



AAIB
Air Accidents Investigation Branch

AAIB Bulletin

9/2015

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None

ROTORCRAFT

None

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None

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None

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AAIB Special Bulletins / Interim Reports

AAIB Special Bulletins and Interim Reports

This section contains Special Bulletins and Interim Reports that have been published since the last AAIB monthly bulletin.

AAIB Bulletin S2/2015

SPECIAL

ACCIDENT

Aircraft Type and Registration:	Embraer EMB-505 Phenom 300, HZ-IBN	
No & Type of Engines:	2 x Pratt & Whitney Canada PW535E turbofans	
Year of Manufacture:	2010 (Serial no: 50500040)	
Location:	Blackbushe Airport, Hampshire	
Date & Time (UTC):	31 July 2015 at 1408 hrs	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 3
Injuries:	Crew - 1 (Fatal)	Passengers - 3 (Fatal)
Nature of Damage:	Aircraft destroyed	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	57 years	
Flying experience:	11,000 hours (of which 1,180 were on type) Last 90 days - 23 hours Last 28 days - 5 hours	
Information Source:	AAIB Field Investigation	

The investigation

The AAIB was notified of the accident at 1415 hrs UTC on Friday 31 July 2015 and immediately initiated a Field Investigation. This Special Bulletin is published to provide preliminary information gathered from ground inspection, the Combined Voice and Flight Data Recorder (CVFDR), and other sources.

This Special Bulletin contains facts which have been determined up to the time of issue. It is published to inform the aviation industry and the public of the general circumstances of accidents and serious incidents and should be regarded as tentative and subject to alteration or correction if additional evidence becomes available.

Preliminary information

The aircraft (Figure 1) was on a private IFR flight from Milan, Italy, to Blackbushe, with the commander and three passengers on board. Following descent from its cruise level, it was handed over from controllers at London Control to Farnborough Approach. They provided a radar service to the aircraft, before instructing the pilot to contact Blackbushe Information, a few miles prior to its entry into the Blackbushe Aerodrome Traffic Zone. The weather at Blackbushe was fine with light and variable winds, visibility in excess of ten kilometres, and no low cloud.



Figure 1

HZ-IBN on approach to Runway 25 shortly before the accident
(photograph taken by Geoff Pierce)

HZ-IBN entered the left-hand circuit for Runway 25 via the crosswind leg. Towards the end of the downwind leg, it overtook a microlight aircraft, before climbing slightly to pass ahead of and above that aircraft. As this climb began, at approximately 1,000 ft above aerodrome level (aal), a TCAS 'descend' Resolution Advisory (RA) was presented to the pilot of HZ-IBN, to resolve a conflict with the microlight. The TCAS RA changed to 'maintain vertical speed' and then 'adjust vertical speed', but these instructions may have been to resolve a second conflict with another aircraft which was above HZ-IBN, to the east of the aerodrome. Following this climb, HZ-IBN then descended at up to 3,000 feet per minute towards the threshold of Runway 25. The aircraft's TCAS annunciated 'clear of conflict' when HZ-IBN was 1.1 nm from the runway threshold, at 1,200 ft aal at a speed of 146 KIAS, with the landing gear down and flap 3 selected.

The operator estimated that the landing weight was 6,522 kg. The aircraft manufacturer calculated that at this weight the target threshold speed was 108 KIAS.

The aircraft continued its approach at approximately 150 KIAS. Between 1,200 and 500 ft aal the rate of descent averaged approximately 3,000 fpm, and at 500 ft aal was 2,500 fpm. The aircraft's TAWS generated six 'pull up' warnings on final approach. The aircraft crossed the threshold of Runway 25 at approximately 50 ft aal at 150 KIAS.

Tyre marks made by the aircraft at touchdown indicated that it landed approximately 710 m beyond the Runway 25 threshold. Runway 25 has a declared Landing Distance Available (LDA) of 1,059 m; therefore the aircraft touched down approximately 349 m before the end of the declared LDA, 438 m before the end of the paved runway surface.

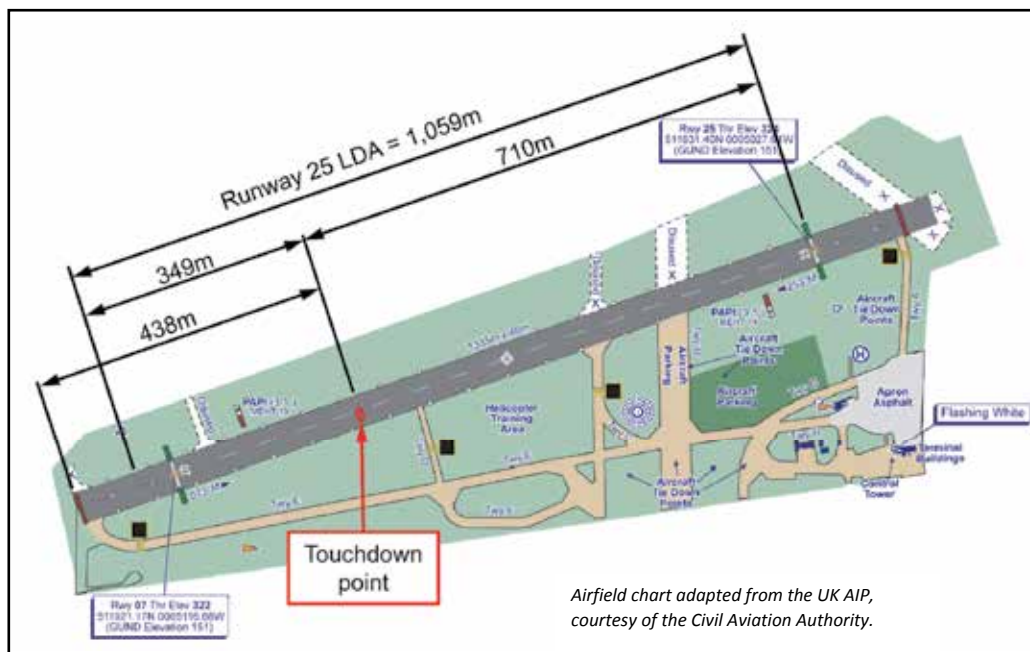


Figure 2

Blackbushe aerodrome chart, showing LDA and approximate touchdown point

Data from the aircraft's CVFDR indicated that the groundspeed at touchdown was 135 kt and the airspeed was 134 KIAS. The aircraft manufacturer estimated that at this speed the landing ground roll required to stop the aircraft would be at least 616 m¹.

Accident site

The aircraft departed the paved surface at the end of Runway 25 approximately three metres to the left of the extended runway centreline. It then collided with a one metre high earth bank causing the lower section of the nose landing gear and the nose gear doors to detach. The aircraft became airborne again briefly, before colliding with several cars parked at an adjacent business and coming to rest approximately 70 metres beyond the earth bank. The aircraft's wing detached from the fuselage during the impact sequence

Footnote

¹ The manufacturer commented that its calculation was based on a maximum performance landing, as performed in flight tests.

and an intense fire developed shortly thereafter, consuming the majority of the aircraft. The aerodrome rescue and firefighting service attended the scene, followed by local emergency services. The four occupants were fatally injured.

Further investigation

The aircraft wreckage has been taken to the AAIB facility at Farnborough and the investigation continues with the assistance of representatives of the State of the Manufacturer and the State of the Operator of the aircraft. A final report will be published in due course.

Published 6 August 2015

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Summaries of Aircraft Accident Reports

This section contains summaries of
Aircraft Accident ('Formal') Reports
published since the last AAIB monthly bulletin.

The complete reports can be downloaded from
the AAIB website (www.aaib.gov.uk).

Aircraft Accident Report No: 2/2015

This report was published on 19 August 2015 and is available in full on the AAIB Website www.gov.uk

**Report on the serious incident to
Boeing B787-8, ET-AOP
London Heathrow Airport
on 12 July 2013**

Registered Owner and Operator:	Ethiopian Airlines
Aircraft Type:	Boeing B787-8
Nationality:	Ethiopia
Registration:	ET-AOP
Place of Accident:	London Heathrow Airport
Date and Time:	12 July 2013 at 1534 hrs

Introduction

On the afternoon of Friday 12 July 2013 the Air Accidents Investigation Branch (AAIB) was notified of a ground fire in a parked and unoccupied Boeing 787-8 on Stand 592 at London Heathrow Airport. The circumstances surrounding the occurrence did not fall within the definitions of an accident or serious incident as defined in ICAO Annex 13, however, the Chief Inspector, in exercise of his powers under the Civil Aviation (Investigation of Air Accidents and Incidents) Regulations 1996, initiated an investigation, treating the occurrence as a serious incident and invoking the protocols of ICAO Annex 13 with regard to the participation of other interested States. An investigation was commenced immediately and a team of AAIB Inspectors was deployed.

The AAIB were assisted in the investigation by Accredited Representatives from the National Transportation Safety Board (NTSB) (representing the State of Design and Manufacture), the Civil Aviation Authority of Ethiopia (representing the State of Registry and the Operator) and the Transportation Safety Board of Canada (representing a State of component manufacture), with technical advisors from the Federal Aviation Administration (FAA), the operator and the aircraft and component manufacturers.

Summary

The aircraft suffered extensive heat damage in the upper portion of the aircraft's rear fuselage, in an area coincident with the location of the Emergency Locator Transmitter (ELT). The absence of any other aircraft systems in this area containing stored energy capable of initiating a fire, together with evidence from forensic examination of the ELT, led the investigation to conclude that the fire originated within the ELT.

The ground fire on ET-AOP was initiated by the uncontrolled release of stored energy from the lithium-metal battery in the ELT. It was identified early in the investigation that ELT battery wires, crossed and trapped under the battery compartment cover-plate, probably created a short-circuit current path which could allow a rapid, uncontrolled discharge of the battery. Root Cause testing performed by the aircraft and ELT manufacturers confirmed this latent fault as the most likely cause of the ELT battery fire, most probably in combination with the early depletion of a single cell.

Neither the cell-level nor battery-level safety features prevented this single-cell failure, which propagated to adjacent cells, resulting in a cascading thermal runaway, rupture of the cells and consequent release of smoke, fire and flammable electrolyte.

The trapped battery wires compromised the environmental seal between the battery coverplate and the ELT, providing a path for flames and battery decomposition products to escape from the ELT. The flames directly impinged on the surrounding thermo-acoustic insulation blankets and on the composite aircraft structure in the immediate vicinity of the ELT. This elevated the temperature in the fuselage crown to the point where the resin in the composite material began to decompose, providing further fuel for the fire. As a result, a slow-burning fire became established in the fuselage crown and this fire continued to propagate from the ELT location, even after the energy from the battery thermal event was exhausted.

Fourteen Safety Recommendations have been made during the course of the investigation. In addition the ELT manufacturer carried out several safety actions and is redesigning the ELT unit taking into account the findings of this investigation. Boeing and the FAA have also undertaken safety actions.

The following causal factors were identified in the ground fire:

- a) A thermal runaway failure of the lithium manganese dioxide battery in the ELT resulted in the uncontrolled release of stored energy within the battery cells.
- b) The location and orientation of the ELT, and the compromised seal on the battery cover-plate, allowed the resulting hot gas, flames and battery decomposition products to impinge directly on the aircraft's composite fuselage structure, providing sufficient thermal energy to initiate a fire in the rear fuselage crown.
- c) The resin in the composite material provided fuel for the fire, allowing a slow-burning fire to become established in the fuselage crown, which continued to propagate from the ELT location even after the energy from the battery thermal runaway was exhausted.
- d) The Navigation Radio System safety assessment conducted in support of the ELT certification, did not identify any ELT battery failure modes which could represent a hazard to the aircraft, and therefore these failure modes were not mitigated in the ELT design or the B787 ELT installation.

The following factors most likely contributed to the thermal runaway of the ELT battery:

- a) The trapped ELT battery wires created a short-circuit condition, providing a current path for an unplanned discharge of the ELT battery.
- b) The ELT battery may have exhibited an unbalanced discharge response, resulting in the early depletion of a single cell which experienced a voltage reversal, leading to a thermal runaway failure.
- c) The Positive Temperature Coefficient (PTC) protective device in the battery did not provide the level of external short-circuit protection intended in the design.
- d) There was no evidence that the reset behaviour, and the implications of the variable switching point of the PTC, had been fully taken into account during the design of the ELT battery.
- e) The absence of cell segregation features in the battery or ELT design meant the single-cell thermal runaway failure was able to propagate rapidly to the remaining cells.

Findings

General

- 1) The fire in ET-AOP initiated while the aircraft was parked, unpowered and unoccupied.
- 2) The extent of the damage to the ELT and the absence of other systems in the vicinity of the ELT capable of providing an ignition source, identified the ELT as the source of the fire.

ELT battery failure

- 3) The ELT fire resulted from the uncontrolled release of the stored energy within the battery cells.
- 4) The battery failure most likely resulted from an external short-circuit, in combination with the early depletion of a single cell, leading to thermal runaway which propagated to adjacent cells.
- 5) The ELT battery failure did not result from external heating, mechanical damage or environmental conditions within the aircraft.
- 6) The external short-circuit was created by the battery wires being crossed and trapped under the ELT battery compartment coverplate, when the ELT battery was last accessed.
- 7) The trapped wires remained undetected until the incident.

- 8) The PTC protective device did not provide the level of external short-circuit protection intended in the battery design.
- 9) The trapped wires compromised the environmental seal of the battery cover-plate, allowing the escape of hot gas, flames and battery decomposition products.
- 10) The location and orientation of the ELT within the aircraft, and the compromised seal on the battery cover-plate, allowed the hot gas, flames and battery decomposition products to impinge directly on the composite fuselage structure, providing sufficient thermal energy to initiate a slow-burning fire in the rear fuselage crown.

Battery design

- 11) The range of temperatures across which the PTC is required to operate means that in certain conditions, the switching point of the PTC exceeds the rated maximum continuous discharge current for the battery.
- 12) The PTC reset behaviour was not well understood during the battery design.
- 13) The absence of cell segregation features in the battery or ELT design contributed to the severity of the incident, as the initial cell thermal runaway was able to propagate rapidly to the remaining cells.

Battery and ELT certification

- 14) The ELT battery held a valid TSO-C142 approval.
- 15) The guidance and requirements of RTCA DO-227, invoked by TSO-C142, were outdated and did not adequately take account of advances in lithium battery technology since the inception of DO227 in 1995.
- 16) The NRS system safety assessment, conducted in support of the B787 certification campaign, did not identify any battery failure modes which could represent a hazard to the aircraft, and as a result, the ELT battery was not identified as a potential ignition source.

Structural fire

- 17) The location of the fuselage insulation blankets in the region of the ELT allowed sufficient heat to be retained close to the skin to allow the fire to become self-sustaining.
- 18) The fire progressed outward from the location of the ELT, in the space between the insulation blankets and the fuselage skin, moving between frame bays, through the stringer cut-outs in the shear ties.

- 19) There was no evidence that a flash-over fire occurred, or was about to occur, nor that the rate of progression of the structural fire was increasing.
- 20) Structural loads modelling, based on the damage sustained during the ground fire, determined that the aircraft's ability to carry flight loads had been compromised.
- 21) Thermal modelling conducted to assess the likely effects of a similar fire occurring in-flight, predicted that the increased rate of convective cooling, from the external airflow and lower air temperatures, would substantially reduce the progression of such a fire.
- 22) Boeing's structural loads modelling, based on the predicted damage from the thermal modelling of an in-flight ELT fire, predicted that the fuselage would remain capable of carrying flight loads but might experience a depressurisation if the damage were extensive.

Fire detection and firefighting

- 23) The location of the ELT in the fuselage crown made it difficult for the Heathrow Airport RFFS to locate the source of the fire.
- 24) At the time of the incident, the published ARFF information for the B787 did not indicate the location of ELT battery and the Heathrow Airport RFFS were not aware that there was a lithium-metal battery above the ceiling panels that could be the source of the fire.
- 25) In the event of an in-flight ELT battery fire, detecting the fire and locating its source, would be challenging for cabin crew, due to the inaccessible location of the ELT in the cabin.
- 26) In the event of an in-flight ELT battery fire, fighting the ELT fire and any subsequent structural fire would be challenging for cabin crew, due to the inaccessible location of the ELT in the cabin.

Toxicity

- 27) It has not been possible to determine accurately the composition and quantity of the combustion products produced by the structural fire.

Aircraft certification aspects

- 28) At the time of the B787 certification the ELT battery was not identified as a possible ignition source close to the aircraft skin, so the composite flammability tests did not take this into account as a specific source of ignition.

Safety Recommendations

Safety Recommendation 2013-016 issued on 18 July 2013

Safety Recommendation 2013-016

It is recommended that the Federal Aviation Administration initiate action for making inert the Honeywell International RESCU 406AFN fixed Emergency Locator Transmitter system in Boeing 787 aircraft until appropriate airworthiness actions can be completed.

In response to Safety Recommendation 2013-016, the FAA issued Airworthiness Directive (AD) 2013-15-07 on 26 July 2013 requiring, within 10 days, either the removal, or inspection and corrective action as necessary, of Honeywell RESCU 406AFN ELTs installed on B787-8 aircraft¹.

Honeywell subsequently issued an Alert Service Bulletin (SB) instructing operators of all aircraft types equipped with specified RESCU 406AF / AFN ELTs, to perform an inspection of the ELT and its battery and to correct any anomalies. Embodiment of this SB was mandated by Transport Canada AD CF-2013-25 issued 15 Aug 2013 and FAAAD 2013-18-09 issued 18 September 2013.

This Safety Recommendation has been assessed by the AAIB as '*Adequate – Closed*'.

Safety Recommendation 2013-017 issued on 18 July 2013

Safety Recommendation 2013-017

It is recommended that the Federal Aviation Administration, in association with other regulatory authorities, conduct a safety review of installations of Lithium-powered Emergency Locator Transmitter systems in other aircraft types and, where appropriate, initiate airworthiness action.

In April 2014 the FAA provided the following response to the recommendation:

'The FAA is currently conducting a safety review of Lithiumpowered ELT systems with other regulatory authorities to identify any unsafe conditions in other aircraft types. The FAA expects to provide an update on the status of the safety review by March 31 2015.'

This Safety Recommendation has been assessed by the AAIB as '*Adequate – Closed*'.

Footnote

¹ On 26 July 2013 the European Aviation Safety Agency (EASA) issued AD 2013-0168, with the same intent.

Safety Recommendations 2014-020 to 2014-024

The following Safety Recommendations were issued on 18 June 2014.

Safety Recommendations 2014-020

It is recommended that the Federal Aviation Administration develop enhanced certification requirements for the use of lithium-metal batteries in aviation equipment, to take account of current industry knowledge on the design, operational characteristics and failure modes of lithium-metal batteries.

Safety Recommendation 2014-021

It is recommended that the Federal Aviation Administration require that electrical performance and design-abuse certification tests for lithium-metal batteries are conducted with the battery installed in the parent equipment, to take account of battery thermal performance.

Safety Recommendation 2014-022

It is recommended that the Federal Aviation Administration work with industry to determine the best methods to force a lithium-metal cell into thermal runaway and develop design-abuse testing that subjects a single cell within a lithium-metal battery to thermal runaway in order to demonstrate the worst possible effects during certification testing.

Safety Recommendation 2014-023

It is recommended that the Federal Aviation Administration require equipment manufacturers wishing to use lithium-metal batteries to demonstrate (using the design-abuse testing described in Safety Recommendation 2014-022) that the battery and equipment design mitigates all hazardous effects of propagation of a single-cell thermal runaway to other cells and the release of electrolyte, fire or explosive debris.

Safety Recommendation 2014-024

It is recommended that the Federal Aviation Administration review whether the Technical Standard Order (TSO) process is the most effective means for the certification of lithium-metal batteries installed in aircraft equipment, the actual performance of which can only be verified when demonstrated in the parent equipment and the aircraft installation.

As of June 2015, final response from the FAA is awaited for Safety Recommendations 2014-020 to 024, however in a letter dated 31 October 2014, the FAA provided the following interim comment in respect of Safety Recommendation 2014-022:

'We plan to request that the Radio Technical Commission for Aeronautics (RTCA) task Special Committee 225, 'Rechargeable Lithium Batteries and Battery Systems', to revise and update RTCA Document DO-227, 'Minimum Operational Performance Standards for Lithium Batteries', for non-rechargeable lithium metal batteries. The revision would include methods to force lithium metal cells into thermal runaway and develop design abuse testing that would subject a single cell within a lithium metal battery to thermal runaway conditions.

The tasking would include exploring the mitigation of the worst possible effects of this condition during certification testing. We plan to include evaluation criteria to ascertain pass/fail criteria under these conditions.'

In the same correspondence, the FAA provided the following interim comment in respect of Safety Recommendation 2014-024:

'We believe a Technical Standard order (TSO) is effective in approving the design and production of an article to meet the Minimum Performance Standards. A TSO alone is not sufficient for certification approval. In order to complete a certification of a lithium metal battery installed in aircraft equipment, an airworthiness regulation approval is required. The airworthiness regulation must be complied with during Type certification, and Supplemental Type certification (including their respective amendments).

I believe the FAA has effectively addressed Safety Recommendation [2014-024] and we do not plan any further action.'

Safety Recommendations 2015-014 to 2015-021

The following additional Safety Recommendations are made in this report:

Safety Recommendation 2015-014

It is recommended that the Federal Aviation Administration, in conjunction with the European Aviation Safety Agency and Transport Canada, conduct an assessment of the circuit protection offered by the existing Honeywell RESCU 406AF and 406AFN ELT battery, to determine whether the ELT/battery design incorporates an acceptable level of circuit protection to mitigate against external short-circuits and unbalanced discharge.

Safety Recommendation 2015-015

It is recommended that the Federal Aviation Administration, in conjunction with the European Aviation Safety Agency and Transport Canada, conduct a review of installed aircraft equipment on transport category aircraft powered by lithium-metal batteries, which have been approved under TSO-C142 /C142A or by equivalent means, to ensure that the design of such batteries incorporates an acceptable level of circuit protection to mitigate against known failure modes including, but not limited to, external short-circuits and unbalanced discharge.

Safety Recommendation 2015-016

It is recommended that the Federal Aviation Administration, in conjunction with the European Aviation Safety Agency and Transport Canada, require equipment manufacturers intending to use lithium-metal batteries in aircraft equipment to demonstrate that the battery design incorporates an acceptable level of circuit protection to mitigate against known failure modes including, but not limited to, external short-circuits and unbalanced discharge.

Safety Recommendation 2015-017

It is recommended that the Federal Aviation Administration, in conjunction with the European Aviation Safety Agency and Transport Canada, require equipment manufacturers, intending to use lithium-metal batteries in aircraft equipment, to quantify the heat produced by the battery over a range of discharge conditions and demonstrate that the battery and equipment design can adequately dissipate the heat produced.

Safety Recommendation 2015-018

It is recommended that the Federal Aviation Administration, in conjunction with the European Aviation Safety Agency and Transport Canada, require the manufacturers of lithium-metal batteries and manufacturers of aircraft equipment powered by lithium-metal batteries, to conduct battery-level and equipment-level 'failure mode and effects analyses' to identify failure modes and their effects.

Safety Recommendation 2015-019

It is recommended that the Federal Aviation Administration, in conjunction with the European Aviation Safety Agency and Transport Canada, review all previously-approved aircraft equipment powered by lithium-metal batteries to determine whether they comply with the intent of the '*Toxic Gas Venting Precautions*' described in TSO-C142/ TSOC142a Appendix 1.

Safety Recommendation 2015-020

It is recommended that the Federal Aviation Administration, in conjunction with the European Aviation Safety Agency and Transport Canada, review whether the '*Toxic Gas Venting Precautions*' described in TSO-C142/ TSO-C142a Appendix 1 should be applied to portable aircraft equipment powered by lithium-metal batteries.

Safety Recommendation 2015-021

It is recommended that the Boeing expedite the modelling of the B787 Environmental Control System, to examine the distribution of the ELT battery combustion products through the aircraft cabin, and demonstrate the results of this modelling to the Federal Aviation Administration.

AAIB Field Investigation Reports

A field investigation is an independent investigation in which AAIB investigators collect, record and analyse evidence.

The process may include, attending the scene of the accident or serious incident; interviewing witnesses; reviewing documents, procedures and practices; examining aircraft wreckage or components; and analysing recorded data.

The investigation, which can take a number of months to complete, will conclude with a published report.

SERIOUS INCIDENT

Aircraft Type and Registration:	Saab-Scania SF340B, G-LGNM	
No & Type of Engines:	2 General Electric CO GE CT7-9B turboprop engines	
Year of Manufacture:	1990 (Serial no: 340B-187)	
Date & Time (UTC):	3 October 2014 at 0930 hrs	
Location:	En route from Aberdeen to Sumburgh	
Type of Flight:	Commercial Air Transport (Passenger)	
Persons on Board:	Crew - 3	Passengers - 25
Injuries:	Crew - None	Passengers - None
Nature of Damage:	None	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	51 years	
Commander's Flying Experience:	9,168 hours (of which 6,283 were on type) Last 90 days - 87 hours Last 28 days - 37 hours	
Co-pilot's Flying Experience:	2,340 hours (of which 928 were on type) Last 90 days - 105 hours Last 28 days - 44 hours	
Information Source:	AAIB Field Investigation	

Synopsis

The aircraft's rate of climb deteriorated in icing conditions, while the aircraft was experiencing mountain wave effect during the latter part of a climb to FL130. Once level, the aircraft did not accelerate as expected and a descent was initiated, with the autopilot engaged using vertical speed mode. An unusual vibration was then experienced, followed by a stall warning system activation and the autopilot disengagement. The aircraft was recovered in a non-standard manner, a safe airspeed was achieved and the autopilot was re-engaged. Subsequently, a normal landing was made at the planned destination.

Unusual ice formation, seen on the wings, corroborated calculations by the manufacturer that the aircraft had encountered severe icing.

History of the flight

The aircraft was operating a scheduled passenger service from Aberdeen to Sumburgh. The crew, consisting of two pilots and one cabin crew member, reported for duty at 0440 hrs at Aberdeen and had already flown to and from Sumburgh, with passengers. During these flights, little cloud and no significant icing had been encountered.

On departure from Aberdeen at 0900 hrs, for the second flight to Sumburgh, there was a strong south-south-westerly airstream and severe mountain waves were forecast between FL40 and FL280. The takeoff weight was calculated to be 12,729 kg, 426 kg below the maximum certified weight, and the CG was in the normal operating range.

The planned cruising level was FL150 and ATC approved a climb to FL130. Close to FL65, the aircraft entered cloud and the crew switched on the engine anti-icing systems, together with the wing and stabiliser de-icing boots. Above FL110, the rate of climb reduced. A small amount of ice had formed around the windscreen wipers but the commander initially assessed that the reduced rate of climb was due to downdraughts caused by mountain wave effect.

Ice was seen to accrete on the propeller spinners, and propeller de-icing was selected to NORM when the OAT reached -5°C. No propeller vibration was apparent and no ice from the propellers was heard to strike the fuselage. The commander, who was PF, used the autopilot's vertical speed (VS) mode and reduced the IAS from more than 160 KIAS, the normal minimum speed for climbing in icing, to 145 KIAS, which was the appropriate V_{ERICING} speed¹ for use in exiting icing conditions. The half-bank mode and IAS (hold) mode were engaged and the aircraft continued to climb at 145 KIAS. The commander realised the aircraft was being affected by ice, as well as by mountain wave effect, but was confident that it was close to the cloud tops and would climb above the icing level.

The pilots later recalled that the indicated rate of climb varied from a maximum of about 800 ft/min to a slightly negative rate. Climb power was maintained and the propeller rpm were also kept at the normal setting of 1,230 rpm. The co-pilot later stated that he realised that the power and propeller rpm should have been increased when the speed was reduced below 160 KIAS, in accordance with standard operating procedures (SOPs), but he had not suggested this at the time². Approximately $\frac{3}{4}$ inch of ice could be seen on the windscreen wipers, while the de-icing boots on the wing appeared to clear any ice that formed on them.

The aircraft reached FL130 (OAT -7°C) at 0925 hrs but it only accelerated to 164 KIAS, rather than the expected 180 KIAS or greater. The commander's reaction was to climb the aircraft another 100 ft, then descend back to FL130 using VS mode. This was not a manoeuvre the commander had previously employed, but he had seen it used by another pilot. Before commencing it, he and the co-pilot had a brief discussion about what was intended. The commander thought that the angle of attack (AOA) and drag would reduce during descent and the aircraft would accelerate. Instead, during the short climb, the IAS reduced quickly towards 150 KIAS and did not increase in the descent.

On regaining FL130, the autopilot remained engaged and the active vertical mode was ALTS which is the altitude hold mode displayed when the aircraft is maintaining a

Footnote

¹ See *Procedures – Minimum IAS* later in this report.

² See *Crew comments – Reducing to minimum IAS* later in this report.

pre-selected altitude³. The pilots believed they were experiencing moderate icing and should descend to FL110 to increase airspeed. After ATC had approved the descent, the commander commented that the ice conditions were more than moderate and that the airframe was accumulating a lot of ice. FL110 was entered in the altitude pre-selector and the commander selected a rate of descent of 1,000 ft/min, using VS mode.

The commander noticed that, despite the selected rate of descent, the aircraft's pitch attitude remained high (around 5° nose-up) and he increased the selected rate to 2,500 ft/min. The airframe then started to vibrate and the commander said "FEEL THAT, THAT'S A STALL... I THINK... ICING STALL". (The co-pilot later likened the vibration to the sensation of driving a car over a cattle grid.) Approximately 10 seconds after the vibration started, at 09:28:49 hrs, the aural stall warning sounded for approximately one second, the stick shaker operated and the autopilot disengaged.

The commander took manual control and pitched the aircraft to 2° nose-down. He later reported that a little more force than usual had been required to lower the nose of the aircraft but it then responded normally as the speed increased to greater than 190 KIAS. The vibration ceased and the aircraft seemed to be in trim, without any pitch trim adjustment by the commander. The autopilot was re-engaged approximately 9 seconds after disconnection and, shortly afterwards, an elevator mis-trim annunciation was displayed on both Electronic Attitude Director Indicators (EADIs). It was acknowledged by the crew and cleared within a few seconds.

Thirty-five seconds after the stall warning, the ICE PROT caution illuminated on the Central Warning Panel (CWP), with an associated aural chime. This signified that a caution light relating to the ice protection system had come on and the co-pilot announced to the commander that the TIMER light on the Stabiliser and Wing De-Ice Panel had illuminated.

After levelling at FL110, the co-pilot followed the abnormal checklist procedure for 'TIMER light on' and selected ONE CYCLE⁴. This cleared both the CWP caution and the TIMER light. The flight was continued to its original destination, without climbing again, and without further incident.

Recorded information

The aircraft's flight data recorder (FDR) and cockpit voice recorder (CVR) were downloaded and analysed at the AAIB. The salient FDR data (see Figures 1 and 2) present an overview of the incident period.

Figure 2 starts at 09:28:00, with the aircraft descending to FL130 (from FL131), which it reached 11 seconds later. As the aircraft levelled off, the airspeed began to reduce to less than 150 KIAS, gradually at first and then more rapidly. Consequently, with the aircraft now in ALTS mode, the pitch attitude increased in order to maintain altitude.

Footnote

³ See *Flight guidance and autopilot vertical modes* later in this report.

⁴ See *Ice protection systems* later in this report.

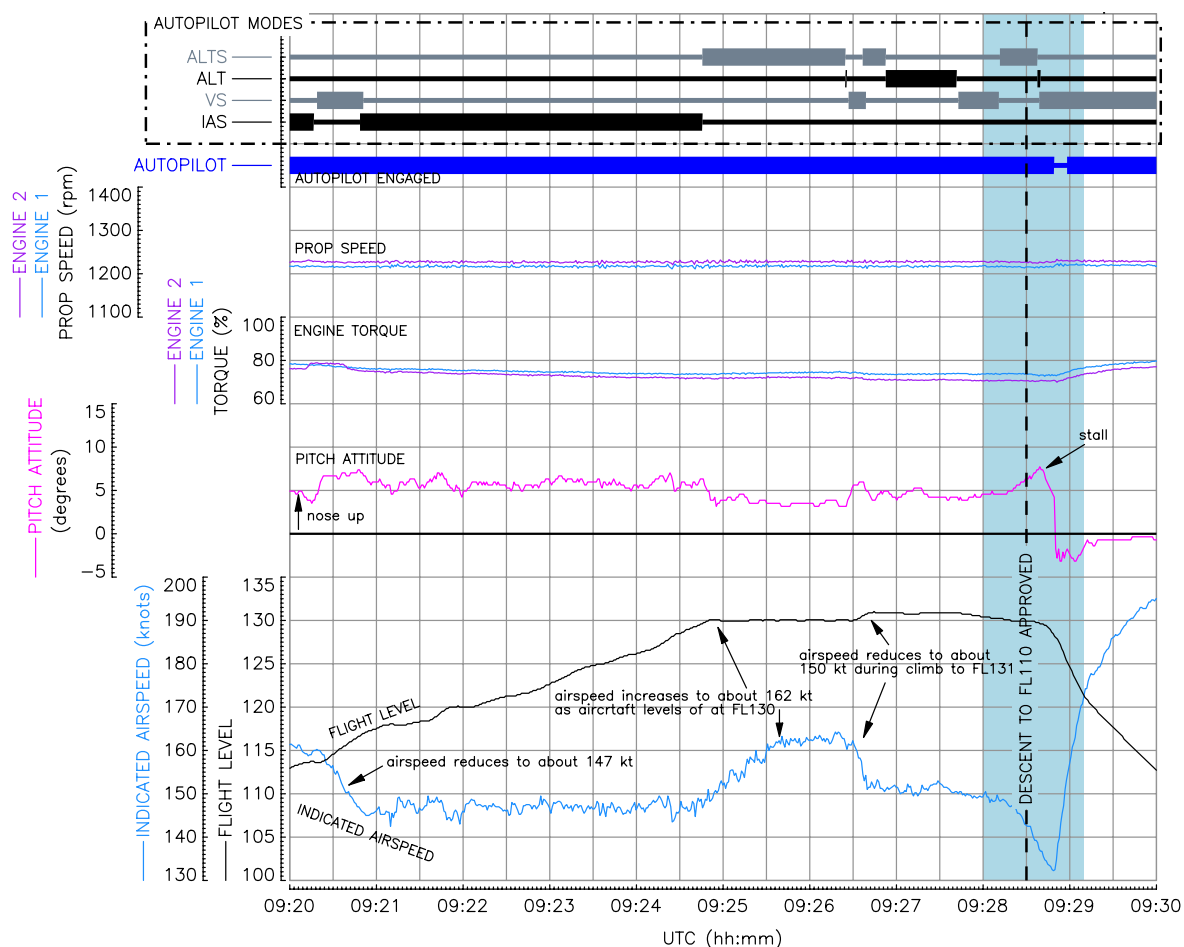


Figure 1
FDR data overview of event
(shaded area to the right is detailed in Figure 2)

At 09:28:26, the airspeed had slowed to 145 KIAS, reaching 140 KIAS 10 seconds later as the increasing angle of attack (AOA) exceeded 5.9° . The shaded blue area under the AOA curve illustrates the period when the AOA was 5.9° or more, when a stall warning would have occurred if the 'Ice Speed function' had been operative⁵.

The radio transmission to ATC, requesting descent, began at time 09:28:23 and approval for descent was given six seconds later. During this period the airspeed continued to reduce and the pitch attitude to increase. At 09:28:38, the autopilot mode changed to VS. About this time, the crew experienced vibration (buffet) and the AOA reached 8° .

When the buffet was first experienced, the pitch attitude, having peaked at between 7° and 8° nose-up, began to reduce steadily at a rate of $0.5^\circ/\text{s}$. However, the AOA continued to increase, as the aircraft started to descend and the airspeed decreased at a rate of 0.5 kt/s .

Footnote

⁵ See *Stall warning system* later in this report.

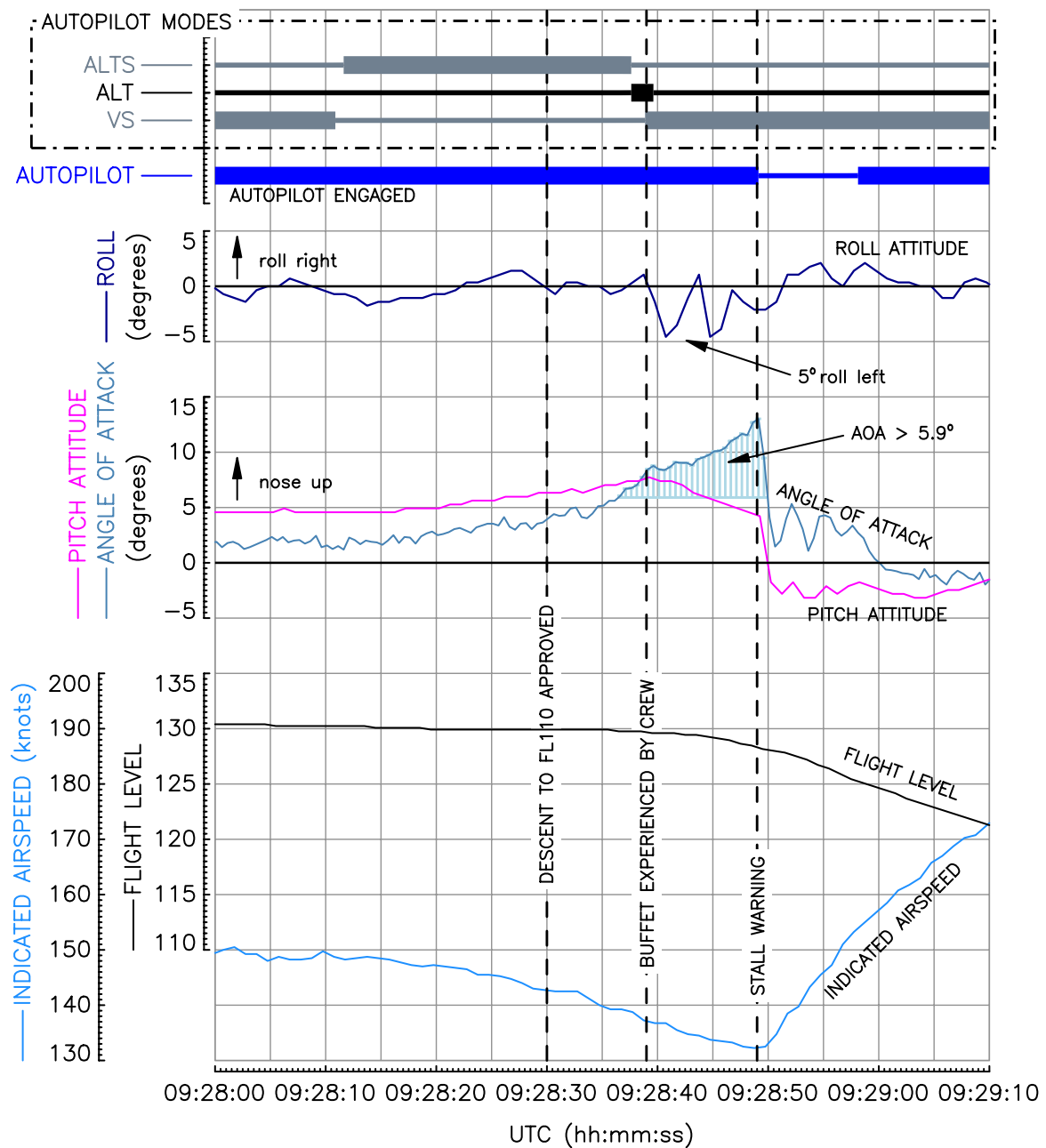


Figure 2
FDR data at the time of the event

The aircraft also rolled left, twice in quick succession, to 5° angle of bank (AOB). At 09:28:49, as the AOA reached 13° (with the pitch attitude at 4°), the stall warner sounded and the autopilot disengaged. The airspeed at this point was 132 KIAS. Subsequently, the AOA reduced, the airspeed increased and the autopilot was re-engaged.

Aircraft information

The Saab-Scania SF340B is a twin turboprop aircraft which can seat up to 36 passengers. It was certified in 1984 in compliance with Appendix C of Federal Aviation Regulation (FAR) and Joint Aviation Regulation (JAR) 25, with regard to icing conditions. The aircraft's stall characteristics in icing conditions were demonstrated during test flights, with simulated ice-shapes attached to the airframe to represent a build-up of ½ inch of ice on protected surfaces⁶ and 3 inches on unprotected surfaces. These tests showed that this amount of simulated ice increased the clean stall speed by 10%. Later, during certification tests to Canadian standards, a build-up of 1 inch of ice on protected surfaces was simulated. The manufacturer subsequently informed operators that, in this case, the stall speed could increase by 15 to 20 KIAS, compared to an increase of around 10 KIAS for the JAR-certified ½ inch shape.

Ice detection

G-LGNM was not fitted with an ice detector. The manufacturer's Aircraft Operations Manual (AOM) states:

'The windshield wiper arms give a visual cue of ice accumulation, although airframe ice can be present without any build-up on the wiper arms. Even though the wiper arms are the primary visual cue, accumulation of ice shall be monitored on all visible surfaces.'

A note in the manufacturer's Airplane Flight Manual (AFM) warned that ice can build-up on the aircraft without being visible.

Ice protection systems

The Saab 340B has systems to anti-ice the engines, de-ice the airframe and propellers, as well as systems to heat the windshields, pitot tubes, OAT probe and AOA sensors. Icing conditions are considered to exist for the engines and the airframe when the temperature is +5°C or colder and any visible moisture is present. Engine anti-icing is to be turned ON prior to entering icing conditions.

De-icing of the leading edges of the wings and stabiliser is achieved through the inflation and deflation of pneumatic boots, using engine bleed air. The associated controls and indicators are on the left side of the cockpit overhead-panel and this system is to be switched to CONT when entering icing conditions, without waiting for any visual signs of ice formation. In CONT mode, one complete cycle of the system takes place every third minute and involves inflating the boots on the horizontal and vertical stabiliser surfaces for 6 seconds, inflating the boots on the outboard wings for 6 seconds, inflating the boots on the inboard wings for 6 seconds and finally inflating the stabiliser boots again for 6 seconds. When pressurised engine air is not being fed to the boots, suction is applied to keep them deflated. Sensors monitor boot inflation and deflation and, if a fault is

Footnote

⁶ The leading edges of the wings and stabiliser have de-icing boots for protection, see *Ice protection systems*.

detected, a **TIMER** light on the overhead panel illuminates, together with an **ICE PROT** caption on the CWP. A single cycle of the boots can be initiated by manually selecting the system to **ONE CYCLE**, instead of **CONT** or **OFF**.

The propellers are electrically heated, with power applied to two blades, on opposite sides of the hub, at the same time. The control switch should be moved from **OFF** to **NORM** when ice accretion is observed on any part of the aircraft and the temperature is between -5°C and -12°C . This initiates a continuous cycle, with power on for 11 seconds and then off for 79 seconds. In temperatures below -12°C the switch should be moved to **MAX**, in order to cycle the power on for 90 seconds and then off for 90 seconds. The operator noted that, when the system is operated, there can be intense vibration through the airframe as each pair of blades sheds ice, in turn.

Stall warning system

The AOA sensors, on either side of the aircraft, feed data to two independent stall warning computers that alert pilots to an impending stall. There is no indication in the flight deck of the AOA but if an AOA of 12.1° is detected by either computer, when the flaps are up and the de-icing boots are turned on, a stick shaker will operate, together with a sharp, continuous aural warning. Also, the autopilot will simultaneously be disengaged (if engaged at the time). Should one computer sense an AOA greater than 18.6° then, provided the other computer senses an AOA of at least 12.1° , the stick push system will apply a force to the control column to achieve 4° of down-elevator. According to the AFM, 105 KIAS would be the stick push speed for a clean aircraft weighing 12,500 kg (the estimated weight of G-LGNM at the time it approached the stall).

A modification to the stall warning system introduces an '*Ice Speed Function*'. This is activated with either engine anti-ice switch set to **ON**, once the aircraft has been airborne for six minutes or more. A blue **ICE SPEED** push button on the instrument panel illuminates when the system is active and the AOA at which the stall warning (stick shaker) will operate is reduced from 12.1° to 5.9° . Although G-LGNM had this modification incorporated, permission to use the system on Saab 340s had been temporarily withdrawn by EASA⁷. The reason for the modification is that a wing will tend to stall at a lower AOA, and therefore at a higher IAS, when it is contaminated. The AOA of the stick pusher was not changed by the modification. No tables were provided for the stall speed in JAR-certified icing conditions but, applying the likely 10% increase in IAS from flight trials, the stall speed of an aircraft weighing 12,500 kg would be 115.5 KIAS.

Elevator trim

Elevator trim is commanded using the **MAIN** trim switches on the pilots' control wheels, or the **STDBY** trim switch on the centre console if there is a failure of the main system. Trim commands are added in parallel to the control column commands for manual flight.

Footnote

⁷ After this incident EASA approved an updated modification and all the operator's aircraft were expected to have the system operational by August 2015.

When the autopilot is engaged, the system uses an auto-trim function to maintain a trimmed flight position. The auto-trim monitors torque on the control servo motor and makes trim corrections to relieve high torque forces. An elevator mis-trim annunciator shows on the EADIs when the torque forces exceed a preset threshold. If the autopilot is engaged when the aircraft is out-of-trim, the torque threshold may be reached and the annunciator may show until the auto-trim has operated to offload the servo. This can occur during normal flight conditions.

Flight guidance and autopilot vertical modes

When the aircraft captures and maintains a pre-selected altitude, the active vertical mode, as displayed on the PFD, becomes *ALTS*. Alternatively, at any time the *ALT* button is pressed, the aircraft will maintain its current altitude and *ALT* is displayed on the PFD. When *ALTS* is displayed and the altitude pre-selector is moved, the aircraft will continue to hold the current altitude but the displayed mode will change to *ALT* until a new vertical mode (such as *VS*) is engaged. There is no overspeed or under-speed protection when the vertical mode is *VS*, *ALT* or *ALTS*.

Propeller spinners

Both spinners on G-LGNM's propellers, in common with those on many of the operator's other aircraft, were painted with black rings (see Figure 3). The rings were not mentioned in any guidance material and the manufacturer stated that they had been incorporated on certain aircraft as part of a trial. The intention, which was not advised to operators, was that if ice was seen to accrete aft of this line it could indicate that the conditions were beyond the aircraft's certified limits ie a severe icing encounter. However, the manufacturer later determined that this was not an accurate cue for severe icing and was more conservative than the certified visual cue (see *Ice detection* section earlier in this report). The manufacturer has



Figure 3

Propeller spinner showing black-painted ring

stated that no guidance about the use of the black lines was ever provided to pilots and that spinners with black lines are interchangeable with those without lines.

Meteorological information

The crew's meteorological forecast indicated that a cold front, orientated north-east to south-west, would pass through the planned route around mid-morning and that either side of the front there would be broken or overcast altocumulus cloud, with a base of 8,000 ft and tops above 10,000 ft. The forecast warned of associated moderate icing and moderate turbulence in this cloud. Ahead of the front, the freezing level was estimated to be at 9,000 ft and at least 3,000 ft lower behind the front. Mountain waves, with a maximum vertical speed of 900 ft/min at 9,000 ft, were forecast over a large area either side of the front. Turbulence in the mountain waves was forecast to be moderate or occasionally severe. A SIGMET⁸, valid between 0600 hrs and 1000 hrs, forecast that severe⁹ mountain waves could affect the area in which the aircraft would be flying between FL040 and FL280.

An aftercast from the Met Office estimated that the incident occurred in the air mass just ahead of the cold front, with a particularly moist layer above the freezing level which was at 9,000 - 9,500 ft. The best estimate for the wind velocity at FL130 was from 200° at 70 - 75 kt. It was calculated that downdraughts of 100 - 150 ft/min, caused by mountain wave effect, might have been encountered at FL130 in G-LGNM's position. The severe mountain waves mentioned in the forecast, and in the SIGMET, were confined to an area closer to the Grampian Mountains, to the southwest of G-LGNM's position.

It was calculated that the aircraft would have encountered a layer of altocumulus cloud layer about 7,500 ft in depth, with tops at FL150, and with conditions conducive to moderate or severe icing. The water droplets in the cloud at FL130 were likely to have been of mid to large size. A mid-size droplet has a diameter of 0.015 to 0.05 mm, while a large-size droplet has a diameter of 0.05 to 1 mm.

Moderate and severe icing

The accepted aeronautical terms for describing icing intensity are 'trace', 'light', 'moderate' and 'severe' but there is no internationally recognised definition of icing severity, as there is for turbulence or mountain waves. The UK Aeronautical Information Publication (AIP) states that, from a reporting perspective, moderate icing exists when the rate of accumulation is such that even short encounters are potentially hazardous and the use of de-icing/anti-icing equipment, or diversion, is necessary. In comparison, severe icing exists when the rate of accumulation is such that de-icing/anti-icing equipment fails to reduce or control the hazard and immediate diversion is necessary. The term 'diversion' in this context implies a diversion from the intended routing and not necessarily a diversion to an alternative airfield.

There are no absolute parameters used by the Met Office to forecast moderate or severe icing conditions. Forecasters are encouraged to consider a number of parameters together, including the type and extent of cloud, as well as its depth, temperature and relative

Footnote

⁸ SIGMET messages are issued by the Met Office when significant meteorological conditions are forecast.

⁹ ICAO Annex 3 defines severe mountain waves as those where downdraughts exceed 600 ft/min.

humidity. The forecasters are aware that severe icing can occur with short exposure to deep, convective clouds but that it may also occur with prolonged flight in stratiform cloud at temperatures just below 0°C. When preparing forecasts, they appreciate that aircraft of different shapes and speed accrete ice at differing rates.

Procedures

The operator's Operations Manual (OM), issued in accordance with EASA regulations, is split into several parts and is supplemented by various external publications. OM, Parts B1 and B2 summarise the procedures to be used for operation of aircraft but the manufacturer's AFM, AOM and the abnormal and emergency checklists are also contained in the OM. The operator states that the AFM and the AOM are to be treated as the definitive guides, unless specific instructions to the contrary appear in the Part B1 and Part B2 (collectively referred to hereafter as Part B).

Flight in icing conditions

OM Part B repeats much, but not all, of the guidance given in the AFM and the AOM concerning flight in icing conditions. The AOM includes a Supplement that focusses on operations in cold weather and icing conditions but this is not comprehensive. Some of the guidance that relates to icing conditions is contained elsewhere within the AFM and the AOM.

The first chapter of the AOM Supplement is titled '*Aspects of Operation in Icing Conditions*'. It states that the Saab 340 is certified for operation in icing conditions, in accordance with Appendix C of FAR/JAR 25. It also explains that this regulation specifies two criteria, an '*Intermittent Maximum Condition*' in cumuliform cloud and a '*Continuous Maximum Condition*' in stratiform cloud. This information is repeated in OM Part B. Both manuals state that '*Moderate icing conditions equals the Appendix C definition of intermittent or continuous icing*', while the Limitations Section of OM, Part B states additionally: '*The aeroplane is approved for icing conditions forecast to be not greater than moderate*'.

OM, Part B and the AOM both include a graph of liquid water content against droplet diameter, to illustrate that 50 microns¹⁰ is considered to be the maximum diameter of mean water droplets in intermittent conditions, reducing to 40 microns in continuous conditions. It is stated that larger droplets are commonly called Supercooled Large Droplets (SLD) and that '*such conditions are often called freezing rain and freezing drizzle*'.

A later section in the first chapter of the AOM Supplement is titled '*SLD detection*'. It states:

'Substantial ice build-up on the spinner further aft than normally observed might be an indication of freezing rain / drizzle. If observed, increase scanning of the wing leading edge and if accumulation of ice on the upper surface aft of the protected surface is observed, exit these conditions immediately to avoid

Footnote

¹⁰ Under Met Officer categorisation, a droplet measuring 50 microns (0.05 mm), is a large-size droplet.

extended exposure. If the autopilot is engaged, hold the control wheel firmly and disengage the autopilot. Keep the autopilot disengaged until the upper wing surface is free from ice. If an unusual roll response or uncommanded roll control movement is observed, reduce the angle of attack.'

Diagrams indicate how ice spreading back on the spinner towards the propeller blade roots could indicate the possible presence of SLD. No mention is made of the black-painted rings on the spinner.

In addition to the instruction to disengage the autopilot, should ice be seen on the un-protected upper surface of the wings, the AOM includes an instruction to disengage the autopilot if there is a significant performance loss in icing conditions. This instruction is not repeated in OM, Part B.

The OM makes few references to severe icing and this condition is only mentioned twice by the manufacturer's manuals, in relation to the de-ice boots and to propeller rpm. The de-ice boots may have to be operated manually in severe icing, between automatic cycles, to minimise ice accumulation. While use of maximum propeller rpm is to be considered if severe icing conditions are '*experienced or expected*'. Increasing the propeller rpm helps to shed ice from the blades.

Minimum IAS

The OM states that in icing conditions, for '*climb above MSA, cruise, descent, holding and approach*', the minimum IAS is V_{CM} (the conservative manoeuvring speed). A table provides the V_{CM} appropriate to each flap setting. With flaps set to zero, the V_{CM} is 160 KIAS and this increases by 10 KIAS for each 10° of bank above a bank angle of 30°. As a proviso, the OM states that a lower speed, known as $V_{CLEAN+15}$ (referred to as $V_{ERICING}$ by the operator), may be used for a flaps 0 climb to exit icing conditions, when above MSA.

V_{CLEAN} is the speed quoted by the manufacturer for the final stage of a single-engine climb or for drift-down. It provides a margin of at least 1.25 to the stall speed, up to 15° angle of bank. By adding 15 KIAS, this speed becomes $V_{CLEAN+15}$ or $V_{CLEAN-ICE}$, the '*Enroute Climb Speed – with residual airframe and propeller ice*'. This gives a margin of 1.4 to the clean stall speed, with a maximum of 15° angle of bank. Crews use reference cards to check the relevant speed for a specific aircraft weight and configuration. The OM states that this speed offers optimum climb performance and '*gives the required margin to stall with ice on the wings for straight flight*'. It also indicates that use of this speed allows the aircraft to climb through a layer of ice clouds in the shortest distance. At this speed, half bank mode is recommended to improve the margin to the stall.

Power setting

The OM notes that, in icing conditions, engine performance should be carefully monitored to ensure proper climb performance. Both OM, Part B and the AOM state:

'If experiencing extreme icing conditions and safe speed and/or climb rate can not be maintained, do not hesitate to temporarily set TAKEOFF PWR/ MAX CONTINUOUS PWR, if that is required to escape from the situation. Extreme icing conditions do not necessarily imply a large amount of ice but ice accumulation causing a large impact on performance making airspeed decrease towards the minimum safe speed in icing conditions.'

No other explanation or definition is provided for the term 'extreme icing.'

Setting of normal climb power is carried out in accordance with torque setting charts, using 1,230 propeller rpm. Charts carried on the aircraft show that, at FL130, the climb power appropriate for G-LGNM, at 140 KIAS and a temperature of -7°C, was 73% torque. It is noted that for each 40 KIAS increase in speed, the indicated torque would increase by 1%. The torque figures recorded on G-LGNM at the top of climb were: 74% for the left engine and 72% for the right engine. Throughout the latter stages of the aircraft's climb, its level off and the subsequent descent, the torque figures remained between 70 and 80%, the variation being a function of altitude and airspeed changes (torque reducing with increasing altitude and reducing airspeed).

The AOM states that Maximum Continuous Power (MCP) is available for two engine operation '*in extreme icing conditions*' and is not intended for use during '*normal icing conditions*'. OM, Part B substitutes the phrase '*extreme icing conditions*' with '*severe icing conditions*' and notes that MCP, with a propeller rpm of 1,384, may be used to ensure safe obstacle clearance or maintain a safe flying speed. The charts show that MCP for 150 KIAS, at FL130 and -7°C, is 77% torque, with 1,384 propeller rpm. Therefore, use of MCP, with 1,384 propeller rpm, would have increased G-LGNM's power by approximately 18% at FL130.

Stalling

Guidance in the OM states:

'With ice on the wing stall might be encountered before, or at, stick pusher activation. In some adverse cases stall may even be encountered before the artificial stall warning is activated.'

Natural stall warning in the form of buffeting, caused by partial separation over the wing may be experienced at a speed of up to 25% above the ice free stall speed.'

This might however be mistaken/hidden by the "vibration" caused by the uneven shedding of ice from the propellers.'

Should unusual vibrations be experienced, the Emergency Checklist states:

'If in any doubt whether it is a natural pre-stall warning in the form of buffeting, or an unusual vibration, always perform stall recovery.'

The stall recovery procedure is included in the AOM, in the chapter entitled '*Flight Procedures, Training*.' Here, alongside guidance and hints for instructors, is a list of the recovery procedures for recovery from a stall warning (stick shaker or natural buffeting) or from a stall. The PF is instructed to call "STALL - MAX POWER", immediately decrease the pitch by about 5° (to trade altitude for airspeed), press the autopilot disconnect and simultaneously use all power available, even at high altitude. A note states:

'In a real situation with an iced up aircraft stall warning can be in the form of buffeting and the same stall recovery procedure shall be carried out. This cannot be simulated in a simulator as ice buildup is not accompanied by buffet in the simulator.'

The AOM states that stall onset is recognised by light buffeting just prior to the stall, followed by a nose-down movement and a possible roll to the left or right, which cannot be controlled until the AOA is reduced. An iced-up aircraft may roll past 90° and the nose may drop '*excessively*'.

Winter operations brief

The operator issues a Notice to Aircrew (NOTAC) to promulgate changes to the OM or to remind crew about specific procedures. NOTACs have a limited validity period before they have to be re-issued or incorporated in the OM. Prior to this incident, the operator circulated a NOTAC each autumn to remind pilots about important aspects relating to flight in icing conditions. NOTAC 66/13, '*Winter Operations Brief (Revised), Winter 2013 -2014*', had expired five months before the incident but both pilots said they were familiar with its content. The NOTAC drew together various procedures from different parts of the OM and offered some guidance that was not covered by the AFM, the AOM or the Part B.

Specifically, the NOTAC associated the setting of MCP with an election by the pilots to reduce speed to $V_{\text{CLEAN}+15}$ in icing conditions. It stated that, if an adequate rate of climb could not be achieved at 160 KIAS, the pilots should assess if the best course of action was to continue climb or to initiate descent, to escape icing conditions. If the climb was continued, the initial recommended actions were to move the condition levers to the MAX position, set MCP according to the appropriate chart, select half bank and climb straight ahead at a speed not below $V_{\text{CLEAN}+15}$.

In cruise flight, there was a recommendation to exit icing conditions if 180 KIAS could not be maintained and a statement that a minimum of 160 KIAS should be maintained at all times after the top of climb. In a reference to the detection of SLD, the notice stated, '*Typically these large droplets (SLD) give a thin layer which covers a large area and can lead to Severe Icing*'.

One section of the NOTAC was devoted to icing-induced stalls. It pointed out that these have occurred on several occasions to Saab 340s being operated at less than 160 KIAS. The following points were noted:

- *Loss of performance (reducing airspeed, increasing nose up attitude, poor rate of climb) in icing conditions may be indicative of serious airframe icing, even if it is not observable*
- *Build up of ice can cause aircraft to stall at speeds 30% above normal stall speed¹¹*
- *The stall warning/protection system may not activate due to the higher stall speed. A light buffet may be an early indication of impending stall*
- *There may be little or no pitch change in an icing induced stall, first indication may be a roll which oscillates from side to side with increasing severity*
- *If corrective action is not taken at an early stage the aircraft may enter an extreme rate of descent situation*
- *If the crew suspect an icing induced stall has developed, or is developing then recovery action should be taken immediately as follows:*

Disconnect autopilot

Lower nose approximately 5 degrees

Apply maximum climb power

Minimum speed should be 1.4 x Vs (Ver icing), preferably Vcm

Beware of pulling up too quickly following recovery to prevent secondary stall

- *Stall recovery from an icing induced stall is not about losing the minimum amount of altitude, it is about ensuring the aircraft recovers from the stall, altitude may have to be traded for airspeed.'*

Training

Operator training for icing conditions

The operator's syllabus for type rating training encompasses aircraft operation in icing conditions. Winter operations training is also provided to pilots and a presentation is given during annual classroom training, which, in recent years, has included a video about flight in icing conditions, either one produced by NASA or one from the manufacturer. Pilots are also expected to refer to the '*Winter Operations Brief*' NOTAC each autumn, in preparation for flight in icing conditions during winter.

Simulator training

Icing conditions had been incorporated into recurrent simulator training details for both pilots. However, the operator reported that it had not previously been possible to simulate severe icing or the pre-stall buffet.

Footnote

¹¹ The figure of 30% appears to have been taken from the manufacturer's ice awareness video. This mentions that as a general rule, minimum speeds should be increased by about 30% to allow for ice accumulation.

Stall awareness and stall recovery were covered during type rating training and testing. Thereafter, stall training was one of a number of abnormal and emergency items that were regularly included in recurrent simulator details. The commander and the co-pilot had received stall training about one year before the incident. Their last simulator checks took place one month and two months, respectively, before the incident.

Crew comments

The commander was a line training captain with around 10 years' experience flying the Saab 340. He stated that his duty on 3 October 2014 involved his third consecutive early report time but that he did not consider his performance was negatively affected. The co-pilot, who had been flying the Saab 340 for two years, stated that this was his first duty with an early report time, following days off. He said that, as a result, he had not achieved a full night's sleep and that, as often happened on his first early-start duty, he felt a little tired and perhaps not as alert as he would have liked. Both pilots were based at Aberdeen and were familiar with the Sumburgh route.

The OM was regarded by both pilots as their prime point of reference for Saab 340 operation. They had access to the AFM and the AOM but the electronic format, in which these manuals were presented, made them difficult to browse on a computer and search for specific text. They only tended to refer to these manuals if they could not find what they were looking for in OM, Part B.

Weather

As no significant icing was encountered on the first return flight to Sumburgh, the pilots were not expecting problems with icing on this sector. They regarded forecasts of icing conditions and mountain wave effect as routine for that area. Both of them thought that they had seen severe icing once or twice in the past but it had been a transient experience, when ice had built-up quickly rather than gradually. They knew severe icing was not always associated with the identification of freezing rain or drizzle but they only expected to encounter it in cumuliform clouds and they thought that on this occasion they were flying in stratus-type¹² cloud.

Ice detection

The pilots stated that they used the wiper arms, in conjunction with looking at the wings, to check for ice accretion. They said that ice did not show up well if it was behind the boots on the wings or on the spinner because those areas had light-coloured paint. They observed that most of the aircraft they flew had a black line painted on the spinner. The co-pilot believed that if ice was observed aft of this line then the propeller heating should be turned on. The commander believed that if ice accreted aft of this line it indicated severe icing. He could not recollect seeing any undue ice accretion while they were climbing. The co-pilot recalled that he saw ice about two thirds of the way back towards the black line on the spinner when they turned on the propeller de-icing, between FL110 and FL120. Neither

Footnote

¹² The cloud they were flying in was altocumulus, see *Meteorological information*.

of the pilots were aware of any vibration from ice being shed by the propellers, or any noise from ice hitting the fuselage, when the de-icing was activated.

Once the aircraft levelled off, the pilots believed there was about $\frac{3}{4}$ inch of ice on the wipers. Later, after descending, the co-pilot deduced that the bottom part of the windshield may have iced-up without him noticing because it blended with the white backdrop formed by the cloud outside. When this ice melted, he estimated there was 1 - 2 inches of ice on the underside of the wipers. The co-pilot also reported that, about the time the airframe vibration began, he had observed a ridge of ice about $\frac{1}{2}$ inch high on the de-ice boots, to the rear of the area that inflated. He did not bring this to the commander's attention because they had already requested descent. Neither he nor the commander saw more than $\frac{1}{4}$ inch of ice elsewhere on the boots at any time, nor could they see any ice behind the boots. The commander reported that after they had descended he saw a broken ridge of ragged ice about $\frac{3}{4}$ of an inch high along the rear edge of the boots. At this time there seemed to be ice on the spinner about three quarters of the way back towards the black line. Neither pilot saw ice aft of the black line at any stage.

Reducing to minimum IAS

When the commander reduced the airspeed to less than 160 KIAS in the climb, he did not think that this had to be accompanied by an increase in power to MCP. His understanding was that maximum propeller rpm was only appropriate to assist in the shedding of propeller ice, which he did not regard as an issue. The co-pilot was aware that the SOP was to increase power to MCP, if the speed was reduced below 160 KIAS due to icing. However, on two previous occasions he had flown with commanders who had not increased power to MCP in these circumstances. He did not advocate it on this occasion because this commander was a senior line-training captain who, in the recent past, had not been open to a suggestion the co-pilot had made, concerning an unrelated SOP.

Both pilots believed it acceptable to fly at less than 160 KIAS when level, with a minimum of $V_{\text{CLEAN}+15}$, provided they were trying to vacate icing conditions. However, they did not regard a speed of less than 160 KIAS as acceptable for cruise flight.

Stall warning and recovery

The decision to descend was made once it became apparent that, whilst level, the airspeed would not return to 160 KIAS. The co-pilot was not initially aware of the airspeed reducing below 145 KIAS, as he was busy obtaining ATC permission to descend and writing down the approved level. The commander recalled that his concentration was focussed on setting the new level into the autopilot controller and initiating a descent using VS mode. After he had commanded a 1,000 ft/min rate of descent, he noticed that the aircraft's pitch attitude still exceeded 5° , which was higher than he expected. He did not appreciate that the AOM included an instruction to disengage the autopilot if there was a significant loss of performance due to icing conditions.

In order to reduce the pitch, the commander adjusted the commanded vertical speed to 2,500 ft/min and it was while he was doing this that he started to feel the aircraft vibrate. He

did not recall identifying the vibration as pre-stall buffet but was aware of the need to increase the airspeed. He believed the descent, in commanded vertical speed, would achieve this by pitching the nose down. Eventually, as he reached for the controls to disengage the autopilot, because of the high nose attitude, the stall warning activated.

The co-pilot's recollection was that he had been looking out of the window when he experienced the unfamiliar vibration. It was high-frequency and more violent than the irregular propeller vibration he had experienced in the past, when ice was shedding. His recollection was that the aircraft also rolled slightly from side to side. When he looked back inside, he noticed that the airspeed had reduced to less than 145 KIAS. He was about to warn the commander when he saw him reaching for the controls.

The commander observed that, although, initially, more force than normal was needed to pitch down, he did not need to trim the aircraft and it felt in-trim when the autopilot was re-engaged. He was, therefore, surprised to see the elevator mis-trim annunciation.

Previous accidents and incidents

Flight in icing conditions, worse than those prescribed in certification standards, was studied in 1994. This followed a fatal accident investigation to an ATR-72 at Roselawn, Indiana, USA, which concluded that a ridge of ice accreted beyond the de-ice boots, leading to loss of control. This ice was attributed to the presence of SLD with a diameter larger than the 0.05 mm considered in Annex C to FAR/JAR 25.

On 2 January 2006, a Saab 340B (N306AE) stalled at 11,700 ft while climbing in icing conditions. The airspeed reduced during the climb and at 144 KIAS a roll anomaly was experienced. As was the case with G-LGNM, the autopilot arrested this slight rolling motion through a correcting aileron deflection. The crew saw little evidence of ice prior to the stall but they reported experiencing a heavy vibration. Recorded data showed that the IAS decayed quickly in the 10 seconds before a sharp wing-drop and departure from controlled flight at 130 KIAS. This led to descent through 4,000 ft before control was regained.

On 18 May 2011, a Saab 340A (LV-CEJ), at a similar weight to G-LGNM, crashed in Argentina, fatally injuring all 22 people on board¹³. Icing conditions prevented the aircraft from climbing to FL190 and MCP was not selected. To vacate the conditions, the aircraft descended to FL140 but the icing became severe and, in level flight, the AOA increased and IAS decayed. Pre-stall buffet commenced at 145 KIAS but this was mis-identified as propeller vibration and propeller rpm was set to MAX. The stall warning activated and the autopilot disengaged at 138 KIAS, 13 seconds after the onset of the buffet. The aircraft initially pitched 22° nose-down and rolled left to approximately 82° AOB. The stick pusher operated several times but the pilots did not regain control from the upset that occurred following the stall warning.

Footnote

¹³ See Argentinian Civil Aviation Accident Investigation Board (JIAAC) Technical Report 096/2011, published 11 March 2015.

Prior to 2006, there had been other stall events to Saab 340 aircraft, in icing conditions, and changes were made to the manufacturer's guidance. In some incidents, pre-stall buffet was not correctly identified and a sharp wing drop occurred, leading to unusual attitudes and significant loss of altitude.

Manufacturer's assessment of the data

The manufacturer compared the DFDR data from the G-LGNM incident with nominal performance data¹⁴ at seven points before and after the stall warning. It was calculated that, as the aircraft passed FL125 in the climb and also later, while at FL130, it experienced aerodynamic drag forces more than three times the datum level recorded during certification trials in simulated icing conditions. At the time of the stall warning, these drag forces had increased to almost four times the datum level. Once the aircraft had descended to FL110, they had reduced to twice the datum level.

After allowing for downdraughts of 300 ft/min, twice the strength of those calculated by the Met Office, the calculated drag forces were still greater than expected. The most likely reason for this was that the aircraft had accumulated severe icing. The manufacturer considered that the ice the pilots saw behind the inflatable area on the de-icing boots was also an indication of severe icing. The manufacturer noted the instruction in the AOM to exit the conditions immediately and disengage the autopilot, if ice accumulated '*aft of the protected surface*'.

Calculations by the manufacturer indicated that if MCP had been applied when IAS was first reduced to 145 KIAS, the aircraft would have been capable of continued climb to FL170, to vacate the icing conditions. Alternatively, an increase to MCP, after levelling at FL130, would have ensured that the IAS remained above 160 KIAS for a considerable period, despite the conditions.

The manufacturer analysed the aircraft's response to the VS command input prior to the stall warning. The conclusion was that the autopilot system responded normally and gradually increased the rate of descent to achieve a smooth transition from level flight. Flight trials confirmed that it could take between 10 and 15 seconds, from initiation of a descent using VS mode, to achieve a steady rate of 1,000 ft/min. During this incident, the stall warning activated 11 seconds after VS mode was engaged.

A diagram (Figure 4) produced by the manufacturer indicates why an aircraft's AOA can be much greater than its pitch angle, when descending.

Footnote

¹⁴ The manufacturer's nominal data had been validated through flight test calibration.

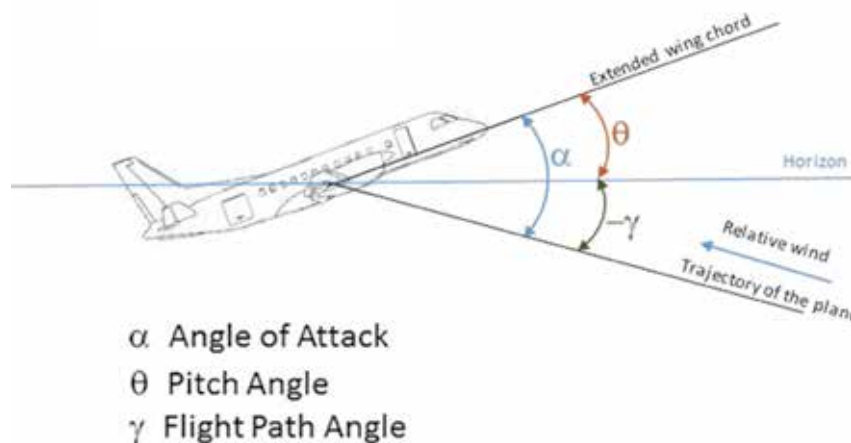


Figure 4

Manufacturer's illustration of AOA greater than pitch angle in descent

Operator's review of the event

A report by the operator stated that many of its pilots regarded an IAS of $V_{\text{CLEAN}+15}$ as acceptable to vacate icing conditions in straight and level flight. This was attributed to lack of clarity in the OM. The operator also noted that its pilots did not recognise the need to set MCP in a low speed situation when straight and level.

Consideration was given to the way in which stall recovery had been taught in the simulator. The operator identified that it had been usual to initiate recovery from idle power. In this incident, the aircraft already had a relatively high power setting and the commander believed that a pitch reduction alone was appropriate. The operator concluded that clarification was needed about the manner in which maximum power should be achieved during stall recovery.

The review also noted that many of the operator's pilots perceived that the aircraft would achieve a commanded rate of descent using VS mode more quickly than it actually does (see *Manufacturer's assessment*).

Analysis

Mountain wave

The critical portion of the flight took place in altocumulus cloud, downwind of a mountain range and near a cold front. Moderate icing and severe mountain waves, with downdraughts of up to 900 ft/min, were forecast but subsequent Met Office analysis suggested that the downdraughts experienced in G-LGNM's position should not have exceeded 150 ft/min. The pilots reported that the VSI showed large variations in the rate of climb, which could have indicated the presence of updraughts or downdraughts exceeding 150 ft/min. However, with IAS mode engaged during the latter part of the climb, any tendency for the airspeed to increase or decrease would also have caused an attitude change that would have affected the VSI reading. Hence, the observed variations in the rate of climb were not directly representative of the rate of updraughts or downdraughts.

Severe icing conditions

The conditions at FL130 were capable of supporting SLD greater than 0.05 mm (50 microns) in diameter which can lead to the formation of severe icing. Analysis by the manufacturer concluded that the aircraft was affected by a large increase in aerodynamic drag. This could have been due to ice or downdraughts or a combination of the two. Even if the downdraughts had been twice as great as the Met Office calculated, the increase in aerodynamic drag indicated that the aircraft had probably encountered severe icing conditions.

The manufacturer also noted that the ice ridges, which the pilots saw behind the inflatable area of the de-icing boots, corroborated the presence of severe icing. The co-pilot observed this about the time the airframe vibration began, but he did not discuss it with the commander because they were in the process of descending, to vacate the icing conditions. Also, the OM did not state that this was an indication of severe icing.

The lines painted on the aircraft's spinners caused confusion. The manufacturer had painted them as a trial but there was no written information about them and both pilots had a different understanding of their significance.

The evidence suggested that severe icing conditions were encountered by G-LGNM by the time it passed FL125, in the climb, and that it remained in severe icing after levelling.

Procedures

The OM states that MCP should be used if ice accumulation due to '*extreme icing conditions*' causes a '*large impact on performance*' and the IAS decreases towards the minimum safe speed. The OM, as extant at the time of the incident, also stated that a speed reduction to $V_{\text{CLEAN}+15}$ may be used for flaps 0 climb to exit icing conditions, when above MSA. However, it did not link this to an increase in power to MCP and the setting of maximum propeller rpm. Nevertheless, the pilots were familiar with NOTAC 66/13, which recommended that, if the climb were continued, the initial actions should be to move the condition levers to the MAX position, set MCP according to the appropriate chart, select half bank and climb straight ahead at a speed not below $V_{\text{CLEAN}+15}$.

The commander did not set MCP when reducing the IAS below V_{CM} because he thought that downdraughts were primarily responsible for the reduction in the rate of climb, not icing. Furthermore, he believed that propeller rpm only needed to be increased to aid the shedding of propeller ice if severe icing conditions had been identified. The co-pilot did not advocate the setting of MCP because he considered that the commander would not value such a suggestion. The manufacturer's analysis determined that, if MCP had been set, the aircraft could have been climbed to FL170 and vacated icing conditions.

After levelling off, and an unsuccessful attempt to increase IAS using a non-standard technique, the crew concluded that they should vacate icing conditions by descending. In level flight, the minimum approved speed is 160 KIAS (V_{CM}) but the pilots believed 145 KIAS ($V_{\text{CLEAN}+15}$) was acceptable, if they were attempting to vacate icing conditions. As ice accumulation was having an impact on the aircraft's performance, and reducing airspeed,

the SOP to use MCP in such circumstances was applicable, even though, the SOP included the potentially confusing reference to '*extreme icing conditions*'. Had MCP been set, it was calculated that the aircraft would have achieved a speed in excess of 160 KIAS for a considerable period.

In the event, while the commander was programming the autopilot and setting a descent rate to increase airspeed, the IAS reduced below 145 KIAS. During the time that it took to make the flight guidance inputs and for the system to react, IAS reduced at a rate of 1 kt every two seconds and the AOA increased. The pitch attitude reduced by 2° in response to the descent rate commanded (1000 ft/min), but it was still 5° nose-up. IAS continued to decrease and the AOA increased even further.

It was stated in the OM that the stall protection systems would operate at a pre-determined AOA and that, in icing conditions, a stall could precede the activation of these systems. There were notes to the effect that, in icing, a stall would occur at higher airspeeds than with a clean wing. Accordingly, the AOM mentioned that the autopilot should be disengaged in response to a significant performance loss in icing conditions. Had this been done, the aircraft could have been pitched down more quickly and the speed decay arrested. This requirement was not included in the Part B or in the operator's expired NOTAC 66/13.

Stall indications and recovery

The AOM stated that in (certified) ice conditions, buffeting might be experienced at an IAS up to 25% above the clean stall speed. This equated to 131 KIAS at G-LGNM's weight. However, the aircraft apparently encountered severe icing, which placed it outside certified conditions, and a strong vibration (the pre-stall buffet) was noticed at 137 KIAS. The co-pilot was not sure of the significance of the vibration, while the commander was attempting to use the autopilot to lower the nose and increase airspeed. The Emergency Checklist states that if there is any doubt about the source of an unusual vibration or buffeting, a stall recovery must be performed.

As the IAS decreased, a roll to the left was corrected by the autopilot. This reflected a previous investigation, concerning N306AE, which noted a similar rolling motion prior to the stall of that aircraft. The OM recommends a reduction in AOA in the event of an uncommanded roll movement. This appears in a section relating to '*SLD Detection*'.

Of note, the stall warning would have been set to a lower AOA if the '*Ice Speed Function*' had been operational. If so, the warning would have operated at an IAS of about 140 KIAS, before the pre-stall buffet and the uncommanded roll.

When the stall warning activated and the autopilot dis-engaged (at 132 KIAS, with an AOA of 13°), the commander effected a recovery by pitching the nose down to accelerate the aircraft. However, he did not call '*STALL - MAX POWER*' and use all available power, as specified in the AOM.

The pilots' previous stall training had commenced from an approach configuration, with a low power setting and with the propeller rpm already at MAX. The pilots had practised

carrying out a stall recovery by advancing the power levers but not the condition levers. This anomaly was highlighted during the investigation and has been addressed by the operator in a new training schedule (see *Safety Actions* later in this report).

ICE PROT caution

No definitive explanation could be given for the illumination of the ICE PROT caution and the TIMER light as the airspeed increased. It was likely to have been caused by a discrepancy in one of the sensors in the de-ice boot system but, as it cleared when the abnormal checklist actions were taken, there is no evidence that it was a contributory factor in the incident.

Guidance material

The OM refers to 'normal icing condition' and to 'extreme icing conditions' as well as to 'moderate' and 'severe icing' conditions. Only the latter two terms are accepted aeronautical terms and compatible with the UKAIP. G-LGNM is not certified for the severe icing conditions it experienced and OM, Part B states that the aircraft is not approved for icing conditions forecast to be worse than moderate. The AFM and the AOM include two separate actions to be taken if severe icing is encountered, while there are several other instructions linked to 'extreme icing conditions'. The only clear instruction to vacate specified icing conditions is linked with the observation of ice accretion on the upper surfaces of the wings, aft of the protected surfaces, but this does not take account of a statement elsewhere that ice can build-up without being visible.

The manufacturer is reviewing the manuals to address these observations (see *Safety Actions* later in this report).

Conclusion

G-LGNM probably encountered both severe icing conditions and mountain wave effect while climbing. The crew reduced the airspeed to $V_{\text{CLEAN+15}}$ for optimum climb performance, but the propeller rpm and power were not increased to MCP. The co-pilot perceived that the command gradient between himself and the commander was too steep for him to feel comfortable advocating such a procedure, even though he believed it appropriate.

After levelling-off, airspeed initially increased before reducing back towards $V_{\text{CLEAN+15}}$, a speed that was only intended for use when climbing out of icing conditions, and in combination with MCP. It was apparent that the aircraft's performance was being impaired by ice and it would have been appropriate to set MCP, as well as disengage the autopilot.

Pre-stall buffet was experienced and the recovery was delayed until after the stall warner had activated. Not all the stall recovery vital actions were implemented, although control was regained before a wing drop developed, as had happened in previous Saab 340 stall events.

The manufacturer is reviewing the guidance in the AFM and AOM, relating to flying the Saab 340B in icing conditions, and the operator has updated its advice to crews on the same subject.

Safety actions

The operator

- After the event, the crew received extra simulator training. The instructor was able to simulate a vibration which was similar, although not identical, to the pre-stall buffet that the pilots had experienced.
- During this simulator training the crew practised stall recovery when at cruise altitude. This differed from their previous stall training, which was practised from an approach configuration, with the propeller levers already set to MAX and with the power levers at a low setting. This had not prepared them for the situation at cruise altitude where the power levers were at a high setting and the propeller levers needed to be moved to MAX during stall recovery.
- The operator has since developed a recurrent simulator training package that encompasses performance degradation in icing conditions, leading to pre-stall buffet, with associated stall recovery practice. This training, which all the operator's pilots are scheduled to receive, began in Spring 2015.
- The operator produced an updated NOTAC about Saab 340B operations in icing conditions and intends to incorporate this information in Part B of its OM. The NOTAC offers more detail about severe icing conditions, instructs crews to aim for a minimum cruise IAS of 180 KIAS and to disconnect the autopilot and descend immediately if IAS decays below V_{CM} . The NOTAC also lists the stall recovery actions because they do not feature in the abnormal or emergency checklists for the aircraft.
- The operator has ensured its crews can access bookmarked, electronic versions of the AFM and AOM and intends to liaise with the manufacturer to improve the available search functions.
- The operator acknowledged the crew resource management issues which were raised by the co-pilot's reluctance to advocate his position. These issues were addressed as part of the re-training which both pilots received before returning to line operations.
- A modification which re-instates the 'Ice Speed Function' has been approved by EASA and is to be installed in all the operator's aircraft by August 2015.

The manufacturer

- The manufacturer is reviewing the guidance provided in the AFM and the AOM that relates to operation of the Saab 340B in icing conditions. This review includes crew actions to be taken on identifying specified icing conditions, using accepted aeronautical terminology compatible with the UK AIP.

- An Operational Newsletter has been issued to inform operators that the black lines on the propeller spinner have no operational significance.
- The manufacturer and the operator have begun a dialogue on the simulation of pre-stall buffet in icing conditions, so that other operators can use this training technique.

AAIB Correspondence Reports

These are reports on accidents and incidents which were not subject to a Field Investigation.

They are wholly, or largely, based on information provided by the aircraft commander in an Aircraft Accident Report Form (AARF) and in some cases additional information from other sources.

The accuracy of the information provided cannot be assured.

ACCIDENT

Aircraft Type and Registration:	Auster 5 Alpha, G-AJGJ	
No & Type of Engines:	1 Lycoming O-290-3 piston engine	
Year of Manufacture:	1944 (Serial no: 1147)	
Date & Time (UTC):	27 January 2015 at 1520 hrs	
Location:	Lee-on-Solent Airfield, Hampshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Damage to propeller, nose and right wingtip	
Commander's Licence:	Not known	
Commander's Age:	Not known	
Commander's Flying Experience:	Not known	
Information Source:	Aircraft Accident Report Forms submitted by the pilots and additional inquiries by the AAIB	

The aircraft was being flown to familiarise a prospective new member of the syndicate which owned it. An existing syndicate member occupied the right seat and the possible new member occupied the left seat. After a short flight, the aircraft landed and tipped onto its nose and right wingtip.

The Air Navigation Order defines the commander of an aircraft as:

*‘ **Commander** in relation to an aircraft means the member of the flight crew designated as commander of that aircraft by the operator, or, failing such a person, the person who is for the time being the pilot in command of the aircraft’*

Neither of the two occupants consider that they were the commander of the aircraft and both provided conflicting accounts, so it has not been possible to determine the exact circumstances that led to the accident.

ACCIDENT

Aircraft Type and Registration:	Avid Speedwing Avid Flyer, G-BUZE	
No & Type of Engines:	1 Rotax 582 piston engine	
Year of Manufacture:	1995 (Serial no: PFA 189-12047)	
Date & Time (UTC):	13 September 2014 at 1200 hrs	
Location:	Near Midhurst, Sussex	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Damaged beyond economic repair	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	30 years	
Commander's Flying Experience:	169 hours (of which n/k were on type) Last 90 days - 5 hours Last 28 days - not provided	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

About 10 minutes into the flight from a farm strip, the pilot noticed the engine temperature rising. He advised a colleague at the farm by radio, turned back toward the strip and reduced power in an attempt to cool the engine; however, the engine then stopped. The pilot selected a field in which to make a forced landing and tried, unsuccessfully, to restart the engine.

The aircraft was fast on the initial touchdown, bounced, and then struck a fence and trees at the end of the field, before coming to a stop inverted. The pilot, uninjured, exited the aircraft via the pilot's door. On later inspection of the engine, the pilot identified that the radiator cap was missing and that the engine had seized due to the lack of cooling.

ACCIDENT

Aircraft Type and Registration:	DH82A Tiger Moth, G-EMSY	
No & Type of Engines:	1 De Havilland Gipsy Major I piston engine	
Year of Manufacture:	1940 (Serial no: 83666)	
Date & Time (UTC):	15 May 2015 at 1251 hrs	
Location:	Old Sarum Airfield, Wiltshire	
Type of Flight:	Training	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Damage to propeller, engine cowling, upper wing and empennage	
Commander's Licence:	Commercial Pilot's Licence	
Commander's Age:	31 years	
Commander's Flying Experience:	1,817 hours (of which 45 minutes were on type) Last 90 days - 110 hours Last 28 days - 47 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

The purpose of the flight was for the part-owner of the aircraft to renew his SEP (Single Engined Piston) rating. He was seated in the rear seat and the instructor was seated in the front. After a flight of about an hour's duration, they returned to Old Sarum and the rear seat pilot carried out a touch-and-go landing. He flared the aircraft somewhat too high, causing it to bounce on touchdown. He continued with the manoeuvre, opened the throttle and attempted to rotate into a climbing attitude, but was unable to prevent a nose-down pitching moment which developed instead. The propeller and the nose struck the ground and the aircraft flipped over inverted. The instructor vacated first and assisted the rear seat pilot to do likewise; both were unhurt.

The two pilots suspected that a sudden gust of wind may have lifted the tail, causing the accident.

ACCIDENT

Aircraft Type and Registration:	Druine D.62B Condor, G-AWAT	
No & Type of Engines:	1 Continental Motors Corp O-200-A piston engine	
Year of Manufacture:	1968 (Serial no: RAE/627)	
Date & Time (UTC):	17 April 2015 at 1030 hrs	
Location:	Private strip east of Oxford	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Right landing gear, right main spar and skin, propeller and lower engine cowl damaged	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	71 years	
Commander's Flying Experience:	10,086 hours (of which 6 were on type) Last 90 days - 27 hours Last 28 days - 10 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Whilst accelerating along the grass runway during the takeoff roll, the aircraft crossed a set of raised farm vehicle tracks running perpendicular to the runway. The undulating ground caused the aircraft to become airborne prematurely, stall and then land heavily. The impact resulted in the landing gear collapsing, with subsequent damage to the engine propeller, cowl and the skin and main spar of the wing.

ACCIDENT

Aircraft Type and Registration:	Grumman AA-5 Traveller, G-TALJ	
No & Type of Engines:	1 Lycoming O-320-E2G piston engine	
Year of Manufacture:	1973 (Serial no: AA5-0479)	
Date & Time (UTC):	24 June 2015 at 1210 hrs	
Location:	Shobdon Aerodrome, Herefordshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Damage to propeller and rear fuselage	
Commander's Licence:	Light Aircraft Pilot's Licence	
Commander's Age:	57 years	
Commander's Flying Experience:	155 hours (of which 4 were on type) Last 90 days - 4 hours Last 28 days - 2 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Whilst landing on Runway 27 at Shobdon the pilot became aware that the aircraft was too low and raised the nose and applied power. The pilot stated that the engine then spluttered and was slow to respond, with the result that the aircraft landed a few metres short of the tarmac threshold on a disused concrete surface, suffering damage. Photographs of the damage showed a scraped ventral strake, indicating an abnormally nose-high attitude, and considerable tip damage to a propeller blade, suggesting that the engine was developing a substantial amount of power.

ACCIDENT

Aircraft Type and Registration:	NAMC CJ-6A Chujiao, G-BXZB	
No & Type of Engines:	1 Nanchang Aircraft Mnfr Co HUOSAI-6J1A piston engine	
Year of Manufacture:	1969 (Serial no: 2632019)	
Date & Time (UTC):	16 May 2015 at 1330 hrs	
Location:	Goodwood Airport, West Sussex	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Propeller bent and engine shock-loaded	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	53 years	
Commander's Flying Experience:	13,232 hours (of which 500 were on type) Last 90 days - 120 hours Last 28 days - 30 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot and further inquiries by the AAIB	

Following an uneventful familiarisation flight the pilot reported that the aircraft was configured for landing with cockpit indications showing the landing gear was extended. Two eyewitnesses observed that the landing gear had extended and looked normal.

Following a normal touchdown the right main landing gear collapsed, quickly followed by the left and then the nose landing gear. The pilot submitted a photograph taken during the landing roll showing the aircraft with both main landing gears retracted but the nose landing gear still extended (Figure 1). The pilot and passenger were uninjured and exited the aircraft without difficulty.



Figure 1

View of the landing roll showing the main landing gear retracted and the nose landing gear extended

The pilot reported that he checked the position of the landing gear selectors in both cockpits following the incident and confirmed the front selector was down and the rear selector was locked in the neutral position. When the aircraft was lifted using a crane, both main landing gears extended without assistance but the nose landing gear could only be extended when the uplock was released using a screwdriver.

The CJ-6 landing gear is pneumatically operated and the pilot considers that it is possible that the landing gear retracted because of an air leak or anomaly with the landing gear selector(s). At the time of reporting, the aircraft is awaiting repair and the definitive cause is unknown.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28-140 Cherokee, G-CGHM	
No & Type of Engines:	1 Lycoming O-320-E3D piston engine	
Year of Manufacture:	1974 (Serial no: 28-7425143)	
Date & Time (UTC):	18 June 2015 at 1215 hrs	
Location:	Caernarfon Airport, Gwynedd	
Type of Flight:	Training	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Damage to propeller and nose leg, engine shock-loaded	
Commander's Licence:	Student	
Commander's Age:	48 years	
Commander's Flying Experience:	31 hours (of which 31 were on type) Last 90 days - 13 hours Last 28 days - 6 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot and his instructor	

The student pilot was conducting a solo flight watched by his instructor. The instructor observed that the approach to land was slightly high and fast with the result that the aircraft bounced on touchdown. The pilot did not increase power and the aircraft bounced a second time followed by a third, when a propeller strike occurred. The student opened the throttle and went around, subsequently landing successfully.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28-161 Cherokee Warrior II, G-HAMR	
No & Type of Engines:	1 Lycoming O-320-D3G piston engine	
Year of Manufacture:	1984 (Serial no: 28-8416077)	
Date & Time (UTC):	13 May 2015 at 1230 hrs	
Location:	Membury Airfield, Berkshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Landing gear detached, damage to propeller, wings and fuselage underside	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	51 years	
Commander's Flying Experience:	152 hours (of which 152 were on type) Last 90 days - 3 hours Last 28 days - 2 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Synopsis

After landing on a narrow runway, the brakes appeared to the pilot to be ineffective. In order to avoid running off the end of the runway the pilot steered the aircraft to the right, where it struck some concrete blocks, resulting in the landing gear being torn off.

History of the flight

The aircraft was engaged on a series of cross-country flights involving four aircraft from an Elstree-based flying club and had arrived at Oaksey Park, in Wiltshire, without any problems. The next leg was to Membury Airfield and the pilot conducted a walk-round check of the aircraft before starting the engine and taxiing to a point near the runway, where he carried out a power check. The brakes were applied several times during taxiing and the aircraft was also held against the brakes while full power was applied.

The takeoff and flight to Membury were uneventful and, after over-flying the airfield, the aircraft joined a right-hand circuit for Runway 05. Touchdown was normal, at a speed of around 70 kt, and the pilot allowed the aircraft to settle before applying the brakes. There appeared to be no retardation so the pilot pressed harder on the pedals, but to no avail. The passenger, in the right-hand seat, then attempted to apply the brakes but again they appeared ineffective. By now the end of the runway, which terminated in an earth bank, was approaching and the pilot managed to "instinctively" steer the aircraft the right. However,

the right main landing gear then struck one of a series of concrete blocks, placed there to prevent vehicular traffic from an adjacent access road driving onto the runway. This caused the aircraft to swing to the right and resulted in the landing gears being torn off before the aircraft came to rest against a wire fence. Both occupants were uninjured and, having shut off the fuel and electrics, exited the aircraft unaided.

The investigation

The collision with the concrete blocks had torn off the landing gears and had also caused significant damage to the aircraft underside; the aircraft was subsequently assessed as being damaged beyond economic repair. A representative of the insurance company noted that the hydraulic reservoir that supplied the braking system was empty. However, this was most probably accounted for by the right-hand brake line being severed when the right gear struck one of the blocks; splashes of hydraulic fluid were observed on an adjacent block. In addition, skid marks on the ground were found, indicating that the wheels were locked at the point where the aircraft departed the runway.

Airfield information

The aircraft landed on the asphalt Runway 05 at Membury; this is 650 m long but only 8 m wide and lies between the access road to the right and the 05 grass runway to the left. The latter is the same length as the asphalt runway but 30 m wide. The decision to land on the asphalt runway was made during a conversation between the crews of all four aircraft before they departed Oaksey Park. G-HAMR was the last aircraft to land at Membury and the pilot commented that he was aware that the preceding aircraft had parked on a grass area to the left of the runway end.

Discussion

The brakes on this aircraft type are simple and the left and right callipers are effectively independent, with the fluid reservoir being the only common component; a dual brake failure is thus considered unlikely. In this case available evidence, mainly in the form of skid marks from both main landing gear wheels, suggested that the brakes were functioning prior to the collision with the concrete blocks.

The runway was of adequate length for landing although the width, at 8 m, was relatively narrow. It is possible that the resulting visual perspective presented to the pilot on final approach made the runway appear longer than it actually was, such that, after touchdown, the end of the runway was approaching faster than he expected. The pilot later commented that, although the grass area to the left of the end of the runway may have been a safer option to aim for, he was deterred by the recently arrived aircraft that were parked there.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28R-201 Cherokee Arrow III, G-RJMS	
No & Type of Engines:	1 Lycoming IO-360-C1C6 piston engine	
Year of Manufacture:	1978 (Serial no: 28R-7837059)	
Date & Time (UTC):	19 June 2015 at 0900 hrs	
Location:	Crosland Moor Airfield, Yorkshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 3
Injuries:	Crew - None	Passengers - 2 (Minor)
Nature of Damage:	Damaged beyond economic repair	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	82 years	
Commander's Flying Experience:	1,880 hours (of which 1,285 were on type) Last 90 days - 10 hours Last 28 days - 5 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Synopsis

During takeoff, the aircraft developed a swing to the left which the pilot was unable to correct with the use of rudder. The aircraft left the runway, ran down an embankment and through a stone wall before coming to rest. The cause of the loss of directional control has not been established.

History of the flight

The pilot was taking off on tarmac Runway 25 and the wind was from the northwest at 12 kt. This runway has an uphill slope and the pilot stated that he lined up on the left of the runway "so as to point as near to the wind direction as possible". However, as he opened the throttle and released the brakes, the aircraft developed a swing to the left which he was unable to correct using right rudder. The left wingtip contacted some bushes bordering the runway which increased the yaw such that the aircraft left the runway, ran down an embankment and through a stone wall before coming to rest in a field with all three landing gears collapsed. The occupants evacuated the aircraft normally with some minor bruising to the rear seat passengers who had only been provided with lap belts.

The AAIB has been provided with photographs which appear to show propeller contact marks on the runway, close to where the takeoff roll commenced, which the pilot believes may be evidence that the nose landing gear retracted and compromised his ability to steer the aircraft. However, the marks appear very faint and do not persist for the rest of the

ground run. Contact with the runway by a propeller under high power would be expected to leave the more characteristic deep propeller slash marks. No work has been done to establish the condition of the nose landing gear in order to confirm or refute this possible scenario.

ACCIDENT

Aircraft Type and Registration:	Piper PA-28-236 Dakota, G-FRGN	
No & Type of Engines:	1 Lycoming O-540-J3A5D piston engine	
Year of Manufacture:	1994 (Serial no: 2811046)	
Date & Time (UTC):	15 May 2015 at 1800 hrs	
Location:	North Moreton Airfield, Oxfordshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Damage to propeller, engine, nose gear, wing, fuselage and landing gear	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	72 years	
Commander's Flying Experience:	683 hours (of which 534 were on type) Last 90 days - 4 hours Last 28 days - 4 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

The aircraft was due to land on Runway 35 with a 10 kt wind from 240°. The pilot reported that the approach to land was commenced too high and too fast. As a result, the aircraft landed long and continued to the end, impacting on a mound to the right of the runway. The pilot, who was uninjured, considered in his report that the best course of action would have been to execute a go-around.

ACCIDENT

Aircraft Type and Registration:	Pulsar XP, G-PLSA	
No & Type of Engines:	1 Rotax 912-UL piston engine	
Year of Manufacture:	2005 (Serial no: PFA 202-12283)	
Date & Time (UTC):	21 April 2015 at 1325 hrs	
Location:	Fife Airport	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - Minor	Passengers - N/A
Nature of Damage:	Propeller blades broken off, extensive damage to fuselage around the cockpit, nosewheel and right gear detached, damage to nose and both wing roots	
Commander's Licence:	National Private Pilot's Licence	
Commander's Age:	76 years	
Commander's Flying Experience:	223 hours (of which 29 were on type) Last 90 days - 5 hours Last 28 days - 4 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Synopsis

On the third approach to land, fast with a high nose attitude and unable to reduce the engine speed below 3,500 rpm, the pilot lost control during the flare after the engine inadvertently went to full throttle.

History of flight

After experiencing a number of issues with the running of the aircraft's engine, the pilot decided to fly some circuits and see whether the problem occurred at any particular rpm. The wind was a light variable headwind for Runway 24. The takeoff and climb were normal but, on downwind the pilot could not reduce the rpm below 3,500 rpm, and consequently had difficulty slowing the aircraft. On the approach, the pilot attempted to slow down by raising the nose above the horizon. The speed, however, remained too fast for a landing so the pilot decided to go around. The second approach was equally fast during the approach, and the pilot applied the same nose-high technique to reduce speed, noticing that the rpm was still about 3,500 with the throttle pulled fully back. Again, the pilot commenced a go-around (with the aircraft yawing to the left on application of full power). For the third approach, still fast and nose-high, the pilot aimed to touch down on the numbers in order to have all the runway to bring the aircraft to a stop. As the pilot tried to flare and reduce power, the engine instead went to full power, causing the aircraft to yaw violently to the left. A further

attempt by the pilot to reduce power resulted in the nose dropping and the aircraft impacting the ground on the grass to the left of the runway. The pilot, with only minor injuries, freed himself from the lap and shoulder harness and exited the aircraft. He acknowledged that he had not considered turning the engine off for the landing.

A subsequent inspection of the engine and throttle by an LAA Inspector found that the rear nut securing the throttle lever to the angle bracket attachment on the rear of the instrument panel had come undone, allowing it to sit freely on the throttle shaft. The shaft was, however, stepped, with a larger diameter engine side, meaning that the nut could prevent the larger diameter of the shaft entering the bracket assembly, and stopping the throttle from closing fully. The LAA's June 2015 Light Aviation magazine also contains details of this event.

ACCIDENT

Aircraft Type and Registration:	Robin R2160, G-OCFC	
No & Type of Engines:	1 Lycoming O-320-D2A piston engine	
Year of Manufacture:	2002 (Serial no: 374)	
Date & Time (UTC):	27 May 2015 at 1100 hrs	
Location:	Bodmin Airfield, Cornwall	
Type of Flight:	Training	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Damage to wings, fuselage and nosewheel assembly	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	85 years	
Commander's Flying Experience:	18,348 hours (of which 552 were on type) Last 90 days - 35 hours Last 28 days - 15 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Synopsis

The aircraft was about halfway along the runway during its takeoff roll when the instructor sensed that it was no longer accelerating. He abandoned the takeoff but could not prevent the aircraft from over-running the end of the runway. A change in wind direction and inadvertent use of brakes by the student may have been causal factors.

History of the flight

The aircraft taxied to grass Runway 31, which has an available takeoff run of 610 m. The wind was observed to be from 230° at 10 kt and the instructor told his student to use the full length of the runway, including the displaced threshold.

During the first part of the takeoff roll, acceleration appeared to be normal and by halfway along the runway the indicated airspeed was about 50 kt. At this point the aircraft swerved to the left and the instructor intervened to regain the runway heading, but the airspeed appeared not to increase. Despite an attempt to rotate the aircraft and lift off, it remained on the ground and the instructor realised that it would over-run the runway despite hard braking. The aircraft came to rest in a gorse bush and both occupants vacated it by jettisoning the canopy. Neither was injured.

The instructor looked at the windsock and saw that the wind direction had changed 180°, such that there was a tailwind during the attempted takeoff. He stated that the windsock

was not visible from Runway 31 until about halfway along its length and that flying for the rest of the day was carried out from the shorter Runway 21. In the 'Remarks' section, the aerodrome chart for Bodmin states:

Warning: *In strong wind conditions windshear and turbulence may be encountered on the approaches to all runways. Downdraught effect and sudden changes in surface wind velocity are possible in light wind conditions in summer months due to the effect of sea breezes from both coasts.'*

The instructor thought the student may have been inadvertently applying brake, accounting for the swing to the left, and that this and the change in wind direction was responsible for the apparent shortfall in performance. He stated that the still-air takeoff distance for this aircraft should have been approximately 400 m.

ACCIDENT

Aircraft Type and Registration:	Zenair CH 601HD Zodiac, G-OANN	
No & Type of Engines:	1 Rotax 912-UL piston engine	
Year of Manufacture:	2000 (Serial no: PFA 162-12932)	
Date & Time (UTC):	15 June 2015 at 1438 hrs	
Location:	Manchester (Barton) City Airport	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Nose landing suspension bungee broken; one propeller blade broken off	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	61 years	
Commander's Flying Experience:	260 hours (of which 162 were on type) Last 90 days - 117 hours Last 28 days - 45 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Following an uneventful flight from Headcorn the aircraft made an approach to Runway 27L at Barton; ATC informed the pilot that there was a slight tailwind component. The pilot reported that the aircraft touched down approximately halfway along the runway, at a speed of around 45 kt, although the groundspeed was probably around 50 kt. The surface was bumpy and it took some time for the pilot to slow the aircraft. As the aircraft passed over the numbers at the far end of the runway, at a speed of 10-15 kt, the nose landing gear bungee broke. This caused the nose of the aircraft to dip such that the propeller contacted the ground, breaking off one of the three blades. The aircraft came to a halt shortly afterwards. There were no injuries and the airfield staff assisted in moving the aircraft to the side of the runway.

The pilot considered that the bungee failure occurred due to the aircraft's excessive speed over a bumpy surface, following a late touchdown with a tailwind component.

ACCIDENT

Aircraft Type and Registration:	Kolb Twinstar Mk III Xtra, G-CGZA	
No & Type of Engines:	1 Jabiru 2200A piston engine	
Year of Manufacture:	2013 (Serial no: PFA 205-14316)	
Date & Time (UTC):	4 June 2015 at 1130 hrs	
Location:	Swinefleet Common, Swinefleet, Yorkshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Propeller loss and damage to the tailboom	
Commander's Licence:	National Private Pilot's Licence	
Commander's Age:	63 years	
Commander's Flying Experience:	288 hours (of which 83 were on type) Last 90 days - 13 hours Last 28 days - 2 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

The propeller separated from the engine in flight, without warning and damaged the tail boom. The pilot was able to carry out an emergency landing without incident. The propeller was not recovered, but photographs taken of the fracture faces of the propeller retaining bolt shanks, which had remained attached to the engine crankshaft, showed clear evidence of failure due to the presence of high cycle fatigue. As a result of this incident, and two similar events¹, the Light Aircraft Association (LAA) have confirmed that they are in discussion with the engine manufacturer regarding the issue. Additionally details of the event, together with the recommended procedures for propeller attachment, have been published in the July edition of the LAA's engineering "Safety Spot" (<http://www.lightaircraftassociation.co.uk/2015/Magazine/Jul/SafetySpot.pdf>).

Footnote

¹ AAIB Bulletin 09 2007, G-CDFA, Ref EW/G2007/04/20 (<https://www.gov.uk/aaib-reports/kolb-twinstar-mk-3-extra-g-cdfa-6-april-2007>) and ATSB report A0-2013-046 (https://www.atsb.gov.au/publications/investigation_reports/2013/aaib/ao-2013-046.aspx)

ACCIDENT

Aircraft Type and Registration:	Pegasus XL-Q, G-MTYF	
No & Type of Engines:	1 Rotax 462 piston engine	
Year of Manufacture:	1988 (Serial no: SW-WQ-0042)	
Date & Time (UTC):	4 June 2015 at 1820 hrs	
Location:	Over Farm Airfield, Gloucestershire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Damage to nosewheel, pod and wing	
Commander's Licence:	National Private Pilot's Licence	
Commander's Age:	50 years	
Commander's Flying Experience:	101 hours (of which 101 were on type) Last 90 days - 13 hours Last 28 days - 6 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Synopsis

The aircraft was climbing away after takeoff when the engine momentarily lost power and, as the pilot turned back towards the airfield, the engine stopped completely. Although the subsequent landing was on the airfield, it was in the crop bordering the runway and the nose landing gear collapsed. The pilot attributes the engine failure to an incorrectly seated carburettor float chamber which he routinely removed to fill with fuel as part of the pre-start priming procedure.

History of the flight

The aircraft had taken off from Runway 16 at Over Farm but, after approximately 30 seconds of flight and at a height of about 500 ft agl, the engine momentarily lost power. The pilot looked for a site to land immediately but the engine appeared to regain power and he thought he would be able to return to the airfield. He commenced a wide left turn back towards it but, after a few seconds, the engine lost power again and stopped completely. Initially he tried to land back onto Runway 16 but soon realised he would not make it and landed at an angle of about 20° to the runway in a crop of rapeseed which bordered it, which caused the nose landing gear to collapse before the aircraft came to rest. The pilot released his seatbelt and climbed out of the trike unaided.

The pilot realised he had made two errors. He had followed his usual procedure of removing the carburettor float chamber to fill it with fuel to assist starting but had not replaced it

correctly and it had been drawing air into the carburettor. His second omission had been that he had not performed a two-minute power assurance check, as was his usual practice. He feels that the problem would have manifested itself when he was on the ground had he done so.

ACCIDENT

Aircraft Type and Registration:	SD-1 Minisport, G-CIMA	
No & Type of Engines:	1 Kohler CH750 piston engine	
Year of Manufacture:	2012 (Serial no: 12)	
Date & Time (UTC):	24 May 2015 at 0845 hrs	
Location:	Meldreth Valley Farm, Cambridgeshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - 1 (Minor)	Passengers - N/A
Nature of Damage:	Damaged beyond economic repair	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	72 years	
Commander's Flying Experience:	2,206 hours (of which 14 were on type) Last 90 days - 18 hours Last 28 days - 3 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent AAIB enquiries	

Synopsis

Whilst attempting to take off from his home strip, the pilot, who owned the aircraft, became aware that the aircraft was not gaining height. He was therefore forced to attempt a landing straight ahead, in a tall crop. The pilot considered that the aircraft had marginal takeoff performance from the strip.

History of the flight

The pilot reported that he took off into a light wind which was blowing approximately along Runway 21 of the strip. The upslope on this runway is approximately 2%. The takeoff initially appeared normal, but whilst the engine appeared to the pilot to be functioning correctly and maintaining the correct rpm, he was unable to climb without losing airspeed once he was beyond the end of the strip and had left ground effect. Consequently, it became necessary to land ahead in a field of crop. The tall crop caused severe damage to the aircraft.

Background information

The SD-1 Minisport is an ultralight single seat aircraft of tailwheel layout and falls into the single-seat deregulated category when operated in the UK.

The aircraft type is available with a choice of engines. In the case of G-CIMA, the geometry of the CH750 engine installation results in the crankshaft axis and the directly-driven propeller being positioned lower on the fuselage than in the case of some other engine

types available. Additionally, the propeller diameter is smaller than that on some other installations. Consequently, the slipstream has only limited effect on the high mounted stabilator. The owner/pilot confirmed that the ability to raise the tail to put the aircraft axis in the low drag horizontal position during takeoff is almost entirely dependent on airspeed, rather than being largely affected by applied engine power. In addition, the low wing and short landing gear enables the aircraft to fly horizontally in ground effect at speeds well below that required for level flight in free air.

Although limited performance figures have been stated by the manufacturer, being an unregulated design, these have not been independently verified.

The pilot began operating the aircraft from his home base during January 2015, and had carried out approximately 50 flights totalling approximately 14 hours at the time of the accident. The aircraft had accumulated 201 airframe hours since new, having previously served as a demonstrator by the designer and manufacturer in the Czech Republic. The pilot also operates another fixed wing microlight aircraft type from the strip; this has superior airfield performance and is of high wing configuration.

The pilot now considers that G-CIMA had marginal performance from the strip, having on a few earlier occasions noted that he had difficulty in establishing a positive climb rate when out of ground effect. Consequently, a combination of adverse factors on the day of the accident probably resulted in the achieved airspeed being inadequate for a successful climb out. Some of the possible contributory factors are:

1. The steady increase in ambient temperature between when he began operating the aircraft in January and that at the time of the accident in May. This would have resulted in a progressive, but not very noticeable reduction in performance which may have seemed more than adequate when he first flew the aircraft;
2. The wind direction on the day favouring a takeoff direction opposite to the otherwise preferable downhill direction;
3. A lower windspeed at the strip than that quoted in the TAF and the METAR for nearby Cambridge, used for flight planning;
4. Delay in transitioning from a high drag tail-down position to a low drag fuselage level position early in the takeoff roll.

It was not possible to estimate the required takeoff distance accurately because reliable takeoff performance data, taking account of wind speed and direction, surface slope and condition, ambient temperature and pressure, pilot technique and loaded weight, was not available for the type. In addition, frequently flying a type with superior takeoff performance, and having little difference in behaviour in and out of ground effect, may have caused the pilot to have been less alert to the marginal takeoff performance of his SD-1 aircraft.

INCIDENT

Aircraft Type and Registration:	Streak Shadow SA, G-BXVD
No & Type of Engines:	1 Rotax 912-UL piston engine
Year of Manufacture:	1999 (Serial no: PFA 206-13304)
Date & Time (UTC):	16 April 2015 at 1911 hrs
Location:	Rossall Field airstrip, Cockerham, Lancashire
Type of Flight:	Taxiing familiarisation only
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Serious) Passengers - N/A
Nature of Damage:	Right wing, fuselage and landing gear damaged
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	60 years
Commander's Flying Experience:	366 hours (of which 0 hours were on type) Last 90 days - 0 hours Last 28 days - 0 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft was being taxied for practice, with no intention of flight. Whilst undertaking a fast taxi along Runway 02 at Rossall Field airstrip, the pilot lost directional control and the aircraft departed the runway. During the runway excursion, the pilot inadvertently applied full power and the aircraft briefly became airborne before landing heavily, causing extensive damage to the aircraft and serious injuries to the pilot.

History of the flight

The pilot had recently purchased the aircraft and the majority of his flying experience had been gained on flex-wing weightshift microlights. He had partially completed a conversion course to fly three-axis microlights in 2009, but had not flown this type of aircraft since. As the pilot had recently serviced the aircraft's engine, he performed an engine run before commencing taxiing practice around the airfield for approximately 30 minutes. The pilot reported that this was in order to improve his proficiency in taxiing the Streak Shadow as it was different from the microlights he had previously flown. He then performed a fast taxi along Runway 02, towards a hangar where he kept the aircraft and where he intended to put it away.

During the fast taxi the pilot lost directional control and the aircraft departed the runway to the left, into rough grass. The pilot increased power and he reported that he felt the elevators "banging" as the aircraft ran over rough ground, so he held the control column

aft to stop this. Shortly afterwards the aircraft's nosewheel dropped into a pothole and the pilot's left hand fell forwards, inadvertently moving the throttle to the fully open position. The aircraft became airborne and the pilot reduced power and pitched nose-down, but there was insufficient height to prevent a heavy landing during which the pilot sustained a crushed vertebra and a cracked rib and sternum. The aircraft came to rest in a level attitude having sustained damage to the right wing, landing gear and fuselage.

The pilot stated that he considered the accident could have been avoided if he had reduced power as soon as the aircraft had departed from the runway. The aircraft was equipped with a three-point harness of which the pilot had only fastened the lap strap, as he did not intend to fly the aircraft. He noted that had the harness' shoulder strap also been fastened, it is probable that his body would not have moved forward when the nosewheel dropped into the pothole, thereby avoiding the inadvertent application of full power.

ACCIDENT

Aircraft Type and Registration:	Tanarg/Ixess 15 912S(1), G-IMUP	
No & Type of Engines:	1 Rotax 912ULS piston engine	
Year of Manufacture:	2006 (Serial no: BMAA/HB/478)	
Date & Time (UTC):	5 April 2015 at 1230 hrs	
Location:	Dunkeswell Airfield, Devon	
Type of Flight:	Training	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - 1 (Minor)	Passengers - N/A
Nature of Damage:	Damaged beyond economic repair	
Commander's Licence:	Student	
Commander's Age:	51 years	
Commander's Flying Experience:	40.5 hours (of which 3 were on type) Last 90 days - 15.5 hours Last 28 days - 14 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot and additional enquiries by the AAIB	

Synopsis

When running the engine to warm it up prior to a flight, the owner-pilot reports that, instead of stopping when he intended to shut it down, the engine ran up to high power and the aircraft started to move. The pilot was unable to hold it on the brakes and the aircraft struck two parked cars before coming to a halt. Relative unfamiliarity with the type of aircraft he had chosen may have been a factor in the accident.

History of the event

The pilot intended to perform a solo flight under the supervision of his instructor and had warmed up the engine by running it for 10 minutes at 2,000 rpm. He stated that, in order to stop the engine, he retarded the throttle to idle, selected magneto 1 and selected the ignition switch to OFF (this aircraft had a separate switch to select ignition on and off and another to select individual or both magnetos).

After another 5 minutes, he started the engine again but, whilst performing the same shutdown procedure, noticed that the engine ran very roughly when switched to magneto 1. When he switched the ignition off, the engine did not stop, but instead ran up to full power after about three seconds. Despite pressing hard on the brakes, he could not prevent the aircraft from moving forwards and he steered left to avoid other parked aircraft. He was now heading towards two parked cars, which the aircraft struck, but the pilot managed to roll himself out of the trike before impact and suffered only a

graze to his left hand. As he was not intending to fly immediately, he had not fastened his seat straps.

After recovery, the aircraft was evaluated for damage, during which no pre-impact defects with the throttle or ignition system were found. The pilot was of the opinion that, having accumulated the bulk of his flying experience on a different make of microlight, he would have been better advised to have purchased a similar machine to continue his tuition, as he would be more familiar with the engine controls. He also stated that he will in future be more aware of the aircraft positioning in relation to obstructions when starting the engine.

Miscellaneous

This section contains Addenda, Corrections and a list of the ten most recent Aircraft Accident ('Formal') Reports published by the AAIB.

The complete reports can be downloaded from the AAIB website (www.aaib.gov.uk).

TEN MOST RECENTLY PUBLISHED FORMAL REPORTS ISSUED BY THE AIR ACCIDENTS INVESTIGATION BRANCH

- | | |
|--|--|
| 5/2010 Grob G115E (Tutor), G-BYXR and Standard Cirrus Glider, G-CKHT Drayton, Oxfordshire on 14 June 2009.
Published September 2010. | 1/2014 Airbus A330-343, G-VSXY at London Gatwick Airport on 16 April 2012.
Published February 2014. |
| 6/2010 Grob G115E Tutor, G-BYUT and Grob G115E Tutor, G-BYVN near Porthcawl, South Wales on 11 February 2009.
Published November 2010. | 2/2014 Eurocopter EC225 LP Super Puma G-REDW, 34 nm east of Aberdeen, Scotland on 10 May 2012 and G-CHCN, 32 nm southwest of Sumburgh, Shetland Islands on 22 October 2012
Published June 2014. |
| 7/2010 Aerospatiale (Eurocopter) AS 332L Super Puma, G-PUMI at Aberdeen Airport, Scotland on 13 October 2006.
Published November 2010. | 3/2014 Agusta A109E, G-CRST Near Vauxhall Bridge, Central London on 16 January 2013.
Published September 2014. |
| 8/2010 Cessna 402C, G-EYES and Rand KR-2, G-BOLZ near Coventry Airport on 17 August 2008.
Published December 2010. | 1/2015 Airbus A319-131, G-EUOE London Heathrow Airport on 24 May 2013.
Published July 2015. |
| 1/2011 Eurocopter EC225 LP Super Puma, G-REDU near the Eastern Trough Area Project Central Production Facility Platform in the North Sea on 18 February 2009.
Published September 2011. | 2/2015 Boeing B787-8, ET-AOP London Heathrow Airport on 12 July 2013.
Published August 2015. |
| 2/2011 Aerospatiale (Eurocopter) AS332 L2 Super Puma, G-REDL 11 nm NE of Peterhead, Scotland on 1 April 2009.
Published November 2011. | |

Unabridged versions of all AAIB Formal Reports, published back to and including 1971, are available in full on the AAIB Website

<http://www.aaib.gov.uk>

GLOSSARY OF ABBREVIATIONS

aal	above airfield level	lb	pound(s)
ACAS	Airborne Collision Avoidance System	LP	low pressure
ACARS	Automatic Communications And Reporting System	LAA	Light Aircraft Association
ADF	Automatic Direction Finding equipment	LDA	Landing Distance Available
AFIS(O)	Aerodrome Flight Information Service (Officer)	LPC	Licence Proficiency Check
agl	above ground level	m	metre(s)
AIC	Aeronautical Information Circular	mb	millibar(s)
amsl	above mean sea level	MDA	Minimum Descent Altitude
AOM	Aerodrome Operating Minima	METAR	a timed aerodrome meteorological report
APU	Auxiliary Power Unit	min	minutes
ASI	airspeed indicator	mm	millimetre(s)
ATC(C)(O)	Air Traffic Control (Centre)(Officer)	mph	miles per hour
ATIS	Automatic Terminal Information System	MTWA	Maximum Total Weight Authorised
ATPL	Airline Transport Pilot's Licence	N	Newtons
BMAA	British Microlight Aircraft Association	N_R	Main rotor rotation speed (rotorcraft)
BGA	British Gliding Association	N_g	Gas generator rotation speed (rotorcraft)
BBAC	British Balloon and Airship Club	N_1	engine fan or LP compressor speed
BHPA	British Hang Gliding & Paragliding Association	NDB	Non-Directional radio Beacon
CAA	Civil Aviation Authority	nm	nautical mile(s)
CAVOK	Ceiling And Visibility OK (for VFR flight)	NOTAM	Notice to Airmen
CAS	calibrated airspeed	OAT	Outside Air Temperature
cc	cubic centimetres	OPC	Operator Proficiency Check
CG	Centre of Gravity	PAPI	Precision Approach Path Indicator
cm	centimetre(s)	PF	Pilot Flying
CPL	Commercial Pilot's Licence	PIC	Pilot in Command
°C,F,M,T	Celsius, Fahrenheit, magnetic, true	PNF	Pilot Not Flying
CVR	Cockpit Voice Recorder	POH	Pilot's Operating Handbook
DFDR	Digital Flight Data Recorder	PPL	Private Pilot's Licence
DME	Distance Measuring Equipment	psi	pounds per square inch
EAS	equivalent airspeed	QFE	altimeter pressure setting to indicate height above aerodrome
EASA	European Aviation Safety Agency	QNH	altimeter pressure setting to indicate elevation amsl
ECAM	Electronic Centralised Aircraft Monitoring	RA	Resolution Advisory
EGPWS	Enhanced GPWS	RFFS	Rescue and Fire Fighting Service
EGT	Exhaust Gas Temperature	rpm	revolutions per minute
EICAS	Engine Indication and Crew Alerting System	RTF	radiotelephony
EPR	Engine Pressure Ratio	RVR	Runway Visual Range
ETA	Estimated Time of Arrival	SAR	Search and Rescue
ETD	Estimated Time of Departure	SB	Service Bulletin
FAA	Federal Aviation Administration (USA)	SSR	Secondary Surveillance Radar
FIR	Flight Information Region	TA	Traffic Advisory
FL	Flight Level	TAF	Terminal Aerodrome Forecast
ft	feet	TAS	true airspeed
ft/min	feet per minute	TAWS	Terrain Awareness and Warning System
g	acceleration due to Earth's gravity	TCAS	Traffic Collision Avoidance System
GPS	Global Positioning System	TGT	Turbine Gas Temperature
GPWS	Ground Proximity Warning System	TODA	Takeoff Distance Available
hrs	hours (clock time as in 1200 hrs)	UHF	Ultra High Frequency
HP	high pressure	USG	US gallons
hPa	hectopascal (equivalent unit to mb)	UTC	Co-ordinated Universal Time (GMT)
IAS	indicated airspeed	V	Volt(s)
IFR	Instrument Flight Rules	V_1	Takeoff decision speed
ILS	Instrument Landing System	V_2	Takeoff safety speed
IMC	Instrument Meteorological Conditions	V_R	Rotation speed
IP	Intermediate Pressure	V_{REF}	Reference airspeed (approach)
IR	Instrument Rating	V_{NE}	Never Exceed airspeed
ISA	International Standard Atmosphere	VASI	Visual Approach Slope Indicator
kg	kilogram(s)	VFR	Visual Flight Rules
KCAS	knots calibrated airspeed	VHF	Very High Frequency
KIAS	knots indicated airspeed	VMC	Visual Meteorological Conditions
KTAS	knots true airspeed	VOR	VHF Omnidirectional radio Range
km	kilometre(s)		
kt	knot(s)		

