

Aircraft Accident Report No: 2/2016

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**Report on the serious incident to
Saab 2000, G-LGNO
Approximately 7 nm east of Sumburgh Airport, Shetland
15 December 2014**

Registered Owner and Operator:	Loganair Ltd
Aircraft Type:	Saab AB Saab 2000
Nationality:	British
Registration:	G-LGNO
Place of Serious Incident:	Approximately 7 nm east of Sumburgh Airport, Shetland Latitude: N 59° 52' 56" Longitude: W 001° 05' 07"
Date and Time:	15 December 2014 at 1910 hrs All times in this report are UTC

Summary

The aircraft was inbound to land on Runway 27 at Sumburgh when the pilots discontinued the approach because of weather to the west of the airport. As the aircraft established on a southerly heading, it was struck by lightning. When the commander made nose-up pitch inputs the aircraft did not respond as he expected. After reaching 4,000 ft amsl the aircraft pitched to a minimum of 19° nose down and exceeded the applicable maximum operating speed (V_{MO}) by 80 kt, with a peak descent rate of 9,500 ft/min. The aircraft started to climb after reaching a minimum height of 1,100 ft above sea level.

Recorded data showed that the autopilot had remained engaged, contrary to the pilots' understanding, and the pilots' nose-up pitch inputs were countered by the autopilot pitch trim function, which made a nose-down pitch trim input in order to regain the selected altitude.

Five Safety Recommendations are made relating to the design of the autopilot system and the certification requirements for autopilot systems.

Conclusions

During the approach phase of a routine flight the aircraft was struck by triggered lightning. Procedures intended to prevent flight in areas where lightning may be encountered do not protect against triggered strikes. The lightning caused only minor damage to the aircraft's radome and APU exhaust. Functional tests after the flight, and inspections of the elevator control system and autopilot system, did not reveal any faults.

Evidence from the manufacturer's simulation work indicated that the aircraft had responded as expected to the recorded control deflections.

The commander's actions following the lightning strike were to make manual inputs on the flying controls, which appear to have been instinctive and may have been based on his assumption that the autopilot would disconnect when lightning struck. However, the autopilot did not disconnect and was attempting to maintain a target altitude of 2,000 ft amsl by trimming nose-down while the commander was making nose-up pitch inputs. The control forces felt by the commander were higher than normal because the autopilot was opposing his inputs and he may have attributed this to a flight control malfunction caused by the lightning strike. He did not recall having seen or heard any of the aural or visual mistrim cautions which were a cue that the autopilot was still engaged. This was probably the result of cognitive tunnelling.

The commander applied and maintained full aft control column (nose-up elevator) input; however, the autopilot's nose-down elevator trim authority exceeded the commander's elevator nose-up authority and the aircraft pitched nose-down and descended, reaching a peak descent rate of 9,500 ft/min. The autopilot then disengaged due to an ADC fault and this allowed the commander's noseup pitch trim inputs to become effective. The aircraft started to pitch up just before reaching a minimum height of 1,100 ft above sea level.

If the autopilot system had been designed to sense pilot applied control forces and to disengage when it sensed a significant force (about 25 lbf according to FAAAC 25.1329-1C), the autopilot would have disengaged shortly after the aircraft climbed above 2,000 ft, in response to the aft column inputs applied by the commander. This would have prevented the subsequent loss of control. If the autopilot system had been designed such that operating the pitch trim switches resulted in autopilot disengagement, the autopilot would also have disengaged early in the sequence of events.

Of 22 airliner types surveyed, the Saab 2000 was the only type that had an autopilot which, when engaged, had the following three attributes:

Applying an override force to the column will move the elevator but will not cause the autopilot to disengage

The autopilot can trim in the opposite direction to the pilot applied control column input

Pressing the main pitch trim switches has no effect and will not cause the autopilot to disengage

The Airbus A300 and Fokker 70/100 aircraft previously had such attributes, and suffered one accident (A300) and several incidents (Fokker 70/100) due to pilots overriding the autopilot; these resulted in autopilot redesigns on both aircraft types.

In order to help prevent a similar recurrence of a loss of control due to autopilot override on the Saab 2000 and other aircraft types, five Safety Recommendations are made.

Safety Recommendations and safety action

Safety Recommendations

Safety Recommendation 2016-050

It is recommended that the European Aviation Safety Agency review the design of the Saab 2000 autopilot system and require modification to ensure that the autopilot does not create a potential hazard when the flight crew applies an override force to the flight controls.

Safety Recommendation 2016-051

It is recommended that the European Aviation Safety Agency review the autopilot system designs of aircraft certified under Part 25 or equivalent regulations and require modification if necessary to ensure that the autopilot does not create a potential hazard when the flight crew applies an override force to the flight controls.

Safety Recommendation 2016-052

It is recommended that the Federal Aviation Administration review the autopilot system designs of aeroplanes certificated to Federal Aviation Regulation Part 25 and require modification if necessary to ensure that the autopilot does not create a potential hazard when the flight crew applies an override force to the flight controls.

Safety Recommendation 2016-053

It is recommended that the Federal Aviation Administration amend Advisory Circular 25.1329-1C to ensure that requirement 25.1329(I) can only be met if the autopilot automatically disengages when the flight crew applies a significant override force to the flight controls and the auto-trim system does not oppose the flight crew's inputs.

Safety Recommendation 2016-054

It is recommended that the European Aviation Safety Agency amend the Acceptable Means of Compliance for Certification Specification 25.1329 to ensure that requirement 25.1329(I) can only be met if the autopilot automatically disengages when the flight crew applies a significant override force to the flight controls and the auto-trim system does not oppose the flight crew's inputs.

Safety action

The AAIB published Special Bulletin S1/2015 on 2 March 2015 which provided the initial facts of this investigation and reported safety action taken by the aircraft manufacturer and the operator.

Safety action by the aircraft manufacturer

On 24 February 2015 the aircraft manufacturer published Operations Newsletter No.6, informing Saab 2000 operators of the circumstances of this serious incident, and clarifying the operation of the autopilot as follows:

'Autopilot operation

Autopilot disengage:

Manual control inputs will not cause the autopilot to disengage and the main trim switches are disabled when the autopilot is engaged. Consequently, operation of the main pitch trim switches will not have any effect on aircraft trim nor cause the autopilot to disengage.

Disengaging the autopilot is normally done by pushing the disconnect button on either control wheel.

Manual activation of the following will also cause the autopilot to disengage:

- Autopilot engage/disengage lever*
- Go-around button*
- The standby pitch trim switches*

Autopilot disengage will trigger disengage warning (cavalry charge). The autopilot disengage warning is cleared by a push of the autopilot disconnect button located on the control wheel.

Autopilot mistrim

Conflicting manual control column inputs with the autopilot engaged will cause the autopilot trim to occur in the opposite direction of the control input, causing a mistrim situation. This will result in a "P" for pitch and/or "R" for roll appearing on the Primary Flight Display. If the situation is maintained, an AP PITCH MISTRIM or AP ROLL MISTRIM caution message will appear on the EICAS1 with associated flashing amber Master Caution light and a single aural chime. The autopilot will remain engaged.'

Safety action by the operator

The operator put in place a number of '*Mitigations to prevent an unsafe condition occurring when a pilot inadvertently applies an override force to the flight controls*'. It provided a description of these measures as follows:

'1. Notice to Aircrew (NOTAC)

NOTAC 123/14 was issued to all [the operator's] SAAB 2000 pilots on 23rd December 2014 advising to ensure that the autopilot is disconnected in the event of experiencing control abnormalities:

Background

The Saab 2000 autopilot does not disconnect when overpowered or when the control wheel pitch trim switches are operated. If the autopilot is engaged and the autopilot is overpowered it is possible to fly the aircraft and not be aware that the autopilot is engaged. However, in this situation, the autopilot pitch trim will operate to compensate for pilot input and can lead to increased control forces.

Action

In the event that increased control forces are experienced, pilots should ensure that the autopilot is disengaged.

2. Pilot Briefings

On the 19th December 2014 all SAAB 2000 pilots received a briefing on the incident. These briefings were either face-to-face or via telephone and included the reasons behind the NOTAC.

3. Operator Conversion Training

Following Type Rating Training all pilots new to the SAAB 2000 undergo 8 hours of simulator conversion training on [the operator's] procedures. All pilots are now exposed to this condition in the simulator and the corrective action required.

4. Triennial Training

All SAAB 2000 pilots are to be exposed to this condition and the corrective actions required in the simulator during recurrent training on a three yearly cycle.

5. Revision to Autopilot Standard Operating Procedures (SOPs)

At any time the autopilot disconnects automatically or manually

Pilot Flying – Presses autopilot disconnect button (Even if disengagement has been automatic) and announces “Autopilot Disconnect”

Pilot Monitoring- Confirms autopilot has disconnected by checking autopilot engagement indication and switches/paddles and announces “Autopilot disconnect”