather Information

WOF ID	Observation Time	Time Zone	WOF Elevation	WOF Distance From Accident Site	Direction From Accident Site
DFW	0853	CST	603 Ft. MSL	9 NM	225 Deg. Mag.

Sky/Lowest Cloud Condition: Unknown 0 Ft. AGL

Condition of Light: Day

Lowest Ceiling: Broken 8500 Ft. AGL

Visibility: 10 SM

Altimeter: 30.00 "Hg

Temperature: 14 °C

Dew Point: 8 °C

Wind Direction: 170

Density Altitude: Ft.

Wind Speed: 6

Gusts:

Weather Condtions at Accident Site: Visual Conditions

Visibility (RVR): 0 Ft.

Visibility (RVV) 0 SM

Intensity of Precipitation: Unknown

Restrictions to Visibility: None

Type of Precipitation: None

Accident Information

Aircraft Damage: Minor

Aircraft Fire: None

Aircraft Explosion None

Classification: U.S. Registered/U.S. 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				7	7
Other Crew					
Passengers				189	189
- TOTAL ABOARD -				198	198
Other Ground	0	0	0		0
- GRAND TOTAL -	0	0	0	198	198

National Transportation Safety Board

FACTUAL REPORT
AVIATION

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Administrative Information

Investigator-In-Charge (IIC)

GEORGIA R. SNYDER

Additional Persons Participating in This Accident/Incident Investigation:

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