Final Report AO-2014-004: Piper PA32-300, ZK-DOJ,
Collision with terrain, Near Poolburn Reservoir, Central Otago, 5 August 2014

Final Report

Aviation inquiry AO-2014-004

Piper PA32-300, ZK-DOJ
Collision with terrain
Near Poolburn Reservoir, Central Otago
5 August 2014

Approved for publication: August 2016

Transport Accident Investigation Commission

About the Transport Accident Investigation Commission

The Transport Accident Investigation Commission (Commission) is a standing commission of inquiry and an independent Crown entity responsible for inquiring into maritime, aviation and rail accidents and incidents for New Zealand, and co-ordinating and co-operating with other accident investigation organisations overseas. The principal purpose of its inquiries is to determine the circumstances and causes of occurrences with a view to avoiding similar occurrences in the future. Its purpose is not to ascribe blame to any person or agency or to pursue (or to assist an agency to pursue) criminal, civil or regulatory action against a person or agency. The Commission carries out its purpose by informing members of the transport sector and the public, both domestically and internationally, of the lessons that can be learnt from transport accidents and incidents.

Commissioners

Chief Commissioner	Helen Cull, QC (Until 8 July 2016)
Deputy Chief Commissioner	Peter McKenzie, QC
Commissioner	Jane Meares
Commissioner	Stephen Davies Howard

Key Commission personnel

Chief Executive	Lois Hutchinson
Chief Investigator of Accidents	Captain Tim Burfoot
Investigator in Charge	Sam Stephenson
General Counsel	Cathryn Bridge

Email inquiries@taic.org.nz

Web www.taic.org.nz

Telephone + 64 4 473 3112 (24 hrs) or 0800 188 926

Fax + 64 4 499 1510

Address Level 16, 80 The Terrace, PO Box 10 323, Wellington 6143, New Zealand

Important notes

Nature of the final report

This final report has not been prepared for the purpose of supporting any criminal, civil or regulatory action against any person or agency. The Transport Accident Investigation Commission Act 1990 makes this final report inadmissible as evidence in any proceedings with the exception of a Coroner's inquest.

Ownership of report

This report remains the intellectual property of the Transport Accident Investigation Commission.

This report may be reprinted in whole or in part without charge, provided that acknowledgement is made to the Transport Accident Investigation Commission.

Citations and referencing

Information derived from interviews during the Commission's inquiry into the occurrence is not cited in this final report. Documents that would normally be accessible to industry participants only and not discoverable under the Official Information Act 1982 have been referenced as footnotes only. Other documents referred to during the Commission's inquiry that are publicly available are cited.

Photographs, diagrams, pictures

Unless otherwise specified, photographs, diagrams and pictures included in this final report are provided by, and owned by, the Commission.

Verbal probability expressions

The expressions listed in the following table are used in this report to describe the degree of probability (or likelihood) that an event happened or a condition existed in support of a hypothesis.

Terminology (adopted from the Intergovernmental Panel on Climate Change)	Likelihood of the occurrence/outcome	Equivalent terms
Virtually certain	> 99% probability of occurrence	Almost certain
Very likely	> 90% probability	Highly likely, very probable
Likely	> 66% probability	Probable
About as likely as not	33% to 66% probability	More or less likely
Unlikely	< 33% probability	Improbable
Very unlikely	< 10% probability	Highly unlikely
Exceptionally unlikely	< 1% probability	

PA32-300 ZK-DOJ

Source: mapsof.net

Overview of flight and location of accident

Contents

Figures

Abbreviations

AGL	above ground level
CAA	Civil Aviation Authority of New Zealand
CAR	Civil Aviation Rules
Commission	Transport Accident Investigation Commission
Glenorchy Air	Glenorchy Air Services and Tourist Company Limited
GPS	global positioning system
m	metre(s)
mph	miles per hour
RCC	Rescue Coordination Centre New Zealand
UTC	co-ordinated universal time

Glossary

aerodynamic stall	the breakdown of airflow over an aerofoil (wing) that results in the loss of aerodynamic lift
airstrip	an area of land used by an aeroplane for landing or taking off
airworthiness directive	a mandatory instruction to ensure the continued airworthiness of an aircraft or component
angle of bank	the angle at which an aeroplane's wings are inclined about its longitudinal axis, with respect to the horizontal
groundspeed	the speed of an object over the ground
knot	a speed of one nautical mile per hour, equal to 1.85 kilometres per hour
load factor	the ratio of the lift produced by an aeroplane's wings to its weight
load sheet	a form that shows the weight and distribution of the items that make up the loaded weight of an aircraft
longitudinal axis	an axis running from the nose of an aircraft to its tail
miles per hour	imperial speed measurement, equates to 1.6 kilometres per hour or 0.87 knots
MLAT	is a secondary radar system used by air traffic control that tracks an aircraft's flightpath using signals received from an onboard transponder.
rate of turn	the rate at which an aircraft turns, expressed in degrees per second
SPOT Tracker™	a GPS tracking device that sends position reports to a ground based receiver at set time intervals

Data summary

Aircraft particulars

Aircraft registration:	ZK-DOJ
Type and serial number:	PA32S-300, 32S-40638
Number and type of engines:	one Lycoming IO-540-K1A5, normally aspirated
Year of manufacture:	1968
Operator:	Glenorchy Air Services and Tourist Company Limited
Type of flight:	non-scheduled air transport
Persons on board:	three
Pilot's licence:	commercial pilot licence (aeroplane)
Pilot's age:	56
Pilot's total flying experience:	2,181 hours

Date and time	5 August 2014, about 1452[1]
Location	near Poolburn Reservoir
	latitude: 45°17´ 24"
	longitude: 169°44´ 36"
Injuries	one fatal
	two serious
Damage	substantial

[1] All times in this report are New Zealand Standard time (UTC +12 hours) and expressed in 24-hour format.

1. Executive summary

1.1. On 5 August 2014 an aeroplane on a sightseeing flight charter around the lower South Island crashed near the Poolburn Reservoir, killing the pilot and seriously injuring the two passengers.

1.2. The aeroplane aerodynamically stalled while being manoeuvred at low level in the vicinity of an airstrip located on remote farmland. The stall occurred at a height that was insufficient to enable recovery before the aircraft struck the ground.

1.3. The pilot was carrying out a stock-clearing manoeuvre to move cattle that were on the airstrip, and was in the process of turning the aeroplane around at low level to perform a second pass over the airstrip to scare the livestock away before landing, when the accident occurred.

1.4. The following factors were found to have contributed to the accident:

- a northwesterly wind directly across the airstrip made low-level flying difficult, and required more space than normal for the pilot to turn the aeroplane around
- the pilot's decision to turn downwind at low level, and towards higher ground without climbing, reduced terrain clearance and safety margins
- the pilot's decision to continue the turn despite low terrain ahead, and to increase the angle of bank at a low airspeed, led to the aerodynamic stall.

1.5. The Transport Accident Investigation Commission made the following findings:

- pilot incapacitation was very unlikely to have been a contributing factor
- a mechanical or engine failure was very unlikely to have been a contributing factor
- the aeroplane stalled in a turn performed at low level during a stock-clearing manoeuvre
- the operator believed that stock clearing was permitted, but had no written guidelines and had not given its pilots flight training in the manoeuvre
- there was a lack of clarity on whether stock clearing was a permitted activity under the Civil Aviation Rules.

1.6. The Commission made the following recommendation to the Director of Civil Aviation:

- he provide a clear statement to relevant sectors of the aviation industry on whether stock clearing is a permitted activity. If the Director decides it is a permitted activity under a particular Civil Aviation Rule part, he should provide clear guidance on the conduct of the activity.

1.7. The key lessons identified from the inquiry into this occurrence are:

- flying at close proximity to the ground requires a high degree of accuracy as there is little margin for error. It is important that pilots are fully aware of the stall characteristics of their aircraft, in particular how they are affected by manoeuvres such as steep turns. Pilots should also be aware of the effects of wind on the amount of ground covered during a turn
- operators must issue clear guidelines and procedures for their pilots to follow, and ensure that they are being complied with. Pilots should be required to regularly demonstrate proficiency in carrying out the types of manoeuvres and operations they perform for the operator.

2. Conduct of the inquiry

2.1. On 5 August 2014 the Transport Accident Investigation Commission (Commission) was notified of the accident by the Civil Aviation Authority of New Zealand (CAA), and opened an inquiry under section 13 of the Transport Accident Investigation Commission Act 1990.

2.2. The next day two investigators from the Commission travelled to the accident site to commence the site investigation.

2.3. On 7 August 2014 the Chief Executive Officer and Operations Manager of Glenorchy Air were interviewed at Queenstown Airport.

2.4. On 8 August 2014 the aeroplane's fuel control unit was inspected at an engine overhaul facility, under the supervision of the investigator in charge.

2.5. On 9 August 2014 the two passengers were interviewed by the Commission's investigators at Dunedin Hospital.

2.6. On 11 August 2014 the aeroplane wreckage was transported to the Commission's storage facility in Wellington, where a further detailed inspection was carried out.

2.7. On 15 August 2014 the aeroplane's engine was inspected at an engine overhaul facility, under the supervision of the investigator in charge and the engine manufacturer's local representative.

2.8. On 26 August 2014 the aeroplane's propeller was inspected at a propeller overhaul facility under the supervision of the investigator in charge.

2.9. On 23 June 2016 the Commission approved the circulation of the draft report to interested persons for comment.

2.10. Submissions were received from two of the interested persons, including a substantial submission from the operator. The Commission has considered all submissions and any changes as a result of those submissions have been included in this report.

3. Factual information

3.1. Narrative

3.1.1. Glenorchy Air (the operator) was based at Queenstown Airport and carried out scenic and charter flights around the lower South Island and to Milford Sound. An American couple had booked a 'Three Rings'[2] scenic flight with the operator, while on holiday.

3.1.2. At about 0800 on 5 August 2014, the pilot arrived at Queenstown Airport to prepare for the flight. His preparations included checking the weather conditions; telephoning the landowner at one of the remote aerodromes he planned to use; lodging a company flight plan; completing a load sheet[3]; and conducting a pre-flight inspection of the allocated aeroplane, a Cessna 172.

3.1.3. The two passengers arrived at Queenstown Airport just before 0900. They met the pilot, who gave them a safety briefing and discussed the tour's itinerary with them before they boarded the Cessna. However, a technical problem with the Cessna's radio meant the pilot had to take a larger aeroplane, a Piper PA32-300 registered ZK-DOJ (the aeroplane).

3.1.4. The pilot amended the flight plan to show the different aeroplane, but he did not complete a new load sheet. He fuelled the aeroplane to about 250 litres, which provided an endurance of over four hours. This quantity of fuel was more than the standard fuel load required for the planned flight time of two hours 42 minutes[4]. The pilot briefed the passengers about the different features of the aeroplane compared with the Cessna. The male passenger sat in the front right-hand seat because he was unfamiliar with small aircraft and had a tendency to suffer motion sickness. His wife sat in the left seat in the centre row, directly behind the pilot.

3.1.5. They departed Queenstown at 1116, nearly two hours later than originally planned. The passengers recalled some turbulence on the flight, and said that the pilot was very considerate of their comfort and kept them informed throughout the flight.

3.1.6. At 1155 they arrived overhead Ben Ohau Station, circled once around the airstrip and landed. After landing the pilot contacted the operator via cell phone and gave an update on their progress. They spent about 20 minutes at this film location before departing for Mount Sunday, about 25 minutes' flight time to the northeast. At 1247 they arrived overhead Mount Sunday and circled around the hill. Photos taken by the passengers showed the turns, which they described as being made "tightly" at approximately 45 degrees angle of bank[5].

3.1.7. The tour then proceeded to Omarama aerodrome where they stopped for lunch at about 1330. The passengers said the pilot ate lunch with them inside the airport building, then went to check the aeroplane and update the operator again. They departed Omarama at 1424 for Poolburn, about 25 minutes' flight time to the south. Poolburn was the final stop of the tour before returning to Queenstown.

3.1.8. GPS (global positioning system) flight path data recovered from an on-board iPad[6] showed that the aeroplane approached the Poolburn airstrip from the north at approximately 1,000 feet above ground level (AGL), then circled the airstrip before descending and approaching the runway from a northeasterly direction. According to the passengers there were cows on

---

[2] The 'Three Rings' tour was a scenic flight to 'The Lord of the Rings' filming locations at Ben Ohau station, Mount Sunday and the Poolburn Reservoir.
[3] A load sheet shows the weight and distribution of the items that make up the loaded weight of an aircraft.
[4] The company used standard flight plans for its regular tours. For the 'Three Rings' tour the standard flight time was 162 minutes and the minimum fuel load 213 litres when using the PA32.
[5] The angle of bank is the angle at which an aircraft's wings are inclined about its longitudinal axis, with respect to the horizontal.
[6] The aircraft carried an iPad so that passengers could follow the tour on a live map and access information about 'The Lord of the Rings' movies. Pilots could also refer to it for accurate estimated arrival times.

the airstrip and the pilot flew the aeroplane on a low pass along the runway to scare them away. The pilot flew along the runway between 100 feet and 150 feet AGL, at a groundspeed[7] of approximately 95 knots (see Figure 1). After passing over the airstrip the aeroplane remained at approximately 150 feet AGL then turned left. The groundspeed increased to 123 knots before the rate of turn[8] increased and the groundspeed decreased to below 60 knots, at which time the aircraft struck the ground.

3.1.9. The pilot was killed, and the two passengers were seriously injured. The aeroplane was substantially damaged.

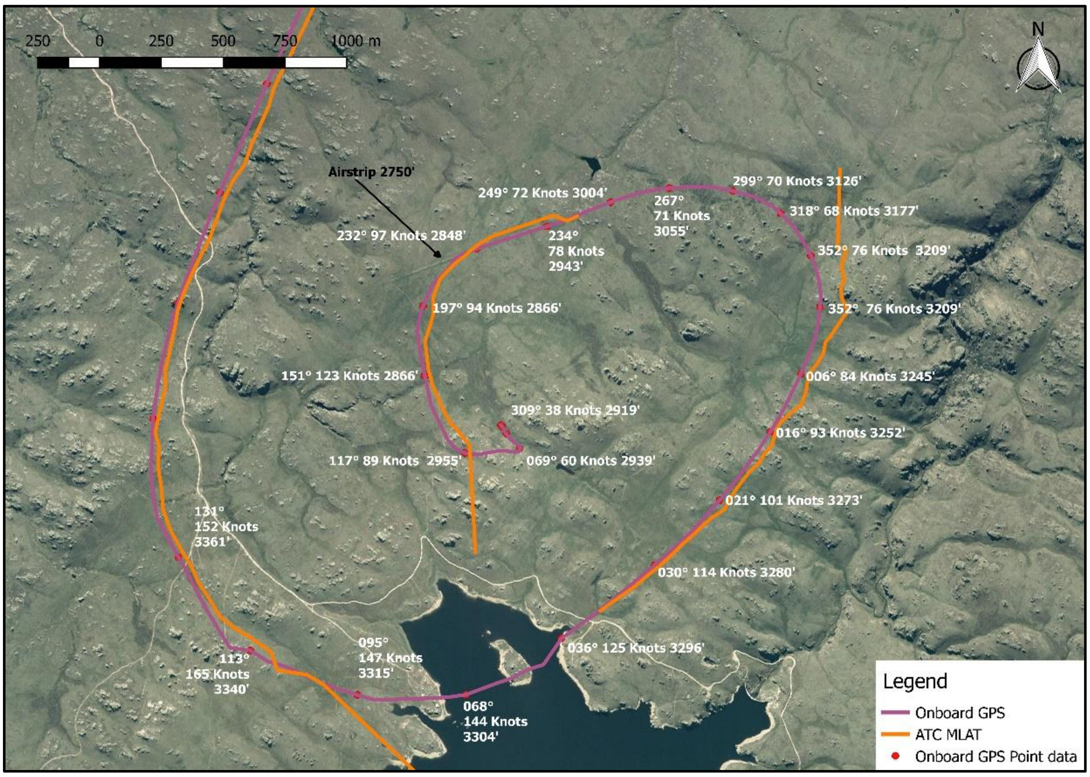


Figure 1
Flight path data
Aeroplane's track (degrees magnetic), groundspeed (knots) and altitude (GPS height, feet, above sea level)
Sourced from Topographic Map CC14 Ophir. Crown Copyright Reserved

3.1.10. When interviewed, the male passenger described essentially the same flight path as described above. He said that when they flew over the airfield the pilot "apologised that we were going to have to bank fairly tightly to make passes over the field to chase them [the cows] off". He recalled seeing the cattle and remembered the final turn, stating;

> "we banked tightly, very sharply, almost wing tip vertical and the ground came up suddenly off one side and me saying something like 'look out' and he [the pilot] saying 'what?' or being surprised".

His next recollection was after the accident, "being huddled over the wing, on the ground". The other passenger could not recall the accident flight or the accident itself.

---

[7] The groundspeed is the speed of an object over the ground, and is affected by wind. For example, if an aircraft flies at an indicated airspeed of 100 knots into a headwind of 20 knots the groundspeed will be 80 knots; if it is a 20-knot tailwind the groundspeed will be 120 knots. A knot is a speed of one nautical mile per hour, equal to 1.85 kilometres per hour.

[8] The rate of turn is the rate at which an aircraft heading changes, expressed in degrees per second.

3.1.11. At 1453 Rescue Coordination Centre New Zealand (RCC) received an alert from the aeroplane's emergency locator transmitter (ELT)[9]. RCC contacted the operator, who confirmed the aeroplane and its location from SPOT Tracker™[10] data. Shortly after this RCC was notified by emergency services of an emergency 111 call from the female passenger.

3.1.12. The first rescue helicopter arrived on scene at 1548, shortly after a local helicopter pilot had arrived with a police officer from Alexandra. A second rescue helicopter arrived shortly afterwards and both passengers were airlifted to Dunedin hospital for medical treatment.

3.2. Site information

3.2.1. The accident site was approximately 750 m south of the Poolburn airstrip and 700 m north of the Poolburn Reservoir. The terrain from the airstrip towards the reservoir rose approximately 150 feet above the airstrip and was covered with rocky outcrops. Towards the northwest of the airstrip the terrain gently sloped downwards and was covered in tussock and grass.

3.2.2. The aeroplane struck the terrain in a left-wing-low and nose-down attitude, on a northerly heading. At this point the left-wing-tip fuel tank, the left wing and left landing gear detached and the aeroplane bounced once. During this sequence the nose landing gear detached. The aeroplane fuselage came to rest upright with the right landing gear detached (see Figure 2).

3.2.3. Fuel from the ruptured left-wing-tip tank was around the accident site, and there was fuel present in the main fuel tanks inside the wings. A sample was taken from the right main fuel tank.

[9] An emergency locator transmitter or ELT automatically transmits a signal when activated by accident forces. The signal is received by satellites that can pinpoint the transmitter location.
[10] SPOT Tracker is a tracking device that sends GPS position reports to a receiver at set time intervals.

Figure 2
Accident site

3.3. Personnel information

3.3.1. The pilot held a commercial pilot licence (aeroplane) that had been issued in April 2008. He had obtained a PA32 series type rating in 2009, and at the time of the accident had accrued approximately 160 flight hours on the type. He had logged 2,181 flight hours in total on aeroplanes.

3.3.2. The pilot held a valid CAA Class 1 medical certificate[11]. In 2008 the pilot had been assessed by the CAA as having an elevated risk of cardiovascular disease.

3.3.3. The pilot had recently returned from a three-month break from flying and had resumed flying duties two days before the accident flight. On his first day back he had flown three solo circuits at Queenstown Airport in a Cessna 172 to regain currency[12] on that type, then a flight to Milford Sound with passengers using a GA8 aeroplane on which he was still current. On the day before the accident flight he had flown three solo circuits in the aeroplane to regain currency in the PA32 aircraft type, then operated one return flight to Milford Sound in a GA8 and another in the aeroplane involved in this accident. He had worked one half-day and one eight-hour duty day in the two-day period before the accident.

[11] A Class 1 medical certificate is required for pilots who conduct commercial flights.
[12] The minimum legal currency requirement for all pilots was three take-offs and landings on type within a 90-day period, in order to carry passengers.

3.3.4. The operator's staff at Queenstown Airport said the pilot appeared to be well rested and in good spirits on the day of the accident.

3.4. Aircraft information

3.4.1. The Piper PA32 is a six-seat, low-wing aeroplane that first flew in 1965. Glenorchy Air had operated the aeroplane since 1996.

3.4.2. At the time of the accident the aeroplane had accrued 8,099 hours. The 300-horsepower Lycoming engine had accrued 6,055 hours and 1,621 hours since its last overhaul. The propeller had accrued 1,991 hours and 682 hours since overhaul. There was no outstanding maintenance or defects, and the aeroplane had been issued with a valid airworthiness certificate.

3.4.3. Company pilots reported that the aeroplane had no unusual mechanical or handling characteristics, other than noting that the fuel management system was more complex than other aircraft in the fleet.

3.4.4. The weight and centre of gravity[13] of the aeroplane at the time of the accident were calculated using the:

- actual basic weight of the aeroplane
- actual weight of the pilot
- actual weights of personal items carried
- estimated passenger weights
- estimated weights of other miscellaneous aeroplane items
- calculated fuel load on board (102 litres).

The weight at the time of the accident was calculated to be approximately 1,215 kilograms. The maximum allowable weight was 1,545 kilograms. The centre of gravity was calculated to be approximately 203 centimetres aft of the datum[14], within the allowable range of 193-244 centimetres aft of the datum.

Fuel system

3.4.5. The fuel system consisted of two aluminium tanks contained in the inboard leading edge section of the wings, plus two fibreglass tanks, one located in each wing tip (see Figure 3). The main tanks had a maximum capacity of 95 litres each and the tip tanks had a maximum capacity of 64 litres each. Fuel was taken from each tank to a combination fuel selector valve and strainer located under the floor below the middle seats.

3.4.6. The fuel selector control was located below the centre of the instrument panel. It had a position for each of the fuel tanks and one OFF position. From the selector valve, fuel was drawn through the electric fuel pump then an engine-driven pump and on to the fuel injector and the fuel nozzles. Four electric fuel quantity gauges and a fuel pressure gauge were mounted on the right side of the instrument panel. A pilot could turn the electric fuel pump 'ON' or 'OFF' by using a switch located below the pilot's side window.

[13] The centre of gravity is the single point in an aircraft through which its total weight (and the force of gravity) can be considered to act.
[14] A datum is a fixed point or reference from which measurements are made.

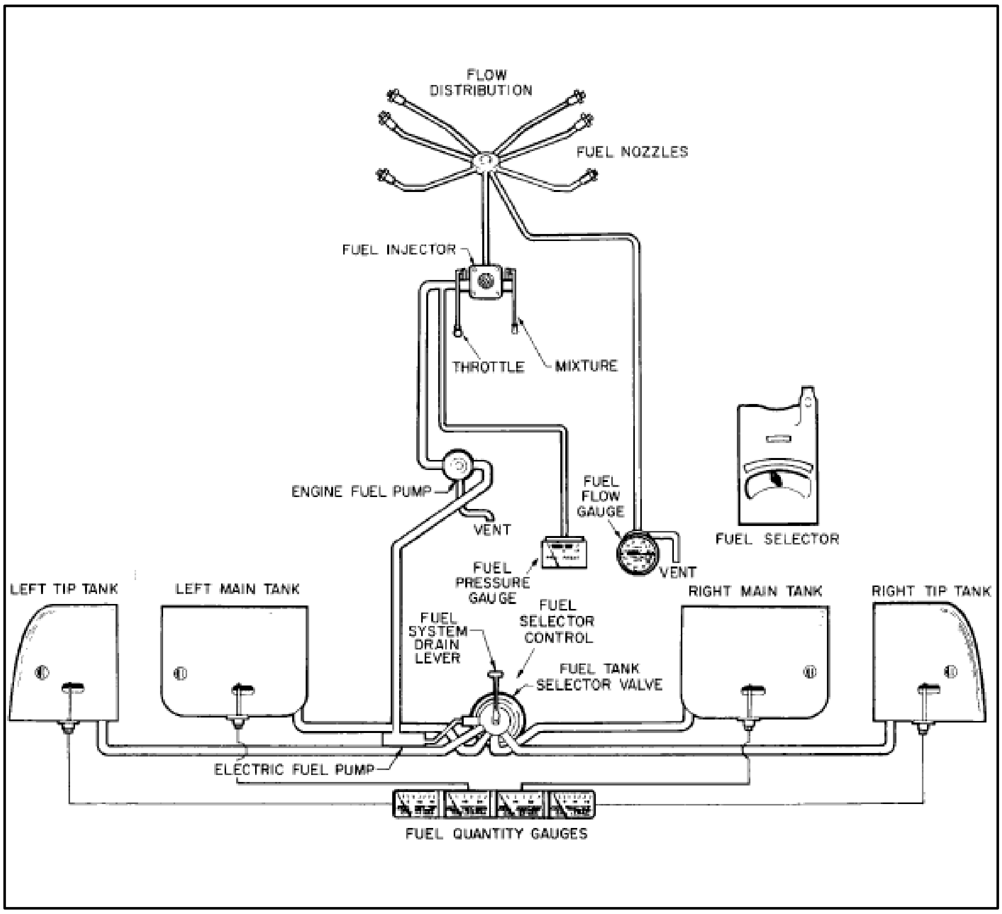


Figure 3
PA32-300 fuel system
Source PA32 owner's manual

3.4.7. The operator's Pilot Operational Supplement outlined procedures for fuel management for the PA32-300. The supplement noted "most forced landings in PA32's have been caused by fuel starvation by inadvertently running a tank dry or not changing tanks properly"[15]. The operator's procedures took into account the additional information in the aircraft Owner's Manual, and included:

- pre-flight checks and fuel contamination checks
- fuelling procedures
- recording of fuel quantities on the load sheet and back of the hand
- in-flight fuel management, including fuel tank selection and electric fuel pump use.

Stall warning system

3.4.8. The PA32-300 stall warning indicator is a red warning light positioned on the upper left side of the instrument panel, designed to alert pilots to an approaching aerodynamic stall[16]. The stall warning indicator is activated by a lift detector vane installed on the front of the left wing.

[15] Refer to Australian Transport Safety Bureau, Aviation Safety Investigation Report 198900823 Piper PA32-300 25 August 1989, and Air Accidents Investigation Branch, Report Piper PA-32-300, G-BAXJ, 25 March 2007, for examples of fuel system management occurrences.
[16] Aerodynamic stall is the breakdown of airflow over an aerofoil (wing) that results in the loss of aerodynamic lift.

It activates at speeds between 5 and 10 miles per hour (mph)[17] (4-9 knots) above the stall speed. The stall warning system is checked during the pre-flight inspection by turning the master switch 'ON,' lifting the detector vane and checking if the stall warning light illuminates[18].

3.5. Wreckage examination

3.5.1. All major components of the aircraft were recovered and transported to the Commission's wreckage examination and storage facility. The engine was removed and sent to an engine overhaul facility for inspection and component testing. Fuel samples taken from the right main fuel tank and the main fuel filter were clean and clear and were the correct type of fuel.

Flight controls

3.5.2. The aeroplane was fitted with one control column[19], on the left side of the cockpit. The control column was found in the full aft position, bent downwards and to the left. Control continuity was confirmed to the elevator[20] and the right aileron[21] and from the rudder pedals to the rudder[22]. No evidence was found of a pre-existing failure of the flight controls.

Engine, propeller and cockpit engine controls

3.5.3. The engine was examined under the supervision of the investigator in charge and the engine manufacturer's local representative. The examination found that the ignition, fuel (see Appendix 1) and oil system components, accessory drives and gears were all serviceable, and that the crankshaft was free to turn. No evidence was found of a pre-existing failure of the engine or its components.

3.5.4. All three propeller blades were found attached to the propeller hub and bent backwards towards the engine cowl (see Figure 4). There was little damage to the blade tips, edges or surfaces. The pattern of bending and lack of significant scoring marks in the ground or on the blades suggested that the propeller had been turning at low power at impact. The propeller was removed and sent to a propeller examination and overhaul specialist. No evidence was found during the examination of a pre-existing failure of the propeller.

---

[17] The PA 32-300 Owner's manual referenced all speeds in miles per hour (a mile being an imperial speed measurement that equates to 1.6 kilometres per hour or 0.87 knots). In New Zealand the knot is the commonly used speed measurement, in accordance with International Civil Aviation Organization standards.
[18] On later-model PA32-300 aeroplanes a horn was added to the stall warning system to give pilots an additional aural warning.
[19] The control column is used by the pilot in conjunction with other controls to change direction and altitude.
[20] The elevator is a moveable surface on the tail of the aircraft, and is used to pitch the aircraft. It changes the aircraft's nose in relation to the horizon – termed the aircraft's 'pitch attitude'.
[21] The ailerons are moveable surfaces on the outboard trailing edge of each wing, and are used to bank the aircraft.
[22] The rudder is a moveable surface on the tail fin of the aircraft, and is used to move the aircraft's nose left or right.

Figure 4
Damage to propeller

3.5.5. An examination of the cockpit engine controls found the mixture control[23] in a partially leaned position, and the propeller was set to the maximum RPM (revolutions per minute) position. The throttle was full aft (idle) and bent to the left (see Figure 5). The fuel selector[24] valve was set to the RIGHT MAIN fuel tank, the electric fuel pump was selected ON, and the ignition was selected to BOTH.

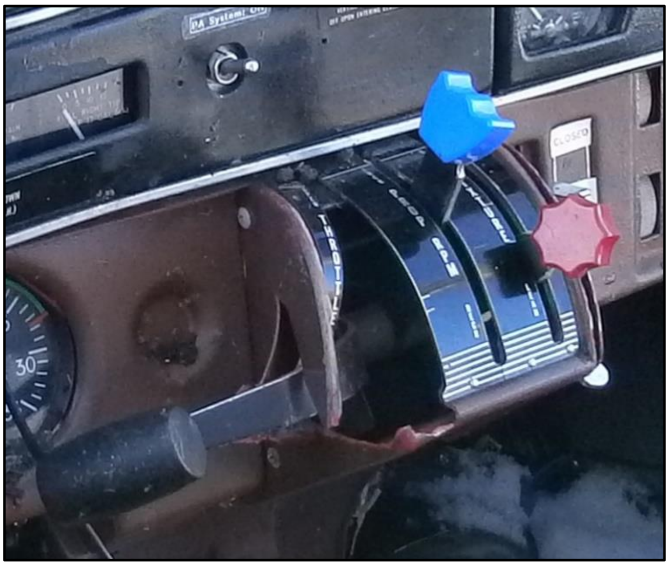


Figure 5
Cockpit engine controls
(throttle, propeller pitch, fuel mixture)

[23] The mixture control is used to adjust the fuel flow to the engine to ensure the correct fuel-to-air ratio for the operating conditions.
[24] The fuel selector is used by the pilot to select which fuel tank supplies the engine. Refer to paragraph 3.4.5 for a further description of the PA 32-300 fuel system.

Instruments and stall warning light

3.5.6. The altimeter subscale was set to 1,011 hectopascals, which approximated the area atmospheric pressure at the time of the accident. The aeroplane's radios were still powered when the first responders attended the site. The aeroplane was not fitted with an artificial horizon[25].

3.5.7. The aeroplane's stall warning light was intact and the stall warning vane[26] on the left wing was undamaged. As the left wing had separated from the aeroplane it could not be tested on site. However, the stall warning vane and light were inspected later and found to be functional.

3.6. Meteorological information

3.6.1. Strong westerly to northwesterly winds of 30-40 knots were forecast for the area at the time of the accident. According to the area weather forecast for the Southland region, the wind strength would increase throughout the day ahead of an approaching front, and occasional moderate turbulence could be expected in the area.

3.6.2. Aerodrome weather forecasts (refer Appendix 2) for Alexandra and Dunedin, the two closest aerodromes to the accident site, forecast the wind at 2,000 feet to increase to 40 knots later in the afternoon, with scattered cloud.

3.6.3. The pilot of the first rescue helicopter said it took 30 minutes to fly from Dunedin to Poolburn due to a 30-40 knot headwind. He said that at the accident site it was a clear day, with a northwesterly wind of 10-15 knots and "smooth".

3.6.4. The local helicopter pilot who was first to the accident site also reported a clear, sunny day with a north to northwest wind estimated to have been 20-25 knots.

3.7. Aerodrome information

3.7.1. Poolburn airstrip was a non-certificated[27] aerodrome and was not promulgated in the Aeronautical Information Publication of New Zealand[28], nor was it required to be. The operator had an airstrip register as required by Civil Aviation Rules (CAR) Part 135.77. The register included the following details for Poolburn airstrip:

- 2,750 feet above sea level
- runway orientated approximately northeast to southwest
- 2% downhill gradient on the north runway
- 900 m take-off distance available on a surface of hard, short grass
- prevailing wind is a cross-wind from the west.

3.8. Organisational and management information

3.8.1. Glenorchy Air was established in 1992 and was certificated by the CAA to carry out air operations under CAR Part 135, Air Operations – Helicopters and Small Aeroplanes. The company provided scenic flights from Queenstown and Glenorchy around the Southern Lakes, Fiordland, the southwest coast and Otago. The company offered three 'The Lord of the Rings' movie location tours, the 'Three Rings' tour being the longest.

---

[25] Artificial horizon is a flight instrument designed to indicate aircraft bank and pitch attitude with respect to the horizon. It is an essential instrument for flight in cloud (instrument meteorological conditions) but not required for flights operated in visual meteorological conditions.
[26] Refer to paragraph 3.4.8 for a detailed description of the stall warning system.
[27] CAR Part 139 specifies the requirements for certification of aerodromes.
[28] The Aeronautical Information Publication of New Zealand contains aeronautical information of a lasting character essential to air navigation, including that pertaining to aerodromes.

3.8.2. At the time of the accident the operator's fleet comprised a four-seat Cessna 172, two eight-seat GA8 Airvans and the PA32.

3.8.3. Of the company's two owners, one was the Chief Executive Officer and the other held the following senior positions:

- Chief Pilot and Operations Manager
- Training Manager
- Maintenance Controller.

An external organisation was responsible for quality assurance and occurrence investigations.

3.8.4. The most recent CAA safety audit had been conducted on 20 May 2014 and issued no findings. The CAA's risk assessment of the operator placed it in the low to medium risk assessment band for this type of operation.

4. Analysis

4.1. Introduction

4.1.1. The Commission determined that an aerodynamic stall (stall) occurred during a turn at low level. There was insufficient height above ground to allow the pilot to recover the aircraft, and the left wing tip struck terrain shortly after it stalled.

4.1.2. Three scenarios were considered as possible reasons for the aeroplane having stalled:

- pilot incapacitation
- mechanical or engine failure
- the pilot's mishandling of the aeroplane during a low-level manoeuvre.

These scenarios are discussed below.

4.1.3. Aircraft equipment and the operator's procedures, as well as regulations and guidelines around stock-clearing manoeuvres, are also discussed.

4.2. Pilot incapacitation

4.2.1. The passengers, who had been with the pilot for more than five hours, recalled that he had been in good spirits and not showing any visible signs of ill health. The front passenger recalled that the pilot was responsive in the moments leading up to the stall. The GPS flight path data showed that the aircraft was flown at a relatively constant height and that the rate of turn was maintained until it increased shortly before the crash. This, along with the bent throttle control lever, suggested that the pilot had been in control of the aeroplane.

4.2.2. The pilot had been assessed by the CAA as having an elevated risk of cardiovascular disease due to higher-than-normal levels of cholesterol and a history of smoking. As a result he had been subjected to regular cardiovascular stress testing. In spite of the perceived elevated risk, the stress testing had not indicated any functional abnormality. In addition, the post-mortem examination found no pre-existing condition that might have incapacitated the pilot.

4.2.3. The operator suggested that the pilot may have been affected by a neurological condition called Transient Global Amnesia (TGA), that could have resulted in a loss of control. According to the CAA's medical manual[29], TGA is a 'transient loss of memory' involving complete or partial amnesia. During a TGA episode there is 'no alteration to conciousness' and there is 'preservation of immediate memory, personal identity, and cognition'. There is also a 'preservation of motor skills' and 'complex tasks are preserved, such as the ability to drive', which suggests that a loss of control would be very unlikely due to TGA.

4.2.4. The Commission's aviation medical consultant[30] was asked to assess the likelihood of an episode of TGA having been a contributory factor. After reviewing the post-mortem examination report and the pilots medical history, he determined it was 'extremely unlikely' that the pilot had experienced TGA.

4.2.5. A toxicological examination of the pilot found no performance-impairing substances and the carbon monoxide level in his blood was in the normal range for a smoker. It was therefore very unlikely that the pilot had been physically incapacitated before the stall.

Finding

1. Pilot incapacitation was very unlikely to have been a contributing factor.

---

[29] CAA Medical Examiners'- Medical Manual Part 3 - Clinical Aviation Medicine
[30] Dr Rob Griffiths MB, ChB(Hons), FAFPHM, FAFOM, MMP, DIH, DipAvMed, FFOM(RCP), FACASM, FACOEM

4.3. Mechanical or engine failure

Flight controls and fuel supply

4.3.1. No evidence of a pre-existing mechanical failure was found, and flight control continuity was confirmed between the cockpit controls and the flight control surfaces. The aircraft's fuel system integrity was confirmed, and the electric boost pump and fuel tank selector valve functioned correctly. Fuel was present in the lines from the selected tank (the right main) to the selector valve and to the engine. A significant amount of fuel was also drained from both main fuel tanks at the accident site.

4.3.2. The aeroplane departed Queenstown with approximately 250 litres of fuel on board, then flew to Ben Ohau and to Omarama, a total flight time of about two hours. As the normal fuel consumption was about 60 litres an hour, approximately 120 litres of fuel would have been used by the time it landed at Omarama. The pilot did not refuel at Omarama although fuel was available there. Therefore there would have been an estimated 130 litres on departure, which was sufficient for the 60 minutes of flight time to return to Queenstown via Poolburn.

4.3.3. The operator's fuel management procedures for the aeroplane required pilots to write down the fuel levels in the fuel tanks prior to each departure. Fuel quantity gauges in older aeroplanes are often unreliable, so pilots measured the fuel tank levels manually, using a wooden dipstick to establish the amount of fuel in each tank. Pilots would then write down the fuel quantities on their hands as they 'dipped' the tanks.

4.3.4. The pilot had the following numbers written on his left hand: 15-3-4-45. The wooden dipstick cannot measure quantities as low as three or four litres. Therefore it is likely that the numbers in full were actually '15-3[0]-4[0]-45'. This would have meant there was 15 litres in the left tip tank, 30 litres in the left main tank, 40 litres in the right main tank, and 45 litres in the right tip tank prior to departing Omarama. This gave a total of 130 litres on board, which is the same as was calculated based on the fuel load departing Queenstown, the average fuel consumption rate, and the total flight time.

4.3.5. The fuel system allowed only one tank to be selected at a time. The operator's fuel management procedures required pilots to take off and land with the fullest main tank selected, and to balance the fuel distribution every half hour by changing tanks as required. The pilot had a notebook in which he recorded the times when he switched tanks and reminders of when to change tanks. There was a note on the day of the flight that said "change right main @ 1455", which suggested he intended to select the right main tank at that time.

4.3.6. If the pilot had followed the normal procedure, he would have taken off from Omarama with the right main tank selected. After take-off he would have selected the right tip tank for half an hour to correct the fuel imbalance, then selected the fullest main tank prior to landing. The aircraft departed Omarama at 1425, so the fuel distribution would have been nearly balanced by 1455. However, the pilot would have started descending as they approached the Poolburn airstrip about five minutes prior to this, at 1450. He would have turned the fuel boost pump on and changed to the fullest main tank before he commenced his descent, as this was the standard operating procedure for the aircraft.

4.3.7. At the time of the accident the electric boost pump was on and the right main fuel tank was selected. This was consistent with the pilot having followed the fuel management procedure and should have meant there was at least 30 litres of fuel in the right main tank, which was supplying the engine. Therefore the pilot's management of the fuel system was considered to have been in accordance with the operator's procedures and was not a contributing factor.

Engine and cockpit controls

4.3.8. The engine, fuel control unit (see Appendix 1) and ignition system were inspected at a specialist engine overhaul facility (see paragraph 3.4.12). No pre-existing defects were found that would have caused a loss in power. The propeller was inspected at a specialist propeller overhaul facility (see paragraph 3.4.13). No pre-existing defects were found, and it was determined that the propeller had been under low power when it struck the ground.

4.3.9. The engine throttle lever was found in the idle position and bent sideways to the left. The pilot had an injury to his right hand that indicated it was very likely that he had been holding the throttle when the aeroplane hit the ground. The throttle could not be moved out of this position after the accident, which suggested that the throttle was at idle prior to ground impact. The pre-impact idle position supported the conclusion from the propeller examination that the propeller was at low power when it hit the ground. One explanation for a low power setting is that the pilot closed the throttle when he realised that a crash was imminent.

4.3.10. The mixture lever that controlled the fuel-to-air ratio within the induction system was found in a partially leaned position after the accident. In order to maintain the same fuel-to-air ratio, the amount of fuel supplied to an engine needs to be reduced as an aircraft climbs, due to the reduction of air pressure as altitude increases. As a rule of thumb, operating at altitudes above 3,000 feet requires the mixture to be leaned by moving the lever rearward. The lever is returned to the full forward or rich position as part of the before-landing checklist during the final approach to land. The aeroplane had been flown to Poolburn at an altitude of about 7,000 feet, so this would have required the fuel mixture to be leaned.

4.3.11. The aircraft was not fully configured for landing and was not on the final approach to land, so the pilot may not have completed the before-landing checklist and may not have returned the mixture lever to full forward position. The lever could also have been moved by one of the occupants as they exited the aircraft after the accident.

4.3.12. Both passengers had been briefed by the pilot on the normal changes in engine sound to be expected during the flight. Neither passenger could recall any abnormal or unexpected engine sounds at any stage. Had there been an engine failure following the stock-clearing pass, there were two alternate airstrips to the southwest of Poolburn airstrip that could have been used. The operator said the pilot was likely to have known of them. However, the GPS flight track showed that after the low pass the aeroplane continued to turn, and increased in altitude and speed. This suggested that the engine was producing normal power during the turn.

Finding

2. A mechanical or engine failure was highly unlikely to have been a contributing factor.

4.4. The low-level manoeuvre

4.4.1. Both passengers recalled the pilot telling them that during the flight he might have to move stock from one or more of the airstrips to enable them to land. He said that this would involve flying at low level over the airstrip to scare the stock off the landing area, and that it might require several passes at low level with tight turns.

4.4.2. Two of the airstrips, Ben Ohau and Poolburn, were on farms and accessible to stock. Neither passenger could recall stock being on the Ben Ohau airstrip, and the GPS flight path data showed that the aeroplane circled around the airstrip once before landing. This suggested that the pilot assessed the airstrip and looked for any animals on the landing area, but found none. The pilot had also called the farm owner at Ben Ohau to check the condition of the airstrip before departing Queenstown.

4.4.3. According to the owner of the Poolburn airstrip, no-one telephoned to ask about the condition of the airstrip, including whether stock would be present, on 5 August 2014. The front passenger recalled seeing cattle on the Poolburn airstrip and that the pilot attempted to clear the animals off the landing area by flying over them at low level. He recalled the pilot saying that cows were stubborn. The passenger said, "We were banking tightly while circling to chase the cows away" and that "it was making me uncomfortable", so he stopped looking outside the window. He remembered looking outside again just before the accident and seeing the ground coming towards them, that he warned the pilot, and that the pilot "seemed surprised about that".

4.5. Flight path data

4.5.1. The GPS flight path data (see Figures 1 and 6), recovered from the on-board iPad, showed the aeroplane flying in a wide arc around the airstrip before descending and flying directly above the airstrip at a height estimated at between 100 and 150 feet AGL. About halfway along the airstrip the aeroplane was turned to the left through approximately 180 degrees. Its groundspeed initially increased during the turn, then decreased rapidly just before impact.

4.5.2. The rate of turn[31] was initially moderate, then a southerly direction was maintained for about 400 m before the aeroplane turned left in a tighter turn. The turn radius of the initial turn away from the airstrip approximated that of a turn made with 30 degrees angle of bank in still wind (see Figure 6, dashed red line). The smaller turn radius during the last part of the turn would have required 45 to 60 degrees angle of bank.

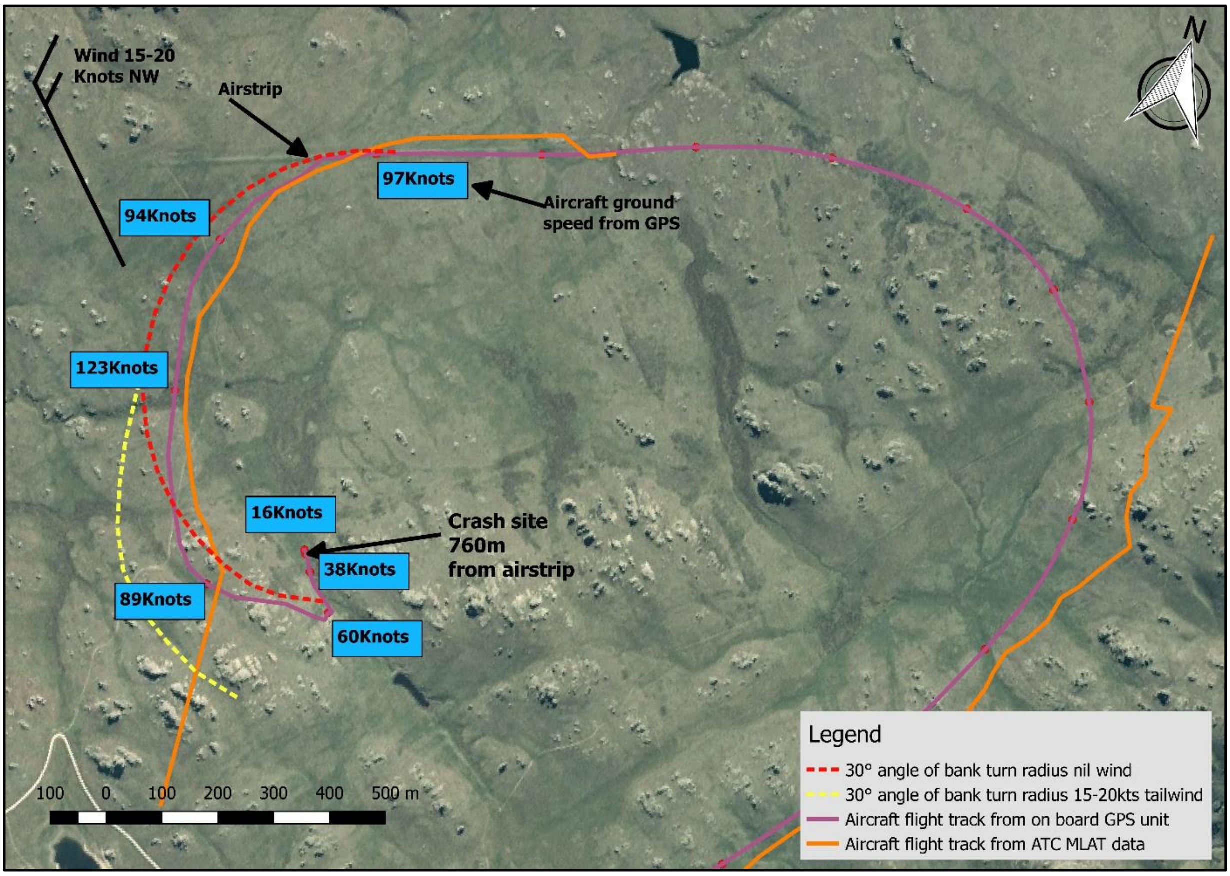


Figure 6
iPad GPS flight track data
(actual and theoretical flight track display, and MLAT[32] data)
Sourced from Topographic Map CC14 Ophir. Crown Copyright Reserved

[31] The rate at which an aircraft heading changes, expressed in degrees per second.
[32] MLAT is a secondary radar system used by air traffic control that tracks an aircraft's flight path using signals received from an on-board transponder.

4.5.3. Figure 6 shows the flight track (in magenta) of the aeroplane as displayed on the on-board iPad by an application called AirNav Pro™. Due to buffering of the GPS data, and in order to show a 'live' view of the flight, the application had to predict the next position of the aeroplane. This feature has resulted in an impossible track being depicted between the points at 89 knots and 16 knots. This part of the data is invalid, and was most likely caused by the software predicting the position shown at the 60 knots point then 'filling in' the track to the final data point at 16 knots. In fact the aeroplane stalled at about the 89 knots point and followed a line between the 89 knots point and the crash site.

4.5.4. The dashed red line in Figure 6 represents the calculated radius (380 m) of a turn carried out in still air (no wind) with an entry airspeed of 90 knots and 30 degrees angle of bank. The dashed yellow line at the bottom of the figure represents the expected flight track of a turn carried out in the wind conditions present at the time (15-20 knots from the northwest) and with 30 degrees angle of bank. The rate of turn is the same for both, but with a tailwind more ground is covered during the turn. This put the aircraft closer to the higher terrain to the south of the airstrip, and the pilot would have had to increase the rate of turn or climb to avoid it.

4.5.5. The aeroplane's altitude increased slightly during the initial part of the turn, from 2,866 feet (GPS altitude[33]) to 2,912 feet. During the final part of the turn it increased to 2,955 feet before rapidly decreasing to 2,760 feet, the altitude of the accident site. The terrain surrounding the airstrip consisted of rocky outcrops and shallow gullies, with lower terrain to the northwest and a rocky ridge about 170 feet higher, 800 m to the southeast of the airstrip. The aeroplane's height above ground increased to about 200 feet during the initial part of the turn, but prior to the final part of the turn it decreased to about 100 feet due to the rising terrain ahead.

4.5.6. When the front passenger recalled seeing ground coming at them, he may have been referring to the higher ground on his side (to the right of the aeroplane) that they were approaching before or during the final part of the turn. The pilot may not have seen the terrain from his position on the left-hand side of the aeroplane (which was in a left turn), or he may have been looking back over his left shoulder to see if the cows had moved off the airstrip. Either way, according to the passenger in the right-hand seat the pilot had seemed surprised by how close the aeroplane was coming to the high terrain, and likely attempted to increase the rate of turn by increasing the angle of bank.

The stall

4.5.7. The stall speed of a PA32-300 in level flight, in the same configuration and at the same weight as the aeroplane at the time of the accident, is about 55 knots. When an aeroplane is banked in a turn there is an increase in the load (weight or G) factor, and the vertical component of lift is reduced (see Appendix 3). A stall will occur at a higher airspeed in a turn than when in level flight. In a 30-degree angle of bank turn the stall speed is 1.1 times the stall speed in level flight (61 knots), at 45 degrees it is 1.2 (66 knots), and at 60 degrees it is 1.4 (77 knots). The groundspeed recorded by the GPS unit as the aeroplane was partway through the final turn was 89 knots and reducing as the rate of turn increased. There was a tailwind of 5-10 knots at that point, so the airspeed was probably closer to 80 knots and approaching the stall speed for a 60-degree angle of bank turn (77 knots).

4.5.8. The front passenger recalled the aeroplane "banking sharply" to "almost vertical". This was likely to have been either an increase in the angle of bank by the pilot to increase the rate of turn, or the left wing dropping when the aeroplane stalled. When an aeroplane stalls in a turn, the inside wing stalls before the outside wing because it is travelling slower through the air. As a result the inside wing drops further and the aeroplane rolls further into the turn. The aeroplane struck the ground in a left wing and nose low attitude with a high vertical and low horizontal speed. The ground impact evidence supported the conclusion that the aeroplane stalled while in a left turn at low level. The stall occurred when the aeroplane was less than

[33] GPS altitude is the height above sea level, referenced to the WGS84 geodetic datum. GPS altitudes can have an error of up to +/- 75 feet, however it is typically accurate to within 20 feet.

150 feet above the ground, much less than the minimum 300-400 feet or more required to recover the aircraft from a stall.

Other factors

4.5.9. Having an artificial horizon installed in an aeroplane can assist a pilot in judging their angle of bank during a turn, especially when at low level over undulating terrain. However, there was no requirement for one to be fitted for this type of operation, and the pilot was experienced with flying in mountainous terrain. The aeroplane was fitted with a turn and slip indicator that gave a basic indication of the rate of turn.

4.5.10. The lack of an aural stall warning may have been a factor that prevented the pilot recognising an impending stall and taking action to avoid it. The stall warning light was operable, but if the pilot had been looking out the side window in the direction of the turn he may not have noticed the light illuminate. A warning horn could have immediately drawn his attention to the impending stall. Later-model PA32-300 aeroplanes were fitted with a stall warning horn as well as the light.

4.5.11. The outer scale of the airspeed indicator (see Figure 8) was calibrated in mph, while the smaller inner scale was in knots. One knot is equal to about 1.15 mph. The airspeed indicators in the other aeroplanes the pilot regularly flew were calibrated in knots only. According to the pilot's training records, he had used knots when learning the airspeed limitations for the PA32-300 type rating. The pilot could have read the airspeed off the outer scale (mph) thinking it was in knots, and thought they were flying faster than they actually were. An airspeed of 90 mph on the outer scale would equate to about 77 knots (the stall speed at 60 degrees angle of bank).

Figure 7
Airspeed indicator and stall warning light (upper left)

4.5.12. The aeroplane had a high groundspeed[34] during the majority of the turn due to the tailwind. This could have been interpreted as a high airspeed by the pilot if he was looking outside the cockpit and saw the ground rushing past. This illusion is exaggerated at low heights above ground, and if a pilot reduces power to decrease the high groundspeed, the airspeed

[34] Groundspeed is the speed that the aircraft flies over the ground and is affected by wind. For example, if an aircraft flies at an indicated airspeed of 100 knots into a headwind of 20 knots the groundspeed will be 80 knots, if it is a 20 knot tailwind the groundspeed will be 120 knots.

decreases. The speed margin above the stall speed is also decreased because the aeroplane is turning (see Appendix 3).

4.5.13. Although it could not be determined whether these factors contributed directly to the accident, they would have made it harder for the pilot to recognise the dangerous situation that was developing.

Finding

3. The aeroplane stalled in a turn performed at low level during a stock-clearing manoeuvre.

The operator's stock clearing procedures

4.5.14. When flying into a farm or remote airstrip, it may sometimes be necessary to clear stock from the strip before a landing can be made. Usually the pilot will fly along the airstrip at low level to scare the stock to one side. After flying along the airstrip, the standard practice is to climb straight ahead to at least 500 feet AGL before turning and re-circuiting for the landing.

4.5.15. In this case the pilot flew along the airstrip at low level, but instead of climbing straight ahead to 500 feet he maintained his height as he entered the left turn. The front passenger recalled being told by the pilot that they would have to circle back to scare the cattle again.

4.5.16. The operator did not have any written procedures for or guidelines on how to carry out stock clearing. However, the Chief Pilot said that he had told his pilots that a low pass to scare stock should be done to one side of the airstrip, followed by a straight climb to 500 feet above the airstrip before turning. He said that if stock did not move after one low-level pass, pilots should not make further attempts.

4.5.17. Other pilots of the operator had different views on how stock clearing should be carried out. None of the pilots had been given flight instruction on the manoeuvre, nor had they been assessed for their competency in carrying it out. They offered a range of minimum heights for the manoeuvre, from 50 feet to 150 feet AGL. They also had different views on whether it was necessary to climb straight ahead to 500 feet after the pass before turning.

4.5.18. In this case the pilot had indicated that he would perform a second pass, and his low-level turn was consistent with that intention. According to his logbook he had performed multiple passes to clear stock at Poolburn and at other airstrips before. This, and the different views of the operator's pilots, showed that the Chief Pilot's verbal instructions about stock clearing were either unclear or being ignored.

4.5.19. Most of the operator's pilots said that the circuit[35] direction at Poolburn was always to the left, which would take an aircraft towards the higher terrain when approaching from the north. In this case, with a strong crosswind from right to left, it would have been safer to turn right into the wind, because the terrain sloped down from the airstrip and it would have resulted in a lower groundspeed. It was not possible to determine whether the pilot had carried out stock clearing in similar wind conditions, or if he had flown in a different circuit direction, during previous flights into Poolburn.

4.5.20. Alternatively, the pilot could have climbed straight ahead to 500 feet AGL before turning. Had there been an engine failure during the low-level turn to the left, there would have been few options for a safe landing because of the rocky terrain and high groundspeed of the aeroplane.

[35] The circuit is a rectangular path followed by aircraft when taking off or landing, while maintaining visual contact with the airfield.

> **Finding**
>
> 4. The operator believed that stock clearing was permitted, but had no written guidelines and had not given its pilots flight training in the manoeuvre.

4.6. Civil Aviation Rules

4.6.1. CAR did not define or refer to stock clearing, nor was it covered anywhere in the advisory circulars or guidelines published by the CAA. The commercial pilot licence training syllabus did not include stock-clearing techniques. The agricultural rating syllabus[36] likewise did not include a requirement for stock-clearing training.

4.6.2. CAR Part 91.127 states that no person may operate an aircraft at an aerodrome unless the runway is clear of all persons, animals, vehicles, or other obstructions during landing or take-off. It does not specifically prohibit a pilot from carrying out a low approach and overshoot to clear animals off the runway.

4.6.3. In accordance with CAR Parts 91 and 135, the minimum height for visual flight rules (VFR) air transport flights is 500 feet above the surface, or 500 feet above any obstacle within a 150 m radius of the aircraft. Aircraft must also not be operated at a height less than required to safely execute an emergency landing in the event of an engine failure. These requirements do not apply to the pilot in command of an aircraft conducting a take-off or landing, a balked landing or discontinued approach, or taxiing. There is no definition in CAR Part 1 for balked landing or discontinued approach.

4.6.4. A low approach and overshoot involves an aircraft carrying out a normal approach to land, but it stops descending at low level before climbing straight ahead to 500 feet or more to circuit for landing or to depart the area. On occasions there may be good reason to fly at low level along a runway or airstrip for a short distance before climbing away. This manoeuvre is typically carried out to inspect an unprepared landing area for any hazards, prior to landing.

4.6.5. An article published in the CAA safety magazine Vector in March 2012, following a low flying incident, discussed low approach and overshoot manoeuvres. The pilot involved in the incident was quoted as saying, "A low pass down the runway was accepted common practice as part of a go-around [low approach and overshoot]" and that "the rules didn't prohibit the manoeuvre". The published response from the CAA at the time was "just because the rules are silent on the matter doesn't make it an acceptable practice".

4.6.6. The pilot of the accident aeroplane carried out a modified low approach and overshoot, and instead of climbing out straight ahead after flying along the airstrip he turned at low level in order to make another low-level pass over the airstrip. In the absence of any specific guidelines from the operator or within the civil aviation system regarding stock clearing, the pilot carried out what he may have thought was an acceptable manoeuvre for stock clearing. Entries in the pilot's logbook, and the briefing he gave to the passengers about making "close passes" and "tight turns to get back around", suggested this may have been his usual technique for clearing livestock that had not moved after the first pass.

4.6.7. The CAA was asked by the Commission to clarify the requirements for operators who carry out stock clearing during commercial or air transport operations. The CAA responded by saying that stock clearance is not authorised under CAR Part 135. The reason the CAA gave was that CAR Part 91, which applies to all pilots under all CAR, states that pilots must ensure a runway is clear of animals during landing.

4.6.8. CAR Part 91 states that a pilot is allowed to fly below 500 feet AGL for the purposes of taking off or landing, and for carrying out a balked landing or discontinued approach. As stock clearing could be interpreted as being a form of balked landing or discontinued approach,

---

[36] The agricultural rating training syllabus was reviewed, as it was considered by the investigation to be the most likely place to find any guidelines about stock-clearing procedures.

and in the absence of any clear guidance from the CAA, the stock-clearing procedure could be interpreted as being allowed.

4.6.9. This operator and others had been carrying out stock-clearing manoeuvres for many years, possibly in the belief that it was not prohibited under CAR. The CAA's view that stock clearing is not permitted on an air transport flight may not be shared by all aviation industry participants. Therefore the Commission is recommending that the Director of Civil Aviation provide appropriate guidance to the aviation industry on stock clearing.

Finding

5. There was a lack of clarity on whether stock clearing was a permissible activity under the Civil Aviation Rules.

5. Findings

5.1. Pilot incapacitation was very unlikely to have been a contributing factor.

5.2. A mechanical or engine failure was very unlikely to have been a contributing factor.

5.3. The aeroplane stalled in a turn performed at low level during a stock-clearing manoeuvre.

5.4. The operator believed that stock clearing was permitted, but had no written guidelines and had not given its pilots flight training in the manoeuvre.

5.5. There was a lack of clarity on whether stock clearing was a permissible activity under the Civil Aviation Rules.

6. Safety actions

General

6.1. The Commission classifies safety actions by two types:

(a) safety actions taken by the regulator or an operator to address safety issues identified by the Commission during an inquiry that would otherwise result in the Commission issuing a recommendation

(b) safety actions taken by the regulator or an operator to address other safety issues that would not normally result in the Commission issuing a recommendation.

Safety actions addressing safety issues identified during an inquiry

6.2. No safety actions were identified.

Safety actions addressing other safety issues

6.3. No safety actions were identified.

7. Recommendations

General

7.1. The Commission may issue, or give notice of, recommendations to any person or organisation that it considers the most appropriate to address the identified safety issues, depending on whether these safety issues are applicable to a single operator only or to the wider transport sector. In this case, a recommendation has been issued to the Civil Aviation Authority.

7.2. In the interests of transport safety it is important that these recommendations are implemented without delay to help prevent similar accidents or incidents occurring in the future.

Recommendation

7.3. The operator involved in this accident had conducted stock-clearing manoeuvres with fare-paying passengers on board, in the belief that it was not prohibited under CAR.

7.4. Anecdotal evidence suggests that other operators had been conducting similar stock-clearing manoeuvres, also in the belief that it was permitted.

7.5. The CAA expressed an alternative view that pilots operating under CAR Part 135 were not authorised to carry out stock clearing. Its rationale for this view was that Rule Part 91, which applies to all pilots, states that a pilot must ensure a runway is clear of animals during landing.

7.6. There appeared to be a difference between what the CAA said was an unauthorised activity and what the industry understood to be a permitted activity.

7.6.1. Therefore, on 24 August 2016 the Commission recommended that the Director of Civil Aviation provide a clear statement to relevant sectors of the aviation industry on whether stock clearing is a permitted activity. If the Director decides it is a permitted activity under a particular Civil Aviation Rule part, he should provide clear guidance on the conduct of the activity. (019/16)

On 7 September 2016 the Civil Aviation Authority replied:

> In our response to the Commission's draft report, 11 August 2016, we explained there is no CAA rule provision for stock clearing; therefore, the Director cannot provide clear guidance on the conduct of the activity in the context of existing CA Rules.
>
> However, the CAA recognises that an operation to a remote airstrip presents a risk to air transport in that the landing area may have visible hazards, including the presence of stock, which could affect the safety of a landing. Whilst there are no existing provisions in the rules to descend below 500 feet (aside for take-off/landing or a baulked landing/discontinued approach), the Director will agree to pursue a means to enable air transport operators to overfly a remote airstrip below 500 feet for the purposes of ensuring the landing area is visibly free from hazards.
>
> The CAA remains focused on safety management based on risk mitigation. The CAA believes the alternative safety action will address the safety issue raised by the Commission and we will advise when the work has been completed.

8. Key lessons

8.1. Flying at close proximity to the ground requires a high degree of accuracy as there is little margin for error. It is important that pilots are fully aware of the stall characteristics of their aircraft, in particular how they are affected by manoeuvres such as steep turns. Pilots should also be aware of the effects of wind on the amount of ground covered during a turn.

8.2. Operators must issue clear guidelines and procedures for their pilots to follow, and ensure that they are being complied with. Pilots should be required to regularly demonstrate proficiency in carrying out the types of manoeuvres and operations they perform for the operator.

9. Citations

Air Accidents Investigation Branch. (2007). *Report Piper PA-32-300, G-BAXJ, 25 March 2007.* Farnborough: Air Accidents Investigation Branch.

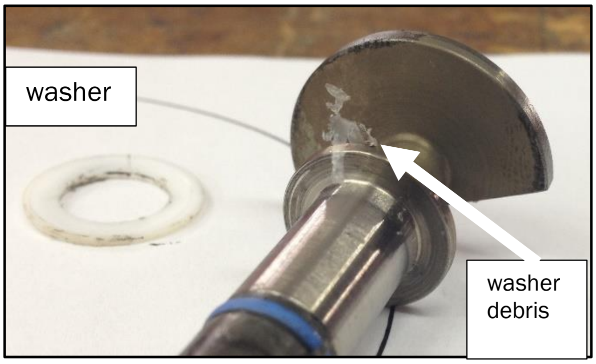
Australian Transport Safety Bureau. (1989). *Aviation Safety Investigation Report 198900823 Piper PA32-300 25 August 1989*. Canberra: Australian Transport Safety Bureau.

Civil Aviation Authority. (2012). Low Approach and Overshoot. *Vector* March/April 2012 pp 8-9.

Appendix 1: Fuel control unit inspection

At the time of the accident CAA Airworthiness Directive[37] DCA/MA/17 was applicable to Robinson R44 II helicopters fitted with Lycoming IO-540 series engines and Precision Airmotive RSA-10AD1 fuel control units (FCUs). Teflon thrust washers inside these FCUs had shown signs of delamination, which had the potential to restrict fuel flow and cause a reduction in power. The aeroplane's FCU (part number RSA-10ED-1) used the same type of washer. Therefore the possibility of a delaminated washer being a causal factor was examined in detail.

The FCU was taken apart and inspected at an approved engine overhaul facility under the supervision of the investigator in charge. The FCU, fuel nozzles, fuel filter and pump were tested and found to be serviceable and free of blockages. However, a small amount of delamination was detected on washer part number 367757 (see Figure below).



Washer and debris

The Commission notified the Director of Civil Aviation that similar delamination had been found on the washer from the aeroplane's FCU. Following this and further reports from other aeroplane operators, the CAA issued Airworthiness Directive DCA/MA/19 that was applicable to all aircraft fitted with RSA-10ED1 model FCUs and other Precision Airmotive FCUs that contained the Teflon washer.

Despite the breakdown of the washer material, the fuel nozzles and lines were clear of any debris and there was no sign of any blockages.

[37] An airworthiness directive is a mandatory instruction to ensure the continued airworthiness of an aircraft or component.

Appendix 2: Meteorological forecasts

```
TAF NZDN 041342Z 0414/0507 20005KT 30KM SKC
BECMG 0422/0500 30012G25KT
2000FT WIND 27030KT
BECMG 0504/0506 30040KT
QNH 0414/0502 MNM 1008 MAX 1017
QNH 0502/0507 MNM 1001 MAX 1010

TAF NZLX 041435Z 0414/0507 04005KT 20KM -RA SCT050
BECMG 0423/0501 34012G25KT
TEMPO 0503/0507 6000 SHRA
2000FT WIND 32030KT
BECMG 0423/0501 32040KT
QNH 0414/0500 MNM 1010 MAX 1019
QNH 0500/0507 MNM 1004 MAX 1013

TAF NZQN 041342Z 0414/0507 VRB02KT 30KM SCT020 BKN050
BECMG 0422/0500 28012G25KT
2000FT WIND 30035KT
BECMG 0504/0506 30045KT
QNH 0414/0503 MNM 1010 MAX 1019
QNH 0503/0507 MNM 1004 MAX 1013


AL issued at 16:37 UTC 04-Aug-2014
FANZ73 NZKL 041637
ARFOR AL VALID 1700 TO 0200 UTC
 3000   28005
 5000   27010 PS02
 7000   24015 MS02
10000   23025 MS06
FZL     6000FT
VIS     20KM REDUCING TO 15KM IN -RA AND 0500M IN FG.
CLD     AREAS ST 2000 VC FOG, CLEARING MID-MORNING.
        AREAS SCT ACAS ABV 6000 DEVELOPING LATE MORNING, SPREADING N.
WX      PATCHY FG ABT IN SHADED VALLEYS, CLEARING MID-MORNING.
        ISOL -RA DEVELOPING THIS AFTERNOON, MAINLY S OF NZMC.
TURB    OCNL MOD, MAINLY S OF NZMC, MAY BECOME SEVERE, SIGMET POSSIBLE.


PL issued at 16:39 UTC 04-Aug-2014
FANZ74 NZKL 041639
ARFOR PL VALID 1700 TO 0200 UTC
 1000   28005
 3000   24010
 5000   23015 PS03
 7000   22015 MS01
10000   22025 MS07
FZL     6000FT
VIS     30KM REDUCING TO 0500M IN FG.
CLD     AREAS ST 0400 VC FG, CLEARING MID-MORNING.
        AREAS BKN ACAS ABV 6000 DEVELOPING S OF NZTU ABT MIDDAY.
WX      PATCHY FG ABT INLAND VALLEYS, CLEARING MID-MORNING.
        OTHERWISE, NIL SIG.
TURB    OCNL MOD, MAINLY S OF NZTU, DEVELOPING THIS AFTERNOON, MAY
        BECOME SEVERE, SIGMET POSSIBLE.
```

```
CY issued at 17:00 UTC 04-Aug-2014
FANZ76 NZKL 041700
ARFOR CY VALID 1700 TO 0200 UTC
 BECOMING                   NOON
 3000   31005
 5000   29015 PS01          31030
 7000   27025 MS02          30040
10000   26035 MS07
FZL     5500FT
VIS     20KM REDUCING TO 15KM IN -RA AND 0500M IN FG.
CLD     AREAS ST 0800 VC FG, CLEARING MID-MORNING.
        AREAS BKN CUSC 3500 TOPS 7000.
        AREAS BKN ACAS ABV 7000 DEVELOPING THIS AFTERNOON.
WX      PATCHY FG ABT VALLEYS, CLEARING MID-MORNING.
        ISOL PATCHES -RA, MAINLY ABT FAR SOUTH, SPREADING N.
TURB    OCNL MOD, MAY BECOME SEVERE, SIGMET POSSIBLE.
ICE     OCNL MOD ABV FZL, MAINLY SW OF NZQN, DEVELOPING EARLY
        AFTERNOON.
```

```
GE issued at 17:03 UTC 04-Aug-2014
FANZ77 NZKL 041703
ARFOR GE VALID 1700 TO 0200 UTC
 BECOMING                   NOON
 1000   29020
 3000   28030
 5000   27040 PS01
 7000   26040 MS02
10000   25040 MS07          29055
FZL     5500FT
VIS     20KM REDUCING TO 10KM IN -RA AND 0500M IN FG.
CLD     AREAS ST 0400 VC FG, MAINLY ABT INLAND VALLEYS, CLEARING
        MID-MORNING.
        AREAS BKN CUSC 2000 TOPS 6000 DEVELOPING S OF NZNV THIS
        MORNING, SPREADING NORTH.
        AREAS BKN ACAS ABV 6000, MAINLY ABT FAR S, SPREADING N THIS
        MORNING.
WX      PATCHY FG, MAINLY ABT INLAND VALLEYS, CLEARING MID-MORNING.
        ISOL PATCHES -RAS DEVELOPING ABT/S OF NZNV THIS AFTERNOON,
        SPREADING N.
TURB    OCNL MOD, SEVERE AS PER SIGMET.
ICE     OCNL MOD ABV FZL, MAINLY SW OF NZNV, DEVELOPING THIS
        AFTERNOON.
```

Appendix 3: Aerodynamic stalls and steep turns

Introduction

The following information has been copied in part from the Civil Aviation Authority Flight Instructor Guide Briefings for Basic Stalling, Advanced Stalling and Steep Turns. This presentation of this information will be familiar to many New Zealand pilots. Full briefings are available from https://www.caa.govt.nz/FIG/index.html.

Aerodynamic Stall

An aerodynamic stall is not like a stall in a car – the engine does not stop. Aerodynamic stalling is the breakdown of smooth airflow over the wing into a turbulent flow, resulting in a decrease in lift. The lift will no longer fully support the aeroplane's weight, and the aeroplane sinks. The cause of this breakdown of smooth airflow is the result of the wing being at too high an angle of attack to the airflow. For the average aerofoil used on general aviation aeroplanes, this limit is reached at an angle of attack of about 15 degrees.

Lift is primarily controlled through angle of attack and airspeed, and lift must equal the aeroplane's weight to maintain level flight. As the airspeed decreases, the angle of attack must be increased to maintain lift equal to weight.

L = angle of attack x airspeed

As the angle of attack increases, the airflow finds it more and more difficult to follow the contoured upper surface of the wing (aerofoil) smoothly, and the point at which the airflow breaks away from the wing (the separation point) moves forward from the trailing edge. At the same time, the point through which lift acts, the centre of pressure (C of P), also moves forward; this movement is unstable because it reduces the moment of the lift/weight couple. See Figure 1.

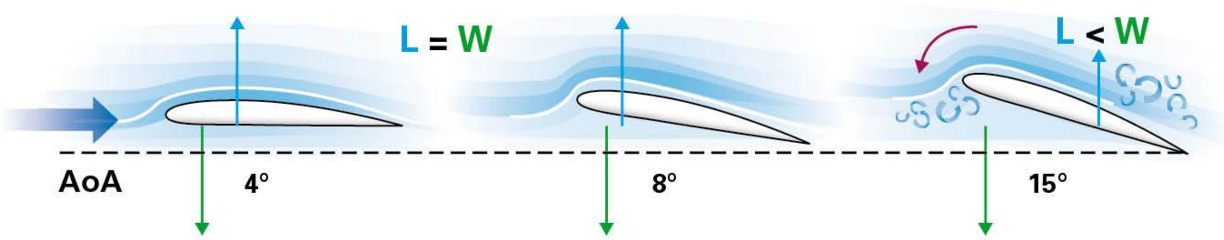


Figure 1
Changes in airflow and centre of pressure with increasing angle of attack

Eventually, the stalling (or critical) angle of attack is reached, and the inability of the air to flow smoothly over the top surface of the wing results in a decrease in lift and a large increase in drag. The result is that the aeroplane sinks. At the same time, the C of P moves rapidly rearward. The rearward movement of the centre of pressure increases the moment provided by the lift/weight couple, causing the nose to pitch down in a stable movement.

The aeroplane's manufacturer provides stalling speeds for one or more aircraft configurations as a guide to the pilot. Although the critical angle remains constant, the stall speed will vary for other configurations and with several factors.

Lift primarily varies with angle of attack and airspeed. Since the critical angle cannot be altered, anything that increases the requirement for lift will require an increase in airspeed to produce that lift. Therefore, when the critical angle is reached the airspeed will be higher. Conversely, anything that decreases the requirement for lift will decrease the airspeed observed at the stall.

Weight

An increase in weight will require an increase in lift, resulting in an increase in the stalling speed.

Loading

Loading, or load factor, is the name given to the force/acceleration that the aeroplane must support, for example, in pulling out of a dive. When you ride a roller coaster, at the bottom of the dip you feel heavier, as you're pushed into your seat by the force/acceleration of changing direction. You haven't actually gained weight, but it feels that way. For an aeroplane this is often referred to as apparent weight, or G, and this increase in apparent weight increases the requirement for lift, and thus it increases the stall speed.

↑ apparent W → ↑ L → ↑ VS

Power

If the aeroplane had enough power, it could climb vertically (like a rocket) and there would be no requirement for lift at all. So when thrust is inclined upwards, it decreases the requirement for lift and reduces the stalling speed. In addition, the slipstream generated by having power on increases the speed of the airflow and modifies the angle of attack (generally decreasing it) over the inboard sections of the wing. The increased airspeed increases the lift and reduces the aeroplane's stall speed.

Flap

Flap increases lift and therefore the stalling speed is reduced. However, flap also changes the shape of the wing, and this results in a lower nose attitude at the stall.

Although flap increases lift, it also increases drag – generally, about the first 15 degrees of flap increases lift with little adverse affect on the L/D ratio. The application of any further flap rapidly increases drag, adversely affecting the L/D ratio.

Steep Turns

A steep turn is defined as a turn of more than 30 degrees angle of bank. It is common practice for flight instructors to teach students to conduct steep turns at 45 degrees angle of bank.

In order to turn the aeroplane, an acceleration towards the centre of the turn must be provided. This is done by banking the aeroplane with aileron. It is the horizontal component of lift (centripetal force) that provides this acceleration towards the centre of the turn. With the lift vector inclined, the vertical component of lift no longer supports the aeroplane’s weight. To maintain a constant altitude or height, the total lift vector must be increased so that the vertical component now equals the weight. Of the options available for increasing lift, changing the angle of attack is the most practical. Any increase in lift will produce a corresponding increase in drag, and therefore, a reduction in airspeed. In the medium level turn, the lift and drag increases are very slight and the decrease in airspeed is minor. The appropriate amount of backpressure on the control column achieves this.

Figure 2
Forces in level flight and in the 45° angle of bank turn

For a steep turn a greater turning (centripetal) force is required and so the aeroplane banks to a steeper angle than for a medium turn. Therefore, increased lift is required in order to provide sufficient vertical component to equal weight and provide the horizontal component. The acceleration pushing the pilot into the seat is known as load factor (commonly referred to as G). This is equal and opposite to lift, and the wings must support it.

At 45 degrees the load factor is +1.4 G and at 60 degrees angle of bank the load factor is +2 G, and the occupants will feel twice as heavy. The load factor is often referred to as apparent weight – because it is an acceleration (force) that the wings must support, similar to weight.

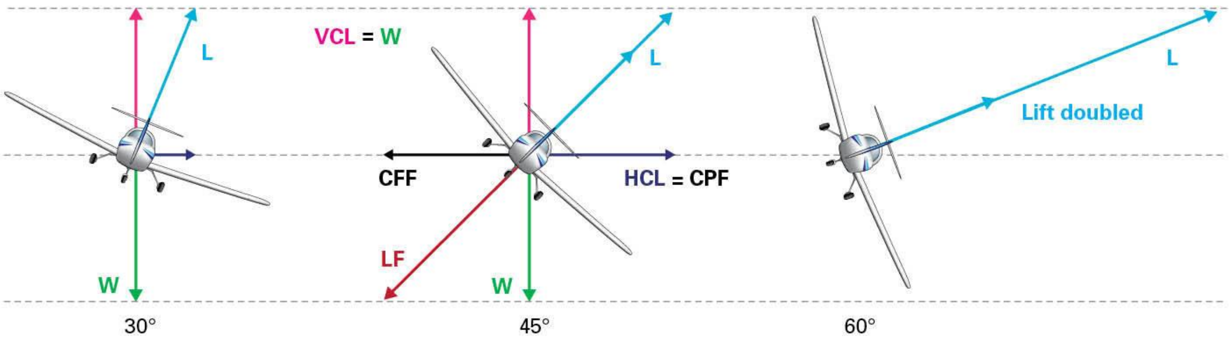


Figure 3
Forces in the 30°, 45° and 60 ° angle of bank turn

The stall speed in a manoeuvre increases as the square root of the load factor (LF). Assuming a stall speed of 55 knots in level flight, at 60 degrees angle of bank the stall speed will increase by the square root of the load factor +2 (√2), which is approximately 1.4. This means that, at 60 degrees angle of bank, the stall speed is increased by 40% to 77 knots.

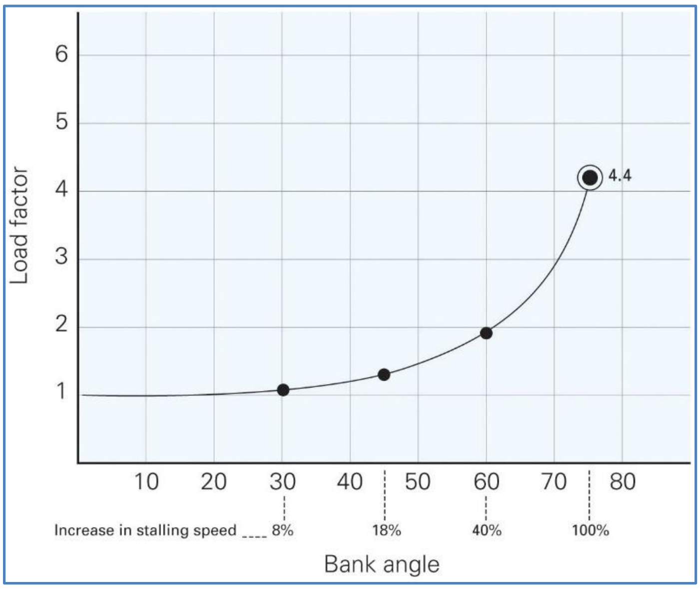


Figure 4
Relationship of Load Factor, Bank Angle and Stall Speed

At the same time, because lift is increased by increasing the angle of attack, adversely affecting the L/D ratio, the drag also increases, resulting in decreased airspeed.

It is an undesirable situation to have the stall speed increasing and airspeed decreasing. Therefore, the power is increased to combat the increased drag to maintain a margin over the stall speed. This can be referred to as a power sandwich.

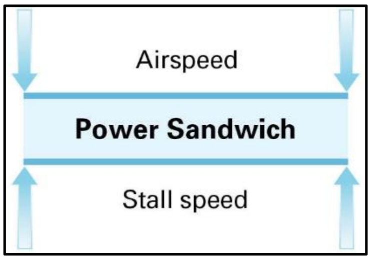


Figure 5
Power Sandwich

As the increase in drag, load factor and stall speed is not linear, the effect of increasing drag must be compensated by an increase in power in turns at angles of bank greater than 30 degrees. At 45 degrees angle of bank this increase will be about 100–200 RPM.

Source: CAA Flight Instructor Guide

Recent Aviation Occurrence Reports published by the Transport Accident Investigation Commission (most recent at top of list)

AO-2015-002	Mast bump and in-flight break-up, Robinson R44, ZK-IPY, Lochy River, near Queenstown, 19 February 2015
AO-2013-008	Boeing 737-300, ZK-NGI, Loss of cabin pressure, near Raglan, Waikato, 30 August 2013
AO-2013-003	Robinson R66, ZK-IHU, Mast bump and in-flight break-up, Kaweka Range, 9 March 2013
AO-2014-002	Kawasaki BK117 B-2, ZK-HJC, Double engine power loss, Near Springston, Canterbury, 5 May 2014
AO-2013-006	Misaligned take-off at night, Airbus A340, CC-CQF, Auckland Airport, 18 May 2013
AO-2010-009	Addendum to Final Report: Walter Fletcher FU24, ZK-EUF, loss of control on take-off and impact with terrain, Fox Glacier aerodrome, South Westland, 4 September 2010
AO-2012-002	Airbus A320 ZK-OJQ, Bird strike and subsequent engine failure, Wellington and Auckland International Airports, 20 June 2012
AO-2013-005	In-flight loss of control, Robinson R22, ZK-HIE, near New Plymouth, 30 March 2013
AO-2013-007	Boeing 737-838, ZK-ZQG, stabiliser trim mechanism damage, 7 June 2013
AO-2013-009	RNZAF Boeing 757, NZ7571, landing below published minima, Pegasus Field, Antarctica, 7 October 2013
AO-2013-002	Robinson R44, ZK-HAD, engine power loss and ditching, Lake Rotorua, 24 February 2013
11-007	Descent below instrument approach minima, Christchurch International Airport, 29 October 2011
11-006	Britten-Norman BN.2A Mk.III-2, ZK-LGF, runway excursion, Pauanui Beach Aerodrome, 22 October 2011
11-003	In-flight break-up ZK-HMU, Robinson R22, near Mount Aspiring, 27 April 2011
12-001	Hot-air balloon collision with power lines, and in-flight fire, near Carterton, 7 January 2012
11-004	Piper PA31-350 Navajo Chieftain, ZK-MYS, landing without nose landing gear extended, Nelson Aerodrome, 11 May 2011

Price $17.00

ISSN 1179-9080 (Print)
ISSN 1179-9099 (Online)