Australian Government

Australian Transport Safety Bureau

Safe Transport

AIR SAFETY INVESTIGATION REPORT
BO/200203074

Inflight Loss of Control due to Airframe Icing

SAAB 340B,VH-OLM

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Released under the provisions of Section 19CU of Part 2A of the *Air Navigation Act 1920*.

When the ATSB makes recommendations as a result of its investigations or research, safety (in accordance with its charter) is its primary consideration. However, the Bureau fully recognises that the implementation of recommendations arising from its investigations will in some cases incur a cost to the industry.

Readers should note that the information in ATSB reports is provided to promote safety: in no case is it intended to imply blame or liability.

Cover photo: SAAB 340B supplied by Glenn Stewart

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This report was produced by the Australian Transport Safety Bureau (ATSB), PO Box 967, Civic Square ACT 2608.

Readers are advised that the ATSB investigates for the sole purpose of enhancing safety. Consequently, reports are confined to matters of safety significance and may be misleading if used for any other purpose.

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PREFACE

The Australian Transport Safety Bureau (ATSB) is an operationally independent multi-modal Bureau within the Australian Government Department of Transport and Regional Services. ATSB investigations are independent of regulatory or other external influence.

The objective of the ATSB is safe transport. To achieve this objective the ATSB carries out investigations and safety studies to identify possible safety issues, and then recommends safety actions aimed at addressing those issues.

In terms of aviation, the ATSB is responsible for investigating accidents, serious incidents, incidents and safety deficiencies involving civil aircraft operations in Australia, as well as participating in overseas investigations of accidents and serious incidents involving Australian registered aircraft. The ATSB also conducts safety studies of the underlying factors and trends within the aviation system that have the potential to affect safety. A primary concern is the safety of commercial air transport, with particular regard to fare-paying passenger operations.

The ATSB performs its aviation functions in accordance with the provisions of the *Air Navigation Act* 1920, Part 2A. Section 19CA of the Act states that the object of an investigation is to determine the circumstances surrounding any accident, serious incident, incident or safety deficiency to prevent the occurrence of similar events. The results of these determinations form the basis for safety advisory notices and recommendations, and ultimately accident prevention programs. As with equivalent overseas organisations, the ATSB has no power to implement its recommendations.

Under the *Air Navigation Act* it is not the object of an investigation to determine blame or liability. However, it should be recognised that an investigation report must include factual material of sufficient weight to support the analysis and conclusions reached. That material will at times contain information reflecting on the performance of individuals and organisations, and how their actions may have contributed to the outcomes of the matter under investigation. At all times the ATSB endeavours to balance the use of material that could imply adverse comment, with the need to properly explain what happened, and why, in a fair and unbiased manner.

ATSB investigations are multi–disciplinary. Investigators are drawn from a range of professional backgrounds including pilots, air traffic controllers, human factors professionals , Licensed Aircraft Maintenance Engineers (LAMEs), professional engineers, and cabin safety and technical analysis specialists.

The ATSB does not adhere only to one ‘investigation model’, but applies the best methods and techniques appropriate to each situation.

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1 In July 2003, the the *Air Navigation Act 1920,* Part 2A was replaced with the *Transport Safety Investigation Act 2003*. However, this investigation was commenced and conducted under Part 2A of the *Air Navigation Act 1920*.

2 Human factors is the multi-disciplinary science that applies knowledge about the capabilities and limitations of human performance to all aspects of the design, operation, and maintenance of products and systems. It considers the effects of physical, psychological, and environmental factors on human performance in different task environments, including the role of human operators in complex systems.

The ATSB employs a broadly systemic approach that aims to identify not only what happened, but why it happened. That approach can reveal both immediate and underlying safety issues. A key principle is that human error, though undesirable, is nevertheless both prevalent and pervasive. Hence, recommended safety action is typically aimed at limiting and mitigating the effect of human error.

ATSB investigations include analysis of any relevant human factors or organisational issues. Consideration of these aspects does not, however, in any way diminish the importance and priority given to operational, mechanical, and technical issues. The different aspects are, in fact, very much complementary.

GLOSSARY OF TERMS AND ABBREVIATIONS

AGL	above ground level
AMSL	above mean sea level
AOA	angle of attack (angle between wing chord and air flow)
AOM	Aircraft Operating Manual
AP	Autopilot
ASI	airspeed indicator
ATPL	Airline Transport Pilot Licence
ATSB	Australian Transport Safety Bureau
BOM	Bureau of Meteorology
CASA	Civil Aviation Safety Authority
FAR	Federal Aviation Regulation (USA)
FD	Flight Director
FDR	Flight Data Recorder
GPS	Global Positioning System (satellite navigation system)
HDG	Heading
IAS	indicated airspeed
ICAO	International Civil Aviation Organization
JAR	Joint Aviation Regulation (Europe)
KIAS	Indicated airspeed measured in kts
MAC	Mean Aerodynamic Chord
MDA	Minimum Descent Altitude (instrument approach)
NDB	Non directional Beacon
NSW	New South Wales
OAT	outside air temperature
PIC	Pilot In Command
PTT	Microphone ‘press to talk’
SOP	Standard Operating Procedure/s
Stall	A condition where the airflow across a wing is interrupted resulting in the wing producing insufficient lift to counter the weight of the object.
UTC	coordinated universal time
VHF	very high frequency

EXECUTIVE SUMMARY

On the evening of 28 June 2002, a Saab 340B, VH-OLM, was being operated on a regular public transport service, from Sydney to Bathurst, NSW. The pilot in command (PIC), the flying pilot, had commenced a descent from 12,000 ft for a Katoomba-Bathurst Global Positioning System (GPS) arrival and subsequent landing on runway 17 at Bathurst. The PIC reported that as the aircraft descended to the minimum descent altitude (MDA), visibility alternated between visual and instrument flight conditions. During the descent, the PIC had retarded the power to about 17 per cent and slowed the aircraft to about 135 kts in preparation for a Category B circling approach.

The copilot, non-flying pilot, reported that during the descent the engine anti-ice was on, but not the propeller de-ice, nor had the airframe boot de-ice system been activated. The PIC reported that during descent, they entered cloud a number of times and noted ice accretion on the windshield wiper. The flight crew reported that they did not observe any wing ice during the descent.

At the MDA (3,810 ft), the aircraft's Flight Guidance and Autopilot System (autopilot) captured the altitude and, as the airspeed was decreasing due to the reduced power setting, commanded the trim system to progressively raise the nose of the aircraft to maintain the MDA. The PIC commanded the autopilot to roll the aircraft to the right to begin tracking downwind for runway 17. At about this time, the copilot observed that the airspeed was decreasing and called 'speed'. As the PIC applied power to compensate for the decreasing airspeed, the aircraft rolled to the left and pitched down without warning. During the recovery from the steep pitch and bank angles, the aircraft rolled to the right and descended to 112 ft AGL. The PIC regained control of the aircraft and climbed it to the missed approach altitude and carried out an uneventful landing.

The aircraft's aerodynamic stall warning systems of stick shaker, audible alarm, visual warnings and stick pusher, did not activate during the initial roll to the left. However, the autopilot disconnected during the subsequent roll to the right, due to activation of the stall warning.

The investigation determined that following capture of the MDA by the autopilot, the aircraft speed continued to decrease due to the reduced power setting. As a consequence, the aircraft stalled. However, this occurred prior to the stall warning system operating due to the likely presence of airframe ice that had accumulated during the descent.

The investigation found that it is possible for the aircraft to stall prior to the activation of the stall warning system if the aircraft has accumulated ice on the wings.

The investigation, classed as a serious incident[3], identified a number of other occurrences involving Saab 340 aircraft stalling where little to no stall warning had been provided to flight crew while operating in icing conditions. This included a Saab operated by an Australian operator, which resulted in a number of ATSB recommendations being issued in that investigation, not all of which were accepted and acted upon. Some of those recommendations have been re-issued.

3 ICAO Annex 13 defines a serious incident as; an incident involving circumstances indicating that an accident nearly occurred. The annex notes a number of examples including operations outside the approved flight envelope or other occurrences which could have caused difficulties controlling the aircraft.

1 FACTUAL INFORMATION

1.1 History of the flight

On the evening of 28 June 2002, a Saab 340B, VH-OLM, was being operated on a 35 minute regular public transport service from Sydney to Bathurst, NSW. The pilot in command (PIC), the flying pilot[4], had descended the aircraft from 12,000 ft to 5,700 ft as part of the Katoomba-Bathurst Global Positioning System instrument arrival. Approximately two minutes later, the landing gear was extended prior to a subsequent descent from 5,700 ft, with the flaps extended to 20 degrees during the descent. The PIC reported that visibility alternated between visual and instrument flight conditions and noted ice accretion on the windshield wiper, as the aircraft descended to the minimum descent altitude (MDA) of 3,810 ft. During the descent, the PIC had retarded the power on the left engine to about 15 per cent and the right engine to about 19 per cent and slowed the aircraft to about 135 kts in preparation for a Category B circling approach.

The copilot reported that during the descent the engine anti-ice was turned on, but the propeller de-ice and the airframe boot de-ice system was off in accordance with the operator's procedures for the prevailing conditions. The copilot commented that they had checked, with the leading edge wing lights, for the presence of ice on the wings during the descent, but had not seen any ice.

One and a half minutes later, at the MDA, the aircraft's Flight Guidance and Autopilot System (autopilot) captured the preselected altitude and, as the airspeed was decreasing due to a reduced power setting, commanded the trim system to progressively raise the nose of the aircraft to maintain that altitude. The PIC, who had been looking out at the aerodrome, commanded the autopilot to roll the aircraft to the right to begin tracking downwind for runway 17. At about this time, the copilot who had also been looking at the runway, glanced inside and observed that the airspeed was decreasing towards 120 kts and called 'speed'. As the PIC applied power to compensate for the decreasing airspeed, the aircraft rolled to the left without warning and pitched down. However, as the PIC recovered the aircraft from the steep nose-down pitch and bank angles, the aircraft rolled, through wings level, to the right and descended to 112 ft above ground level (AGL). The PIC regained control of the aircraft and climbed it to the missed approach altitude and then carried out a Non-Directional Beacon approach and uneventful landing. The flight crew reported that during the initial recovery they received one terrain alert from the aircraft's ground proximity warning system.

The copilot carried out a post-landing inspection of the aircraft's exterior and reported that there was no ice on the airframe.

The aircraft's aerodynamic stall warning systems of stick shaker, audible alarm, visual warnings and stick pusher, did not activate during the initial roll to the left. However, the autopilot disconnected during the subsequent roll to the right due to activation of the stall warning. The PIC noted a slight stick shake or shudder just prior to the stall. A passenger on the flight, who was an experienced pilot, later reported pre-stall buffet prior to the aircraft stalling.

4 Flying pilot; pilot responsible for flying the aircraft. The non-flying pilot assists the flying pilot with additional tasks such as radio communication

The aircraft and flight crew completed their assigned duties that evening which included a sector to Parkes, NSW and return to Sydney via Bathurst. The next day the PIC reported to the operator's fleet manager that the aircraft 'dropped a wing' at Bathurst, but that they had recovered the aircraft and landed and there was no evidence of airframe ice. The fleet manager advised him to submit a report. The PIC submitted an incident report to the operator four days later on Tuesday, 2 July 2003.

The day before the PIC submitted his report, a passenger sent a confidential report to the ATSB regarding the incident. The ATSB quarantined the flight recorder and after retrieval and examination of the data, commenced an investigation. The ATSB subsequently notified the operator about the seriousness of the incident. The operator immediately grounded the aircraft to conduct an airworthiness examination. During the intervening time, the aircraft had been operating on its scheduled routes and had flown 27 hours spread across 35 flights.

1.2 Injuries to persons

Injuries	*Flight crew*	*Passengers*	*Others*	*Total*
Fatal	-	-	-	-
Serious	-	-	-	-
Minor	-	-	-	-
None	3	29	-	32

1.3 Damage to aircraft

An engineering examination of the aircraft and engines by the ATSB and the operator, following the serious incident did not reveal any damage to the aircraft or engines.

1.4 Other damage

Nil

1.5 Personnel

1.5.1 Pilot in command

Type of licence	ATPL
Medical certificate	Current and valid
Flying experience (total hours)	9,530
Total hours on the type	1,939
Command hours on the type	240
Hours flown in the last 24 hours	6
Hours flown in the last 90 days	148

The PIC began employment with the operator in 1994 as a first officer on Metro 23 aircraft. He then moved to a first officer position on the Saab 340 aircraft in 1996 and flew that aircraft type for two years before obtaining a command position in 1998 on the Metro 23 aircraft. He held that position until he gained his command endorsement on the Saab 340 aircraft in 2000.

The PIC commented that 'it had been a long day before the Sydney to Bathurst flight.' The flight crew had commenced duties at approximately 1100 for a sector to Dubbo NSW via Bathurst. On their return to Sydney, they had been instructed by the operator to fly an additional sector from Dubbo to Orange NSW. The subsequent turnaround[5] at Orange was about 40 minutes and he was only able to get a snack. The PIC said that there had been changes to the rostering since the collapse of the parent company. Prior to that, they were assured of breaks. The PIC said that he and the copilot had the occasional yawn, but no more than usual.

The PIC reported that on the day of the incident he rose at about 0630. He commented that he had been up a few times during the night with his young children, but said that he was feeling well at the time. On the Wednesday (two days before the incident) he had been off duty and had worked the day before the incident.

The PIC reported that he was not taking any medication and rarely drank alcohol. He said that the previous six months had been stressful due to uncertainty about the commercial viability of the operator.

1.5.2 Copilot

Type of licence	ATPL
Medical certificate	Current and valid
Flying experience (total hours)	6,620
Total hours on the type	1,451
Hours flown in the last 24 hours	4
Hours flown in the last 90 days	123

The copilot said that she had been with operator for seven years; five as a copilot on Metro 23 aircraft and almost two years as a copilot on the Saab aircraft.

The copilot said that with six sectors already flown and three to go, it had been a big day with a heavy workload. She had signed on about 1100 and they had flown an extra sector to Orange that was not rostered. She said that the incident had occurred towards the end of the day, at night, with significant weather. She said that she had not had a meal that day except a sandwich at Dubbo at about 1330. The PIC commented that the copilot had said a few times that she was tired.

The copilot did not have access to her roster during the interview and could not comment on her history of work prior to the event. Operator records show that she was rostered for the previous two days.

5 Turnaround time is normally counted as time on duty as the crew are required to prepare for the next flight.

1.6 Aircraft information

Manufacturer	Saab
Certification	Certified in accordance with FAR/JAR Part 25
Model	340B
Serial number	340B-205
Registration	VH-OLM
Year of manufacture	1990
Certificate of airworthiness number	Issued 10 Oct 1990 (BK/2221)
Certificate of registration number	Issued 10 Oct 1990 (BK/02221/04)
Maintenance release	Valid to 28,989.2 hrs/06 Dec 2002
Total airframe hours	28,793.5
Allowable take-off weight	13,155 kg
Actual take-off weight	13, 114 kg (as recorded on the load sheet)
Landing weight	12,930 (as recorded on the load sheet)
Allowable centre of gravity limits	21 per cent to 38 per cent MAC
Centre of gravity at incident	33 per cent MAC

1.6.1 Weight and balance

The aircraft load sheet that was lodged by the flight crew at Sydney, prior to the flight, indicated that the aircraft was 41 kg under the maximum takeoff weight. The company's Operations Manual-Standard Operating Procedures (SOP) for this model aircraft indicated that a 25 kg taxi fuel burn should be allowed for in a standard plan, but in the case of a Sydney departure, 50 kg could be used. The load sheet from the incident flight indicated that a taxi allowance of 127 kg was allowed for in the planning; 77 kg more than the SOP. Even if a standard Sydney taxi allowance of 50 kg had been used, the aircraft would have been overweight by 77 kg on takeoff at Sydney. Although the aircraft may have taken off slightly over weight, based on the fuel burn for the Sydney – Bathurst sector, the aircraft was probably at less than maximum weight at the time of the serious incident and therefore within normal operating parameters.

1.6.2 Maintenance

An engineering examination of the aircraft's engines, the maintenance history, the flight guidance and autopilot system, the stall warning system, and the anti-ice and de-ice systems, by the ATSB and the operator, indicated that the systems were capable of normal operation at the time of the incident.

1.6.3 Operating procedures

The flight crew routinely had access to a number of documents issued by the operator and the manufacturer. Two of the controlled documents[6] that were issued to crew were the SOP and the company's Aircraft Operations Manual (AOM) for the Saab 340B. The SOP deals with operator procedures, whereas the AOM deals more specifically with the aircraft type.

Crews would also have had access to the Airplane Flight Manual (AFM) which was issued by the manufacturer. The AOM advises that should there be a conflict between the AOM and the AFM, the AFM is to take precedence. The SOP also names the AFM as having precedence should a conflict arise between the manuals.

6 A document that is controlled in its publication, amendment service and copy holders.

All three manuals contained sections dealing with flight in icing conditions, but these sections were scattered through the manuals. Additionally, some of the instructions or advice was contradictory and had not been updated in accordance with the manufacturers AFM, as will be seen later in the report.

1.6.4 Stall warning system

The stall warning system fitted to the Saab 340 consists of two independent dual channel stall warning computers, left and right angle-of-attack sensors, two stick shakers (one mounted on each control column) and a stick pusher actuator connected to the left control column. A mechanical linkage also transfers the stick push to the right control column. There are stall warning lights on each of the pilot's instrument panels, and three amber stall warning system failure lights on the centre warning panel. The flight crew can test the system using the test function in the overhead avionics panel.

The system provides five distinct warnings of an impending stall: autopilot disengage; stick shaker; aural clacker; a visual warning and finally, a stick pusher.

The stall warning computers receive inputs from separate angle-of-attack sensors that are situated on the forward section of the fuselage. These sensors are electrically heated. The sensors measure the airflow relative to the fuselage; called vane angle-of-attack. This vane angle-of-attack is used as an input to the stall warning computers.

A weight-on-wheels sensor inhibits the stick pusher for seven seconds after takeoff to prevent inadvertent activation while the aircraft is in close proximity to the ground. A sensor detects the position of the flaps and increases the angle-of-attack signal provided to the stall warning computer between 0 and 1 degree, based on flap position. Activation of the wing de-ice system disables the flap compensation, and the angle-of-attack signal is reduced by 0.4 of a degree to increase the stall margin by 1-2 kts when the de-ice boots are inflated.

The stall warning computer activates the stick shaker (including autopilot disconnect) at 12.5 degrees angle-of-attack, and the stick pusher at 19 degrees angle-of-attack with the flaps in the retracted position. In the case of OLM, the warning would have occurred at 13.1 degrees as the flight crew had 20 degrees of flap extended during the incident. Initiation of this warning occurs when either of these sensors reaches the predetermined angle-of-attack. Both pilots receive the stick shaker warning through their respective control column. If the autopilot is engaged, activation of the stick shaker causes the autopilot to disengage.

Stick pusher activation is dependent on one angle-of-attack sensor reaching 19 degrees and the other being greater than 12.5 degrees. When the stick pusher is activated, one of the PUSH lights on each pilot's instrument panel will illuminate. If both angle-of-attack sensors reach 19 degrees, then both PUSH lights on each pilot's instrument panel will illuminate. Between the onset of stick shaker activation and stick push activation, both the stick shaker and aural warning 'clacker' will operate continuously.

Stick pusher activation applies 80 lbs (36 kg) forward force on each control column which results in a 4 degrees elevator down position. The system is equipped with a gravity switch, which operates at < 0.5 g to prevent the actuator from forcing the aircraft into an unacceptable nose-down attitude.

Failure of a stall warning computer causes a warning light to illuminate in the central warning panel located in the cockpit. If this warning light illuminates, the stick pusher is inoperative. However, the stick shaker and the aural warning 'clacker' will still operate.

The Saab 340B AOM stated that:

> In a stall with an iced-up aircraft, the stall will in many cases occur before stick shaker/pusher activation and a more pronounced roll might occur. In an extreme case, a roll off of more than 90 degrees and excessive nose drop can occur.

A warning is then given stating that moderate to severe airframe icing changes the stall identification, speed and handling characteristics considerably. The AOM goes on to describe the stall recovery procedures. A section in the AFM warns that a stall may be encountered before the artificial stall warning is activated.

The PIC commented that he was aware of the stall warning system from his Saab endorsement training. There was a visual and aural warning, and a stick shaker and pusher. He said that the straight and level stall speed was 96 kts and that sometimes the stick shaker would operate during take-off, if the vane was flown up by a wind gust. He said that he thought that the incident had been a wing drop and not a stall as there had been no indication from the stall warning system. During his endorsement training, the stall warning system always worked. The copilot mentioned that there were no special stall recovery procedures in the Saab and stated that it followed from early training.

1.6.5 Ice and rain protection

The Saab 340 aircraft is certified for operations in known icing conditions in accordance with FAR/JAR Part 25, appendix C.

The aircraft ice and rain protection systems are divided into anti-ice systems and de-ice systems.

Anti-ice systems are fitted to the engine, pitot tubes, temperature probe, angle-of-attack sensors and windshield. De-ice systems are fitted to the wing, vertical and horizontal stabilisers and propellers.

The pitot tubes, temperature probe and angle-of-attack sensors are automatically heated as soon as one alternating current (AC) generator is on line following engine start.

The wing, vertical and horizontal stabiliser de-icing systems consist of conventional inflatable boots located on the respective leading edges. The boots are inflated by using precooled engine bleed air that is controlled by a pressure regulator and supply valve. De-icing occurs when accumulated ice is cracked by rapid inflation of the boots. A timer control unit regulates boot inflation cycles. The unit is selectable to either one cycle or continuous operation. In the one-cycle mode, the boots are inflated in a predetermined order and then deflated. In the continuous mode, inflation of the boots will be repeated every three minutes. Each boot can be manually inflated using a push button for each zone.

Boot operation is monitored and a fault light will illuminate if a fault is detected in either the operation of the valves or the boots. If a boot remains inflated after normal operation of the system, the fault light will also illuminate. The flight crew can monitor inflation of the boots by observing the boot indication lights located on the overhead panel.

The propeller is equipped with de-icing boots that are electrically heated. A three-position switch for each propeller controls operation of the system. The system can be operated in either the NORM mode or the MAX mode. In NORM mode the power to the boots is on for 11 seconds and off for 79 seconds. In MAX mode the system operates for 90 seconds on then 90 seconds off. MAX mode is recommended when temperatures are colder than -12°C. The AOM noted that the use of MAX mode at temperatures warmer than -12°C, or

NORM mode at temperatures warmer than -5°C, may cause accumulated ice to melt and refreeze behind the boots.

The SOP stated that icing conditions are deemed to exist when visible moisture in any form is present eg, clouds, mist, rain, snow, or standing water on the tarmac - whenever the OAT is 5° C and below during ground or flight operations. The manual goes on to say to monitor the accumulation of ice.

> The windscreen wiper will give a visual cue of icing, although airframe ice can be present without any build up on the wipers. Ice on the wing will increase the stall speed. Therefore, maintain an airspeed not less than V_{CLEAN} [7]+ 15 KIAS [145 kts at Bathurst]. If abnormal trim changes, or nose down or pulsating elevator control forces occur after flap extension, immediately retract the flap to previous position, and land with reduced flap.

The AOM advised flight crew to activate the engine anti-ice early if icing is considered likely. The AOM goes on to advise crews that switching the cockpit interior light on at night will aid in the discovery of ice accretion on the windshield wipers. The AOM also advised flight crew to operate the boot de-ice system when ice has accumulated to about 6 mm thickness on the leading edges. In continuous icing, consider the use of the AUTO mode to reduce PIC workload. However, the SOP instructed flight crew to operate the boot de-icing system only when ice has accumulated to approximately 10 mm thick on the leading edges.

Volume 2 of the same manual instructed flight crew to operate the boot de-ice system at the first sign of ice formation anywhere on the aircraft, or upon annunciation of the ice detector system (if installed) whichever occurs first.

An ice detection system is not fitted as standard equipment on the Saab 340 but is available as an optional item of equipment. The aircraft involved in this incident did not have the optional ice detection system installed.

During a previous investigation by the ATSB, the manufacturer advised that the ice detection system was for engine anti-ice only. It alerted the flight crew to the fact that they had not switched the engine anti-ice system on. Furthermore, any warnings from the system were suppressed when the engine anti-ice system was selected on.

The copilot reported that the flight crew checked for ice accretion on the wings during the descent, but none was observed. About five minutes elapsed from the time the aircraft would have entered cloud until the aircraft stalled.

1.6.6 Flight guidance and autopilot system

The aircraft was equipped with a flight control computer that includes the flight director/autopilot, elevator and rudder auto-trim functions, and a yaw damper that provides directional stability augmentation.

The autopilot operates in a number of different modes in both the vertical and lateral planes. There are 11 modes that can be selected by the flight crew. Only one of these modes - IAS mode - will provide protection against penetrating the required stall speed margins. According to the PIC, the ALT mode was selected prior to capturing the MDA.

7 Final climb speed reached by the aircraft at the end of the acceleration segment which will give a margin of at least 1.25 times above the stall speed in a clean configuration.

The autopilot is also fitted with a half-bank mode. When activated, this reduces the angle of bank from the normal bank limit of 27 degrees to 13.5 degrees. The AFM section - Operations in Icing Conditions, recommended that half-bank mode be used whenever possible in icing conditions. During a previous investigation, the manufacturer advised, that this limitation would provide extra margins above the stall, particularly in icing conditions.

The SOP encouraged the flight crew to make use of the autopilot:

> 'Maximum use of the FD and AP is encouraged. This includes take-off, climb, cruise, descent and instrument approaches'.

The manual goes onto say that all approaches shall be conducted with the half-bank mode OFF. The flight crew were operating the autopilot in the full bank mode as directed by the SOP.

The autopilot can be disconnected by any of the following:

- the PIC deliberately disconnecting the autopilot; or
- the stall warning system, triggering the stall warning; or
- use of the manual trim by the flight crew; or
- faults in the system; or
- rapid roll rates (greater than 10 deg/sec).

Any excessive control force will not cause the autopilot to disconnect. However, it will cause that particular part of the system to disengage, with a matching warning on the centre warning panel. This is known as command cutout[8].

1.6.7 Limits on the use of autopilot

The SOPs, which aligned with the manufacturer's procedures, stated that operations were not authorised for flight below:

> 200 ft AGL – during take-off or go around
>
> 500 ft AGL – during cruise
>
> 50 ft AGL – during approach
>
> 100 ft AGL – for non-coupled approach
>
> - speeds below 1.3 x stall speed - in HDG mode
>
> - In icing conditions, FD/AP IAS MODE IS THE ONLY VERTICAL MODE TO BE USED DURING CLIMB WHEN ICE ACCUMULATION IS OBSERVED OR IF IT IS NOT CERTAIN THERE IS NO ICE ACCUMULATION ON THE AIRCRAFT.'

This limitation is repeated in the FLIGHT PROCEDURES - GENERAL section of the AOM. There are no other limits published in the manuals on the use of the autopilot in icing conditions.

8 Command Cutout; the autopilot does not disengage at extreme aircraft attitudes. There is a feature in the autopilot known as 'command cutout'. Above certain aircraft attitudes and roll rates the command seen by the appropriate server on a particular axis is set to zero and the aircraft's control surface is driven to towards the position it was in prior to the initiation of the cutout. The server loop will hold the flight surface in this position until attitudes, roll rates and accelerations return to stable flight where the autopilot will assume command.

1.6.8 Flight controls

The primary flight controls of the Saab 340, the ailerons, elevator and rudder, are conventional, manually operated rod and cable assemblies. All control surfaces are mass balanced[9]. There is no hydraulic assistance to the flight controls.

Pitch trim on the Saab 340 is activated by the operation of trim switches on either control wheel to actuate elevator trim tabs. There is no trim wheel.

A common trim tab position indicator is located on the lower right corner of the centre instrument panel. It provides the only indication to the flight crew of the position of the various trim tabs and is not in the flight crew's primary field of view.

The yaw damper, elevator and rudder auto-trim systems activate whenever the autopilot is engaged. The auto-trim systems continuously re-trim the aircraft to minimise torque applied to the autopilot servos and to keep the control forces to zero.

The elevator trim systems do not provide any aural indication to alert the flight crew whenever they are operated. The only visual indication to the flight crew that the elevator trim system has re-trimmed the elevator, is movement of the elevator trim index on the common trim tab position indicator.

The aircraft was fitted with an Aileron Spring Unit. The unit allowed pilots to initially maintain authority in the roll axis if one aileron seized, until the aileron disconnect handle in the cockpit was pulled by a PIC. In the event of an aileron seizing, the PIC must overpower a preloaded spring unit (commonly referred to as yawning) to manipulate an aileron. When the PIC reduces control input pressure the unit will close allowing the ailerons to be normally coupled.

1.6.9 Operator's approach procedures

The chief pilot reported that a steep arrival would have been required for this instrument approach into Bathurst, therefore both engines would have been at flight idle during descent. He said that the approach by the aircraft was by the book until levelling out. As the aircraft levels, the flight crew are required to apply power to maintain airspeed. Given the weight of the aircraft, and the weather at the time of the incident and that there is no auto coupling of the power levers to the autopilot, the chief pilot indicated that power should have been increased by the flight crew to about 50 per cent to 60 per cent and then monitored and adjusted if necessary. The chief pilot went onto say that if the crew waited half a second after levelling, the speed would start to decrease because the aircraft (configuration) was pretty 'dirty[10]'. The SOP instructed the flight crew to add 5 per cent torque in icing conditions.

The PIC commented that in hindsight, perhaps he should have increased power, but when he checked, the speed was still decreasing towards the circling approach speed. He said that maybe he was looking at something else just before the incident or perhaps he was distracted while attaining visual conditions and thinking about the turn to downwind.

The SOP instructed the non-flying pilot to monitor the approach, paying particular attention to speed, flight path and engine instruments.

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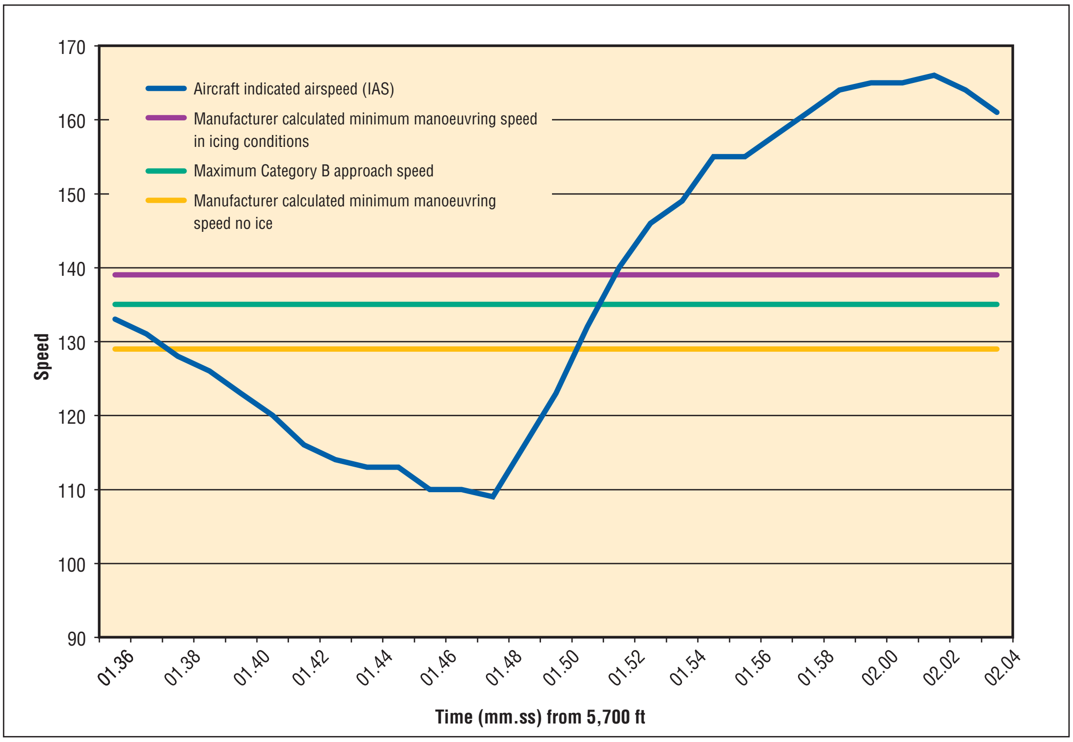
9 Mass attached to a flight control surface, typically ahead of the hinge axis, to reduce or eliminate inertial coupling with airframe flutter modes.

10 Dirty; in this context meaning flap and landing gear extended.

1.6.10 Target speeds

FIGURE 1:
Recorded aircraft speed and recommended target speeds



The PIC indicated that he had intended to slow the aircraft to 130-135 kts, during the descent and level off at the MDA.

The flight plan for each flight detailed speeds to be used for approaches and landings. These speeds are air speeds based on aircraft takeoff, approach and landing configurations and are calculated to ensure a safe margin above the stall speed. Figure:1 displays the speeds that the flight crew could have used to calculate a target speed for an approach at Bathurst.

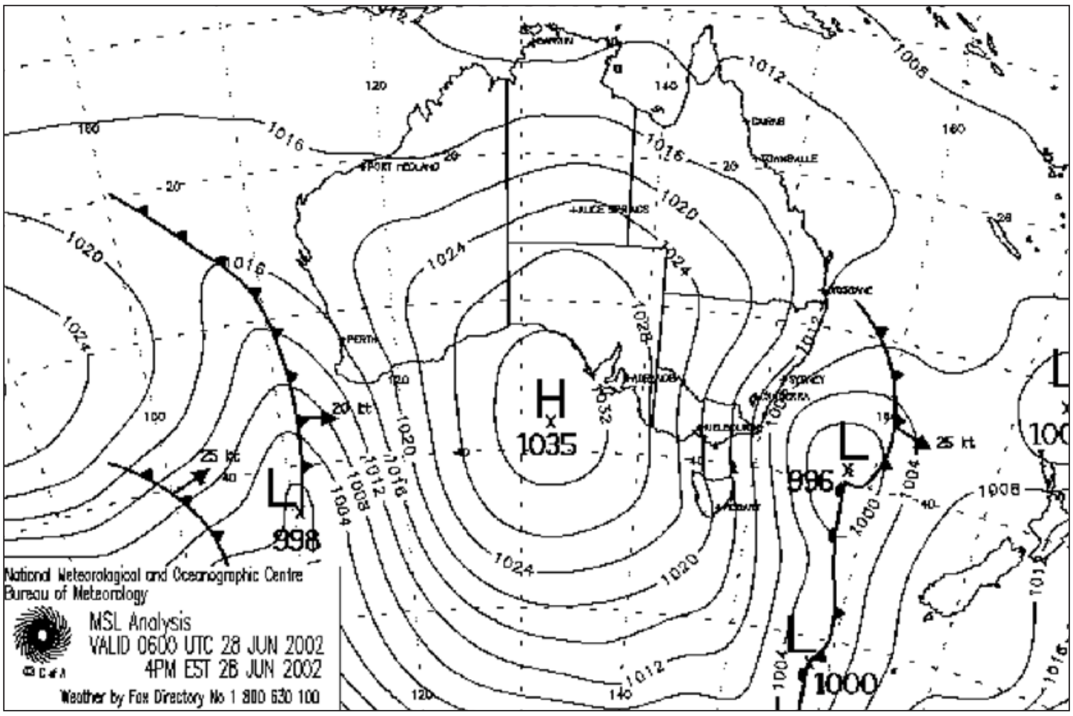
1.7 Meteorological information

The area forecast provided by the Bureau of Meteorology (BOM), that was available to the flight crew prior to the Sydney – Bathurst flight, noted a freezing level of 4,000 ft and moderate icing in cloud above the freezing level. The forecast indicated a cloud base of 2,000–3,000 ft above sea level for the second half of the trip.

The forecast for their arrival at Bathurst predicted snow showers, a temperature of 2°C, with broken cloud down to 800 ft and a south-westerly wind gusting to 28 kts.

The Bathurst aerodrome weather report and area report provided to the ATSB by the BOM indicated that at the time of the serious incident, the temperature was 3°C, with a 13 kt wind from the southwest, gusting to 17 kts at Bathurst.

FIGURE 2:
Synoptic chart for 1600 hrs on 28 June 2003



A specialist area report provided by the BOM indicated that airframe icing would have been possible from the time the aircraft entered cloud until it left cloud, or descended below the freezing level.

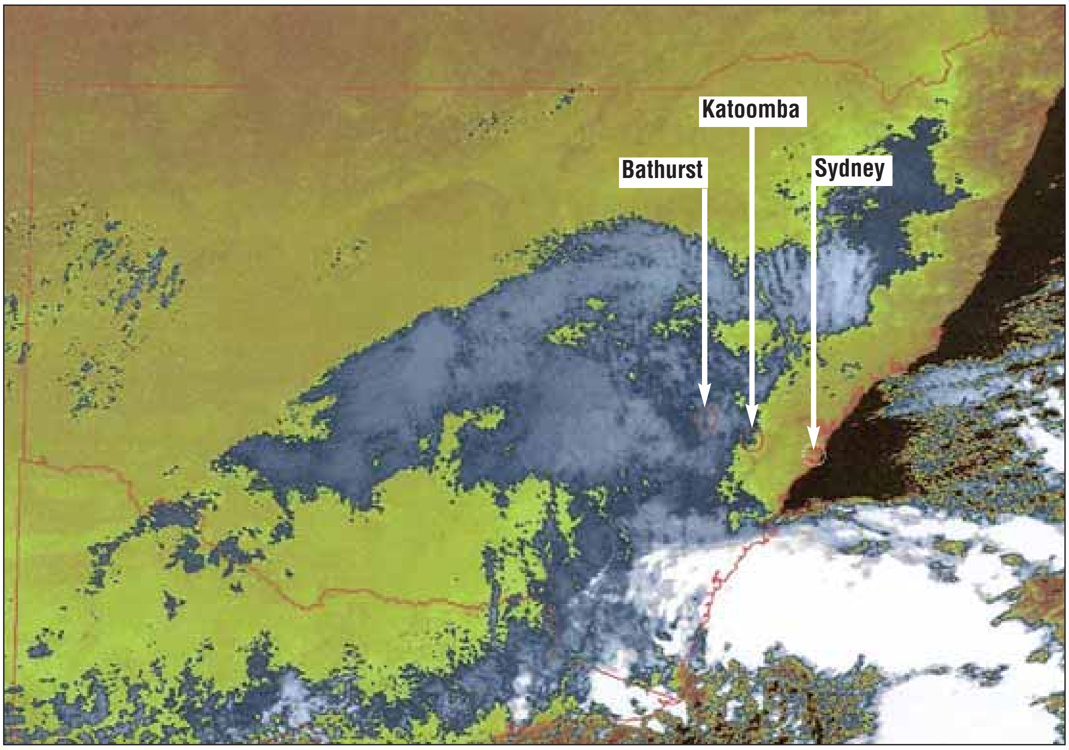
Based on the temperature and dewpoint temperature at Bathurst at 1800, and the Wagga Wagga aerological sounding at 0900, the cloud base was estimated at 3,000 ft above mean sea level (AMSL). The freezing level would have been about 3,500 ft AMSL.

The temperatures recorded by the flight data recorder during the descent to Bathurst were consistent with the aircraft entering cloud at about 7,500 ft. The satellite image of the cloud in the area at about 1727, shows that cloud, mostly unbroken, extended from Katoomba to Bathurst. Satellite derived cloud-top temperatures in this area were mainly between -7°C and -9°C.

The report went onto say that due to the presence of orographic cloud containing large super cooled droplets of water, the aircraft would have encountered conditions conducive to clear ice accretion on the airframe during the descent to Bathurst.

The PIC reported that during descent, they entered cloud a number of times and noted ice accretion on the windshield wiper.

FIGURE 3:
Infra-red cloud image at 1727 on 28 June 2002



1.8 Aids to navigation

The flight crew utilised a ground based non directional beacon (NDB) at Bathurst for lateral tracking and a satellite global positioning system (GPS) receiver, which provided distance information from Bathurst, for a Katoomba–Bathurst GPS arrival–instrument approach. This approach allows the flight crew to gradually descend the aircraft, during non–visual conditions, to the MDA. If visual, it is then necessary to position the aircraft to conduct a circuit before landing at Bathurst. The flight crew reported that the ground based equipment and GPS receiver were serviceable at the time of the incident and the GPS receiver was receiving the satellite signal.

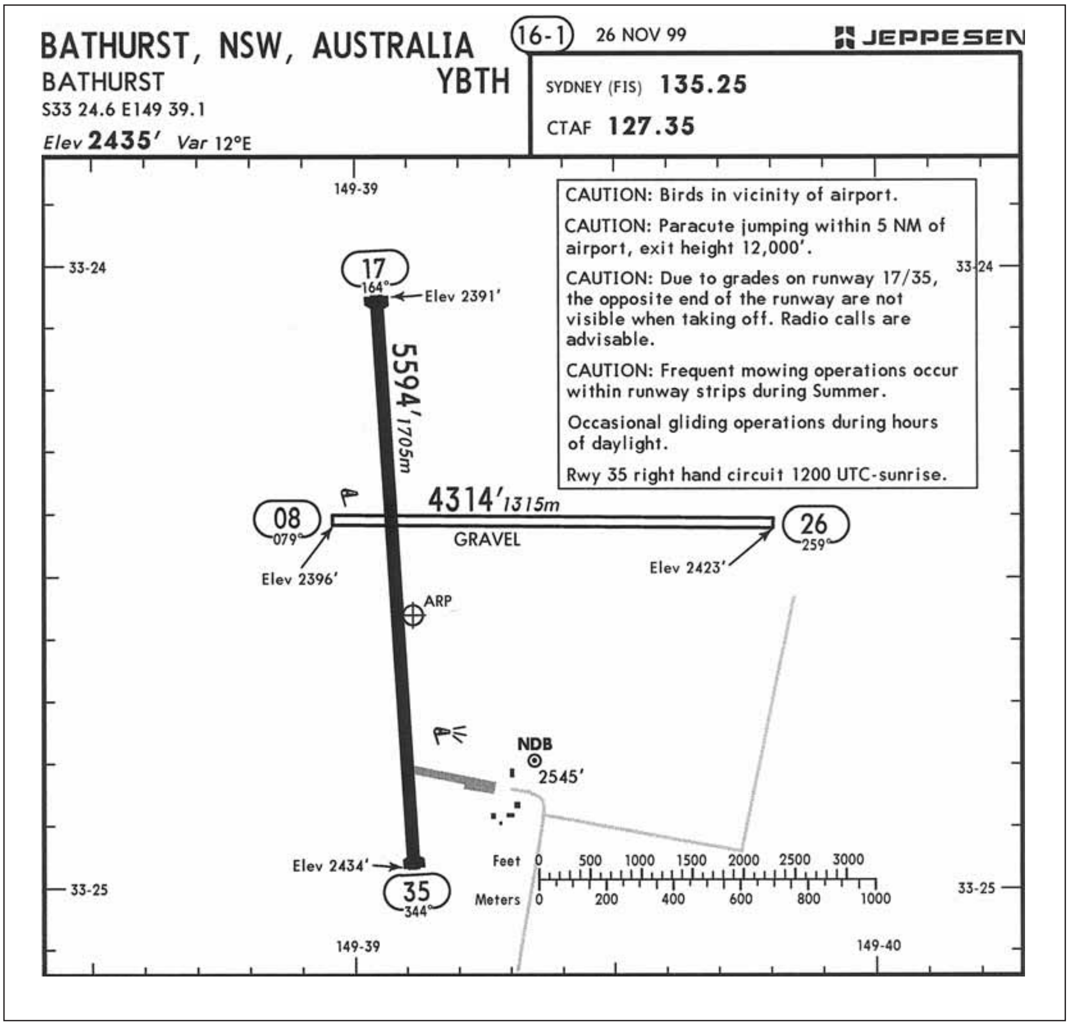
1.9 Communications

There was no information to suggest that there were any problems with radio communication equipment or facilities.

1.10 Aerodrome information

Bathurst aerodrome is located in eastern New South Wales at an elevation 2,435 ft above sea level and is equipped with a north–south runway and an east–west runway of 1,705 and 1,315 m respectively. The north–south runway is fitted with runway edge lights for night operations. Bathurst aerodrome does not have a control tower. Aircraft crews are expected to provide self separation via radio broadcasts and visual lookout. The aircraft had approached the aerodrome from the east and because of the south-westerly wind, was turning right onto a downwind circuit, as part of a circling approach, for a landing onto runway 17, when the event occurred.

FIGURE 4:
Bathurst airport



The SOP contains a section detailing local radio frequencies, hazards and weather at Bathurst. The section on the weather advises flight crew to expect poor weather during winter months and probability of fog during autumn, winter and spring. The section goes on to comment about turbulence and the possibility of snow during winter months.

1.11 Flight recorders

The aircraft was fitted with both a flight data recorder (FDR) and a cockpit voice recorder (CVR). After the occurrence, the aircraft completed a further 35 flights (27 hours) before the operator became aware of the full nature of the incident. Since the CVR only recorded the last 30 minutes of crew communications and radio transmissions the occurrence sequence had been overwritten. Consequently the CVR was not examined by the ATSB.

The FDR was a Fairchild Model F1000 digital recorder coupled to a Telephonics flight data acquisition unit. The aircraft flight recorder system recorded 55 parameters. The FDR was downloaded and analysed at the ATSB using the Bureau's Recovery, Analysis and Presentation System software. A copy of the FDR data was provided to the airframe and engine manufacturers and to the operator.

The FDR did not record UTC or local time, but elapsed time (since last recorder power up) was recorded. Incident reports from the flight crew indicated that departure time from Sydney was 1810 EST and that the incident occurred at 1830 . A transmission was made on

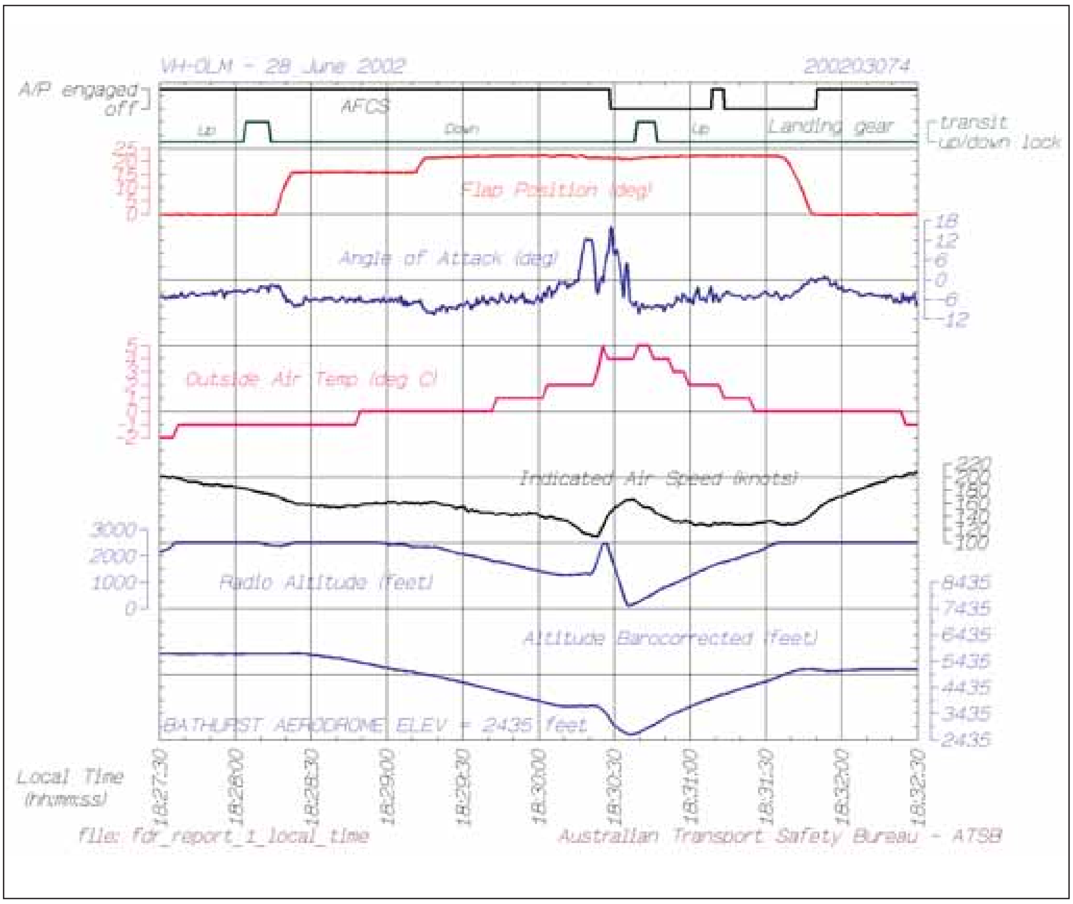
VHF1 when track to Bathurst was obtained. The time of this transmission was designated the local departure time of 1810. Application of this time to the FDR put the incident at 1830 local time. Local time was used for the description of events recorded on the FDR and on the graphical representation.

At 1807:24 (hhmm:ss) the flight crew lifted off from Runway 25 Sydney and at 1816:47 OLM attained a cruise level of 12,000 ft, climb time was therefore 9 minutes 23 seconds. The OAT at this altitude was -11°C. At 1817:33 the OAT decreased to -12°C. At 1820:45 the OAT decreased to -13°C.

At 1822:17 the flight crew commenced descent and the OAT increased to -12 degrees. Cruise time at 12,000 ft was therefore 5 mins 30 seconds At 1826:35 OLM attained 5,712 ft with the OAT at -2°C.

Figure 5 shows a graphical representation of the recorded values of pressure altitude, radio altitude, indicated airspeed, outside air temperature, angle of attack, flap position, landing gear position and autopilot engagement. This information is for a five-minute period leading up to and after the departure from controlled flight. Figure 6 shows the same information for the one-minute period immediately surrounding the occurrence.

FIGURE 5:
Recorded data, five minute period



At 1828:28 the flight crew commenced descent from 5,712 ft AMSL with the landing gear extended, flaps at the 15 degrees setting, and the autopilot engaged. At the commencement of the descent, the recorded aircraft speed was 158 KIAS, engine torques 40 per cent and an OAT of -1°C.

At 1829:22, 54 seconds into the descent, the flaps were extended to the 20-degree setting, propellers set to approximately 1,400 rpm and the engine torques reduced to around 16–22 per cent respectively.

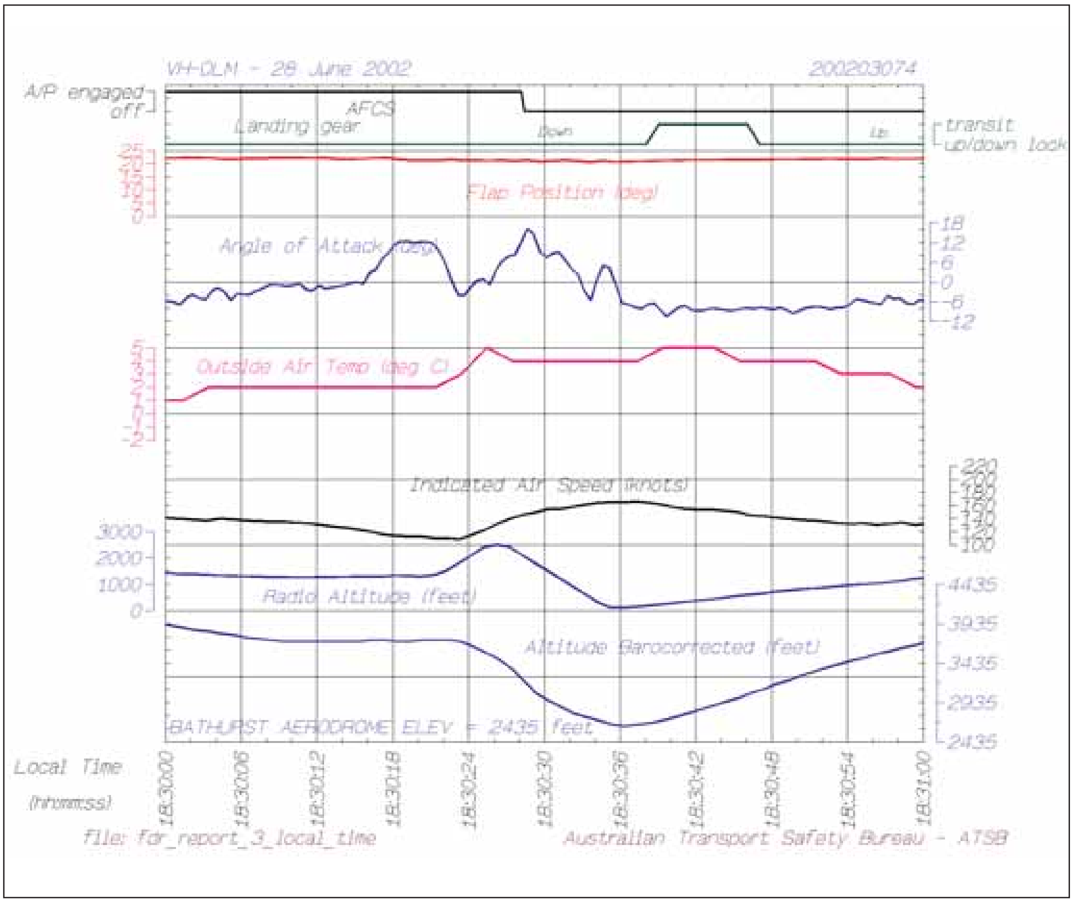
At 1830:09, the flight crew levelled the aircraft off at 3,712 ft AMSL. The recorded speed was 135 KIAS, with engines 1 and 2 torques at 15 per cent and 19 per cent respectively. The radio altitude was 1,272 ft AGL and the OAT was recorded as 2°C.

At 1830:11, with a recorded speed of 133 KIAS and a radio altitude of 1,264 ft, the aircraft commenced a right bank into a turn in response to aileron deflection. This was likely as a result of pilot input to the autopilot.

The aircraft attained 28 degrees right roll at 1830:17, with an angle of attack of 8.9 degrees and speed of 116 KIAS.

Approximately 1 second later, at an angle of attack of 12.35 degrees and speed of 114 KIAS the aircraft commenced a roll back to the left in response to autopilot driven aileron deflection and the engine torques were increased through 28 per cent.

FIGURE 6:
Recorded data, one minute period



An angle of attack of 12.55 degrees was recorded 1 second later. The speed at this time was 113 KIAS, pitch angle 10 degrees noseup. The left roll continued through 8 degrees right bank and the engine torques continued to increase through 38 per cent.

An uncommanded left roll then commenced, with the aircraft rolling rapidly and reaching 109 degrees left bank at 1830:23. At this time the speed was 109 KIAS, the engine torques had decreased through 34 per cent and the aircraft began pitching nose down through 7 degrees.

The pilot responded with aileron input to roll the aircraft back to the right. At 1830:24 the aircraft began descending with an increasing nose-down attitude and 90-degrees left bank. The aircraft was descending through 3,488 ft (estimated 960 ft AGL) at 1830:26 when it attained its maximum nose-down pitch of 27 degrees; engine torques at this time were 51 per cent.

At 1830:28 the autopilot disengaged when the angle of attack increased from 12.02 degrees to 16.22 degrees. The aircraft was passing through 3,216 ft AMSL (estimated 688 ft AGL), rolling back to the right and travelling at 146 KIAS in a 19 degrees nose down attitude.

Figure 7 shows a graphical representation of the recorded values of pressure altitude, vertical acceleration, pitch, roll, pitch trim, engine torques and aileron positions. This information is for a five-minute period leading up to and after the departure from controlled flight.

FIGURE 7:
Recorded data, five minute period

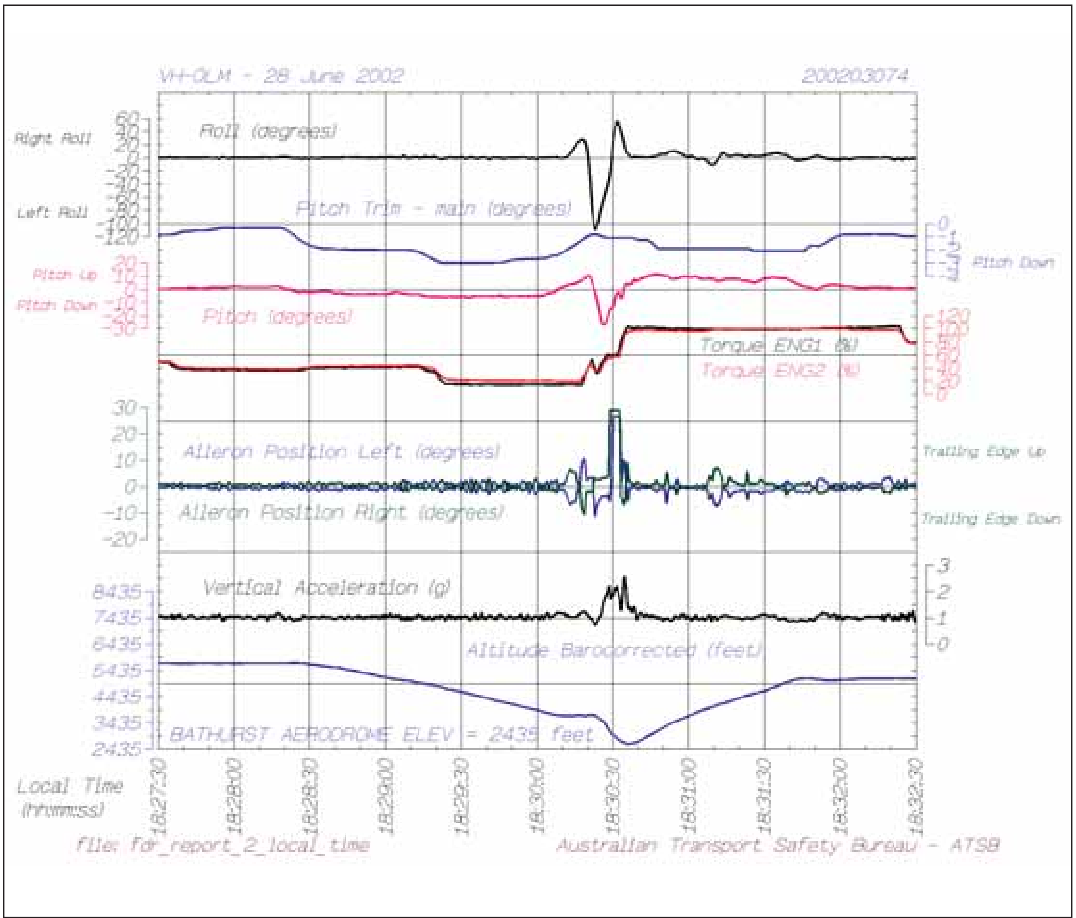
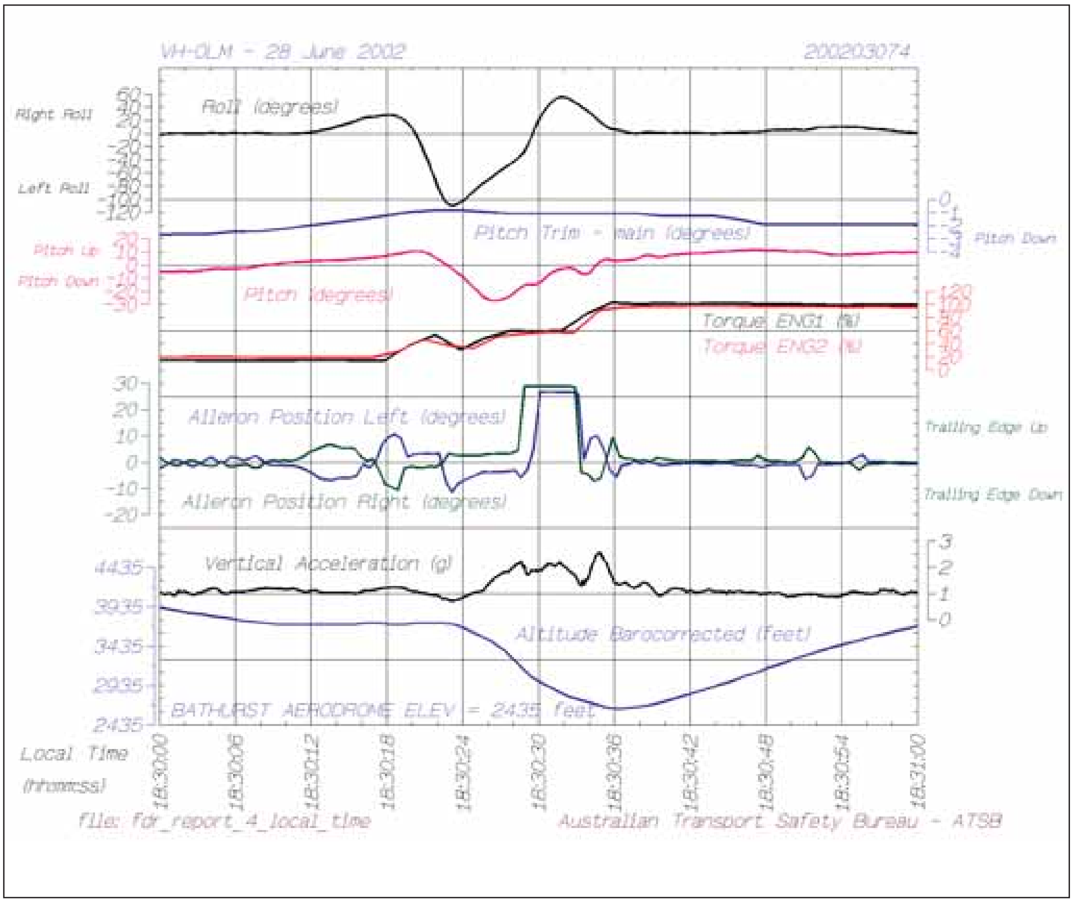


Figure 8 shows the same information for the one-minute period immediately surrounding the occurrence.

FIGURE 8:
Recorded data, one minute period



During the following 3 seconds the aircraft descended a further 336 ft to 2,880 ft AMSL (estimated 352 ft AGL), while rolling right through wings level to 56 degrees right wing low. Both ailerons were simultaneously in the maximum positive position (trailing edge up) of 27 degrees (left) and 29 degrees (right) for this period (see para 1.16.1)

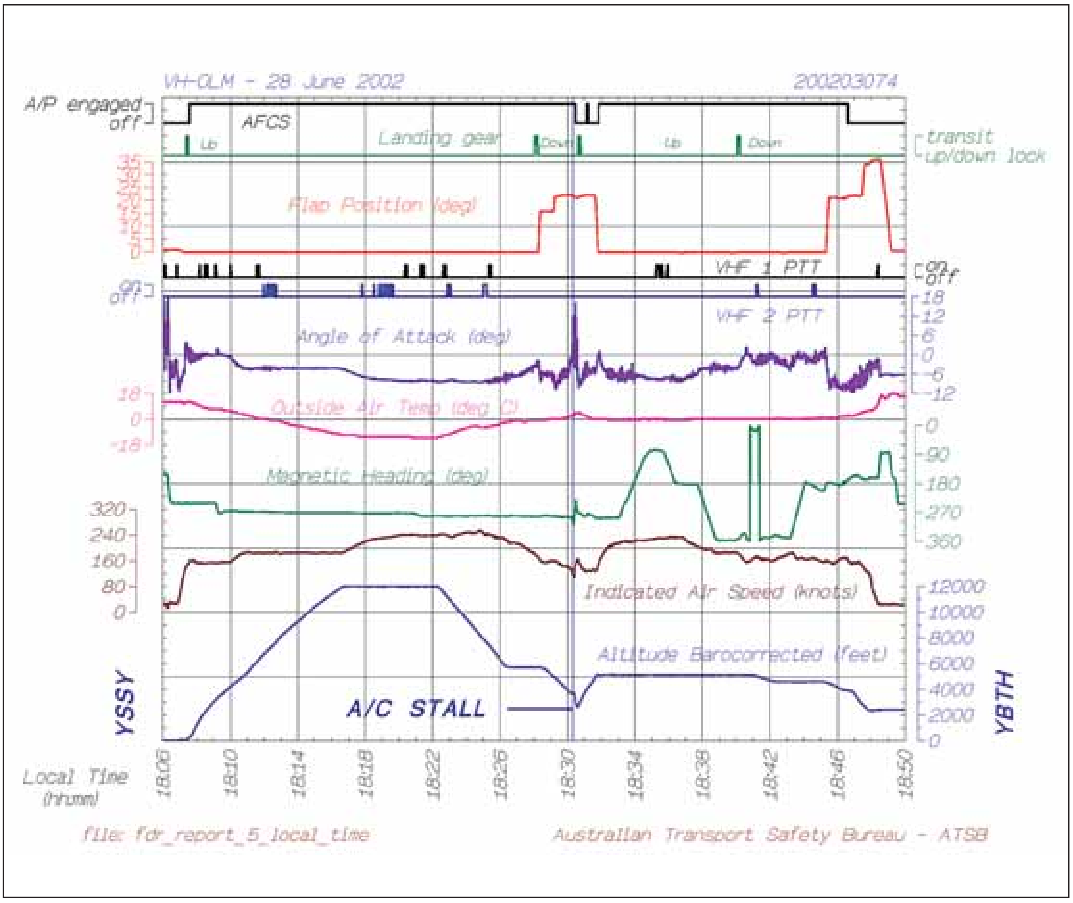
During the following five seconds the aircraft continued to descend, rolling back to almost wings level and nose-up pitch in response to pilot commands. The engine torques increased towards 100 per cent and a vertical acceleration of +2.56g was recorded. The minimum altitude during the stall recovery was recorded at 1830:36. The altitude AMSL was 2,640 ft, 112 ft AGL and speed 165 KIAS.

The aircraft then began to climb with the crew retracting the landing gear at 1830:39 and retracting the flaps about one minute later, before a missed approach procedure was carried out.

Following the stall, the aircraft descended approximately 1,072 ft in 13 seconds prior to regaining altitude. The radio altitude data, although recorded, was erratic during this period due to the excessive pitch and roll angles of the aircraft.

Figure 9 provides the entire flight profile of altitude, indicated airspeed, magnetic heading, OAT, angle of attack, VHF 1 & 2, PTT, flap position, landing gear and autopilot.

FIGURE 9:
Recorded data, Sydney - Bathurst



1.12 Wreckage information

The aircraft was not damaged.

1.13 Medical information

Although the flight crew had been on duty for some time, there was insufficient evidence to suggest that they were suffering from the effects of fatigue. There was no evidence that personal, psychological, or physiological factors affected the performance of the flight crew.

1.14 Fire

There was no evidence of fire during the flight.

1.15 Survival aspects

Not applicable.

1.16 Tests and research

1.16.1 Manufacturer's analysis

The weather report and load sheet from the serious incident, along with a copy of the data from the aircraft's flight data recorder, was sent to the aircraft manufacturer for analysis.

The manufacturer had detailed knowledge of the aircraft regarding aerodynamic and power models, system functions, wind tunnel data and certification flight test results.

The manufacturer entered the flight recorder data into software packages to enable them to determine a number of parameters including engine power settings, air speed, fuel flow, and known data such as the aircraft weight at the beginning of the flight. A software simulator was also utilised that assisted to analyse whether the aircraft behaved as the type design and as certified. The data from the incident was compared with the data that was collected as part of the original certification process.

The analysis focused on the FDR data reliability, engineering simulations, lift coefficient versus angle of attack behaviour, drag differences, speed analysis, rolling moment analysis, autopilot and control system behaviour, engine parameters and flight crew procedures.

The manufacturer's analysis, incorporating data from the BOM, indicated that the roll upset occurred as a result of an aerodynamic stall over the left wing. That in turn resulted from a low power setting, increasing aerodynamic drag due to airframe and wing ice build-up and decreasing airspeed following an altitude capture by the autopilot after the descent, as part of the instrument approach. This was in combination with load factor and an autopilot commanded roll rate to the left when levelling from a right full-bank turn (27.5 degrees). The stall occurred at 9.5 degree angle of attack, a speed of 113 KIAS prior to stick shaker and stick pusher speed/angle of attack limits and consequently the autopilot did not disengage at stall. The manufacturer commented that the amount, type and shape of ice accumulation is not possible to determine. However, the aerodynamic behaviour corresponds to a 0.5 inch (12mm) of horn ice on the protected surfaces, as used during certification flight tests of the aircraft.

During most of the stall recovery, the autopilot entered the command cutout mode in the different axis due to the high angular rates and pitch and angle of attack angles. The PIC overpowered the autopilot rolling the aircraft back from 109 degrees left bank, to a left bank angle of approximately 35 degrees, when due to high angle of attack, ice accumulation on the wing leading edges and the continuing roll rate to the right, the right wing stalled, rolling the aircraft to about 56 degrees to the right. During this second stall, the stick shaker / stall warning system was most probably activated and consequently the autopilot disengaged. The manufacturer's analysis showed that during the second stall, both pilots probably were steering their respective control wheels, but due to the stalled outer right wing, together with different directions of the control wheel input by the two pilots, the aileron spring unit opened up shortly after the second stall, resulting in both aileron's trailing edges deflecting fully upwards. As soon as roll rate to the left was achieved, the PIC most probably relaxed somewhat on the control wheel force and together with gradual changes of the aileron hinge moments, the spring unit returned to normal position. The flight crew regained control of the aircraft and commenced a go-around and uneventful landing.

The manufacturer determined that the systems and aircraft behaviour was in compliance with design type configuration.

The manufacturer went on to say that during the approach prior to the roll upset, the aircraft de-icing boot system was not used as prescribed in the AFM. Should the de-icing boot system have been used according to the prescribed procedures, as well as the speed kept to the recommended minimum speeds for the prevailing conditions, a satisfactory stall margin would have existed during manoeuvring for final approach and consequently a stall would have been avoided. The manufacturer commented that the operator's SOP and AOM were not updated in accordance with the manufacturers AFM and AOM.

1.16.2 Test flight

As part of the investigation into this incident the ATSB organised for a flight test to be conducted to further study, and record, the behaviour of the aircraft under basic flight parameters similar to those existing during the incident. A Saab 340B aircraft, VH-EKH, that was representative of the aircraft involved in the incident, was loaded and flown to check, and record, flight characteristics and systems operation during level and banking decelerations toward the stall. The aircraft was piloted by senior flight crew from the new airline owner, while the test flight plan was prepared and the flight supervised by a test pilot from the Civil Aviation Safety Authority (CASA). The tests were flown in clear conditions with no chance of airframe icing present. Under the profiles flown, the aircraft and its stall warning and autopilot systems performed in accordance with the manufacturer's published information.

1.17 Organisational information

At the time of the serious incident, the operator, along with some of its Australian code share partners, was in the hands of an administrator and on the verge of being sold.

The investigation team interviewed the company management team, the flight crew, chief pilot, the safety officer and personnel from CASA responsible for surveillance of the operator. The team reviewed the company's operating procedures both for the aircraft type and destination aerodrome and also examined surveillance documentation from CASA.

The investigation found nothing to indicate that the financial health of the parent operator or the impending sale of the operator had any influence on the circumstances leading to this incident.

1.18 Additional information

1.18.1 Previous incidents

On 11 November, 1998, VH-LPI, a Saab 340A turbo-propeller aircraft was enroute between Albury, NSW and Melbourne, Victoria on a scheduled public transport service. The aircraft was operating in instrument meteorological conditions and had accumulated a deposit of ice on the wings and windscreen wipers. The flight crew interpreted this ice deposit as being less than that required for them to activate the de-ice systems on the wing leading edges, in accordance with the aircraft flight manual procedures. As the aircraft approached Melbourne the flight crew were instructed to enter a holding pattern at Eildon Weir. They reduced power in order to slow the aircraft to the holding pattern airspeed. The flight crew subsequently allowed the airspeed to fall below the target speed of 154 kts, and despite remedial action, did not regain the target speed.

Shortly after the aircraft entered the holding pattern, it suffered an aerodynamic stall and rolled approximately 126 degrees to the left and pitched nose down to approximately 35 degrees. The flight crew regained control after approximately 10 seconds. The aircraft lost 2,300 ft of altitude. The flight crew was not provided with a stall warning prior to the stall.

The investigation found that despite being certified to all required certification standards at the time, the Saab 340 aircraft can suffer from an aerodynamic stall while operating in icing conditions, without the required warnings being provided to flight crew. This problem had been highlighted when the aircraft was introduced to operations in Canada and as a result a modified stall warning system was mandated for Canadian registered Saab 340 aircraft. The factory installed stall warning systems on Canadian registered Saab 340s are essentially the same as those fitted to Australian and other Saab 340 aircraft operated worldwide. However, to meet Transport Canada's requirements, an added input has been provided to the stall warning computers. This input is designated as ICE SPEED and is controlled by the activation of an ICE SPEED switch.

Activation of the ICE SPEED switch causes the stall warning computer to operate on lower triggering levels for the stall warning and the stall identification. The stall warning will operate at 5.9 degrees angle-of-attack with flaps at zero and at 2.1 degrees angle-of-attack with flaps in the 35 degree position. There is a linear movement of the triggering level between the flaps zero and flaps 35 position. The stall identification occurs at an angle of attack of 11 degrees regardless of flap setting. This modification was not fitted to other Saab 340 aircraft worldwide.

Included in the LPI investigation report are details of an accident due to airframe icing to an ATR-72 aircraft at Roselawn, Indiana, USA, in 1994 and the response of regulatory authorities and manufacturers of turbo-prop aircraft. The Federal Aviation Administration (FAA) issued a number of airworthiness directives as a result of that incident. Airworthiness directive 96-09-21 applied to Saab 340 aircraft and required a flight manual amendment covering operations of the aircraft in severe icing conditions. The airworthiness directive stated (in part):

> Since the autopilot may mask tactile cues that indicate adverse changes in handling characteristics, use of the autopilot is prohibited when any of the visual cues[11] specified above exist, or when unusual lateral trim requirements or autopilot trim warnings are encountered while the airplane is in icing conditions.

The Swedish airworthiness authority, Luftfartsverket (LFV), did not consider that these issues applied to the Saab 340 and therefore they did not issue a corresponding airworthiness directive for the type. As the airworthiness directive dealt with operations in severe icing conditions, LFV did agree to insert certain sections of the airworthiness directive into the Saab 340 AFM. Section 2.11 of the AOM was modified to contain instructions on the use of the autopilot in freezing rain or drizzle. Neither of these icing conditions was encountered by the aircraft during the LPI incident or the approach to Bathurst by OLM.

The LPI report went on to say that the manufacturer indicated that the airworthiness directive was not incorporated into the Saab 340 manuals due to disagreements concerning the applicability of the information to the Saab 340. They also indicated that the airworthiness directive was applicable to US operators only.

The Australian CASA did not impose the requirements of airworthiness directive 96-09-21 to flight manuals of the Saab 340 because the state of manufacture did not issue it. CASA stated that this was in accordance with the standards and recommended practices of ICAO Annex 8 - Airworthiness of Aircraft. The investigation team of LPI found however, that the airworthiness directive had been implemented in the flight manuals of other turboprop aircraft, either by a manufacturer's amendment, or a flight manual amendment issued by CASA.

Research by the ATSB during the LPI investigation identified several other events involving Saab 340 aircraft.

11 Accumulation of ice on the upper surface of the wing aft of the protected area and accumulation of ice on the propeller spinner farther aft than normally observed.

On 23 September 1991, a European operated Saab 340 sustained pre-stall buffet during climb in icing conditions. Subsequently, the left wing dropped and shortly afterwards the autopilot disconnected. The flight crew regained control and descended the aircraft approximately 4,000 ft. The flight crew reported that only a moderate amount of ice was present on the wings and that they had operated the de-icing boots at least once during the climb. It was also reported that there was 'a sandpaper like' deposit of ice on the wings and propeller spinners. Analysis of this event by the manufacturer revealed that the flight crew had been operating the aircraft in an incorrect autopilot mode during the climb.

The manufacturer's performance analysis of this event concluded that drag increase from ice on the aircraft was between 4–6 per cent.

The manufacturer stated:

> As the nature of ice accretion is very unpredictable there are reasons to believe that the predicted performance will cover the main part of icing encounters but there might be occasions that will result in an increased performance degradation.

The manufacturer's report also contained the following analysis of the stall speed in the occurrence:

> Experience from flight test with simulated ice shows a 10 per cent increase in stall speed…with 3 inches of simulated ice on the inner wing, flight test has shown an increase in stall speed of 18 per cent in clean (flaps up) configuration. It has also been proven during all our flight tests with natural and simulated ice that the aircraft does not exhibit any uncontrollable roll and pitch manoeuvres at stall.

As a result of this event the manufacturer issued an AOM bulletin. This was issued as Operations Bulletin number 44 to the Saab 340 AOM on 21 December 1994. Subsequently, the bulletin was incorporated into the AOM as 'Supplement No. 1 Operation in Icing Conditions'.

The supplement included information that the stall speed would increase in icing conditions. This increase was quoted as being '10 per cent for flight with 0.5 inch (12mm) of simulated ice and 18 per cent with 3 inches (75mm) of simulated ice' (clean, flaps up configuration). It also included information that stall warning in the form of buffeting may be experienced at speeds up to 25 per cent above the clean (ice free) stall speed.

On 23 March 1994, a United Kingdom operated Saab 340 encountered icing conditions during climb. Although the rate of ice build-up observed by the flight crew did not appear to be heavy, aircraft performance progressively deteriorated. The wing de-ice boots were not activated. A severe vibration commenced and the flight crew thought that ice on the left propeller was responsible. The autopilot then disconnected, and the aircraft rolled rapidly to the left to about 60 degrees angle of bank. Analysis of the event by the manufacturer revealed that the aircraft had stalled and rolled to the left with little or no warning to the flight crew. A contributory factor of the occurrence was that the flight crew had been operating the aircraft in an inappropriate autopilot mode during the climb.

On 12 June 1994 a New Zealand operated Saab 340 aircraft was involved in an incident while operating in icing conditions. The crew of the aircraft was instructed to enter a holding pattern at 11,000 ft. They had operated the engine anti-ice and propeller de-ice systems in accordance with the flight manual instructions and had just cycled the wing de-ice boots to remove a small amount of ice accretion. The indicated speed dropped from 180 KIAS to 140 KIAS and the aircraft sustained severe vibration from a suspected propeller imbalance due to ice deposits. The flight crew disconnected the autopilot and lowered the nose to regain airspeed. As this happened the aircraft began to roll up to 30 degrees to the left and right, with little response from the flight controls. This continued until the speed increased to 180 KIAS.

Subsequent analysis of this occurrence by the manufacturer concluded that the aircraft had entered a stall condition. The roll control difficulties experienced by the flight crew were similar to the flight test experience with the Saab 340 during the Canadian certification tests. The manufacturer reported that the ice accumulation on the aircraft involved in this occurrence would have had rough surface texture due to the temperature of -7 °C.

In February 1998, the flight crew of a United States operated Saab 340 reported that during the climb to 16,000 ft they had experienced icing conditions. After the flight crew had levelled off, the stall warning system activated and the left wing dropped. The aircraft continued to react sluggishly to aileron and elevator control until the flight crew had descended the aircraft to 11,000 ft. The PIC reported there was a small amount of mixed ice on the airframe and that he did not want to activate the de-icing boots for fear of 'ice bridging[12]'. He also described the ice shape as being 'odd, like a mushroom'.

Following the LPI incident, the company operating LPI warned their crews about the weather conditions conducive to icing and emphasised the need to maintain at least V_{HOLD}[13] speed and to disconnect the autopilot before ice accretion, to ensure that any trim changes or other unusual control inputs were detected.

During the course of the LPI investigation, a number of recommendations were issued by the ATSB in 1998, 1999 and 2000, concerning flight in icing conditions and modifications to the Saab 340 stall warning system.

The recommendations and status are listed below.

Recommendation: R20010049

The Australian Transport Safety Bureau recommends that Saab include information in both the aircraft flight manual and the aircraft operating manual advising of the differing shedding capabilities of the wing de-ice boots at different temperatures.

Status: NO RESPONSE

Recommendation: R20010050

The Australian Transport Safety Bureau recommends that Saab advise operators that use of autopilot modes that do not include IAS mode will not afford protection against penetration of the required stall margins.

Status: NO RESPONSE (Issued as an AFM and AOM supplement 37/1)

Recommendation: IR 19980269

The Bureau of Air Safety Investigation recommends that Kendell Airlines note the circumstances of the above incident and alert their aircrew accordingly.

Status: CLOSED-ACCEPTED

12 Classic ice bridging occurred when ice accreted around the inflated tube and remained after the tube deflated. The resulting cavity beneath the ice allowed the tube to inflate and deflate beneath the 'ice bridge' resulting in no ice removal from the wing. Providing that the de-ice system (which includes the boots) are maintained correctly, there is no documented evidence to date of de-icing boot ice bridging in modern turbopropeller aircraft.

13 The speed in a clean configuration for holding patterns. This speed is calculated to give a margin of 1.3 to VS in a 25 degree banked turn and an additional 15 KIAS to compensate for turbulence, windshear etc. In icing conditions, with residual ice on the wings, the speed will give at least a margin of 1.4 to VS in a 25 degree banked turn. In icing conditions, with severe turbulence or equivalent conditions, a higher speed might be required.

Interim Recommendation: IR 19980270

The Bureau of Air Safety Investigation recommends that Hazelton Airlines note the circumstances of the above incident and alert their aircrew accordingly.

Status: NO RESPONSE

Interim Recommendation: IR 19980271

The Bureau of Air Safety Investigation recommends that Macair note the circumstances of the above incident and alert their aircrew accordingly.

Status: NO RESPONSE

Interim Recommendation: IR 19980272

The Bureau of Air Safety Investigation recommends that the Civil Aviation Safety Authority of Australia note the circumstances of this incident.

Status: CLOSED-ACCEPTED

Interim Recommendation: IR19980273

The Bureau of Air Safety Investigation recommends that Saab amend the Saab 340 Aircraft Operations Manual to more appropriately alert pilots that the stall warning system may not activate when the aircraft is operating in icing conditions.

Status: CLOSED-ACCEPTED

Interim Recommendation: IR19980274

The Bureau of Air Safety Investigation recommends that Saab note the circumstances of this incident and alert SF340 operators accordingly.

Status: CLOSED-ACCEPTED

Interim Recommendation: IR19990072

The Bureau of Air Safety Investigation recommends that Saab modify the stall warning system of the worldwide fleet of Saab 340 aircraft to include the ice speed modification, as a matter of priority.

Status: CLOSED-NOT ACCEPTED

Interim Recommendation: IR19990073

The Bureau of Air Safety Investigation recommends that the Federal Aviation Administration note the circumstances surrounding this incident, and note the fact that the Bureau shares a number of concerns regarding aircraft certification procedures, particularly those involving flight in known icing conditions.

Status: NO RESPONSE

Interim Recommendation: IR19990074

The Bureau of Air Safety Investigation recommends that the Joint Airworthiness Authorities note the circumstances surrounding this incident, and note the fact that the Bureau shares a number of concerns regarding aircraft certification procedures, particularly those involving flight in known icing conditions.

Status: CLOSED- ACCEPTED

Interim Recommendation: IR19990075

The Bureau of Air Safety Investigation recommends that Luftfartsverket note the circumstances surrounding this incident, and note the fact that the Bureau shares a number of concerns regarding aircraft certification procedures, particularly those involving flight in known icing conditions. The Bureau also recommends that Luftfartsverket as the initial certifying agency of the Saab 340 aircraft, review the certification aspects of the aircraft's stall warning system, particularly in icing conditions.

Status: CLOSED-NOT ACCEPTED

Interim Recommendation: IR19990076

The Bureau of Air Safety Investigation recommends that the Civil Aviation Safety Authority examine the circumstances surrounding this incident and take whatever steps it considers necessary to ensure the safety of the Saab 340 fleet operating within Australia.

Status: CLOSED-NOT ACCEPTED

A number of the recommendations were accepted and acted on by the recipients, including additional training by the operator of LPI and the publication of an alert bulletin by the manufacturer to operators of the aircraft type. Those recommendations were listed as CLOSED-ACCEPTED. However, the recommendation for the modification of the stall warning system was not accepted by the recipients.

As a result of interim recommendation 19980273, which was issued following the LPI investigation, the manufacturer issued an operations bulletin in February 1999, No. 56 titled Artificial Stall Warning in Icing Conditions.

> The bulletin stated that: to highlight the fact that the design of the artificial stall warning system does not always provide a stall warning before stall is encountered if there is ice on the wing-
>
> **BACKGROUND**
>
> Even a small amount of ice on the wing will reduce the lifting capability and increase the stall speed of the aircraft. The aircraft will stall at a lower angle of attack than for the normal clean (free of ice) case.
>
> Most artificial stall warning systems are designed to give an artificial stall warning (shaker and aural warning) and subsequent pusher at preset angles of attack for a clean wing. In the case of the Saab 340 the artificial stall warning will activate approximately 8 kts before stall with a clean wing. The stall warning system has one trigger level, which is designed for a clean wing. This means that with ice on the wing, the aircraft may stall at an angle of attack which is lower than the preset warning angle of attack and stall may be encountered before the artificial stall warning is activated.
>
> **PROCEDURE**
>
> With reference to the above, it is essential that the flight crew is aware of the adverse effects of ice on the aircraft The operational speeds shall be increased according to AFM (section 5) and AOM (section 27/1) if ice is observed on the aircraft or if it is not certain there is no ice on the aircraft. The amount of ice allowed to build up shall be kept at a minimum.

The AFM of the operator of OLM included the manufacturer’s warning that an aircraft with ice on the wing may stall before activation of the stall warning system.

The operator provided two copies to the ATSB of part B of their operations manual. One copy included a section titled ‘Cold Weather Operations’ which was dated after the serious incident and contained information and procedures for crews for operations in icing conditions, while the other manual did not contain that section, but contained various procedures all dated prior to the serious incident including the brief information already mentioned earlier in this report. The operator indicated that that the latter copy is an amendment which was being rewritten prior to the serious incident and supersedes the earlier copy. The operator went onto say that parts of the information contained in ‘Cold Weather Operations’ was previously contained in the AOM, the SOP and the AFM. The AOM and the SOP had been issued to crews as controlled manuals.

From surveillance records examined by the ATSB, it appears that routine surveillance by CASA did not highlight the inconsistencies in the operator’s manuals.

1.18.2 Manufacturer issued revisions and amendments to procedures

The manufacturer issued a number of revisions, amendments and additions to procedures for flight in icing conditions. Below is a list of known amendments relevant to the incident.

Date		*Amendment, revision or bulletin*
February	1999	Artificial Stall Warning in Icing Conditions.
March	1999	Change to guidelines on boot de-ice system and ice bridging
October	1999	Additional information regarding the stall warning and the importance of increasing operating speeds in icing conditions
October	1999	The importance of operating the de-ice boots as soon as ice is detected
October	1999	Additional information regarding recovery from unusual attitudes.
October	1999	Introduction of a new supplement combining information regarding operation in cold weather and icing conditions
November	2000	Clarification for the manual operation of de-ice boots

2 ANALYSIS

2.1 Introduction

Analysis of the recorded data showed that following capture of the MDA by the autopilot, the aircraft speed continuously decreased due to an insufficient power setting. As a consequence, the autopilot commanded an increasing amount of nose up trim to maintain the captured altitude . Eventually the aircraft stalled. However, this occurred prior to the stall warning system operating due to the presence of airframe ice that had accumulated during the descent.

Following the stall the aircraft initially rolled to the left, before rolling through wings level to the right due to residual ice on the airframe and inputs from the flight crew.

2.2 Non operation of de-icing boots by the flight crew

The Bureau of Meteorology report indicated that there was a likelihood of clear airframe ice during the flight. Analysis of the data from the flight recorder indicated that the OAT was -1°C at 5,700 ft at the beginning of the descent and gradually increased to 5°C momentarily during the descent, but decreased to 4°C for the duration of the descent and stall. The flight crew reported passing through cloud during their descent, which probably allowed the accretion of ice on the wings and airframe.

The company's operations manuals stated that icing conditions are deemed to exist whenever the outside ambient temperature is 5°C or less. Additionally, the manual warns that the windshield wiper may give a visual cue of icing, although airframe ice can be present without any build up on the wipers. The manual stated that ice on the wing will increase the stall speed.

The copilot commented that engine anti-ice was on, but not the airframe or propeller de-ice, which she stated was in accordance with operator's procedures for the prevailing temperature. The copilot went onto say that they checked the wings for ice, but none was visible, nor did she note any on the windshield wiper. The PIC commented during the initial interview with the ATSB, that he noted ice accretion on the windshield wiper after landing. The SOP on boot de-ice is quite explicit, in that it stated that flight crew should operate the boot de-icing system when ice has accumulated to approximately 10mm thick on the wing leading edge. However, the AOM advised flight crew to operate the boot de-ice system when ice has accumulated to about 6 mm thickness on the leading edges. Volume 2 of the AOM instructed flight crew to operate the boot de-ice system at the first sign of ice formation anywhere on the aircraft. The manufacturer analysis found that 0.5 inch (12.7mm) of ice had probably accumulated prior to the stall.

The chief pilot indicated that flight crew had access to the AFM, AOM and SOP. However, these documents gave conflicting instructions regarding the operation of the de-ice boots. The AOM advises that should there be a conflict between the AOM and the AFM, the AFM is to take precedence. The SOP also names the AFM as having precedence should a conflict arise between the manuals.

As the aircraft descended through clouds containing super cooled water droplets, ice built up on the airframe and wings. Had the wing de-ice boots been used during the descent, the accretion of ice on the wings should have been minimised allowing the aircraft's stall warning systems to operate as designed. This would have given the flight crew sufficient warning of the impending stall due to the decreasing airspeed and increasing angle of attack.

2.3 Non application of power at the MDA

The chief pilot indicated that a power setting of 50 per cent to 60 per cent would have been appropriate once the aircraft levelled off. Because the power levers are not auto-coupled to the autopilot, the flight crew were required to manually set the correct power. Because of the increasing angle of attack and consequently the decreasing airspeed as the autopilot captured the MDA, the flight crew should have taken immediate action to increase the power from about 17 per cent. However, the power levers were not advanced until the copilot checked the airspeed indicator and alerted the PIC. By not increasing power as the aircraft levelled at the MDA, the airspeed rapidly decreased due to the increasing drag from the increasing angle of attack and the airframe ice accretion This in turn resulted in the autopilot continuing to raise the nose to maintain the preselected altitude, which further increased the drag. The left wing stalled prior to the activation of the stall warning system, due to the presence of airframe ice.

The PIC commented, that in hindsight he should have increased power as the aircraft levelled off, but was unsure as to why power was not increased. He commented that he may have been distracted with the turn onto downwind. The SOP instructs the non-flying pilot to monitor the speed during approach. Just prior to the stall, both flight crew were probably looking outside attempting to sight the runway.

2.4 No stall warning prior to the stall

The manufacturer's analysis indicated that the roll upset occurred as a result of an aerodynamic stall over the left wing. That in turn resulted from probable airframe ice build-up, a reduced power setting and decreasing airspeed following an altitude capture by the autopilot after the descent, as part of the instrument approach. The stall occurred at an angle of attack, of 9.5 degrees, prior to stick shaker and stick pusher angle of attack limits (13.1 degrees and 19 degrees respectively) and consequently the autopilot did not disengage at the stall. According to the recorded data, the speed was about 115 KIAS when this angle of attack was reached.

The operations bulletin published by the manufacturer stated that a small amount of ice on the wing will reduce the lifting capability and increase the stall speed of the aircraft and lower the angle of attack at which the stall occurs. Although the copilot stated that the flight crew checked for the presence of ice on the wing, they did not see any. However, the Bureau of Meteorology stated in their report that clear ice was likely, given the prevailing environmental conditions. The manufacturer determined that icing was likely, but commented that they were unable to determine the amount of ice present on the wing. Therefore the investigation believes it is likely that there was clear ice present on each wing of the aircraft and this resulted in a lowering of the stall angle of attack and raising of the stall airspeed.

The AFM advised crews to use half-bank mode on the autopilot during flight in icing conditions. However, the SOP instructed crews to use full-bank mode during approaches. The use of half-bank mode by the crew during the incident would have increased the safety margin between the aircraft speed and the stall speed and allowed for the triggering of the stall warning system prior to the stall.

The instructions in the SOP for the use of the autopilot were vague, in that it was not clear whether the crew could use the autopilot in icing conditions, except during a climb. 'In icing conditions, FD/AP IAS mode is the only vertical mode to be used during climb when ice accumulation is observed or if it is not certain there is no ice accumulation on the aircraft.' The investigation could not find any other instructions for flight crew regarding the use of the autopilot in icing conditions.

The fitment of the Canadian ice-speed switch modification and providing it was turned on, probably would have resulted in the flight crew being alerted when the angle of attack exceeded approximately 3.7 degrees with 20 degrees of flap extended. According to the recorded data, the aircraft would have been decelerating through 120 kts when that occurred. The stall warning would have disconnected the autopilot, resulting in the cessation of the nose-up trimming of the elevators and, in turn, the cessation of the rapidly increasing angle of attack. Additionally the autopilot disconnect, followed by the stall aural warnings, would have alerted the flight crew to an impending stall. Although the increasing angle of attack and decreasing airspeed occurred relatively quickly, the lower stall warning threshold would have given the flight crew an extra 3-4 seconds to take corrective action.

Had the autopilot been turned off, the PIC, with the continuing need to trim the aircraft, would have realised that something was amiss.

Warnings and alerts are provided as safety backups in the event of humans making errors. The flight crew allowed the autopilot to capture the MDA and begin to trim the aircraft, even though they had not increased engine power to compensate for the increased drag as the aircraft levelled off and began the commanded turn to the right. However, the stall warning system would then have alerted the flight crew in a timely fashion to the impending stall. The flight crew had an expectation that the stall warning system would alert them to an impending stall.

The situation where it is possible for an aircraft to stall prior to a stall warning, indicates that procedures and/or technical safeguards, at the very least, need to be in place to prevent flight crews from being exposed to such a dangerous situation.

2.5 Stall identification and recovery

The PIC reported the serious incident to the operator as a 'wing drop' which can occur as a result of turbulence. The flight crew of LPI also initially reported their incident to air traffic control as encountering turbulence.

When the ATSB received a confidential report from a passenger on the flight and subsequently analysed the FDR data, the ATSB realised the extent of the roll upset and brought it to the attention of the operator. During the initial interview, the PIC indicated that the aircraft had encountered turbulence and that he was unaware of the extent of the upset. However, the PIC also noted a slight stick shake or shudder just prior to the stall. The copilot called speed at about this time. However, it appears that the crew did not observe any pre-stall buffet. The crews involved in other incidents, mentioned earlier in this report, also did not receive an overt pre-stall buffet. Some crews reported vibration, but assumed this to be ice accretion on the propeller. However, a passenger, who was an experienced pilot, reported pre-stall buffet prior to the aircraft stalling. Crews depend on the artificial stall warning system to alert them to an impending stall. However, the previous incidents and the manufacturer's analysis have shown that it is possible for the aircraft to stall in icing conditions, with little to no warning to crews.

The investigation of LPI found that the flight crew had difficulty assimilating information from the electronic display during their upset. However, this was not mentioned by the flight crew of OLM.

Recorded data from the FDR indicated that the PIC initially recovered the aircraft from the acute roll to the left. The manufacturer's analysis found that during the recovery from the initial stall, the copilot probably assisted the PIC to recover the aircraft. However, during the recovery the aircraft stalled again, rolling to the right due to a combination of high angle of attack, load factor and ice accumulation on the right wing. Controlled flight was recovered approximately 112 ft above the ground.

The operator of OLM indicated that a review of their records showed that after the LPI serious incident, training in unusual attitude recovery was carried out in the simulator for all company pilots including the PIC and copilot.

The PIC commented that he was aware of the stall warning system from his Saab endorsement training. In his experience, the stall warning system always worked. The copilot mentioned that there were no special stall recovery procedures for the Saab; the recovery procedure she used during the incident followed from early training.

However, the AOM described in detail the procedures to be followed by the flight crew in the event of a stall.

The investigation was unable to determine if the flight crew later realised the seriousness of the incident.

3 CONCLUSIONS

3.1 Findings

Aircraft

1. There were no known aircraft system malfunctions that would have contributed to the occurrence.
2. The aircraft was certified to operate in known icing conditions in accordance with JAR and FAR part 25 Appendix C.
3. Due to probable ice accretion on the wings, the aircraft entered an aerodynamic stall at a speed higher than that listed in the AFM. The actual stall speed due to roll rate and load factor was higher than the stall speed derived from icing certification flight testing.
4. The Saab 340 aircraft is capable of stalling with an ice deposit on the wings, without providing aircrew with any artificial warning of the impending stall.
5. The ice accretion on the wings was likely to have been a clear ice deposit, which may have been difficult for the flight crew to recognise at night, although they were provided with a visual cue via the windshield wiper.
6. There is a modified stall warning system fitted to Canadian registered Saab 340 aircraft and this different stall warning system (when activated) provides an increased warning margin to the stall, when operating in icing conditions.
7. The aircraft has only one autopilot mode that will provide protection against penetrating the stall margins.
8. In the period before the stall, the autopilot commanded an increasing nose-up pitch, which was automatically trimmed by the autopilot. The continuous trimming was not noticed by the flight crew.
9. The aircraft was not fitted with an audible trim warning to alert crews when the autopilot was trimming the aircraft, nor was this required by certification. The only visual indication to crews of trim movement is the movement of an index on the trim position indicator, which is not located in the flight crew's primary field of vision.
10. The Saab 340 aircraft is not fitted with an ice detection system; only an ice protection system. The optional system mentioned in the report is only applicable to engine operation.
11. The aircraft is capable of accreting ice on the airframe without visual cues being available to the flight crew.

Flight crew

12. The flight crew were correctly licensed and had current and valid medical certificates .
13. There were no medical factors that would have affected the flight crew's performance.
14. The flight crew had activated the engine ice protection systems, however they did not activate the wing de-ice system as they perceived that there was no ice present on the wings.

15. The flight crew were aware of the correct approach speed for the aircraft's weight, however, they allowed the aircraft to decelerate to a lower speed.
16. The flight crew were operating the aircraft using the autopilot at the time of the occurrence.
17. The flight crew were operating the autopilot in full-bank mode. The manufacturer does not recommend the use of this mode in icing conditions.
18. The flight crew reported the event as a turbulence encounter.
19. The flight crew did not notice a significant increase in pitch attitude or decrease in speed until just prior to the stall.
20. The flight crew recovered the aircraft approximately 112 ft above the ground.

Environmental

21. The environmental conditions in which the aircraft was operating were conducive to the formation of clear ice on the airframe as indicated by ice accretion on the windshield wiper.
22. The flight was operated in darkness, making visual identification of ice accumulation on the wings more difficult.

3.2 Significant factors

1. Although provided with visual cues (windshield wiper), the flight crew did not detect airframe or wing ice during the descent and therefore did not take measures to remove the ice.
2. The flight crew left the power setting unchanged at 17 per cent after levelling out when 50 per cent-60 per cent would have been appropriate given the aircraft configuration and environmental conditions.
3. The flight crew allowed the aircraft's speed to slow below a safe speed.
4. The stall warning system did not activate prior to the stall.
5. The aircraft was not fitted with the Canadian stall warning system modification. If this had been fitted and activated, it would have alerted the flight crew and provided them with between 3-4 seconds warning of the impending stall.
6. The SOP did not require activation of the de-ice boots in known icing conditions as per the manufacturer documentation.
7. The SOP allowed for the use of the autopilot during icing conditions which masked tactile cues regarding the increasing nose up attitude.

4 SAFETY ACTION

4.1 Recommendations

As a result of this investigation the Australian Transport Safety Bureau issues the following recommendations.

R20030179

The Australian Transport Safety Bureau recommends that Regional Express note the circumstances of the above incident where Saab 340 aircraft can stall without warning in icing conditions and alert their flight crew accordingly.

R20030180

The Australian Transport Safety Bureau recommends that Hazelton Airlines note the circumstances of the above incident where Saab 340 aircraft can stall without warning in icing conditions and alert their flight crew accordingly.

R20030181

The Australian Transport Safety Bureau recommends that Macair note the circumstances of the above incident where Saab 340 aircraft can stall without warning in icing conditions and alert their flight crew accordingly.

R20030182

The Australian Transport Safety Bureau recommends that the Civil Aviation Safety Authority examine the circumstances surrounding this incident where Saab 340 aircraft can stall without warning in icing conditions and take appropriate action to ensure the safety of the Saab 340 fleet operating within Australia.

R20030183

The Australian Transport Safety Bureau recommends that, as a matter of priority, Saab Aircraft AB modify the stall warning system of the worldwide fleet of Saab 340 aircraft to give sufficient warning of an impending stall to crews during flight in icing conditions.

4.2 Local safety actions

Prior to the occurrence, the operator had drafted the new section in the SOP titled “Cold Weather Operations” which contained an expanded section on operations in icing conditions and recovery from a roll upset. Following the incident, the operator reviewed the section to check that issues arising from the Bathurst incident were covered.

Additionally, formal training in stall recovery, unusual attitude recovery and minimum manoeuvring speeds for circling approaches was included in the next simulator cyclic training program for pilots in the company. This also coincided with the complete changeover to category C approaches, with the resultant increased safety margin with respect to higher circling speeds.

The operator also advised the ATSB that the cyclic simulator sessions now include operations in icing conditions as a formal study item for all pilots. Additionally the inconsistencies between the AFM, AOM and the SOP have been rectified with the revised SOP.

Note: Since the incident, the operators of OLM and LPI are merging to form a new company, but at the time of this report, were still operating under separate air operator certificates. As part of the merger, operating procedures from both companies are being reviewed and combined into a common set of procedures.

The Civil Aviation Safety Authority wrote to the ATSB and requested that the following comments be included.

The crew failed to recognise the sudden loss of height and significant roll as a stall event. Consequently, the crew did not report the incident in a timely manner nor inform the operator of the seriousness of the incident.

This resulted in the aircraft continuing normal scheduled operations when a through inspection of the aircraft should have been conducted before further flight.

The operator should ensure that crews are aware of their obligation to report any incident, and provide sufficient detailed information for a considered evaluation of appropriate actions to be taken.

Inflight Loss of Control due to Airframe Icing
SAAB 340B,VH-OLM, 28 June 2002

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