Australian Government
Australian Transport Safety Bureau

Loss of control involving SOCATA TB 20, VH-HBB

3 km south of Lismore Airport, NSW | 9 November 2012

Investigation

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Aviation Occurrence Investigation
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Addendum

Page	Change	Date
9	Minor typographical error corrected	13 March 2014

Safety summary

What happened

Main wreckage site

Source: ATSB

On 9 November 2012, a student and instructor departed Gold Coast Airport, Queensland for a training flight in a SOCATA TB 20, registered VH-HBB, to Lismore Airport, New South Wales. This included circuit training as part of the student's conversion to the aircraft type. On their fifth circuit, and while making a left turn from downwind to base, the aircraft aerodynamically stalled and the left wing dropped steeply. A recovery was commenced, but the aircraft collided with terrain in a paddock to the east of the Bruxner Highway, about 3 km south of Lismore Airport. Both occupants received fatal injuries and the aircraft was destroyed by the impact and an intense fuel-fed, post-impact fire.

What the ATSB found

The ATSB found that while making a left turn in the circuit, an aerodynamic stall occurred, resulting in a significant left-wing low and nose-down attitude in close proximity to the terrain. The instructor was unable to prevent the stall from occurring due to either insufficient warning or available time to react. Although it appeared that a stall recovery was commenced, the aircraft stalled at an altitude from which they were unable to fully recover to controlled flight before the aircraft collided with the terrain.

The ATSB also found that the aircraft's engine contained crankcase through bolts from a different engine manufacturer that were installed in the engine prior to the aircraft's importation into Australia and were probably unapproved for use in that engine. Although these bolts did not contribute to the accident, their installation meant that the continued safe operation of the engine could not be assured.

Safety message

The accident highlights the need for pilots to minimise the risk of aerodynamic stall, particularly when in proximity to the ground, such as during take-off and landing.

In addition, aircraft owners and maintainers should ensure that all parts fitted to their aircraft are appropriately approved for the application. The use of unapproved parts means that aircraft safety cannot be assured.

Contents

The occurrence

On the morning of 9 November 2012 a student pilot arrived at Gold Coast Airport, Queensland, for an instructional flight in the student's own SOCATA TB 20 aircraft (TB 20), registered VH-HBB (HBB). While awaiting the instructor, the student discussed the day's flight with another instructor from the flying school. The student indicated that the planned flight was part of his conversion to the aircraft, including endorsements for the aircraft's retractable undercarriage and manual propeller pitch control.

After completing the pre-flight preparations, the student occupied the left seat with the instructor occupying the right seat. Recorded air traffic control radar showed HBB climbing away from Gold Coast Airport at 0929 Eastern Daylight-saving Time.[1] The aircraft travelled in a southerly direction and, when west of Byron Bay, New South Wales (NSW), turned to the south-west (Figure 1). Radar contact was lost about 10 NM (19 km) to the north-north-east of Lismore, NSW, due to the low-level limitation of the radar system.

Figure 1: Recorded radar track for VH-HBB

Source: Google Earth (aircraft track and labels added by the ATSB)

At 0946 the student broadcast on the recorded Lismore common traffic advisory frequency (CTAF)[2] that HBB was 8 NM (15 km) north of Lismore Airport, maintaining 2,400 ft inbound for circuits[3] on runway 33. About 30 seconds later the instructor made a similar broadcast, indicating

[1] The accident occurred in New South Wales, which was using Eastern Daylight-saving Time (EDT). EDT was Coordinated Universal Time (UTC) + 11 hours. However, the aircraft departed Gold Coast Airport in Queensland, which was using Eastern Standard Time (UTC + 10 hours). For consistency, EDT is used throughout this report.

[2] The frequency on which pilots operating at a non-controlled aerodrome should make positional radio broadcasts.

[3] A standard rectangular traffic pattern flown around an aerodrome when taking off from, or landing on a runway. See the section titled *Circuits*.

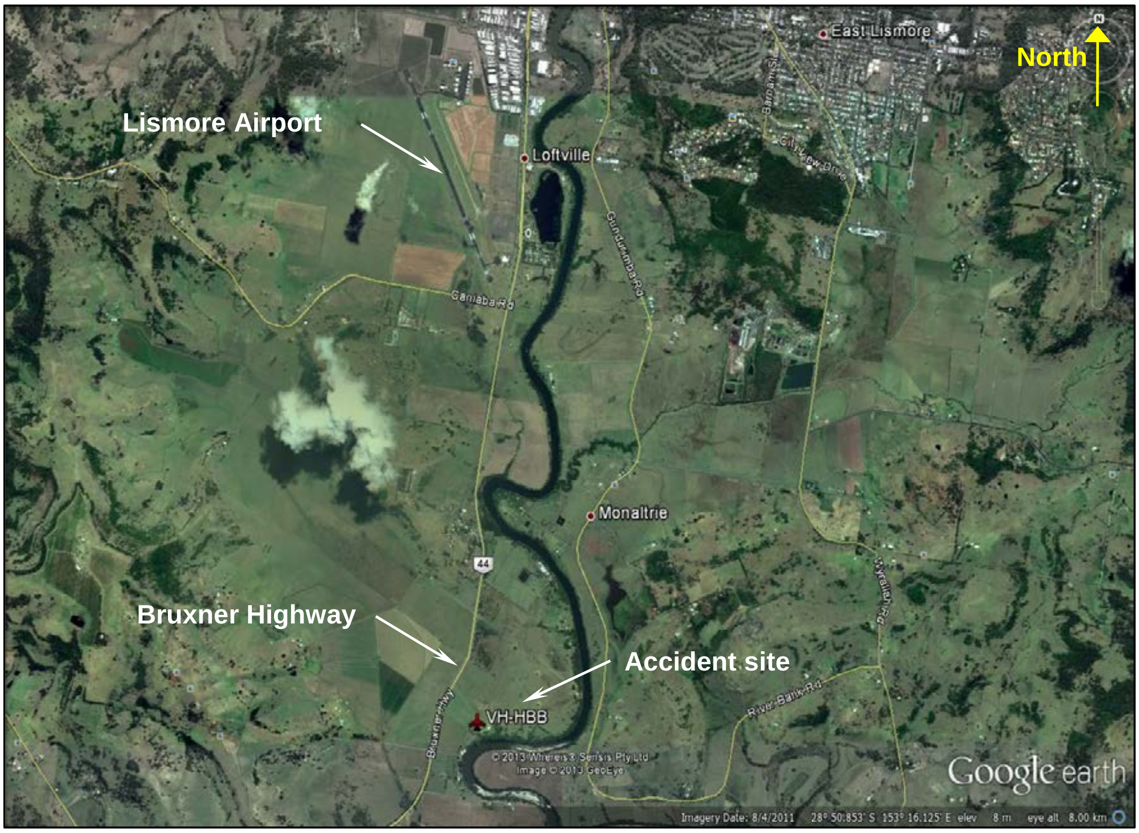
that they were on descent from 2,500 ft inbound via a different circuit joining position to that broadcast by the student.

At 0949 HBB entered the Lismore circuit on the downwind leg (see the section titled *Circuits*), joining another aircraft that was operating in the circuit. Four circuits were completed and at 1012 a broadcast on the CTAF indicated that HBB was on the downwind leg of a fifth circuit.

At about 1015, a number of witnesses travelling along the Bruxner Highway between Lismore and Casino, NSW observed the aircraft to the west of the highway in a left turn when the bank angle suddenly steepened, the aircraft pitched nose-down and descended at an angle of about 70 to 80° to the ground. One witness reported that the aircraft gained significant speed during the descent, before the nose began to rise and the rate of descent decreased.

The aircraft passed over the highway at a very low altitude (described by one witness as about two car heights above the road). A second witness described the wings of the aircraft wobbling up and down before it impacted the ground in a south-easterly direction in a paddock to the east of the highway (Figure 2). The aircraft impacted the ground in a left wing-low attitude with the nose of the aircraft level or slightly nose-up, and pointed to the left of the direction of travel (that is, with a right sideslip).

Figure 2: Location of the accident site with reference to the Bruxner Highway and Lismore Airport



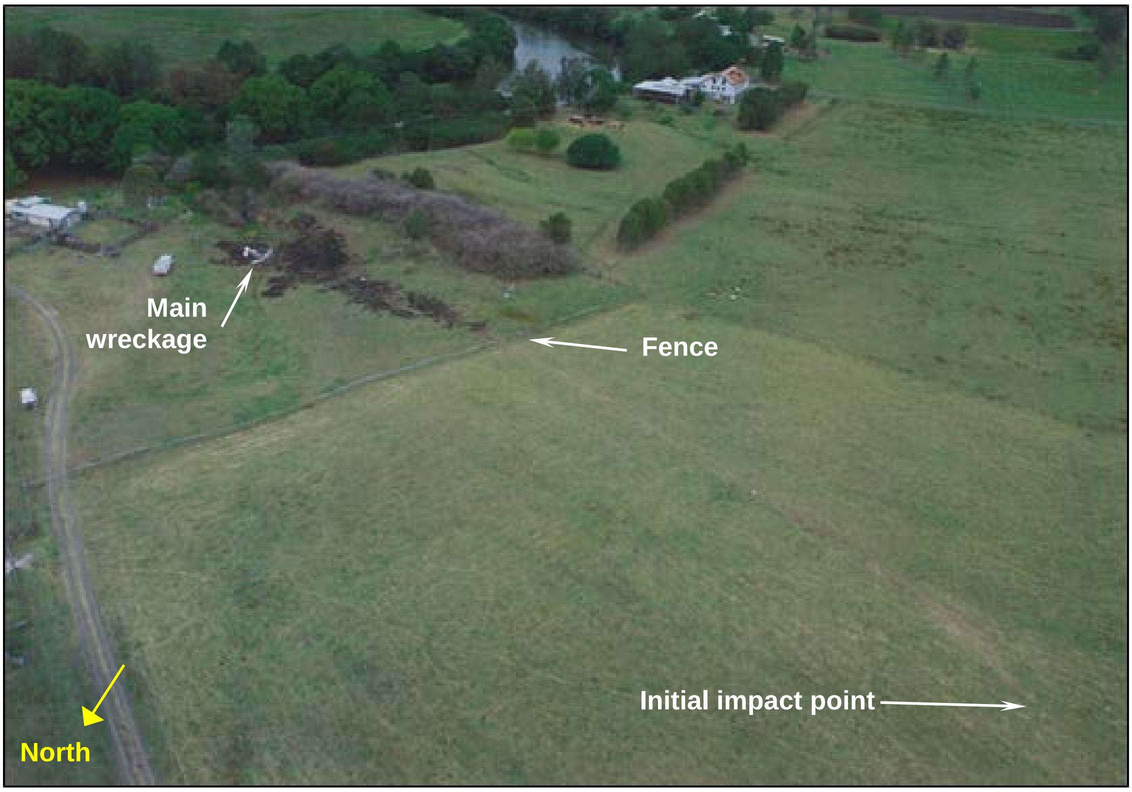
Source: Google Earth (labels added by the ATSB)

The impact broke the left main and nose landing gear from the aircraft and it continued to skid along the ground, yawing[4] to the left as it decelerated. About 100 m from the initial impact point, the aircraft passed through a wire fence that breached a wing fuel tank, releasing fuel that then ignited (Figure 3). About 1 m past the fence, the aircraft impacted a small mound of earth that separated the engine from the aircraft. That impact also resulted in the aircraft yawing further and the right wingtip impacted the ground, rolling the aircraft onto its roof. The aircraft travelled about

[4] Rotation of the aircraft around the vertical axis.

20 m further before coming to rest inverted in a gully about 170 m from the initial impact. Both occupants were fatally injured and the aircraft was destroyed by the impact and an intense fuel-fed fire.

Figure 3: Aerial view of the accident site



Source: NSW Police Force (labels added by the ATSB)

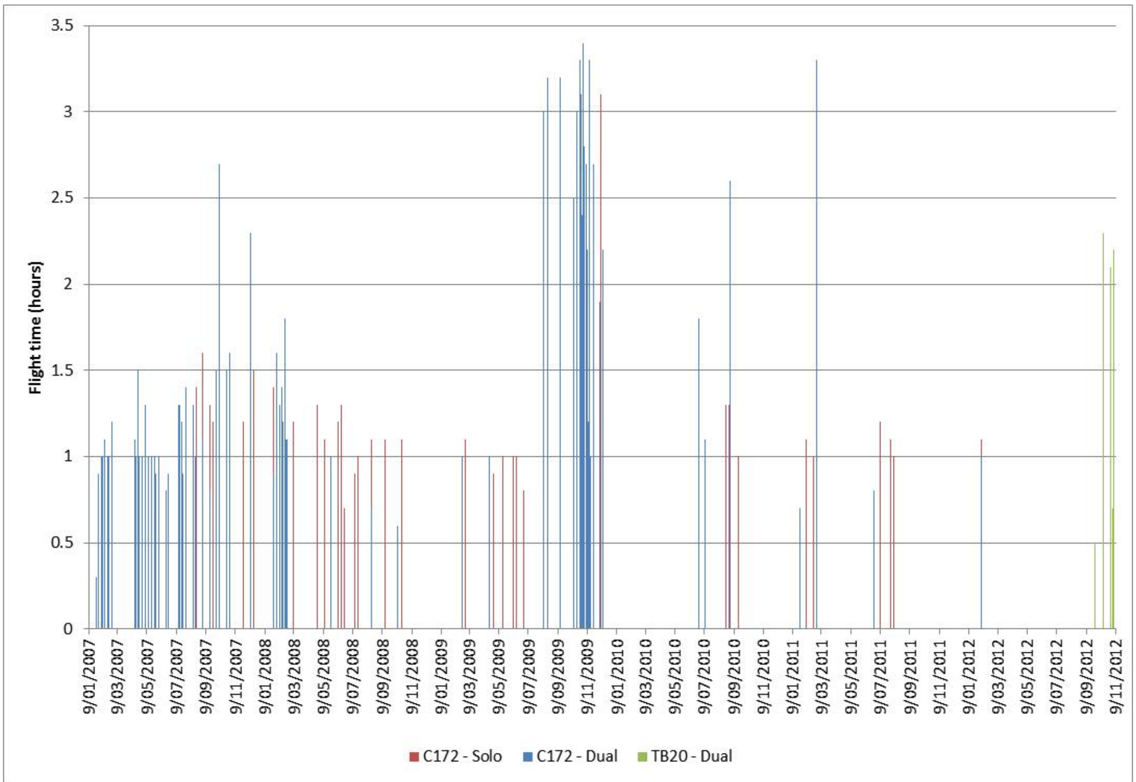
Context

Pilot information

Student pilot

The student commenced part-time flying training on 21 January 2007 and passed the General Flying Progress Test (GFPT) on 22 February 2008, having accumulated 71.3 hours (58.6 hours dual and 12.7 solo).[5] All of this training was carried out in the Cessna 172 aircraft type (C172). After passing the GFPT, the student continued training in C172 aircraft for the Private Pilot (Aeroplane) Licence (PPL(A)) with regular flights until October 2008. Following a break, flight training was re-commenced in February 2009 and continued relatively regularly until December 2009. During that time the student undertook a number of navigation flights, interspersed with general handling revision flights. Over the next 2 years, the student's flying was irregular, generally undertaken in small periods with breaks of 3 to 4 months between each period (Figure 4).

Figure 4: Distribution of the student's flying



Having conducted all of his training in the C172, the student purchased HBB in mid-2012 with the intention of continuing training in that aircraft to complete the requirements for the PPL(A). This training commenced on 25 September 2012 and, in the 12 months prior to this, the student's only flights were a dual check and solo flight on 4 February 2012 of 1 hour and 1.1 hours respectively. At the time of the accident, the student had accumulated a total of 138.7 hours flying time, 8.5 hours[6] of which was carried out in HBB over six flights, with the remainder being conducted in the C172. Table 1 summarises the student's aeronautical experience.

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5 Civil Aviation Regulation 5.76(1)(a) required a student to have at least 20 hours of flight time, which included 5 hours general flight time as pilot in command, before attempting the GFPT for aeroplanes.

6 This included 7.8 hours recorded in the flying school flight dockets and an estimate of 0.7 hours for the accident flight, based on recorded radar and radio transmissions and witness reports of the approximate time of the accident.

Table 1: Student's aeronautical experience

	Total	SOCATA TB 20
Total flying hours	186.7	8.5
Total flying hours in the last 90 days	8.5	8.5
Total flying hours in the last 30 days	8.0	8.0
Total flying hours in the last 7 days	2.9	2.9

The student's training records contained numerous flights covering general aircraft handling, both before and after passing the GFPT. There were a number of notes throughout the student's training records, particularly during the later navigation exercises, noting difficulties controlling the aircraft's attitude, with resultant variation in airspeed and altitude. There were also numerous reminders for the student to use a memory aid to assist in setting and maintaining airspeed. Several entries suggested that the student had a tendency to 'chase' the target airspeed and noted incorrect or overuse of aileron and rudder during crosswind landings. Another entry in 2009 noted that at times the student was not flying the aircraft in balance[7].

The records indicated that, during periods of regular flight training, the student showed gradual improvement in the areas in which he was having difficulty. However, after a break there was a noted degradation in those skills. In response to the difficulties being experienced by the student, the flying school applied a number of special conditions to his solo flights.

Between the student's last flight in the C172 and commencing training in the TB 20, the student changed to another flying school, reportedly to maintain continuity of training with the instructor, who had moved to the other flying school in that time. According to the student's flight training records, the instructor had been teaching the student since the commencement of his training and been responsible for the majority of the student's training. This included at least 71 of the student's 130 flights.

The training records from the latest flying school indicated that the student's training in HBB was for the issue of manual propeller pitch control and retractable undercarriage endorsements. The training records contained entries for the first three training flights in HBB. The instructor noted on the last of these records, most probably from 2 November 2012[8] that the 'student is slowly getting used to the aircraft and is making some forward progress. Constant direction is still required.'

The student had a Class 2 Medical Certificate,[9] valid until December 2012, with the requirement to have reading correction available.

Instructor

The instructor held a Commercial Pilot (Aeroplane) Licence (CPL(A)) with a current Grade 1 Flight Instructor Rating. The licence was also endorsed with a Command Instrument Rating (Aeroplane) Multi-engine instrument rating. Table 2 summaries the instructor's aeronautical experience.

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[7] An aircraft is balanced when there is no sidewards acceleration (force) felt by the occupants. Balance is maintained through the coordinated use of aileron and rudder use. A 'balance ball' instrument was installed in the aircraft to assist the pilot to maintain aircraft balance.

[8] The record was not dated, but was consistent with the entry dated 2 November 2012 in the training record summary. At the completion of that flight the student had accumulated 5.1 hours in the TB 20.

[9] A Class 2 Medical Certificate allows the holder to exercise the privileges of a private pilot licence.

Table 2: Instructor's aeronautical experience

	Total	SOCATA TB 20
Total flying hours	3,996.2	9.6
Total flying hours in the last 90 days	152.1	9.6
Total flying hours in the last 30 days	60.9	8.0
Total flying hours in the last 7 days	16.6	2.9

A review of the instructor's pilot logbook noted that the instructor had flown a range of aircraft, including the Cessna 152 and 172, Cirrus SR20 and SR22 and Beech BE-76. His experience in the C172 exceeded 2,200 hours and he had a total instructional time in all types of aircraft in excess of 3,300 hours.

Prior to commencing the student's TB 20 training, the instructor carried out a 1.1-hour maintenance flight in HBB. During that flight a number of flight sequences, including aerodynamic stalls, were conducted without incident.

The instructor held a Class 1 Medical Certificate,[10] valid until 19 May 2013, the requirement to have reading correction available.

Aircraft information

General

The SOCATA TB 20 is a low-wing, four-seat light, single-engine aircraft designed in France (Figure 5). Power is provided by a Lycoming IO-540-C4 D5D six-cylinder piston engine, rated at 250 horsepower, through a Hartzell two-bladed constant speed propeller.[11]

Figure 5: Exemplar TB 20

Source: ATSB

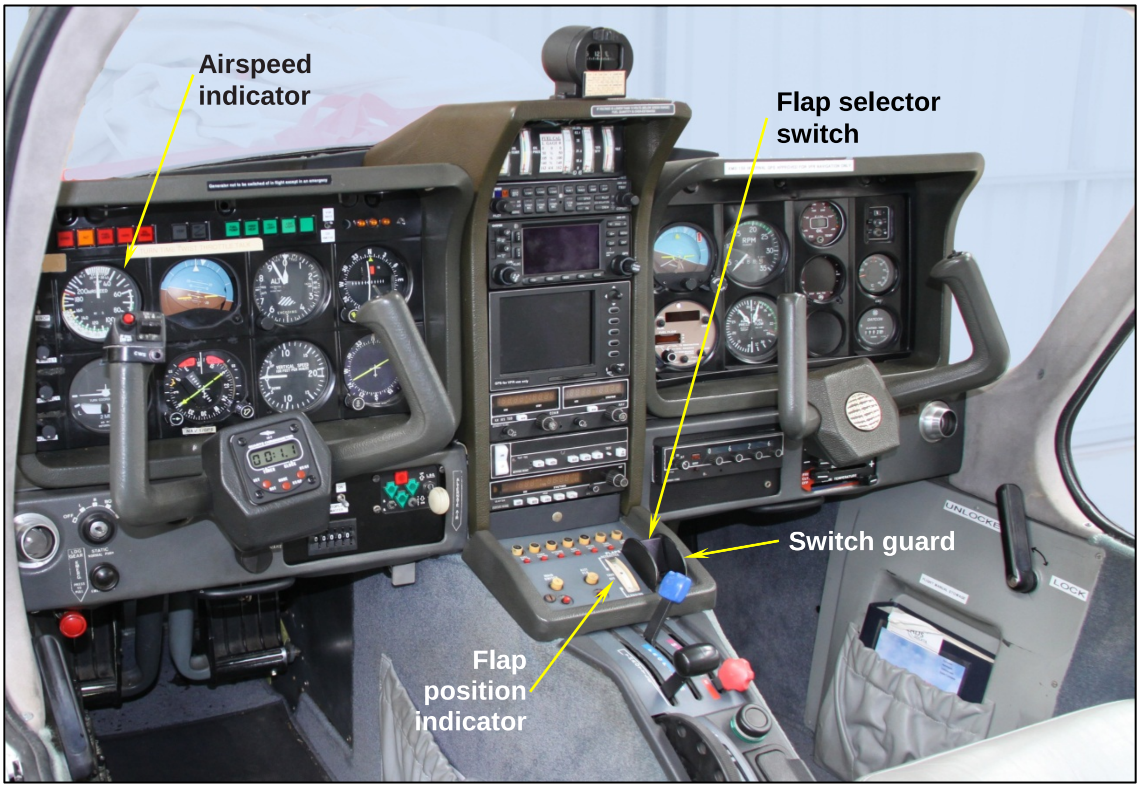
Flaps

The TB 20 is equipped with single-slot flaps on the trailing edge of the wing that span 52 per cent of the total wing span. The flap position is controlled using a three-position selector switch on the centre console. This switch allows the pilot to set the flaps to the retracted (0°), take-off (10°) and landing (40°) positions.

The flap position switch is protected by a switch guard to prevent accidental movement (Figure 6). A flap position indicator is located on the console adjacent to the selector switch.

10 A Class 1 Medical Certificate allows the holder to exercise the privileges of a CPL(A).
11 A propeller system that incorporates a governor to maintain a selected engine speed.

Figure 6: Instrument panel in an exemplar TB 20



Note: Some differences in instrumentation between the pictured aircraft and HBB may have existed.
Source: ATSB

Instruments

The aircraft's primary flight instruments were located on the left side of the instrument panel with the engine instruments in the centre and right sides (Figure 6). The instruments were recessed into the panel, with those on the right side of the panel tilted towards the left seat to improve visibility from the left seat.[12] The airspeed indicator was on the far left of the instrument panel within the left seat occupant's primary scan area (in this case, the student).

Weight and stall performance

Weight and balance

According to the TB 20 Pilot's Operating Handbook (POH), the maximum certified take-off weight was 1,400 kg.

An assessment of the aircraft's weight and balance during the flight was made based upon the aircraft's basic weight, the weight of the occupants from their most recent medical examinations, full fuel minus an estimate of the fuel burnt prior to the accident and an estimate for any baggage carried. Given these estimations, the weight of the aircraft at take-off was calculated to have been about 1,290 kg and, at the time of the accident, to have been about 1,250 kg. The centre of gravity was located between the forward and rear limits throughout the flight, but was closer to the rear limit.

Stall warning system

The TB 20 is equipped with a stall warning system consisting of a stall warning vane in the leading edge of the left wing that is electrically connected to an aural stall warning unit. When the stall warning vane senses that the airflow over the wing approaches the stalling angle, a signal is sent

[12] In aeroplanes, the left seat is generally the primary control seat.

to the stall warning unit, which produces an aural tone through an alarm speaker on the cockpit ceiling. The stall warning system was set to produce a stall warning tone 5-10 kt above the stall speed in all configurations.

The stall speeds listed in the TB 20 POH varied according to aircraft configuration and the bank angle[13] (Table 3).

Table 3: TB 20 stall speeds listed in the POH[14]

Configuration	Bank angle		
	0°	30°	45°
	KIAS[15]	KIAS	KIAS
Flaps retracted Landing gear retracted	70	75	83
Flaps take-off Landing gear up or down	65	70	77
Flaps landing Landing gear down	59	63	70

Stall recovery in the TB 20

The POH contained the following caution regarding stalls:

> **ATTEMPT PRACTICE STALLS ONLY WITH SUFFICIENT ALTITUDE FOR RECOVERY**
>
> Power-on stalls require an extremely steep pitch attitude. If the centre of gravity is at or near its aft limit, a slight tendency toward wing rocking or a wing drop may occur when the stabilator is deflected near its stop.
>
> Aerodynamic warning (pre-stall buffet) is low with power idle and more pronounced at higher power settings. Stall recovery can be effected immediately by easing the stick forward. Altitude loss is minor in all cases and is minimized by prompt application of power at the onset of the stall.

The aircraft manufacturer informed the ATSB that when the aircraft is in a left turn and stalls, the bank angle stays very close to the initial value if less than 60° and the nose will pitch down. If higher than 60° bank angle, the aircraft enters a spiral dive. They also noted that if the aircraft adopted the attitude described by the witnesses, the aircraft could descend up to 800 ft before being able to be fully recovered from the stall.

History of VH-HBB

HBB was manufactured in the United States (US) in 1996 and operated in Israel and the US prior to importation into Australia. In 2006, while operating in the US, the engine was overhauled by a US Federal Aviation Administration (FAA)-approved engine shop. The aircraft had a total time in service of 1,324.9 hours at that time.

The aircraft was purchased from the US and shipped to Australia in a partially disassembled form. It was placed on the Australian Civil Register on 31 August 2012 and re-assembled at the flight school's maintenance facility at Gold Coast Airport in September 2012. During reassembly a 100-hourly inspection was carried out for the Certificate of Airworthiness (CofA), which was issued on 25 September 2012. At that time the aircraft had a total time in service of 2,402.1 hours. The aircraft logbooks indicated that all applicable airworthiness directives were completed during the CofA inspections. Maintenance records showed that no other maintenance was carried out following reassembly and there were no outstanding maintenance issues at the time of the accident.

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13 Because of the additional lift required in a level turn, the stall speed increases as the bank angle increases.
14 For example, the stall speed at 0° bank with the flaps and landing gear retracted is 70 KIAS.
15 Knots indicated airspeed

A maintenance release was issued for the aircraft on 21 September 2012, the original of which was not found and was probably destroyed in the post-impact fire. However, a copy of the maintenance release was made at the time of issue. That copy did not indicate any known defects with the aircraft.

Following the reassembly, the instructor and the maintenance organisation's chief engineer carried out a post-maintenance check flight. The chief engineer recalled that during the maintenance flight, three straight and level stalls were carried out: power off clean, power off with full flap, and power on clean. He recalled that with the power off, the aircraft stalled with a gentle nose down and slight left wing drop. With power on, the aircraft stalled with a slight nose drop and slight roll to the right.

Meteorological information

Observations from the automatic weather station at Lismore Airport were recorded every half hour. The recorded weather conditions at 1000 and 1030 (about 15 minutes before and after the accident) indicated that the wind at the airport was from the north at 6-7 kt (11-13 km/h) and any gusts (if present) were less than 10 kt (19 km/h). Cloud was scattered[16] at 3,200 to 3,400 ft; visibility was greater than 10 NM (19 km) and the QNH[17] was 1016 hPa.

Communications

Lismore Airport operated on a common traffic advisory frequency (CTAF) and all radio communications on this frequency were recorded. Review of those recordings identified the following communications from the pilots in HBB:

Time (EDT)	Description of transmission [who made transmission]	No. of landings completed
0945:53	Inbound call about 8 NM to the north of Lismore indicating that they were planning to join the Lismore circuit at a mid-field crosswind leg [student]	0
0946:20	Inbound call repeated clarifying that they would join the circuit on the downwind leg [instructor]	0
0949:29	Notification of joining the downwind leg [student]	0
0951:54	Notification of turning onto the base leg of the circuit [student]	0
0957:44	Notification of turning onto the base leg of the circuit [instructor]	1
1001:23	Notification of turning onto the downwind leg of the circuit [student]	2
1007:29	[Overtransmission[18] at about the time a transmission from HBB was expected to advise other traffic of a turn onto base]	3
1012:27	Notification of turning onto the downwind leg of the circuit [student]	4

Other than the overtransmission at 1007:29, all transmissions from HBB were clear and understandable.

Other traffic in the circuit

A review of the recorded CTAF transmissions identified that during the time that circuits were being conducted in HBB, there were a number of other aircraft in the circuit and in proximity to the airport. At the time of the accident however, there was only one other aircraft in the circuit that was

16 Cloud cover is normally reported using expressions that denote the extent of the cover. Scattered indicates that cloud was covering between a quarter and a half of the sky.

17 Altimeter barometric pressure subscale setting to provide altimeter indication of height above mean seal level in that area.

18 When more than one aircraft transmits simultaneously on the same frequency, the resulting sound is garbled and speech cannot be distinguished.

positioned approximately opposite to HBB (that is, at about the time of the accident, the other aircraft was upwind, or on early crosswind).

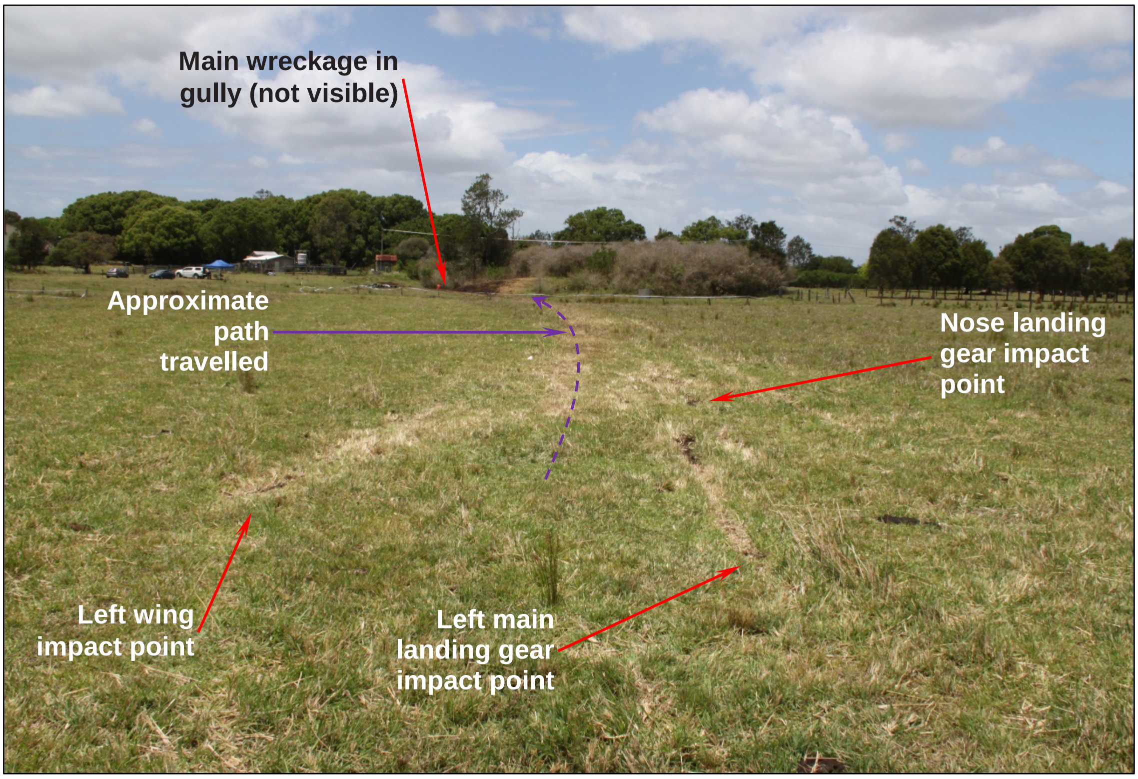
Aerodrome information

Lismore Airport is located to the south-east of Lismore township and was operated as a non-controlled airport (that is, there was no air traffic control service provided by a control tower). The airport had a single sealed runway that was 1,647 m in length, aligned 146°/326° magnetic and designated runways 15/33 respectively. The airport was 35 ft above mean sea level.

Wreckage information

The wreckage trail consisted of two distinct areas that were divided by a fence. The initial part of the wreckage trail was characterised by scoring and gouging of the grass with a sparse distribution of aircraft wreckage (Figure 7). That wreckage was primarily associated with the left wingtip, left main landing gear and nose landing gear.

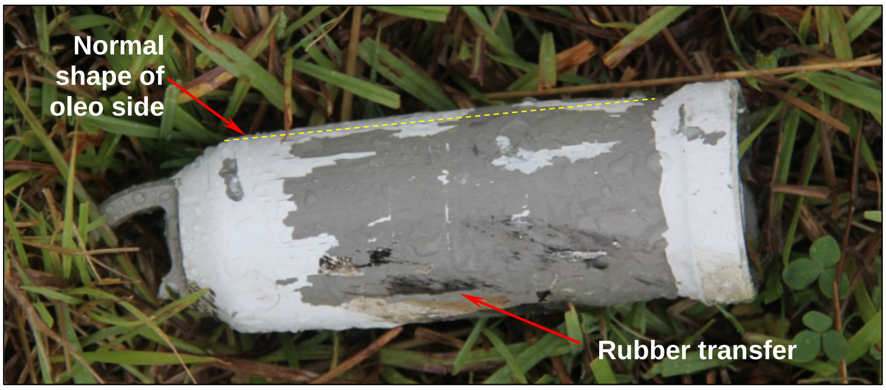
Figure 7: View looking in a south-easterly direction along the wreckage trail from initial impact towards the main wreckage



Source: ATSB

The ground impact marks and the damage to the landing gear indicated that it was extended at impact. There was no indication of pre-existing damage to the left main and nose landing gear. The left main landing gear oleo was bulged out from its normal straight sides and had rubber transfer marks from contact with the tyre, both indicating that it had been subjected to a large vertical load (Figure 8).

Figure 8: Left main landing gear oleo showing bulging



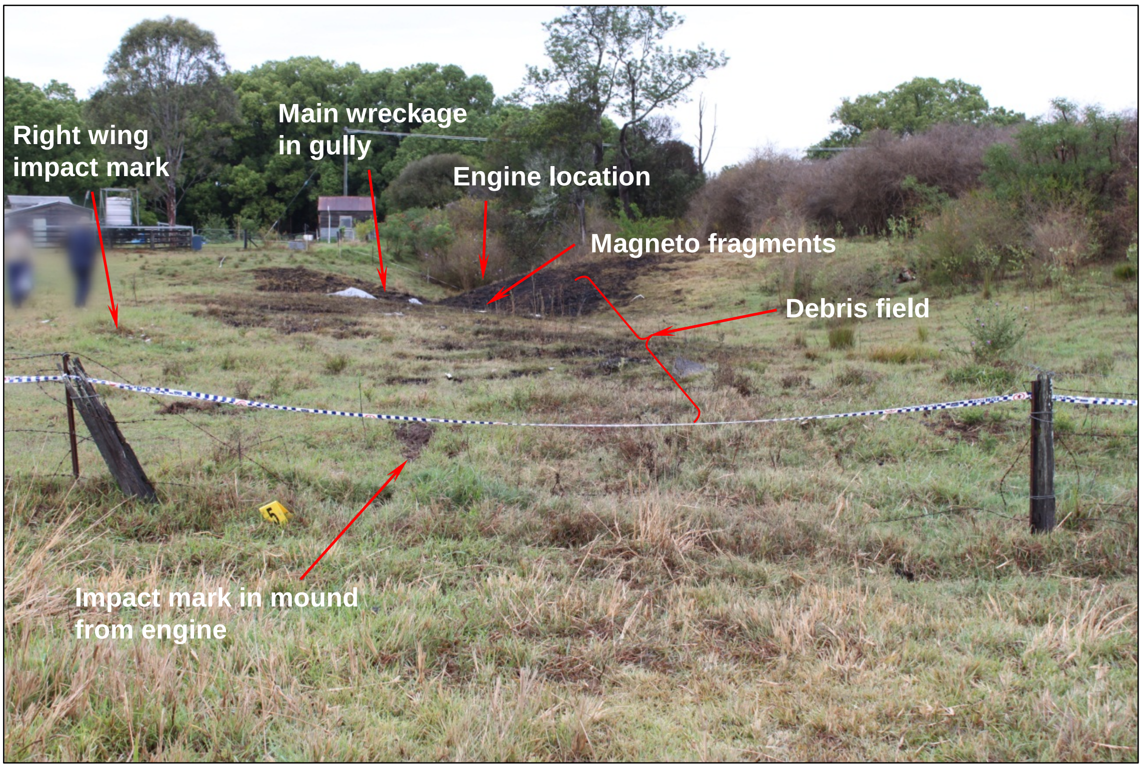
Source: ATSB

The nose landing gear fork had separated from the strut and was deformed in a manner indicating that it had sustained a large side load towards the left. The nose wheel had separated from the fork and was located further along the wreckage trail.

The pitot probe[19] was found separated from the wing. The probe was examined on-site and found to have been filled with soil, similar in appearance to the soil at the accident site. Ground marks indicated that the pitot probe was attached to the wing at impact.

The aircraft passed through a three-strand barbed wire fence that was strung between timber and steel posts spaced about 5 m apart (Figure 9). All three strands of barbed wire were fractured; however, there was no indication of aircraft contact with the fence posts.

Figure 9: Wreckage trail through the fence



Source: ATSB

[19] An open-ended tube facing forward into the oncoming airstream that is used to determine the airspeed.

Beyond the fence, the grass in the area was burnt consistent with an intense fuel-fed fire. A significant ground impact mark about 1 m beyond the fence was probably the point at which the engine separated from the fuselage. Another impact mark to the left of the main wreckage trail contained sections of material from the right wingtip. This was consistent with the right wingtip impacting the ground while the aircraft was moving sideways.

The debris field between the fence and the main wreckage contained fragments of engine cowl, windscreen and windows, engine mount parts and contents from within the cabin.

The main wreckage was located in a shallow gully. The aircraft came to rest inverted and facing in a westerly direction (Figure 10). The fire was most intense in the gully and resulted in significant post-impact damage to the structure. Despite that damage, all the aircraft's major components were accounted for at the site.

Figure 10: Main wreckage

Source: ATSB

Many of the control system components were damaged or destroyed by the fire, which precluded a complete examination. Of those parts that could be examined, there was no indication of any pre-impact damage that would have precluded normal operation.

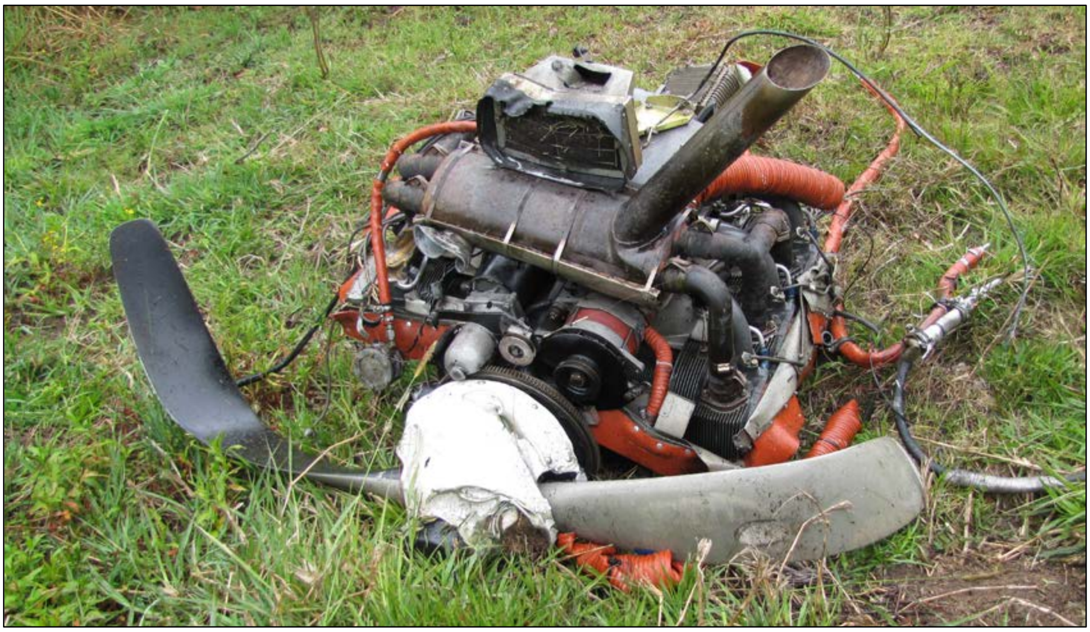
The flap actuator was identified within the wreckage. Measurement of the actuator indicated that the flaps were in the landing configuration (fully extended) at ground impact.

The only stall warning system component that was not destroyed by the fire was the stall warning vane on the wing leading edge, which was distorted and extensively heat damaged. It could be moved by hand but did not electrically function, probably as a result of the impact sequence and subsequent fire.

After the engine separated from the aircraft it impacted the wall of the gully before coming to rest about 13 m beyond the main wreckage. The engine was primarily intact, except for the magnetos[20] on the rear of the engine, and was unaffected by the fire (Figure 11). Remnants of the magnetos were found at the point the engine impacted the gully wall. The engine was retained by the ATSB for further examination. With the exception of the magnetos, which were severely damaged by the impact and unable to be tested, that examination did not identify any issues that would have precluded normal engine operation.

20 A magneto is a form of electrical generator that is part of the ignition system for the engine.

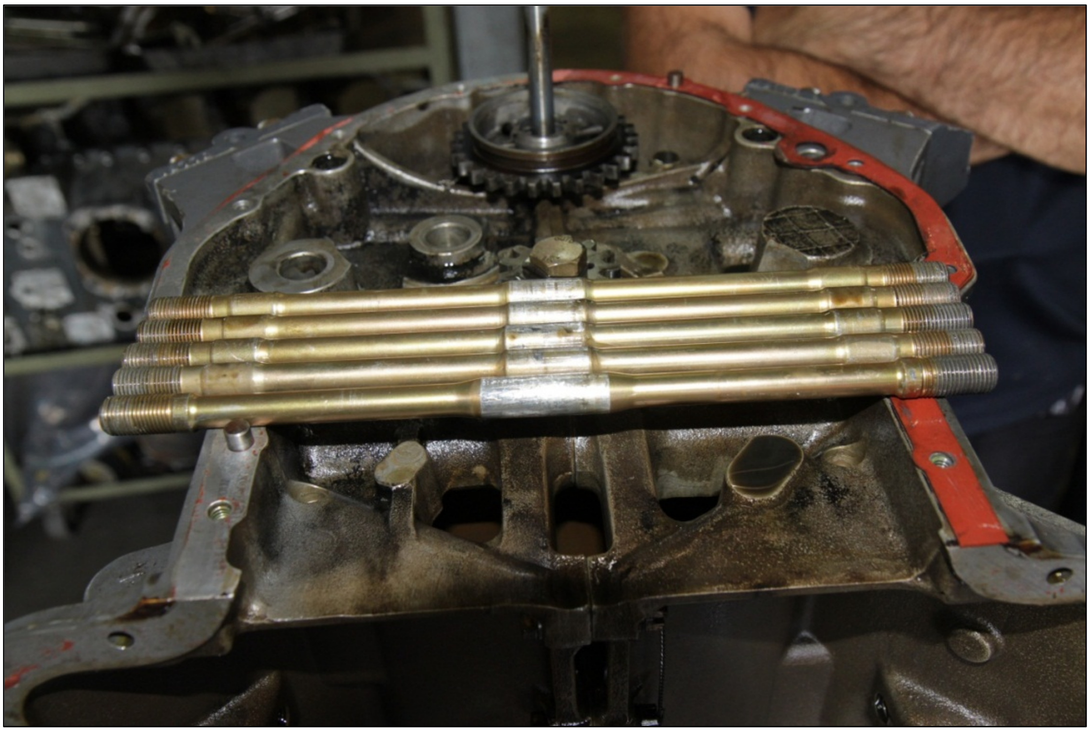
Figure 11: Engine - on-site



Source: ATSB

Although they did not affect engine performance or have an effect on the accident, the engine examination determined that four of the eight through bolts that hold the engine crankcase halves together were from a Continental Motors engine (Figure 12). There was no associated paperwork indicating that those parts were approved for use in a Lycoming engine and they could not be identified without disassembling the engine.

Figure 12: One Lycoming (foreground) and four Continental Motors through bolts from the engine



Source: ATSB

The history of the Continental Motors through bolts was unknown; however, some contained score marks that were made before the bolts were cadmium plated, suggesting that they were second-hand (Figure 13). Continental Motors Service Bulletin SB97-6B, Mandatory Replacement Parts (overhaul), stated:

> … at engine overhaul the following parts must be discarded and replaced with new parts:
>
> 1. …
>
> 22. Crankcase through bolts

Lycoming did not stipulate this requirement for their engine through bolts.

Figure 13: Gouging under the cadmium plating on one of the Continental through bolts (arrow)

Source: ATSB

Disassembly and examination of the propeller did not find any non-impact-related damage. Three distinct marks in the ground at the initial impact point indicated that the propeller was rotating at impact and that power was being delivered by the engine. Although the amount of power could not be determined, the characteristics of the propeller marks in the soil indicated that high power was not being delivered at that time.

Medical and pathological information

Post-mortem examinations identified that the student and instructor died of impact-related injuries and that there was no indication of smoke inhalation prior to death. The examination of the instructor did not identify any conditions that could have contributed to the accident. The examination of the student identified moderately severe coronary artery heart disease, but the examiner could not 'confirm or refute' whether it was contributory to the accident.

Fire

Fire damage to the aircraft wreckage and surrounds indicated that an intense fuel-fed fire started after the aircraft passed through the barbed wire fence. There was no indication of a fire prior to the impact with the fence. The fire resulted in significant post-impact damage to the aircraft.

Additional Information

Aerodynamic stall

A wing generates lift when the airflow around the upper and lower surfaces results in a pressure difference between those surfaces. The amount of lift generated by a wing is proportional to the density of the air, the wing area, the angle of the wing relative to the direction of the airflow (angle of attack) and the square of the airspeed of the aircraft. For small angles of attack, the lift increases as the angle is increased.

At a certain angle of attack, which is a characteristic of the wing shape, the flow over the upper surface of the wing separates from the surface. This condition is known as an aerodynamic stall (or simply a stall) and results in a rapid reduction in the lift generated. For a given aircraft weight, the angle at which a stall occurs can be referenced to an airspeed, and because pilots are not normally provided with an indication of the angle of attack, the speeds at which a stall occurs are normally provided to the pilot in the aircraft's POH.[21]

The US Federal Aviation Administration (FAA) *Airplane Flying Handbook*[22] provides guidance on basic pilot skills and knowledge essential for piloting aeroplanes. The handbook contains a section on stalls that states:

> If an uncoordinated turn[23] is made, one wing may tend to drop suddenly, causing the airplane to roll in that direction.

The handbook also described aircraft behaviour during a cross-control stall - when aileron and rudder inputs are applied in opposite directions during a turn - as follows:

> In a cross-control stall, the airplane often stalls with little warning. The nose may pitch down, the inside wing may suddenly drop, and the airplane may continue to roll to an inverted position. This is usually the beginning of a spin… It is imperative that this type of stall not occur during an actual approach to a landing, since recovery may be impossible prior to ground contact due to the low altitude.

The Australian Civil Aviation Safety Authority *Flight Instructor Manual*[24] also provided information on stalls and guidance on training for the prevention of and recovery from stalls. In the case of a wing drop, this guidance included:

> Use the standard recovery, i.e. simultaneous use of power and forward movement of the control column. In addition rudder must be used to prevent the nose of the aeroplane yawing into the direction of the lowered wing.

and that a common fault during a student's recovery from a stall situation was:

> When a wing drops at the stall the student instinctively tries to correct this with aileron. The use of ailerons at the point of stall must be carefully explained to the student. Even if the use of ailerons at the stall is permitted in the type of aeroplane in use the student must understand that in some types of aeroplanes the use of ailerons will aggravate the situation.

Skill retention

A number of studies have found that the skills associated with safe and efficient flight degrade with time following acquisition of those skills. One study by the FAA that examined the retention of private pilot flight skills at 8, 16 and 24 months following private pilot certification identified a proficiency loss for all subjects and for each flight task studied.[25] Those pilots had a similar number of hours at the 24-month check to the student pilot in HBB (mean of 162.3 total hours with a standard deviation of 51.7). In its report, the FAA noted that:

> Skill loss was substantial…rapid (the majority of skill loss was documented at the 8 month check) and pervasive (virtually every subject and every task exhibited statistically significant loss)…If skills acquired during initial training are not practiced regularly, they will undergo substantial decrement.

and that:

> Flight tasks requiring a relatively high degree of integration among cognitive, procedural, and control components exhibited appreciable loss. Among these tasks were operations into and out of airports…and certain basic instrument maneuvers performed under the hood.[26] In addition, ground reference maneuvers, steep turns, and accelerated stalls showed relatively high amounts of skill decrement.

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21 Stall speeds were provided for the maximum take-off weight. At lower weights, the stall speed is lower, so provision of the speeds at the maximum weight is conservative.

22 US Department of Transportation Federal Aviation Administration 2004, *Airplane Flying Handbook*.

23 An uncoordinated (or unbalanced) turn is one where a sidewards acceleration (force) is felt during the turn due to a sideslip.

24 Civil Aviation Safety Authority 2007, *Flight Instructor Manual Aeroplane*. Issue 2

25 Childs, JM, Spears, WD & Prophet, WW 1983, *Private Pilot Flight Skill Retention 8, 16, and 24 Months Following Certification*. DOT/FAA/CT-83/34SEVILLE TR-83-17.

26 Pilots wear a special hood that shields their view outside of the aircraft so that they are required to fly solely with reference to the flight instruments. This simulates flight in instrument conditions.

In a paper on flight skill decay,[27] it was noted that:

> While it is not possible to isolate "mental" from "control" errors, flight skills deteriorate, in part, because pilots forget or confuse task requirements or they experience decrements in cognitive monitoring over extended periods of time out of the cockpit. Loss of proficiency may occur because pilots undergo a decline in recognizing and organizing the cues that are necessary for safe and efficient flight.

The authors of this paper also noted that pilots 'often were unaware such errors had been made.'

Reaction times

In a study conducted by the US National Aeronautics and Space Administration (NASA) that examined airline pilot training and abnormal events,[28] NASA found that when problems were presented in a routine way as seen in training, pilots gave appropriate responses. However, when the abnormal events were presented unexpectedly, pilots' responses were less appropriate and showed greater individual variation. For example, during stall events that were presented with no warning, response times were significantly longer and more variable compared to the stall demonstration. In the case of low-altitude stalls, response times ranged from 1.9 to 18.2 seconds with an average response time of about 8 seconds. In addition, there was no significant correlation between total flight experience and time to respond to the stall, that is, flight experience did not appear to affect reaction times.

Similar occurrences

A review of international accident investigations identified one TB 20 accident and one TB 10[29] accident where the witnesses described similar characteristics to the accident involving HBB. These accidents and investigation findings are summarised in the following sections.

SOCATA TB 20, registered N575RM, Texarkana, Arizona, USA 3 October 2003[30]

The US National Transportation Safety Board (NTSB) found that:

> The flight was returning to the airport so the student pilot could practice a few landings, including a practice engine-out approach and landing. During the practice simulated engine-out landing, the airplane's left wing struck the ground while turning toward the runway. A witness reported observing the airplane make a turn, and it appeared to be paralleling the runway while continuing "to descend to 500 feet agl [above ground level] or less." At an altitude of 200 or 300 feet agl, the "aircraft rolled into a 60 to 80 degree banked left turn" toward the runway. The airplane appeared to "stall," and the left wing impacted the ground. The witness further reported that "at no time did [he] hear an engine noise or any changes in power from what seemed to be power-off or idle power." The flight instructor reported that the left turn and bank looked like a "normal" standard rate turn at the beginning, but it "suddenly became very steep." The flight instructor stated that she had reminded the student "that even if we were doing the practice engine out procedure back to the runway, that he could add power back if he felt we were getting too low." According to the flight instructor the flight was in preparation for the student pilot to take the single-engine land airplane private pilot examination. No structural or mechanical anomalies were observed during an examination of the airplane.

The NTSB determined that the probable cause of this accident included an inadvertent stall by the student pilot.

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[27] Childs, JM & Spears, WD 1986 'Flight-skill Decay and Recurrent Training', *Perceptual and Motor Skills,* pp 235-242.

[28] Casner, SM, Geven, RW & Williams, KT 2012. 'The Effectiveness of Airline Pilot Training for Abnormal Events' *Human Factors: The Journal of Human Factors and Ergonomics Society.* Published online 26 November 2012, retrieved 30 April 2013.

[29] The SOCATA TB 10 is a very similar aircraft to the TB 20. The primary differences are that the TB 10 has a lower power 4-cylinder engine and fixed landing gear. The wing, empennage and fuselage are otherwise the same, resulting in similar aerodynamic behaviour.

[30] NTSB investigation FTW03FA003, available at http://www.ntsb.gov/.

SOCATA B10, registered OY-CAK, Koege Bay, Denmark 6 August 2004[31]

The Danish Air Accident Investigation Board investigation report into this accident noted that:

> Some of the witnesses saw the aircraft maneuvering at a low altitude just before the accident. The witnesses that were observing the accident saw the aircraft in a "spiral dive", impacting the sea with the right-hand wing and engine first.

and summarised the findings of the investigation as follows:

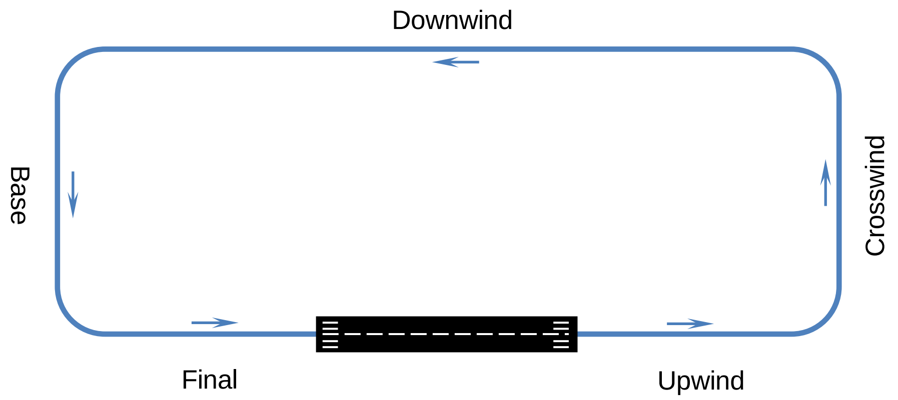
> Due to the aircraft's wing design, the outer part of the aircraft's wing could stall before the rest of the wing. As a result, the aircraft could get into an unintended roll and subsequent spin. The commander carried out flying maneuvers at low altitude and at low speed. During one of these maneuvers, the aircraft started to stall, and went into a spin. Due to the low altitude, the commander could not recover from this spin before it hit the surface of the sea.

Circuits

Terminology

A circuit is a standard flight pattern used around an airport that consists of up to 5 legs – upwind, crosswind, downwind, base and final (Figure 14). Although a standard pattern, the length of each leg and circuit altitude can be adjusted to suit the performance of different aircraft, to give a student more time during the approach or to accommodate other traffic in the circuit.

Figure 14: Standard circuit pattern



The Aeronautical Information Publication (AIP) Australia recommends a normal circuit height for medium performance aircraft (most piston engine aircraft operating between 55 and 150 kt) operating at non-controlled aerodromes of 1,000 ft AGL.[32] The descent to the runway normally commences when turning onto base.

Standard circuit radio transmissions

The AIP Australia provides a summary of the radio broadcasts applicable to aircraft operations at non-controlled aerodromes. These broadcasts provide advisory traffic information to other aircraft and pilots 'whenever it is reasonably necessary to do so to avoid a collision, or [there is] the risk of a collision with another aircraft in the vicinity of the aerodrome'. Other recommended broadcasts include advising when the aircraft was inbound to the aerodrome and/or ready to join the circuit.

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31 Danish Accident Investigation Board investigation HCL 54/04, available at http://www.havarikommissionen.dk/en/.

32 AIP ENR 41 Circuit Information, Separation Minima and Height, paragraph 41.3.1 (page ENR 1.1-72)

Circuit speeds

The pilot's training records for the C172 contained a portion of a circuit diagram with notes regarding the flap setting, speed and target altitudes for the various legs of the circuit. Those notes indicated target speeds/altitudes of:

Late downwind	85 kt at 1,000 ft
Base	75 kt at 750 ft
Final	65 kt at 500 ft

There were no similar notes found for the TB 20 and, because it was not one of their fleet of training aircraft, the flying school did not have a published standard circuit pattern for the TB 20.

Safety analysis

The occurrence

Introduction

While on a training flight from Gold Coast Airport, Queensland, the student and instructor were conducting circuits at Lismore Airport, New South Wales. Based on witness accounts it is likely that during a left turn from the downwind to base leg of a circuit, the aircraft aerodynamically stalled (stall). Those accounts also indicated that following the stall, the aircraft attained a significant left wing-low and nose-down attitude. Although it appeared that a stall recovery was commenced, recovery to controlled flight was not completed before the aircraft collided with the terrain.

Although examination of the wreckage was somewhat limited by the effects of the post-impact fire, no defects were identified that would explain the loss of control. Also, there were no radio transmissions from the aircraft to indicate a problem, and the local meteorological conditions around the time of the accident suggested that a meteorological event, such as a sudden and large wind gust that might contribute to a stall, was unlikely to have occurred.

The evidence indicated that the engine was operating at impact, albeit not at high power as would have been expected as part of the standard stall recovery technique. The ATSB could not conclusively determine why the engine was not at a higher power setting at impact; however, there was no evidence to suggest any impediment to normal engine operation.

Development of and recovery from the stall

Although there was no direct evidence of who was handling the aircraft when the stall occurred, given the purpose of the flight, the student's experience in the aircraft, and the number of circuits already completed, there was no obvious reason why the instructor would have been the handling pilot. However, given the instructor's experience and requisite skill levels, if in control, it is unlikely that his actions would have resulted in the aircraft stalling in the circuit.

The student’s training records indicated slow progress attaining the required flying skills and a rapid degradation in those skills when they were not being regularly applied. Studies have shown that such skill degradation is common following a break in flying activity. The student’s break from flying before commencing training in the TB 20 may have contributed to his difficulty in maintaining aircraft control and airspeed.

Although the student’s training records for the earlier flights in HBB indicated that the student was improving, they also indicated the need for constant direction, consistent with him still having difficulty controlling the aircraft. In that context, it is possible that the turn onto base may have been unbalanced, increasing the risk of a cross-control stall. In such a situation, as identified in the US Federal Aviation Administration (FAA) *Airplane Flying Handbook*, there may have been little warning of the stall. This may explain why the instructor was not able to prevent its occurrence, despite being aware that the student required close supervision.

The ATSB also considered whether the stall may have been due to the student not adequately controlling the airspeed, and why the instructor was unable to prevent it when a stall warning would normally be expected. In this regard, the instructor’s confidence in the student’s ability to control the speed may have improved over the preceding four circuits. Alternately, the instructor may have been distracted by other tasks during the base turn. The position of the airspeed indicator on the far side of the instrument panel from the instructor may have degraded the instructor’s ability to monitor the airspeed while performing other tasks.

The flaps were found in the fully extended position; however, it would be unusual for full flap to be selected when turning onto base in the circuit. The first stage of flaps would typically be selected at that point, but on occasion, full flap may be used to slow the aircraft such as to accommodate other traffic in the circuit. On this occasion, the only other traffic in the area was well ahead of HBB. The ATSB could not determine when the selection of full flap occurred, but the large flaps on the TB 20 would have generated significant drag and resulted in a rapid deceleration. This would have impacted on the time between any stall warning activation and the onset of a stall, reducing the time available to recognise and react to the warning before the stall occurred.

The stall speeds for the TB 20 in a turn with flaps retracted and take-off flap selected are similar to the pilot's noted target speed on base for the Cessna 172 (C172). Given that both the instructor and student had limited TB 20 experience compared to that in the C172, it is possible that one or both of them inadvertently drew on their previous experience and were slowing the aircraft for the C172 target speed, rather than that applicable to the TB 20.

Although the ATSB was unable to determine the factors that led to the aircraft stalling, the stall handling characteristics described by the maintenance facility's chief engineer and the aircraft manufacturer indicated that there should not be a significant wing drop when the aircraft stalled. In this context, the large wing drop reported by the witnesses could have been due to either an initially incorrect stall recovery, or a consequence of an unbalanced turn leading to a cross-control stall.

United States National Aeronautics and Space Administration research into how airline pilots react to unexpected stalls found that their reaction times varied from about 2 to 18 seconds with an average of 8 seconds. Recognising that the study involved airline pilots, the time taken for a pilot to respond to an unexpected event is relevant to this scenario given that it was likely that the instructor did not expect a stall to occur during a circuit. Hence, even though it was apparent that a recovery manoeuvre was commenced, in the time it took to recognise and react to the onset of the stall, the aircraft attained an attitude from which they were unable to complete the recovery in the height available. In addition, it is possible that the student's control inputs inadvertently exacerbated the stall and/or hampered the instructor's efforts to regain control. The extent to which this may have affected the recovery by delaying the initial response or subsequent actions could not be conclusively determined.

The height of HBB when the stall occurred is unknown; however, it would not be unreasonable for an aircraft to be at about 800 ft during the turn onto base. Given that the aircraft manufacturer's advice that it could take up to 800 ft to recover the aircraft from the nose-down attitude described by the witnesses, there may not have been sufficient altitude for recovery regardless of the actions taken.

Unapproved parts

The ATSB found that half of the engine crankcase through bolts were from a different engine manufacturer. While it is possible to use parts that differ to the original manufacturer, such use must be approved. No approval to use Continental Motors bolts in this Lycoming engine was identified in the aircraft documentation and, as such, they were probably unapproved parts.

Because the Australian maintenance organisation did not disassemble the engine, the unapproved bolts were most likely installed in the engine prior to importation into Australia. The logbooks indicated that the engine was overhauled in the United States in 2006, meaning that the incorrect bolts were either installed at that time, or were installed previously and re-used during that overhaul. Additionally, as there was no need to disassemble the engine, and based on the supplied documentation, the Australian maintenance organisation would have been unaware that the incorrect bolts were installed.

The crankcase through bolts did not contribute to the accident. However, the use of unapproved parts was of concern because there had not been an appropriate engineering assessment to determine whether they would perform to a level which was at least equivalent to the original parts. Therefore, the continued performance, and hence safety, of the parts over the normal life of the engine could not be assured.

Of additional concern, some of the Continental bolts showed damage indicating that they were second-hand parts. Although, if they were in an acceptable condition, the original Lycoming through bolts could be re-used, Continental Motors required their through bolts to be replaced at overhaul. Thus, the use of second-hand Continental through bolts was not authorised in any engine and their ongoing integrity could not be assured. To compound this, the damage had the potential to further reduce the life of the bolts by adding points of increased stress, reducing their fatigue life.

Findings

From the evidence available, the following findings are made with respect to the loss of control and collision with terrain involving the SOCATA TB 20, registered VH-HBB, which occurred 3 km south of Lismore Airport, New South Wales on 9 November 2012. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing factors

- During a left turn in the circuit, an aerodynamic stall occurred, resulting in a significant left wing-low and nose-down attitude in close proximity to the terrain.
- The instructor was unable to prevent the stall due to either insufficient warning or available time to react.
- The aircraft stalled at an altitude from which recovery to controlled flight was not completed before the aircraft collided with terrain.

Other factors that increased risk

- Half of the crankcase through bolts fitted to the engine were probably not approved parts for use in that engine, meaning that the continued safe operation of the engine was not assured.

General details

Occurrence details

Date and time:	9 November 2012 – 1015 EDT	
Occurrence category:	Accident	
Primary occurrence type:	Collision with terrain	
Location:	3 km south of Lismore Airport, New South Wales	
	Latitude: 28° 52.15’ S	Longitude: 153° 15.67’ E

Aircraft details

Manufacturer and model:	SOCATA – Groupe AEROSPATIALE TB 20	
Registration:	VH-HBB	
Operator:	Private	
Serial number:	1730	
Type of operation:	Flying training - Dual	
Persons on board:	Crew – 2	Passengers – 0
Injuries:	Crew – 2 fatal	Passengers – 0
Damage:	Destroyed	

Sources and submissions

Sources of information

The sources of information during the investigation included:

- a number of witnesses to the accident
- the aircraft manufacturer
- the flight training schools that the student attended
- the aircraft maintenance organisation
- relevant recorded radio transmissions at Lismore Airport
- the US Federal Aviation Administration
- the Civil Aviation Safety Authority (CASA)
- the Bureau of Meteorology
- Airservices Australia
- the New South Wales Police Force and Coroner.

References

Casner, SM, Geven, RW & Williams, KT 2012, 'The Effectiveness of Airline Pilot Training for Abnormal Events' *Human Factors: The Journal of Human Factors and Ergonomics Society.* Published online 26 November 2012, retrieved 30 April 2013.

Childs, JM & Spears, WD 1986, 'Flight-skill Decay and Recurrent Training', *Perceptual and Motor Skills.*

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Civil Aviation Safety Authority 2007, *Flight Instructor Manual Aeroplane*. Issue 2.

Danish Accident Investigation Board aviation investigation report HCL 54/04.

National Transportation Safety Board aviation investigation FTW03FA003 Probable Cause.

US Department of Transportation Federal Aviation Administration 2004, *Airplane Flying Handbook*.

Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003* (the Act), the Australian Transport Safety Bureau (ATSB) may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the flight training schools attended by the student, one of which included the aircraft maintenance organisation, the aircraft manufacturer,the Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile (BEA) and CASA.

A submission was received from the flying training school/maintenance organisation. The submission was reviewed and where considered appropriate, the text of the report was amended accordingly.

Australian Transport Safety Bureau

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The ATSB is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

The object of a safety investigation is to identify and reduce safety-related risk. ATSB investigations determine and communicate the factors related to the transport safety matter being investigated.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

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Investigation

ATSB Transport Safety Report
Aviation Occurrence Investigation

Loss of control involving SOCATA TB 20, VH-HBB
3 km south of Lismore Airport, New South Wales, 9 November 2012

AO-2012-149
Final – 11 March 2014