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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1. Accident reports can be and sometimes are revised. Be sure to consult the investigative agency for the latest version before basing anything significant on content (e.g., thesis, research, etc).

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!

3. Reports may or may not represent reality. Many many non-scientific factors go into an investigation, including the magnitude of the event, the experience of the investigator, the political climate, relationship with the regulatory authority, technological and recovery capabilities, etc. It is recommended that the reader review all reports analytically. Even a "bad" report can be a very useful launching point for learning.

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National Transportation Safety Board NTSB ID: FTW97IA144 Aircraft Registration Number: N105DA									
FACTUAL REPORT	Occurrenc	ce Date: 03/2	7/1997	Most Critical I	Most Critical Injury: None				
AYIATION VETYBON	Investigated E	Investigated By: NTSB							
Location/Time									
Nearest City/Place	State	Zip	Code	Local Time	Time Zone				
DFW AIRPORT	ТХ	75	5261	0845	CST				
Airport Proximity: Off Airport/Airstrip Distance From Landing Facility: 10 Direction From Airport: 45									
Aircraft Information Summary									
Aircraft Manufacturer			Model/Serie	S			Type of Aircraft		
Boeing			767-232				Airplane		
Sightseeing Flight: No		A	ir Medical T	ransport Flight: N	lo				
Narrative									
Brief narrative statement of facts, conditions and circumstand HISTORY OF FLIGHT	ces pertir	0.0.4.5	ident/incident:	daud time a		·he ····			
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. 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."									
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									

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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.

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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

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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 typedifferent from drawing:10Fatigue cracked bolt:6 (on 3 aircraft)Bolts fractured onretorqueing:5Cracked nuts (also of wrong type):5Missing 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.

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FACTUAL REPORT	UAL REPORT Occurrence Date: 03/27/1997											
AVIATION	QN Occurrence Type: Incident											
Landing Facility/Approach Informa	ation											
Airport Name	Airp	Airport ID: Airport Elevation Runway Used Runway Length Runway W										
DALLAS-FT. WORTH INTL				603 Ft	. MSL	176	२	1340	C	20	0	
Runway Surface Type: Concrete												
Runway Surface Condition: Dry												
Type Instrument Approach: Visual												
VFR Approach/Landing: Full Stop												
Aircraft Information												
Aircraft Manufacturer Boeing			Model/ 767-2	Series 232					Serial N 22217	lumber 7		
Airworthiness Certificate(s): Transport			-									
Landing Gear Type: Retractable - Tricy	/cle											
Homebuilt Aircraft? No Numb	per of Seats: 207		Certified Max Gross Wt. 335000 LBS N						Number	lumber of Engines: 2		
Engine Type: I Turbo Fan				Engine Manufacturer:Model/Series:GECF6-A2						Rated Power: 48670 LBS		
- Aircraft Inspection Information												
Type of Last Inspection	Dat	Date of Last Inspection Time Since Last Inspection						4	Airframe T	otal Time		
Continuous Airworthiness		02	02/1997 283 Hours					ours	45577 Hours			
- Emergency Locator Transmitter (ELT)	nformation											
ELT Installed?	Installed? ELT Operated? ELT Aided in Locating Accident Site?											
Owner/Operator Information												
Registered Aircraft Owner			Street A	ddress 1030 DF		BLVD.						
DELTA AIR LINES, INC.		City State Zi							Zip Code			
				ATLANTA GA 30320								
Operator of Aircraft	Street Address Same as Reg'd Aircraft Owner											
Same as Reg'd Aircraft Owner				City State Z						Zip Code		
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: Sch	Type of Flight Operation Conducted: Scheduled; Domestic; Passenger Only											
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AV ATION Occurrence Typ	UAL REPORT Occurrence Date: 03/27/1997									
Occurrence Type: Incident										
First Pilot Information										
Name	City	ity State Date of Birth Age								
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										
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		С	Current E	Biennial Fl	ight Re	eview?				
Medical Cert.: Class 1 Medical Cert. Status: Valid Medical-	w/ waivers	l		Date	of La	st Medica	Exam:	02/1997		
				Instrument						
- Flight Time Matrix All A/C This Make Aniparite Aliparite Mult-Er	gine N	Night		ial Simulated		Rotorcra	ft	Glider	Lighter Than Air	
Total Time 15000										
Pilot In Command(PIC)						_				
Last 90 Days 150 150										
Last 30 Days										
		Turk								
Seatbelt Used? Yes Shoulder Harness Used? Yes		IOXICO	ology Pe	errormed?	NO		Second	Pliot? Ye	S	
Flight Plan/Itinerary										
Type of Flight Plan Filed: IFR		-								
Departure Point		State	•	Airport Ide	irport Identifier		Departure Time		Time Zone	
ORLANDO	FL		MCO		000	0000				
Destination	State	,	Airport Id	rport Identifier						
Same as Accident/Incident Location	DFW									
Type of Clearance: IFR										
Type of Airspace: Class B										
Weather Information										
Source of Briefing:										
Method of Briefing:										

Currence Date: 03/27/1997 Occurrence Date: 03/27/1997 Occurrence Type: Incident Work Information Weather Information Time Zone WOF Elevation WOF Distance From Accident Site: Direction From Accident Site DFW 0853 CST 603 Ft. MSL VIE Direction From Accident Site: Date: 30.00 'Hg SkylLowest Cloud Condition: Unknown OF HAGL Ondition: Unknown Of Hag SkylLowest Cloud Condition: Unknown SkylLowest Cloud Condition: Unknown SkylLowest Cloud Condition: Unknown SkylLowest Cloud Condition: Unknown SkylLowest Conditions at Accident Site: Visual Conditions SkylLowest Conditions Unknown SkylLowest Conditions Unknown Accident Information Aircraft Fire: None Aircraft Fire: None Aircraft Fire: None Code Information Aircraft Fire: None None SkylLowes Fire: None Aircraft Fire: None Code In	National Transportation Safety Board				NTSB ID: FTW97IA144								
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Arcraft Information Aircraft Fire: None Aircraft Explosion None Classification: U.S. Registered/U.S. Soil - Injury Summary Matrix Fatal Serious Minor None TOTAL First Pilot 0 1 1 Second Pilot 0 1 1 Student Pilot 0 1 1 Flight Instructor 0 0 0 0 Flight Engineer 0 1 1 Cabin Attendants 0 7 7 Other Crew 0 1 189 189 Other Ground 0 0 0 198 198	Type of Pre	ecipitation: None											
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- Injury Summary MatrixFatalSeriousMinorNoneTOTALFirst Pilot111Second Pilot111Student Pilot111Student Pilot11Flight Instructor11Check Pilot11Flight Engineer11Cabin Attendants77Other Crew1189Passengers189198Other Ground00198Other Ground00198	Classificati	on: U.S. Registered/L	J.S. Soil										
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Other Crew Image: Constraint of the second sec	Cabin A	Attendants				7	7						
Passengers Image: Marcine Schwarz MarcineS	Other C	Crew											
- TOTAL ABOARD - Image: Marce and Ma	Passen	igers				189	189						
Other Ground 0 0 0 - GRAND TOTAL - 0 0 198 198	- TOTAL A	ABOARD -				198	198						
- GRAND TOTAL - 0 0 198 198	Other G	Ground	0	0	0		0						
	- GRAND	TOTAL -	0	0	0	198	198						
				FACTUA	L REPO	RT - AV	IATION					F	age 4

National Transportation Sufety Board	NTSB ID: FTW97IA144	
FACTUAL REPORT	Occurrence Date: 03/27/1997	
AVIATION	Occurrence Type: Incident	
Administrative Information		
Investigator-In-Charge (IIC)		
GEORGIA R. SNYDER		
Additional Persons Participating in This Accident/Incide	ent Investigation:	
VINCENT L COLLAMORE DFW FSDO DFW AIRPORT, TX 75261		
PAUL VISLOSKY DELTA AIR LINES ATLANTA, GA 30320		
JOHN HAMILTON BOEING COMMERCIAL AIRPLANE CO. SEATTLE, WA 98124		
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