



National Transportation Safety Board Aviation Incident Final Report

Location:	Truckee, CA	Incident Number:	WPR111A213
Date & Time:	05/02/2011, 1440 PDT	Registration:	N270CS
Aircraft:	CESSNA 421B	Aircraft Damage:	None
Defining Event:	Flight control sys malf/fail	Injuries:	3 None
Flight Conducted Under:	Part 91: General Aviation - Positioning - Air Medical (Medical Emergency)		

Analysis

The airplane entered the downwind leg of the traffic pattern high, and, in an effort to descend, the pilot extended the landing gear and deployed full flaps. About the time the flaps reached their maximum extension, the right flap experienced an instantaneous retraction, and the airplane simultaneously rolled about 80 degrees to the right. The pilot countered with almost full left aileron control input for the remainder of the flight. He began troubleshooting steps, but was unable to extend the right flap or retract the left flap. He diverted to another airport and, for the remaining 35 minutes of flight, employed the assistance of a passenger to help with maintaining left aileron control deflection. The landing was made without further incident.

Postincident examination of the flap control system revealed that the right wing flap extend cable had failed in the area where it made contact with the inboard flap pulley, an area where the cable had experienced multiple bending cycles throughout its life. The failed cable strands exhibited fatigue signatures, and similar frays and failures were observed in the area of the outboard pulley. The corresponding left flap cable also exhibited similar strand failure features in the inboard and outboard pulley contact areas. The cables were installed when the airplane was manufactured, 36 years prior to the incident. Over this period, the airplane had accumulated 4,832.1 total flight hours.

The flap cable was not life limited, and the airplane manufacturer's maintenance manual did not require the removal of flight control cables during inspection. The mechanic who performed the most recent inspection reported that he examined the cables utilizing the methods prescribed in the manufacturer's service manual but did not detect any damage. He further stated that the damage was only obvious once the cables had been removed and subsequently flexed and looped by hand.

A review of Federal Aviation Administration Service Difficulty Reports for the airplane series revealed 33 instances of similar flap cable wear or failure on 25 separate airplanes. About half of the reports indicated flap cable failures occurring during flight; all were during the critical landing approach phase. The failures resulted in asymmetric flap deployment, and some resulted in a violent departure from controlled flight. In a few instances, the damage caused by

the cable separation prevented the retraction of the remaining extended flap, and, therefore, the pilot had to maintain very high opposing aileron control inputs in order to control and land the airplane. A common finding noted in the reports was that the cable damage could not be readily observed unless the cables were removed.

A service bulletin is in development by the airplane manufacturer concerning the inspection procedures and replacement criteria for the flap cables in the airplane series.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this incident to be: Fatigue failure of the right flap extend cable during the landing approach.

Findings

Aircraft	TE flap control system - Fatigue/wear/corrosion (Cause)
	TE flap control system - Failure (Cause)

Factual Information

HISTORY OF FLIGHT

On May 2, 2011, about 1440 Pacific daylight time, a Cessna 421B, N270CS, experienced an uncommanded retraction of the right flap during the downwind leg for landing at Truckee-Tahoe Airport, Truckee, California. California Shock Trauma Air Rescue (CALSTAR) was operating the airplane under the provisions of Title 14 Code of Federal Regulations Part 91 as a repositioning flight. The commercial pilot and two medical flight crewmembers were uninjured, and the airplane was undamaged. The flight departed McClellan Airfield, Sacramento, California, at 1412, with a planned destination of Truckee. Visual meteorological conditions prevailed, and an instrument flight rules flight plan had been filed.

The pilot reported entering the left downwind leg for runway 28 about 8,500 feet mean sea level (msl). He stated that the pattern altitude was 7,500 feet, so in an effort to descend, he reduced airspeed to 140 knots, extended the landing gear, and incrementally deployed the flaps to 45 degrees. About the time the flaps reached their maximum limit, he heard a popping sound, and the airplane simultaneously rolled about 80 degrees to the right. He countered with full left aileron control input, retracted the flaps, and applied full engine power. Once he had attained a positive rate of climb, he retracted the landing gear.

The pilot stated that he was only able to maintain wings-level with full left aileron control input, and full left roll trim, and as such, assumed the airplane had experienced a failure of the right flap. He circled Truckee airport to troubleshoot further, but was unable to extend the right flap, or retract the left. He checked the flap motor circuit breaker, and it was in the closed position. The flap indicator needle was in the zero flap position, and the flap drive motor would not engage, regardless of the flap handle position.

He assessed the possibility of landing at Truckee, Reno, or South Lake Tahoe airports, but due to terrain and wind concerns, he elected to divert back to McClellan. He was able to accomplish left turns with about 5 degrees of bank, and although right turns could be performed, recovery to wings level was slower than normal. In this configuration he was able to maintain a climb rate of about 300 feet per minute, and once the airplane reached 13,000 feet msl, he was able to maintain wings-level by slightly relaxing the control input to about 90 percent deflection.

For the remaining 35 minutes of flight, the pilot employed the assistance of a medical crewmember to help with maintaining left aileron control deflection. The pilot subsequently landed the airplane at McClellan without incident, after making a left downwind approach.

TESTS AND RESEARCH

Flap Control System

The flap control system for the 421B series airplane is operated by an electric motor, which drives a gear reduction unit. Two sprockets, connected in tandem to the reduction unit output shaft, drive four chain-connected cables, which actuate bellcranks in each wing. The flaps are then driven by push-pull tubes connected to the bellcranks. A cam, driven by a gear attached to the aft output shaft of the reduction unit, operates two limit switches. The flap preselect system is comprised of a preselect lever assembly, mounted on the instrument panel; a flap preselect control cable, attached to the preselect lever assembly and routed to the upper right wing flap extend cable; and associated microswitches and electrical wiring. When the preselect lever is

moved to a flap position, the microswitches in the lever assembly are energized, and actuate the flap motor. As the flaps reach the preselected position, the preselect lever assembly microswitches are de-energized.

Initial Flap System Examination

During a cursory inspection of the flap system by the operator, it was discovered that the right wing upper flap extend cable, part number 5000008-62, had separated about 11 inches from the end of the inboard turnbuckle and chain fitting, inboard of the preselect cable clamp. Additionally, a steel braided oxygen system line had come loose, and had fallen into the path of the flap cable in the area of the failure. Based on this finding, and with the permission of the NTSB investigator-in-charge (IIC), the operator removed all the flap cables and their associated pulleys for examination. Examination of the cables and oxygen line revealed that they had not made contact, and in fact, the location of the separation was adjacent to the contact area of the inboard fuselage pulley. Additionally, the corresponding left wing lower flap extend cable, part number 5000008-63, exhibited frays to multiple strands in the area adjacent to its corresponding inboard fuselage pulley.

The airplane's flap system was subsequently examined by the IIC. The flap actuator motor assembly was free of damage. When the upper and lower limit switches were triggered by hand, they produced an audible click, and disengaged the motor appropriately when power was applied to the system.

The flap preselect cable remained intact, and was continuous from its connecting clamp through to the preselect assembly on the instrument panel. The preselect assembly appeared intact, with its limit switches and electrical wires firmly in place. The switch produced an audible click when engaged utilizing the flap lever.

The upper right, and lower left, flap extension cables, along with their associated inboard pulleys, were sent to the NTSB Materials Laboratory for examination.

Materials Laboratory Examination

Both cables were similar in construction, with 1/8-inch diameter 7X19 wire ropes with a turnbuckle fitting on one end, and swiveling clevis fittings on the other. Both cables were approximately 63 inches in length.

The right-hand extend cable had separated at a location approximately 11 inches from the end of the turnbuckle fitting. Examination revealed that most of the individual wire fractures were within a 0.5-inch-long portion of the cable, with the remaining wires separated 2 inches further away. High magnification imaging of individual wire fractures revealed fatigue cracking on more than half of the approximately 24 individual wires that were examined. The other wires displayed necking fracture features consistent with overstress separations.

No external wear was noted along the entire length of the cable, and diameter measurements did not indicate any significant internal wear. Fraying was detected in one region, about 20 to 25 inches from the clevis end, in a region adjacent to the outboard wing stub pulley. Magnified examinations revealed at least 24 individual broken wires within that region.

The left-hand extend cable was visually examined, and about 20 individual wire fractures were present and concentrated in an area between 51 and 53 inches from the outboard clevis end.

Both inboard pulleys were free of obvious wear, and turned smoothly on their bearings. Refer

to the Materials Laboratory Report within the docket for specific examination details.

Maintenance

The airplane had accrued 4,832.1 total flight hours at the time of its last annual inspection, on March 19, 2011. Examination of the maintenance records revealed that the flap extend cables had not been replaced since the airplane's manufacture in 1975. No life limits exist for the flap cable.

The Cessna 421B service manual does not require the removal of flight control cables during inspection. Rather, the inspection calls for visual examination along the entire cable length, and physical examination with a cloth over cables at pulleys, fairleads, pressure seals, and other areas the cable may be subject to chafing or wear. The manual states that individual broken wires are acceptable, provided no more than three individual wires are broken in any given 10-inch cable length.

The mechanic who performed the most recent inspection reported that he examined the flap cables utilizing the methods prescribed in the Cessna service manual, but did not detect any damage. He further stated that the frays in the cables were only noticeable after they were removed, and then flexed and looped by hand.

Service Difficulty Reports

A review of FAA Service Difficulty Reports (SDR's) for the Cessna 401 through 425 series airplane revealed 33 instances of flap cable wear or failure on 25 separate airplanes. Fourteen of the SDR's documented cable failures, all of which occurred during the landing approach phase, and resulted in an asymmetric flap condition. Some of the reports documented that the airplanes entered unusual attitudes just after the cables failed. The majority of these reports did not specify whether the flaps could be retracted, however, four reports specifically stated that the extended flap could not be retracted, and that the pilot landed the airplane with an asymmetric flap condition. In these instances, the reports cited various reasons for the flap not retracting. These included damage to the gearbox assembly caused by the forced retraction of the flap, the failed cables becoming entangled in the retraction mechanism, or the preselect cable being driven to the zero flaps position, thereby interfering with the electrical logic of the flap system.

None of the reports documented a separation of any left flap cables in flight, rather the separated cables were either the right extend type, or not specified. The separations all occurred in the area of the inboard fuselage pulley and preselect cable clamp.

Of the reports that did not describe an asymmetric flap condition in flight, four stated that frayed flap cables were observed during routine inspections. Fourteen of the remaining reports indicated that frayed cables were observed either during rigging procedures, or after the flap cables were removed, and that the position and nature of the damage prevented detection during routine inspections.

The total flight time for each of the damaged cables varied between 3,049 and 13,636 hours.

History of Flight

Approach-VFR pattern downwind	Flight control sys malf/fail (Defining event) Inflight upset
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Pilot Information

Certificate:	Airline Transport	Age:	27, Male
Airplane Rating(s):	Multi-engine Land; Single-engine Land	Seat Occupied:	Left
Other Aircraft Rating(s):	None	Restraint Used:	Seatbelt, Shoulder harness
Instrument Rating(s):	Airplane	Second Pilot Present:	No
Instructor Rating(s):	Airplane Multi-engine; Airplane Single-engine; Instrument Airplane	Toxicology Performed:	No
Medical Certification:	Class 1 Without Waivers/Limitations	Last Medical Exam:	10/05/2010
Occupational Pilot:	Yes	Last Flight Review or Equivalent:	11/17/2010
Flight Time:	3850 hours (Total, all aircraft), 154 hours (Total, this make and model), 3675 hours (Pilot In Command, all aircraft), 61 hours (Last 90 days, all aircraft), 15 hours (Last 30 days, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Manufacturer:	CESSNA	Registration:	N270CS
Model/Series:	421B	Aircraft Category:	Airplane
Year of Manufacture:		Amateur Built:	No
Airworthiness Certificate:	Normal	Serial Number:	421B0869
Landing Gear Type:	Retractable - Tricycle	Seats:	4
Date/Type of Last Inspection:	03/19/2011, 100 Hour	Certified Max Gross Wt.:	7579 lbs
Time Since Last Inspection:	10 Hours	Engines:	2 Reciprocating
Airframe Total Time:	4832 Hours	Engine Manufacturer:	Continental Motors
ELT:	C126 installed, not activated	Engine Model/Series:	GTSIO-520H
Registered Owner:	CALIFORNIA SHOCK TRAUMA AIR RESCUE	Rated Power:	375 hp
Operator:	CALIFORNIA SHOCK TRAUMA AIR RESCUE	Air Carrier Operating Certificate:	On-demand Air Taxi (135)
Operator Does Business As:		Operator Designator Code:	STRA

Meteorological Information and Flight Plan

Observation Facility, Elevation:	TRK, 5900 ft msl	Observation Time:	1445 PDT
Distance from Accident Site:	0 Nautical Miles	Condition of Light:	Day
Direction from Accident Site:	0°	Conditions at Accident Site:	Visual Conditions
Lowest Cloud Condition:	Few / 6000 ft agl	Temperature/Dew Point:	15° C / -4° C
Lowest Ceiling:	None	Visibility	10 Miles
Wind Speed/Gusts, Direction:	10 knots/ 18 knots, 230°	Visibility (RVR):	
Altimeter Setting:	30.33 inches Hg	Visibility (RVV):	
Precipitation and Obscuration:	No Obscuration; No Precipitation		
Departure Point:	Sacramento, CA (MCC)	Type of Flight Plan Filed:	IFR
Destination:	Truckee, CA (TRK)	Type of Clearance:	IFR
Departure Time:	1412 PDT	Type of Airspace:	

Airport Information

Airport:	Truckee-Tahoe (TRK)	Runway Surface Type:	Asphalt
Airport Elevation:	5900 ft	Runway Surface Condition:	Dry
Runway Used:	28	IFR Approach:	None
Runway Length/Width:	7000 ft / 100 ft	VFR Approach/Landing:	Traffic Pattern

Wreckage and Impact Information

Crew Injuries:	3 None	Aircraft Damage:	None
Passenger Injuries:	N/A	Aircraft Fire:	None
Ground Injuries:	N/A	Aircraft Explosion:	None
Total Injuries:	3 None		

Administrative Information

Investigator In Charge (IIC):	Elliott Simpson	Adopted Date:	06/28/2012
Additional Participating Persons:	Richard Conte; FAA FSDO; Sacramento, CA Steve Miller; Cessna Aircraft Company; Wichita, KS		
Publish Date:	06/28/2012		
Investigation Docket:	http://dms.nts.gov/pubdms/search/dockList.cfm?mKey=78994		

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