INCIDENT

Aircraft Type and Registration:	SAAB-Scania SF340B, G-LGNJ
No & Type of Engines:	2 General Electric CO CT7-9B turboprop engines
Year of Manufacture:	1989
Date & Time (UTC):	9 January 2006 at 1719 hrs
Location:	40 nm north-west of Glasgow VOR
Type of Flight:	Public Transport (Passenger)
Persons on Board:	Crew - 3 Passengers - 13
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	45 years
Commander's Flying Experience:	5,250 hours (of which 1,312 were on type) Last 90 days - 130 hours Last 28 days - 40 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

During a descent in icing conditions the autopilot disengaged and the aircraft pitched nose down. Initially, the pilots could not move the control column fore and aft but they were able to re-engage the autopilot and complete the flight in safety. No mechanical fault could be found that would have affected the control system.

History of the flight

The aircraft departed Stornoway on a scheduled passenger flight to Glasgow. Engine anti-ice was selected ON when the aircraft entered icing conditions during the climb to FL135. The pilots selected continuous operation of the airframe de-icing boots when a small accumulation of ice appeared on the wing leading edges and windshield. Thereafter, they monitored ice accumulation and the correct operation of the de-icing boots. Later, when the aircraft encountered turbulence, the co-pilot reduced speed to 200 kt. Approximately 50 nm northwest of the Glasgow VOR, at an indicated outside air temperature of -12ºC, the pilots observed an increased build-up of ice on the propeller spinners, windshield and wipers and so they selected NORMAL operation of the propeller de-icing system. The commander requested descent for arrival at Glasgow and received clearance to descend to FL080. As the co-pilot initiated a descent at 1500 fpm using the autopilot VERTICAL SPEED mode, one of the propellers shed a large piece of ice which struck the fuselage, causing vibration through the airframe. In order to assist symmetrical shedding of ice from the blades, the co-pilot increased propeller rpm to maximum but airframe vibration increased.

Shortly afterwards the autopilot and yaw damper disconnected without command and the pilots perceived that the aircraft abruptly pitched about 5º nose-down. The co-pilot took control manually, confirming visually that the autopilot and yaw damper were deselected, but found that he could not move the control column in pitch. The commander confirmed that his control column also appeared to be stuck and instructed the co-pilot to continue to attempt to fly the aircraft while he assessed the situation. The aircraft appeared to be descending in a stable trimmed descent and the co-pilot was able to re-engage the autopilot and yaw damper. Autopilot function was checked immediately in pitch and roll and found to be working normally. Thereafter, no attempt was made to fly the aircraft manually until shortly before landing. The commander advised ATC that the aircraft needed to descend due to ice and declared a PAN, following which ATC gave radar vectors for the aircraft to intercept the ILS approach to Runway 23 at Glasgow. The commander, who took control of the aircraft for landing, found that during the ground roll the power levers could not be retarded below flight idle. The co-pilot pulled the FLIGHT IDLE OVERRIDE handle, enabling the power levers to be retarded to ground idle for deceleration. The aircraft was taxied to a parking stand and all occupants disembarked normally.

Aircraft information

Ice protection system

The SAAB 340 is a conventional twin turboprop powered aircraft equipped with electrical propeller ice protection and pneumatic de-icing boots on the leading edges of the tailplane and wings. The tailplane is not visible from the cockpit but the severity of any ice accretion on it may be inferred by inspection of aircraft surfaces that are visible, such as the wing leading edges and windscreen. Inflation and deflation of each element of the pneumatic de-icing system is indicated by a gauge in the cockpit.

Autopilot

The aircraft is equipped with an APS-85 three-axis digital flight director and autopilot system which processes outputs from various aircraft sensors, provides information for the Attitude Director Indicator (ADI) command bars and positions the control surfaces using servos. The autopilot also provides automatic pitch and yaw trimming which compensate for any long term servo torque[1] to reduce servo loads and maintain the aircraft in a trimmed condition.

The system consists of one Flight Control Computer (FCC) with dual channels, two Mode Select Panels and an Auto Pilot Panel in the cockpit, and three control servos. Force is applied by each servo to the operating cables of the relevant control surface via an electromagnetic clutch located within each servo. Coupling of the electromagnetic servo is achieved by applying high voltage to one side of the coil of the electromagnet. The other side of the coil is earthed.

The autopilot has three modes: engaged, disengaged and engaged in "cut-off" mode.

The autopilot can be disengaged manually as follows:

By pushing the autopilot disconnect button on the control wheel.

By moving the autopilot/yaw-damper lever to the disengaged position.

By pressing the GO-AROUND buttons.

By operating the pitch trim switches.

Footnote

1 The trim function logic senses servo voltage. The output from the trim logic drives the electric trim actuator. The auto trim function is actuated 0.6 s after servo voltage exceeding a fixed threshold is sensed.

The following will cause automatic autopilot disengagement:

Operation of the stall warning system.

Detection of a fault in the servo-loop circuits.

Loss of valid altitude information.

Bus transmissions errors.

Input data not updated within a specified time.

The autopilot will also disengage automatically if it detects any abnormal values in parameters used by the system. The "cut-off" mode is active when certain conditions are met such as high g values, roll limits and rate limits. In this mode, the autopilot remains engaged but the servos are held in a fixed position until normal parameters return.

There is a diagnostic mode in the FCC that stores autopilot fault codes in volatile memory.

De-icing treatment

The most recent aircraft ground de-icing was completed three days before this incident, early during the morning of 6 January 2006. A type II fluid was used in a mixture of 75% fluid and 25% water; the recorded mixture temperature was 75ºC.

Quick Reference Handbook (QRH) procedures

There was no QRH procedure for autopilot disengagement but there was a procedure for 'ELEVATOR SYSTEM JAMMED'. The memory items were as follows:

AUTOPILOT	DISENGAGE
INTERCONNECT UNIT	OVERPOWER
PITCH DISCONNECT HANDLE	PULL

Meteorological information

A synoptic chart produced by the Met Office indicated a freezing level of 5,000 ft and the possibility of moderate icing[2] in cloud in the area in which the flight was conducted. The commander judged that moderate icing conditions existed when the incident occurred.

Recorded data

The flight data recorder (FDR) was successfully downloaded and provided information about control surface position, autopilot engagement, aircraft attitude, altitude and speed. It showed that at a time corresponding to the reported incident the autopilot was disengaged for seven seconds, after which no disturbance of the system was detected. There was an upward trend of both left and right elevator position before disengagement of the autopilot, indicating that the system acted to maintain the selected vertical speed. No other abnormal data were found.

Engineering inspection

The operator conducted a detailed inspection of the aircraft after the incident flight. All control surfaces and mechanisms were found to function normally and without restriction. In particular, there was no evidence of de-icing fluid residues or mechanical restriction of any surfaces. Inspection of the flight-idle stop system of the power levers revealed no faults. A non-revenue test flight was completed before the aircraft was returned to service. It performed satisfactorily throughout the flight and there have been no further reported instances of flight control restriction on G-LGNJ.

Footnote

2 Moderate icing conditions are said to exist when the rate of accumulation is such that even short encounters become potentially hazardous and the use of de-icing or anti-icing equipment or flight diversion is necessary.

Additional information

Re-hydration of thickened de-icing fluid residues

AAIB Bulletin EW/C2005/03/09 explored the effect of de-icing fluid residues on control surface movement. Several reported occurrences were found to be associated with residues of 'thickened' de-icing fluids that had accumulated in aerodynamically 'quiet' areas of the elevator and aileron controls. These residues re-hydrated on exposure to precipitation and could freeze at altitude, possibly restricting control surface movement. In most cases, controls became restricted whenever the aircraft operated at temperatures below freezing but functioned normally after the aircraft had descended into warmer conditions. The AAIB has conducted several investigations of occurrences related to Type II and Type IV de-icing fluid residues, but none involved Saab 340 aircraft.

Previous ice related occurrences

A review of previous occurrences involving Saab 340 aircraft did not reveal a history of flight control restrictions resulting from flight in icing conditions.

Analysis

Control surface restriction

In response to the AAIB investigation, the aircraft manufacturer explored possible causes of elevator control restriction. It determined that binding between the gear-train in the autopilot servo and its mounting, or an undetermined mechanical problem, could have caused an actual control jam. Alternatively, when the autopilot disengaged, if the high voltage applied to the electromagnetic servo clutch fell slowly instead of instantaneously, the clutch would not have released immediately and would have given the impression of control restriction until it became fully disengaged. Such a condition might occur if there had been chafing of associated wiring or moisture in electrical connectors. However, because no recurrence has been reported by the operator, it is unlikely that either of these conditions existed on G-LGNJ.

The event was not typical of an occurrence related to de-icing fluid residues because the reported control restriction was of short duration and ceased while the aircraft was above the freezing level. No de-icing fluid residues were found during the subsequent inspection.

It was not possible to isolate which action or fault triggered autopilot disengagement in this event.

Ice accretion on the tailplane

Recorded data showed that, in the period immediately before autopilot disconnection, elevator deflection increased in the nose-up sense, but the aircraft maintained an approximately constant attitude, speed and flight path. This is consistent with the autopilot attempting to compensate for reduced tailplane effectiveness, perhaps caused by ice accretion. When the autopilot disconnected, elevator deflection reduced. This might have occurred if the autopilot had not automatically trimmed the increased elevator deflection. A reduction in elevator deflection would account for the nose-down pitch following autopilot disconnection reported by the pilots, although no pitch reduction was apparent from the FDR data.

The manufacturer conducted tests to assess the effects of ice accretion on the tailplane, using a flight mechanics simulator provided with data from the incident flight. It concluded that the aircraft responses to power change and elevator movement were normal and that there were no indications of reduced elevator effectiveness.

Interpretation of wind tunnel data[3] suggested that ice on the leading edge of the horizontal stabiliser resulted in a small reduction in elevator effectiveness with flaps set at 20º and 35º but no reduction with the flaps in the fully retracted position, as in this incident. However, in the absence of flight tests conducted on a representative aircraft with the same (unknown) amount of ice accretion, it is not possible to discount completely the possibility that there had been an accretion of ice on the tailplane sufficient to impair its aerodynamic performance.

There was no evidence to support the commander's assessment that severe icing caused the elevator to become physically jammed.

Inspection of the flight idle stop system revealed no faults. Failure of a weight-on-wheel switch to operate during the landing would prevent the power levers from being retarded aft of the flight idle gate. Such a failure might be temporary if caused by foreign matter ingress or the effects of low temperature.

Conclusion

No explanation was found for the elevator control restriction experienced by both pilots. However, the possibility of some form of temporary ice-related restriction could not be eliminated. Similarly, the possibility of some temporary malfunction of the autopilot clutch seemed very unlikely but could not be entirely eliminated. The 'ELEVATOR SYSTEM JAMMED' checklist was not invoked because the incident began with an uncommanded autopilot disengagement and full control was restored when the autopilot was re-engaged.

The service history of the SAAB 340 suggests that it is not prone to control restrictions relating to ice accretion or accumulations of de-icing fluid residue.

Footnote

[3] These data were acquired separately and were not specific to this investigation