



Australian Government

Australian Transport Safety Bureau

Stick shaker activation involving Saab 340B, VH-ZLJ

30.7 km south-west of Perth Airport, Western Australia on 6 July 2021

ATSB Transport Safety Report

Aviation Occurrence Investigation (Short)

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Addendum

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Safety summary

What happened

On the afternoon of 6 July 2021, a Saab 340B aircraft, registered VH-ZLJ, departed Perth Airport for a scheduled passenger flight to Albany, Western Australia, with two flight crew, one cabin crew, and 16 passengers on board.

At about 1623, while climbing through an altitude of 6,000 ft, and before entering icing conditions, the crew activated the engine anti-ice and wing de-ice systems. Shortly afterwards, caution lights illuminated indicating a fault in the de-ice system. After levelling off at 7,000 ft, the crew actioned the relevant abnormal checklist, but the caution lights remained on. In response, the flight crew requested a descent to 5,000 ft to exit icing conditions and decided to return to Perth.

During the descent, the captain handed over control of the aircraft as pilot flying to the first officer. Over the next 2.5 minutes, air traffic control (ATC) communicated with the flight crew on multiple occasions, issuing a series of vectors and requesting flight information. As the aircraft was levelling off at 5,000 ft under autopilot control, ATC instructed the crew to make a right turn. About 20 seconds after beginning the turn, the aircraft's aerodynamic stall warning stick shakers activated. The first officer initiated the stall recovery procedure before the captain took control as pilot flying to complete the recovery. The aircraft returned to Perth, landing at 1642.

What the ATSB found

The ATSB found that the aircraft's right wing inboard de-ice boot probably delaminated shortly before encountering icing conditions, triggering the de-ice system fault that led to the flight crew's decision to return to Perth.

During the return, the pilot flying became task saturated due to high workload and did not notice the aircraft's reducing airspeed, which was also missed by the pilot monitoring due to a focus on other tasks until the stick shaker activated. The crew managed the recovery from the potential stall condition effectively and the aircraft returned safely to Perth.

What has been done as a result

The aircraft operator has amended flight crew training simulator sessions and related training material to include flight at minimum manoeuvring speeds – minimum airspeeds that provide a margin above a stall during aircraft manoeuvring.

Safety message

This stick shaker activation incident highlights that during periods of high workload, where there is an increased chance of making mistakes or errors, flight crews should prioritise monitoring critical flight parameters. Effective communication can help flight crew recognise a situation when their workload is becoming overwhelming, and consequently better manage the situation – for instance, giving themselves more time to complete the required tasks by discontinuing an approach, or deferring air traffic control requests appropriately.

The investigation

Decisions regarding whether to conduct an investigation, and the scope of an investigation, are based on many factors, including the level of safety benefit likely to be obtained from an investigation. For this occurrence, a limited-scope investigation was conducted in order to produce a short investigation report, and allow for greater industry awareness of findings that affect safety and potential learning opportunities.

The occurrence

At 1619 Western Standard Time¹ on 6 July 2021, a Saab 340B aircraft, registered VH-ZLJ (Figure 1) and operated by Regional Express, departed Perth Airport for a scheduled passenger flight to Albany, Western Australia, carrying 16 passengers. The crew comprised the captain (pilot flying),² the first officer (pilot monitoring) and one cabin crewmember.

Figure 1: VH-ZLJ



Source: Supplied

At about 1623, the aircraft was climbing through 6,000 ft above mean sea level (AMSL) with the autopilot engaged. Consistent with operator procedures, the flight crew activated the engine anti-ice and wing de-ice systems as the aircraft was entering icing conditions. Shortly afterwards, an ice protection master caution light, and *TIMER* light illuminated, indicating a fault in the de-ice system (see the section titled *Airframe de-ice system*). Soon after, the flight crew requested, and received, a clearance from air traffic control (ATC) to level off at 7,000 ft to avoid icing conditions. They then began actioning the *TIMER light on* abnormal checklist.

At 1629 the flight crew requested, and received, a diversion from ATC to avoid storm cells. Despite the crew actioning the checklist, the *TIMER* light remained on during the wing inboard

¹ Western Standard Time (WST): Coordinated Universal Time (UTC) + 8 hours.

² Pilot Flying (PF) and Pilot Monitoring (PM): procedurally assigned roles with specifically assigned duties at specific stages of a flight. The PF does most of the flying, except in defined circumstances; such as planning for descent, approach and landing. The PM carries out support duties and monitors the PF's actions and the aircraft's flight path.

de-ice boot cycle, so at 1630 they commenced a descent to 5,000 ft to exit icing conditions. Shortly afterwards, the crew notified ATC that they would return to Perth.

During the subsequent descent, the captain handed over control of the aircraft as pilot flying to the first officer. Over the next 2.5 minutes, ATC communicated with the flight crew on eight separate occasions, issuing a series of radar vectors and flight information requests. At about 1632, the aircraft was levelling off at 5,000 ft with the autopilot engaged when ATC instructed the crew to make a right turn. About 20 seconds after beginning the turn, the aircraft's aerodynamic stall warning stick shakers activated (see the section titled *Stall warning system*). The first officer initiated the stall recovery procedure before the captain took control as pilot flying to complete the recovery.

The aircraft returned to Perth without further incident, landing at 1642.

Context

Flight crew

The captain held an Air Transport Pilot Licence (Aeroplane), and had 4,695 hours of flying experience, of which over 4,474 hours were on the Saab 340B. The captain made the following comments and observations about the incident.

- The decision to return to Perth was based on the de-ice system fault indication, the low freezing level along the route and no engineering support at the destination (Albany).
- As pilot monitoring during the descent from 7,000 ft to 5,000 ft, the captain notified the operator and communicated with the cabin crew and passengers regarding preparation for the return to Perth.
- During the descent their workload was relatively high, but the captain recalled feeling comfortable handling it at the time. However, in hindsight the captain felt that they did not monitor the first officer appropriately or focus enough attention on the aircraft's airspeed and engine power levels.

The first officer held a Commercial Pilot Licence (Aeroplane), and had 605 hours of flying experience, of which over 386 hours were on the Saab 340B. The first officer made the following comments and observations about the incident.

- After taking over as pilot flying, the first officer became overly focussed on complying with ATC clearances since:
 - the captain was occupied and not available to perform standard clearance cross-checks
 - they were aware of previous instances of flight crew's deviating from clearances because only one pilot had acknowledged them.
- The focus on ATC clearances, in combination with managing related communications, caused the first officer to feel 'task saturated'³ and that the workload was 'very high'.
- The first officer believed that the task saturation resulted in their instrument scan breaking down and not paying sufficient attention to the airspeed and engine power settings.
- The flight crew could have better managed the workload by giving themselves more time to complete tasks.

The ATSB found no evidence to indicate either flight crew were experiencing a level of fatigue known to affect performance.

³ Having too many tasks to complete without enough time, tools, or resources to do them. This can lead to an inability to focus on what really matters. Task saturation can be insidious, and people can become too busy to recognise that they are overloaded.

Meteorological information

The relevant graphical area forecast indicated a freezing level of about 8,000 ft at Perth, reducing to about 6,000 ft at Albany. Moderate showers with broken⁴ cloud from 2,500 ft to above 10,000 ft, severe icing above 6,000 ft, and moderate turbulence below 7,000 ft were also forecast.

The flight crew reported rain and storm cells in the Perth Airport area and encountered occasional cloud at 7,000 ft, where the outside air temperature was 4° C (icing conditions).

Airframe de-ice system

The aircraft's airframe de-icing system consisted of inflatable boots, located on the leading edges of the vertical and horizontal stabiliser, and the inboard and outboard section of the wings. The boots were rapidly inflated, using engine bleed air, to crack any accumulated ice and then deflated. A timer control unit regulated the boot inflation cycles in a sequence – stabiliser, outboard wing, and then inboard wing. Sensors monitored the boot cycles, and a TIMER light would illuminate together with an ice protection master caution light if a fault was detected with the de-ice system.

Post-flight examination of the de-ice system revealed a delamination in the right wing inboard de-ice boot on the underside of the wing (Figure 2). The aircraft operator stated that this was probably caused by an internal stitching failure, resulting in the loss of system pressure. The boot was replaced and the de-ice system was subsequently tested serviceable. The ATSB reviewed the aircraft's maintenance history related to the de-ice system and found it compliant with the required maintenance.

Figure 2: Right wing inboard boot delamination



Source: Operator, annotated by ATSB

⁴ Cloud cover: in aviation, cloud cover is reported using words that denote the extent of the cover – 'broken' indicates that more than half to almost all the sky is covered.

Stall warning system

The stall warning and identification system fitted to the Saab 340B included:

- two independent stall warning computers
- two angle of attack (AOA) sensors – one mounted on each side of the fuselage
- stick shaker device on each control column that provided a physical warning of an impending aerodynamic stall in the form of vibrations and aural clacker sound when activated
- stick pusher device that applied forward force to the control column to reduce aircraft AOA when a stall condition was identified.

The AOA activation level for the aircraft's stall warning system was dependent on flap position, engine anti-ice operation, and airframe de-ice operation. Flight in icing conditions required the operation of engine anti-ice and boot de-ice systems. Accumulation of ice and/or operation of the wing boot de-ice system alters the stall characteristics of the wings. This was compensated for by the stall warning system activating the stick shaker at a lower AOA (earlier) when the aircraft was configured for flight in icing conditions. The stick pusher AOA activation was unchanged. There was no indication in the cockpit of the AOA, but if an AOA sensor activation level was exceeded, the stick shaker and aural clackers activated, and the autopilot (if engaged) disengaged. If the AOA sensor values increased further, the stick pusher was activated.

Post-flight testing revealed that the left AOA sensor triggered the stall warning systems about 1 or 2° earlier than the specified parameters. The left AOA sensor was replaced, and the stall warning system was successfully tested. The ATSB identified that the aircraft's maintenance history related to the stall warning system was compliant with the required maintenance.

Recorded data

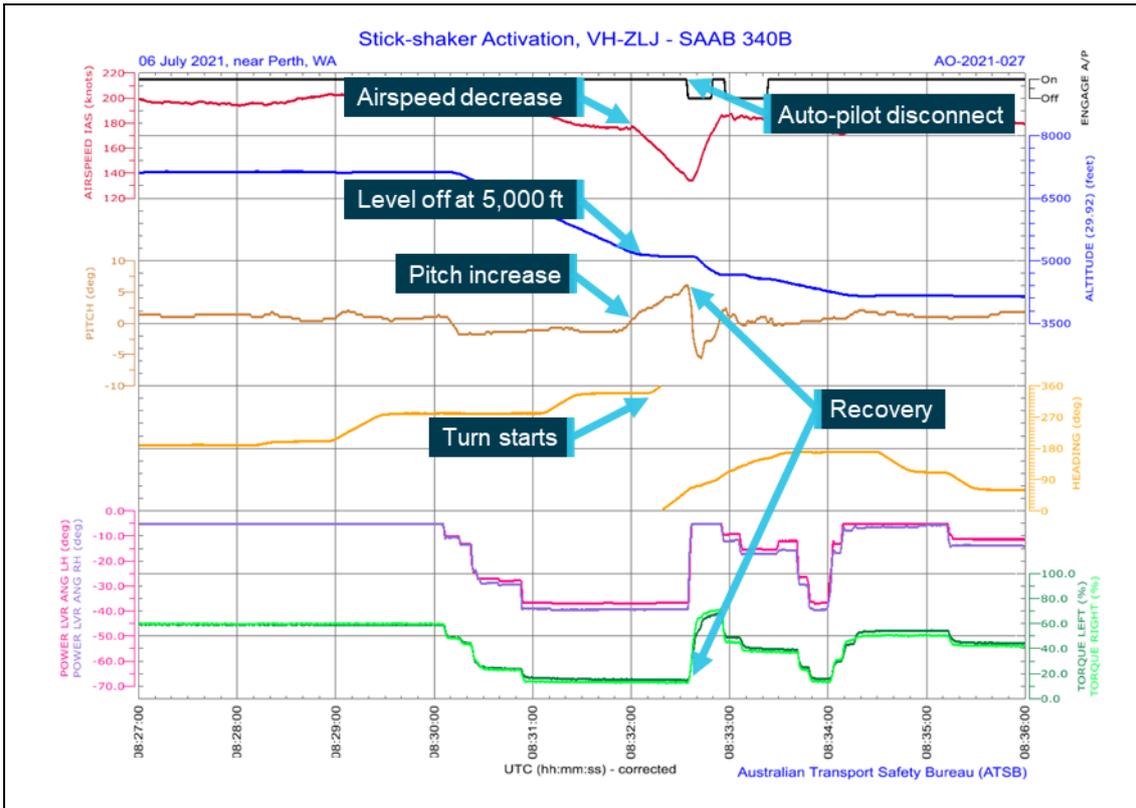
Data from the aircraft's flight data recorder was downloaded, but the aircraft manufacturer identified that some data parameters (AOA and elevator angle) had been corrupted.

Figure 3 shows verified flight data for certain recorded parameters at the time of the incident. The data shows that during level flight at 7,000 ft, engine power was at about 60% torque. During the descent to 5,000 ft, engine power was reduced by the flight crew to about 15% torque. After levelling off at 5,000 ft, engine power remained at that level, however the aircraft's pitch angle increased, while the airspeed decreased. The pitch increase and airspeed reduction continued after the turn was commenced. About 20 seconds later, the autopilot disconnected, and the flight crew initiated the stall recovery.⁵ Altitude lost during recovery was about 450 ft.

The investigation could not determine which AOA sensor triggered the stick shaker, but the flight data was consistent with the aircraft approaching a stalled condition, so the early triggering of the left AOA sensor did not affect the outcome.

⁵ The flight data did not record stick shaker or aural warning activation. However, the airspeed increase, pitch angle reduction, and engine torque data was consistent with flight crew identifying the stall warning and initiating recovery procedures.

Figure 3: VH-ZLJ flight data



Source: ATSB

Similar occurrences

In 2013, an ATSB research report⁶ identified that 245 stall warnings in high capacity aircraft had been reported between 2008 and 2012 in Australia. Almost all of those were low risk events of momentary duration and were responded to promptly and effectively by the flight crew to maintain control of the aircraft. However, there were also several higher risk incidents where stick shaker activation occurred on approach to land when aircraft were in a low speed, high AOA configuration. In these cases, the risk of a stall developing was increased by a lack of awareness of decreasing airspeed and increasing AOA prior to the stall warning, probably due to increased flight crew workload during this phase of flight. None of the reported occurrences resulted in an actual stall.

Safety analysis

Shortly after the aircraft departed Perth, the flight crew received cockpit indications of a de-ice system fault. The fault was probably triggered by a delaminated de-ice boot on the underside of the right wing that failed during its inflation cycle shortly before encountering icing conditions. With a low freezing level and forecast icing conditions along the planned route, the de-ice fault indication led to the flight crew’s decision to return to Perth.

While manoeuvring towards Perth, engine power was reduced to descend the aircraft from 7,000 ft to 5,000 ft. However, when the aircraft levelled off at 5,000 ft, engine power was not increased. Consequently, as the airspeed reduced due to the low engine power, the autopilot maintained the selected altitude (5,000 ft) by pitching the nose up, increasing the AOA and

⁶ ATSB (Australian Transport Safety Bureau) (2013), AR-2012-172, *Stall warnings in high capacity aircraft: The Australian context*, Available from the [ATSB website](#).

reducing the airspeed further. This condition went unnoticed until one of the AOA sensors reached the level required for stick shaker activation.

The first officer, the pilot flying in the time leading up to the stick shaker activation, probably became task saturated while managing flying tasks (changing flight state to descend, level flight and turn) as well as communicating with, and following ATC instructions. This task saturation reduced the attention that the first officer paid to managing the airspeed and engine power. At that time, the captain (pilot monitoring) was also not monitoring these key parameters due to a focus on other communication tasks related to the return to Perth. The crew's reduced awareness of airspeed resulted in the potential stall going unnoticed until the stick shaker activated.

In addition, during that rapid sequence of events, neither pilot recognised the first officer's high workload and task saturation. Consequently, no attempt was made to alleviate the situation, for example by discontinuing the approach or deferring ATC requests for information until the aircraft was straight and level. Such actions would have provided additional time and opportunity for the crew to refocus on flight instruments and key parameters.

Findings

ATSB investigation report findings focus on safety factors (that is, events and conditions that increase risk). Safety factors include 'contributing factors' and 'other factors that increased risk' (that is, factors that did not meet the definition of a contributing factor for this occurrence but were still considered important to include in the report for the purpose of increasing awareness and enhancing safety). In addition 'other findings' may be included to provide important information about topics other than safety factors.

These findings should not be read as apportioning blame or liability to any particular organisation or individual.

From the evidence available, the following findings are made with respect to the stick shaker activation involving Saab 340B, VH-ZLJ, 30 km south-west of Perth Airport, Western Australia on 6 July 2021.

Contributing factors

- The aircraft's right wing inboard de-ice boot probably delaminated shortly before encountering icing conditions, triggering the de-ice system fault that led to the flight crew's decision to return to Perth.
- The pilot flying became task saturated due to high workload and did not notice the reducing airspeed, which was also missed by the pilot monitoring due to a focus on other tasks until the stick shaker activated.

Safety actions

Whether or not the ATSB identifies safety issues in the course of an investigation, relevant organisations may proactively initiate safety action in order to reduce their safety risk. The ATSB has been advised of the following proactive safety action in response to this occurrence.

Safety action by Regional Express

Regional Express has amended flight crew training simulator sessions and related training material to include flight at minimum manoeuvring speeds – minimum airspeeds that provide a margin above a stall during aircraft manoeuvring.

Note: Saab advised the ATSB that it intended to follow-up with Regional Express to obtain further details on the out of limits AOA vane and the delaminated de-ice boot.

Sources and submissions

Sources of information

The sources of information during the investigation included:

- the flight crew
- Regional Express
- Saab
- Airservices Australia
- Bureau of Meteorology.

References

ATSB aviation research investigation report AR-2012-172, *Stall warning in high capacity aircraft: The Australian context*, Australia.

Submissions

Under section 26 of the *Transport Safety Investigation Act 2003*, the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. That section allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the following directly involved parties:

- Regional Express, including flight crew
- Saab
- Civil Aviation Safety Authority
- Airservices Australia.

Submissions were received from Regional Express, and the flight crew. The submissions were reviewed and, where considered appropriate, the text of the report was amended accordingly.

General details

Occurrence details

| | | |
|------------------------|---|---------------------------|
| Date and time: | 6 July 2021 - 1630 WST | |
| Occurrence class: | Serious incident | |
| Occurrence categories: | Stall warnings, Anti-ice protection, Diversion / Return | |
| Location: | 30.7 km south-west of Perth Airport, Western Australia | |
| | Latitude: 32° 05.832' S | Longitude: 115° 41.980' E |

Aircraft details

| | | |
|-------------------------|---|-----------------|
| Manufacturer and model: | Saab Aircraft Co. 340B | |
| Registration: | VH-ZLJ | |
| Operator: | Regional Express | |
| Serial number: | 340B380 | |
| Type of operation: | Air Transport Low Capacity-Passenger – (Air Transport Low Capacity) | |
| Activity: | Commercial air transport-Scheduled-Domestic | |
| Departure: | Perth Airport | |
| Destination: | Albany Airport | |
| Actual destination: | Perth Airport | |
| Persons on board: | Crew – 3 | Passengers – 16 |
| Injuries: | Crew – 0 | Passengers – 0 |
| Aircraft damage: | Nil | |