AVIATION OCCURRENCE REPORT

LOSS OF CONTROL

BEARSKIN LAKE AIR SERVICE LTD.
FAIRCHILD METRO 23 C-GYTL
WINNIPEG, MANITOBA 18 NM NE
21 AUGUST 1997

REPORT NUMBER A97C0168

The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

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Summary

The Bearskin Lake Air Service Flight 317, a Fairchild Metro 23 serial number CC829B, was en route from Red Lake, Ontario, to Winnipeg, Manitoba, with two crew and eleven passengers onboard. Approximately 18 miles north-east of Winnipeg, the crew completed the approach checks and were in descent to 4 000 feet above sea level (asl). Shortly after, the Captain had advised the passengers to fasten their seat-belts in preparation for landing, as the aircraft approached 4 400 feet asl, it pitched up without warning and without any initiating control inputs by the crew. Although the crew immediately attempted to stop the sudden flight deviation, the aircraft climbed to about 6 900 feet asl at a rate of climb of about 14 000 feet per minute with a maximum pitch attitude of 52 degrees nose-up. The combined effort of both crew members pushing forward on the control yokes was required to counteract the nose-up force and to bring the aircraft in a nose-down attitude. The crew believed the aircraft stalled while they were pushing the nose down and they applied full power. The aircraft then descended, reaching a maximum nose-down attitude of minus 26 degrees before the crew were able to level the aircraft. The crew evaluated the amount of flight control available and executed an approach and landing at Winnipeg. Throughout the approach, the first officer exerted full forward pressure on the control yoke with his hands and pushed on the column with both feet. Following the occurrence, two passengers reported neck and back pain.

Ce rapport est également disponible en français.

Other Factual Information

The aircraft was operating in visual meteorological conditions above a scattered cloud layer. Winds at the Winnipeg airport were 010 degrees true at five knots. The crew followed radar vectors to the airport and, after acquiring the runway visually, completed a visual approach.

The crew were certified and qualified for the flight in accordance with existing regulations. Both crew members held valid airline transport pilot licences. The aircraft captain has flown in excess of 10 000 flight hours. The first officer was 27 years of age and had an athletic physique. After landing, he was physically drained from the exertion required to hold the control yoke forward.

Records indicate that the aircraft was certified, equipped, and maintained in accordance with existing regulations and approved procedures. There were no reports indicating that the aircraft had been subjected to heavy turbulence or abnormal flight conditions prior to the uncommanded runaway trim condition.

When the sudden nose-up flight deviation occurred, the first officer was at the controls. The pitch-up happened within two to three seconds and he immediately began to push forward on the yoke and attempted to trim nose-down. He was able to stop the nose-up motion as the airspeed decreased. He noted that the airspeed reduced to less than 40 knots indicated airspeed and that the altitude peaked at about 7 000 feet asl. He felt the stick shaker activate and believed the stick pusher had also activated. His attempt at trimming the aircraft was not effective. Both crew members heard the stall warning horn and believed the aircraft attitude had risen to almost 90 degrees. The crew increased engine power as the nose was pushed over. The subsequent descent was arrested by the crew at about 5 500 feet asl. The crew adjusted the power settings and were able to stabilize the aircraft at 6 000 feet asl and at about 140 knots indicated airspeed.

When the crew lowered one-quarter flap, increased nose-down control force was required; the captain elected to conduct a flapless approach and landing. The crew requested that passengers move to the forward seats in the cabin to obtain a more favourable aircraft centre of gravity and thereby assist in keeping the aircraft nose down. The approach and landing were accomplished with the first officer applying forward pressure to the control column with full force using both hands and both feet. The captain controlled the ailerons, rudders, and power levers. Together, the two crew accomplished a smooth and stable aircraft touchdown on the runway.

The aircraft was equipped with a flight data recorder (FDR) and cockpit voice recorder (CVR), which were analysed at the TSB Engineering Branch. The aircraft was also transponding a discrete code assigned by the air traffic control system (ATS);therefore, the Winnipeg area control centre (ACC) radar system recorded the aircraft's flight profile. Data from the FDR and from the ACC radar corresponded closely. FDR data indicated that the aircraft was descending through 4 600 feet asl at about 238 knots when the pitch-up occurred. The stabilizer position moved from -1.5 degrees to +8.5 degrees (full nose-up) at a rate of about 3.5 degrees per second. The peak vertical acceleration was 3.5 g. The maximum aircraft pitch attitude attained was about 52 degrees nose-up and the minimum airspeed was 54 knots. The FDR also revealed that prior to the sudden flight excursion, the typical rate of stabilizer movement was approximately 0.5 degree per second.

The horizontal stabilizer trim actuator was removed from the aircraft and forwarded to the TSB Engineering

Branch for examination. The data plate identified the unit as a Fairchild Aircraft Corp., linear actuator, part number (P/N) 27-1900-002, serial number (S/N) 115, having a date of manufacture of December 1991. The actuator operates at 18-32 volts dc with a maximum current draw of 8 amperes. The actuator was manufactured for the Fairchild Aircraft Corp. by the Barber-Colman Company (as P/N RYLC-51438-1), for use in the pitch trim system of the SA226 and SA227 aircraft. The "-1" portion of the part number indicates that the actuator is made for autopilot or manual use; the incident aircraft was not equipped with an autopilot. The RYLC-51438-1 is a dual-ram jackscrew, electro-mechanical type actuator designed to control the horizontal stabilizer trim surface. One of the actuator output rams is activated by the pilot's control yoke inputs, and a second output ram moves in accordance with the co-pilot's control yoke inputs. (The report will subsequently use the terminology of "pilot's side" and "co-pilot's side" when referring to components within the actuator). The actuator incorporates a mechanical non-reversible "no-back" mechanism that prevents slipping of the stabilizer trim setting from the selected position and is designed to prevent any uncommanded reversing of the actuator under air-induced loads of up to 2 200 pounds. Redundancy, within the actuator that prevents unwanted reversing of the pitch trim actuator, is provided by the actuator gear train, in conjunction with the actuator motor brake. This redundancy is designed to hold the stabilizer against the air-load if the "no-back" mechanism fails.

The actuator had been overhauled and updated to the latest engineering order configuration in May of 1996. It was installed on the aircraft at that time and had accumulated 1 439 air hours at the time of the failure.

The actuator was transported to the Barber-Colman Company where component teardown and analysis were conducted (Barber-Colman Company TDR number 254). Testing showed that the "no-back" mechanism would not hold even under minor loading of less than 50 pounds. The outboard ball bearing (Barber-Colman P/N CYRB 158), that supports the trunnion gear on the front end cap assembly on the copilot's motor side, had disintegrated and the majority of the trunnion gear teeth were destroyed. The twelve "no-back" rollers or "no-backs", located on both the pilot's and copilot's sides, were extensively deformed, indicating they had been subjected to heavier-than-normal repetitive loads. The rollers had been installed at the time of the May 1996 overhaul. Barber-Colman representatives indicated that they had not previously seen such a large amount of deformation on any rollers removed from any such actuators returned for overhaul. Material analysis of the "no-back" rollers showed that they were manufactured from the appropriate alloy specified by Barber Colman as UNS R30605 in accordance with the relevant standard (AMS 5796).

The rear thrust washers on the pilot's and copilot's sides were fractured virtually in half. Of the three "no-back" springs located on the copilot's side, one spring was fractured, one was deformed, and one spring was normal. The failed thrust bearing washers exhibited heavy indentations that were suspected to have been made by a single impact, likely at the time of the actuator failure and trim surface runaway.

The deformation of the "no-back" rollers prevented them from holding the selected actuator position against the loads imposed on the actuator output tubes by the stabilizer. This load was in turn transferred to the geartrain. The geartrain, with the aid of the motor brake, normally provides a redundant system to hold the stabilizer in the selected position. The catastrophic failure of the ball bearing on the copilot's side caused the geartrain to disengage, allowing the unrestrained operation of the actuator output tubes. The air-load on the horizontal stabilizer then moved the stabilizer to the extreme nose-up condition.

Inspection of the actuator showed signs of mis-rigging of the full-retract position of the unit while it was installed in the aircraft; the actuator was not being shut off electrically in the full-retract position by the externally mounted limit switches. Such mis-rigging would cause the actuator to run into the internal mechanical retract stop, thereby placing stress loads onto the actuator gear system. Analysis of the effects of this mis-rigging indicated that it would not have caused the failures seen in this S/N 115 actuator. The pitch trim actuator installation instructions, outlined in the Fairchild Maintenance Manual at the time that the S/N 115 actuator was installed, required the operator to perform an operational check of the pitch trim system and control. The procedure did not specifically direct the operator to adjust or assess the mechanical/electrical stops, a procedure that was provided elsewhere in the manual. Fairchild Aircraft amended the relevant section of the installation instructions on 01 January 1998, requiring the operator to "Perform Adjustment - Mechanical/Electrical Stops procedures and Operational Check - Pitch Trim and Control procedures in this section." On 03 October, 1997, prior to the maintenance manual change, Fairchild Aircraft issued service letter 227-SL-031 (Subject: Barber Colman Pitch Trim Actuator - Perform Adjustment - Mechanical/Electrical Stops Functional Check and No-back Functional Check), drawing attention to the testing and adjustment procedures for the actuator electrical stops.

When the horizontal stabilizer trim actuator was removed from the aircraft, it was noted that the side opposite from the identification plates exhibited an indentation plus an associated loss of paint in the area of the indentation. Company maintenance personnel could not determine when or how the indentation of the case occurred. The degree of damage and location of the indentation do not appear to be directly related to the mode of failure of the actuator. The Barber-Colman Company, in conjunction with Fairchild Aircraft, has conducted considerable testing but have not been successful in duplicating the failure noted on the S/N 115 actuator.

The FAA has issued Airworthiness Directive (AD) 97-23-01, applicable to all SA226 and SA227 series airplanes that are equipped with a Simmonds-Precision pitch trim actuator (P/N DL5040M5 or P/N DL5040M6) or a Barber-Colman pitch trim actuator (P/N 27-19008-001 or P/N 27-19008-002). The AD calls for the repetitive inspections of the actuators in accordance with the applicable service letters (226-SL-014 etc.) issued by Fairchild Aircraft. In addition to detailing specific inspection time frames, the AD also specifies repetitive replacement times for specific Simmonds-Precision actuators.

Barber-Colman Company has produced more than 300 actuators for the Fairchild SA226 and SA227 aircraft, with no reported occurrences of uncommanded output tube motion caused by actuator failure.

Analysis

The correspondence between the data from the FDR and the recorded ATS radar data indicates that the aircraft reached a maximum nose-up attitude of 52 degrees. The crew's belief that the aircraft's nose-up attitude during the flight upset was steeper than registered in the FDR is understandable. The rapid onset of the pitch-up and the steep attitude achieved would have made accurate assessment of the pitch angle very difficult, particularly while the crew was attempting to regain aircraft control. The visual weather conditions, experience level of the pilot, and the physical strength of the first officer were likely significant factors in the successful recovery of the aircraft. The crew's immediate and coordinated action was critical to avoiding an aerodynamic stall and the probable loss of aircraft control.

The remainder of this analysis will focus on the technical issues regarding the pitch trim actuator. The pitch-trim actuator, S/N 115, failed in a condition which allowed the horizontal stabilizer trim surface of the aircraft to move to an extreme travel position thereby causing an immediate and rapid uncommanded nose-up deviation of the aircraft. The loss of control of the horizontal trim movement resulted when the mechanical "no-backs", within the actuator unit, failed to hold the stabilizer trim surface load. Failure of the "no-back" restraint probably caused the subsequent failure of a bearing in the actuator geartrain. The failure of the bearing permitted the gear that it was supporting to disengage the gear mesh from the rest of the geartrain. Under normal circumstances, the geartrain, in conjunction with the motor brake, provides a redundant system which will hold the stabilizer load should the "no-back" mechanism fail. The combined failures of the "no-back" mechanism and of the gear bearing allowed the uncommanded motion of the actuator output tubes and stabilizer.

No other similar actuator units, that have been returned to the Barber-Colman Company for repair or overhaul, have displayed the type and extent of damage exhibited by the S/N 115 unit. There have been no other similar actuator failures reported, and despite extensive testing by the manufacturers, the noted failure of the S/N115 actuator could not be duplicated. Therefore, the uncommanded output tube movement of this specific unit remains an isolated occurrence that was likely caused by the effects of undefined repeated loading conditions, which progressively forged the actuator "no-back" rollers into a configuration that ultimately prevented them from holding the actuator output tubes in position against the stabilizer flight loads. There were no

reports indicating that the aircraft had been subjected to heavy turbulence or abnormal flight conditions prior to the uncommanded runaway trim condition. Neither the teardown of the actuator nor the examination of the aircraft revealed the source of the repeated heavy loading. The inspection requirements of AD 97-23-01 have been put in place to assess and remove actuators from service before the no-back rollers fail in this manner.

The following TSB Engineering Branch reports were completed:

LP 130/97 - FDR/CVR Analysis
LP 132/97 - Pitch Trim Actuator Examination

Findings

1. During the descent on approach for landing, the aircraft entered an abrupt uncommanded pitch-up.

2. The physical force required to overcome the nose-up force of the horizontal stabilizer tasked the strength and endurance of the young and physically strong co-pilot.

3. The visual meteorological conditions facilitated the re-establishment of aircraft control and the recovery from the nose-high, low airspeed flight condition.

4. The internal “no-back” and geartrain mechanisms failed within the pitch trim actuator (Barber-Colman P/N RYLC-51438-1 / Fairchild Aircraft P/N 27-1900-002).

5. Unrestrained by the “no back” mechanisms and influenced by air loads, the horizontal stabilizer moved rapidly to a full nose-up trim condition.

6. Despite considerable testing, neither Fairchild nor Barber-Colman could duplicate the failure of the actuator “no-back” roller mechanism.

Causes and Contributing Factors

While on descent for the approach, the aircraft entered an uncommanded pitch-up because the “no-back” mechanism and geartrain components failed within the stabilizer pitch trim actuator for undetermined reasons, thereby allowing the air-loads to rapidly move the stabilizer to a full nose-up condition.

Safety Action

Following this occurrence, the Federal Aviation Administration issued AD 97-23-01 which specified additional measurements and inspection of the pitch trim actuator. The stated objective of the AD is "to prevent failure of the pitch trim actuator, which could cause loss of control of the airplane" and is applicable to all SA226 and SA227 series airplanes equipped with specific part number Simmonds-Precision or Barber-Coleman pitch trim actuators.

On 03 October 1997, Fairchild Aircraft issued Service Letter 227-SL-031 outlining procedures for conducting adjustment and functional check of the mechanical/electrical stops and a functional check of the no-back system for the Barber Colman pitch trim actuator. Additionally, on 01 January 1998, Fairchild Aircraft revised the pitch trim actuator installation instructions, outlined in the maintenance manual, requiring an adjustment and an operational check of the mechanical/electrical stops when installing pitch trim actuators.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson Benoît Bouchard, and members Maurice Harquail, Charles Simpson and W.A. Tadros, authorized the release of this report on 18 November 1998.