Australian Government

Australian Transport Safety Bureau

Loss of control and collision with terrain involving de Havilland DH82A Tiger Moth, VH-UZB

Pimpama Airfield, Queensland, 28 December 2015

ATSB Transport Safety Report

Aviation Occurrence Investigation

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Safety summary

What happened

On the morning of 28 December 2015, a DH82A Tiger Moth, registered VH-UZB, departed Pimpama Airfield, Queensland for an adventure flight. The pilot had assessed the weather as suitable, with a headwind of 10-15 kt straight down the intended take-off airstrip.

Shortly after take-off, the pilot manoeuvred at low level, to remain over the clearest terrain for the climb out. At an altitude of between 200 and 300 ft, the engine power unexpectedly reduced. In response, the pilot made a left turn during which the aircraft entered an incipient spin. The pilot reported attempting to recover from the spin, however, the aircraft collided with terrain. The passenger was fatally injured and the pilot sustained serious injuries. The aircraft was substantially damaged.

What the ATSB found

The ATSB examined the aircraft's engine, its components and fuel system, but was unable to determine the reason for the partial power loss. The investigation also found that when the aircraft entered the spin, there was insufficient height to recover before ground contact.

Safety message

The partial power loss of an aircraft's engine presents a more complex scenario than a complete power loss, where a forced landing is inevitable. The scenario is further complicated when the partial loss occurs shortly after take-off. Further, in a partial power loss situation, the power may continue to deteriorate and/or stay at the same reduced level and/or return to normal.

Prior to take-off, pilots should consider options and actions in the event of a partial power loss. Factors to consider should include their piloting skills, experience, conditions on the day and the aircraft type-specific characteristics to decide a height below which a forced landing straight ahead is required, should a partial or complete power loss occur. Self-briefing on this subject before take-off reduces the decision-making load if a power loss does occur.

When an emergency landing is required, flying the aircraft in a controlled manner, wings level and at the recommended glide speed has a better survivability outcome than when control of the aircraft is lost.

VH-UZB

Source: Supplied

Contents

The occurrence

On the morning of 28 December 2015, a de Havilland DH82A Tiger Moth, registered VH-UZB, was prepared to conduct a 20-minute local adventure flight[1] operated by Gold Coast Aerobatic Adventures. The aircraft was to depart from and return to Pimpama Airfield near the Gold Coast, Queensland, with the pilot and one passenger.

The pilot arrived at the airfield at about 0800 Eastern Standard Time[2] and drove onto the airfield to check the windsock. He assessed the wind as being straight down the cross strip from the southeast. Based on the wind direction, he elected to conduct the take-off towards the southeast on the cross strip (Figure 1). He also assessed that, due to the forecast conditions, there would be some mechanical turbulence[3] during the flight. The pilot reported that the weather was forecast to deteriorate later in the day but he considered the conditions for the period of the adventure flight were suitable. While the cross strip was shorter than the main landing strip, it was adequate for the Tiger Moth and the pilot had reportedly used the cross strip many times for both take-off and landing.

At about 0815, the passenger and a relative arrived at the airstrip. They observed the pilot in the process of getting the aircraft out of the hangar. They went over and spoke with him while he inspected and prepared the aircraft for the flight. The pilot and passenger discussed the wind, with the pilot commenting that it would assist with take-off and landing. The pilot continued to prepare the aircraft and added about 20 L of fuel to the fuel tank, providing a total of about 60 L, sufficient for the planned flight.

The pilot assisted the passenger into the front seat of the aircraft and secured his 4-point harness. He then explained the operation of the intercom and stressed to the passenger the importance of not operating the controls.[4] The pilot then completed the pre-engine start actions.

The pilot hand swung the propeller to start the engine with wheel chocks in place (the Tiger Moth is not equipped with a starter motor). After starting the engine, the pilot climbed into the rear seat[5] of the aircraft and completed the checklist items and engine run-ups. The run-ups and magneto checks were conducted and the engine was running normally. At about 0900, after setting the engine throttle to idle, the pilot exited the aircraft, turned on the on-board video recorder and removed the wheel chocks.

After getting back in the aircraft and fastening his harness, the pilot taxied the aircraft to the take-off strip. The aircraft was stopped about halfway between the end of the take-off airstrip and the intersection of the two strips (Figure 1). The pilot reported that he elected to take-off from this location because the grass at the departure end of the runway was significantly longer than the part that he would use. The aircraft was equipped with a skid instead of a tailwheel, so the pilot exited and manually positioned the aircraft in the take-off direction.

At about 0906, the pilot commenced the take-off, with the aircraft becoming airborne 17 seconds later. About 2 seconds after it was airborne, at a height of approximately 20-40 ft above ground, the pilot commenced a left turn. After a substantial turn to the left, the pilot made a right turn back

1 A flight conducted under the administration of The Australian Warbirds Association Limited. Adventure flights are flights that are conducted to give the passenger the experience of manoeuvres, g-forces and sensations that would be expected when an ex-military aircraft was flown in its original military service role.

2 Eastern Standard Time (EST): Coordinated Universal Time (UTC) + 10 hours.

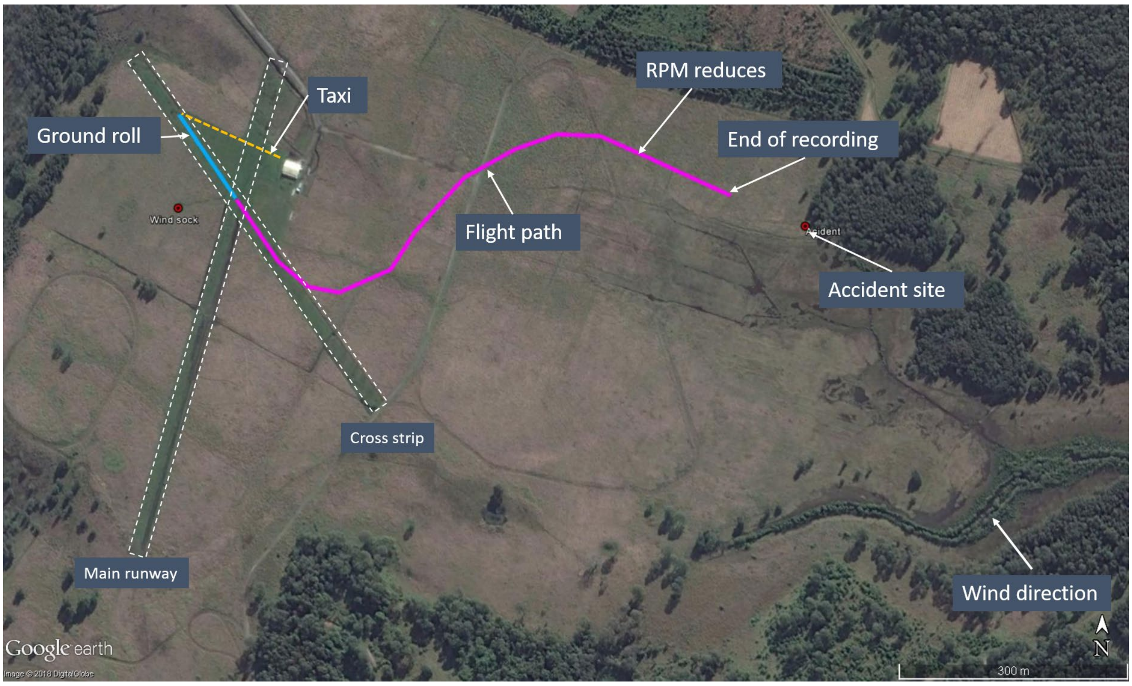
3 Mechanical turbulence is due to friction between the air and the ground (especially irregular terrain, such as trees, and man-made obstacles) creating eddies and therefore turbulence in the lower levels. The intensity of this eddy motion depends on the strength of the surface wind, the nature of the surface and the stability of the air.

4 The passenger seat had rudder pedals, a throttle control and fuel cut off, however there was no control column or mixture control.

5 The Tiger Moth is configured with two seats in tandem. The passenger seat is at the front while the pilot in command is seated at the rear.

to the approximate take-off heading (Figure 1). The pilot stated that these turns allowed additional time to climb out over clear terrain before overflying trees.

Figure 1: Flight path of the aircraft



Source: Google Earth, modified by the ATSB

The yellow dotted line indicates the aircraft's taxi, the blue line the ground roll and the pink the flight path, based on analysis of the on-board video recording (the recording stopped before the accident).

About 27 seconds after lift-off, when the aircraft was travelling approximately parallel to the take-off strip, the pilot observed a change in engine noise and a reduction in engine RPM.[6] He reported that he retarded and then fully advanced the throttle but the engine only returned to a similar lower power condition.

The pilot assessed that, as the aircraft still had partial power, he would make a left turn and return to the airfield to land. Following review of the draft report, the pilot reported that following his decision to return to the airfield, the aircraft's performance deteriorated further so he attempted to perform a forced landing in a cleared area. Soon after he started the turn, the aircraft aerodynamically stalled[7] and began to enter a left spin. The pilot recalled applying full right rudder in an attempt to stop the spin, however, the aircraft collided with the ground.

At 0916, about 9 minutes after the accident and after regaining consciousness, the pilot, who was trapped in the aircraft, called emergency services to request assistance. Emergency services arrived at the airfield at 0935 but there was a delay in locating the accident site. A rescue helicopter subsequently located the aircraft 45 minutes after the pilot's phone call. The passenger received fatal injuries and the pilot sustained serious injuries. The aircraft was substantially damaged.

6 Revolutions per minute

7 Aerodynamic stall occurs when airflow separates from the wing's upper surface and becomes turbulent. A stall occurs at high angles of attack, typically 16˚ to 18˚, and results in reduced lift.

Context

Pilot information

The pilot held a commercial pilot (aeroplane) licence and was endorsed to operate the Tiger Moth aircraft. The pilot's logbook showed a total flying experience of 1,111.4 hours to the last recorded flight on 21 December 2015, of which 23.8 were on tail-wheel aircraft, including 7.6 hours on the Tiger Moth. All the pilot's Tiger Moth experience was in UZB. The pilot had last completed a single-engine aeroplane flight review on 22 December 2014, which was valid until 31 December 2016. The pilot held a tail-wheel design feature endorsement and an aerobatic flight activity endorsement.

Medical information

The pilot held a valid Class 1 Aviation Medical Certificate without restrictions. His last medical examination was conducted on 30 January 2015 and was valid until 30 January 2016. The pilot stated that he was well rested and in good health on the morning of the occurrence.

Tiger Moth training

The pilot held a current single-engine aircraft rating and a tail-wheel undercarriage endorsement, so no additional training was required by the Civil Aviation Safety Authority (CASA) to operate the Tiger Moth.

The operator's operations manual indicated that initial training to conduct adventure flights consisted of 5 hours on type, conducted over four flights. The training could however, be tailored depending on previous experience. Flight reviews, medical and licence currency requirements were to be maintained in accordance with those applicable to charter operations. In addition, pilots were also required to have flown the aircraft type within 60 days prior to conducting an adventure flight.

The operator's insurance certificate (valid between 14 January 2015 and 14 February 2016) attached to the operations manual, indicated that, for adventure flights, pilots were to be approved by the company director subject to having a commercial pilot licence and 25 hours tail-wheel experience (as applicable for tail-wheel aircraft).

The pilot commenced employment with the operator about 4 weeks prior to the accident. Before conducting adventure flights, the pilot received 3.7 hours of training, from the aircraft owner and operator, in the accident aircraft, at Pimpama. The training included:

- general handling
- slipping and skidding turns
- aerial work
- stalls and spins
- emergency procedures, including:
  - full and partial engine failures
  - glide approaches
  - engine failures on take-off.

Organisational and management information

The operator company, PDRL, was established in 2008 and specialised in warbird adventure flights. They operated under a number of trading names, including Gold Coast Aerobatic Adventures. Their primary base of operation was in the Hunter Valley, New South Wales with the operation at Pimpama established in 2015. The accident pilot was the sole pilot operating at Pimpama and had been operating from that location since November 2015. The aircraft operated by PDRL were operated in the Limited Category[8] under the administration of the Australian Warbird Association Limited (AWAL).

The PDRL operations manual detailed how its warbird operations in limited category aircraft were to be conducted to ensure compliance with the regulations and AWAL policies. This included operations involving VH-UZB and noted the accident pilot as one of the operator's pilots. The manual specifically stated that the over-arching philosophy was that aircraft should be operated as if they were in the charter category, though recognising the specific requirement for limited category aircraft.

After the accident, AWAL conducted an audit of the operator in March 2016, at its New South Wales facilities. The audit included a review of the operator's facilities and operations as well as an aircraft inspection. The audit identified a number of required administrative corrective actions, but overall the results of the audit were deemed 'acceptable'.

CASA requirements

Civil Aviation Regulation (CAR) 1988 subregulation 166A(2)(f) requires that a pilot conducting a take-off from an uncontrolled aerodrome maintain the same track as the take-off until the aircraft is 500 ft above the terrain, unless as per subregulation 166A(4) it is necessary to avoid terrain.

Aircraft information

General

The DH82A Tiger Moth is a two-seat, single-engine biplane with a tailskid and fixed undercarriage. The accident aircraft VH-UZB (Figure 1), serial number 291, was manufactured in the United Kingdom in 1941 and had accumulated 7,986.4 hours total time in service at the time of the accident. The aircraft was powered by a Gipsy Major series 1 four-cylinder piston-engine, engine serial number 150.

Figure 2: VH-UZB

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8 A warbird, historic or replica aircraft could be issued with a limited certificate if the administering authority was satisfied that the aircraft could operate at an acceptable level of safety if flown in accordance with any limitations or conditions placed upon the aircraft's limited certificate. Airworthiness of limited category aircraft was self-administered by the Australian Warbirds Association.

Source: Supplied

The Special Certificate of Airworthiness issued to VH-UZB in the Limited Category on 20 May 2015 required that the aircraft be operated in accordance with the Royal Australian Air Force (RAAF) Publication No. 416, *Pilot's Notes for Tiger Moth Aircraft*. A copy of the publication was found in the aircraft at the accident site. These notes did not provide details of any crosswind take-off limitations. The aircraft was fitted with several placards that listed the relevant operating limitations. A summary of those limits are listed at Table 1.

Table 1: Relevant operating limits and speeds for VH-UZB

Condition	Limit (RPM)	Speed (kt)
Normal full throttle	2,100	
Take-off	2,100	
Climbing	2,100	56
Cruise 1,900-2,050 RPM	2,100	74
Stall		39

A review of industry-accepted pilot handling notes for the aircraft found a maximum crosswind component listed as 10 mph (8 kt) in Tiger Moth Type Conversion Syllabus.[9]

Tiger Moth aerodynamic characteristics

First flown in 1931, the Tiger Moth has high overall drag[10] in comparison to more modern aircraft. The aircraft operates at relatively slow speeds and its light weight results in low inertia. Therefore, in order to maintain airspeed after a reduction in engine power, the attitude of the aircraft needs to be adjusted more quickly and by a greater amount than more modern aircraft.

The Civil Aviation Authority (CAA) of NZ accident report 03/2955 (ZK-DHA) noted that a rate one[11] level turn commenced at about 56 kt will reduce the airspeed to 52 kt. Steeper turns require full power to initiate and maintain the turn at a safe margin above the stall speed (which increases with the angle of bank in a level turn). An engine failure will require an immediate lowering of the nose to avoid stalling and loss of control.

Another CAA of NZ accident report - 06/4477 (ZK-BAR) stated that, from a test flight and research into Tiger Moth spin characteristics, it was determined that in a spin the aircraft airspeed is usually low and the descent rate was high. In a spin, the Tiger Moth typically rotated once every 2-3 seconds and descended at 4,000 feet per minute - one full turn equated to a height loss of about 200 ft. That investigation report also noted that recovery from a spin, if done quickly, correctly and precisely, would require about half a turn to stop. The aircraft would recover in a dive with airspeed increasing rapidly, resulting in further height loss. Therefore, any spin entered during climb-out after take-off or from circuit height (1,000 ft AGL) makes a recovery highly unlikely before collision with terrain. An analysis of accident records showed that a considerable number of stall/spin accidents commenced from relatively low altitude.

A RAAF test pilot in a discussion[12] of the Tiger Moth's spin characteristics noted that during incipient spin recovery, the rapid yaw and roll ceased within half a turn of application of the recovery technique. The test pilot found that the height loss from the commencement of recovery from the incipient stage to wings level, climbing flight at 58 kt was about 250 ft. Flight testing also identified that rotation associated with a fully developed spin ceased within one turn, once

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9 Available from https://www.tigermothclub.co.nz/downloads/

10 Drag is the aerodynamic force that opposes the aircraft's motion through the air.

11 In turning flight, the number of degrees of heading change per unit of time (usually measured in seconds) is referred to as the rate of turn. A rate one or standard rate turn is accomplished at 3°/second resulting in a course reversal in one minute or a 360° turn in two minutes.

12 Available from https://www.tigermothclub.co.nz/downloads/

recovery was initiated and that 300 ft was lost during recovery to the same parameters. These height losses were based on the time from initiation of recovery and did not take into account the height lost during the time taken to recognise and react to the situation.

Maintenance history

In 2009, at 7,884 hours total time in service, the accident aircraft was refurbished and an overhauled engine was installed. The last recorded maintenance was an oil change and tappet inspection. Prior to that a periodic inspection and maintenance release issue was performed on 13 April 2015 at 7,936.8 hours total time in service.

Fuel

The aircraft was operated using Mogas.[13] It was reported that unleaded 91 and 95 was used and mixed with a cylinder head lubricant. The RAAF Publication No. 416 pilot notes contained within UZB's flight folder recommended a 73 octane fuel. Within industry it was accepted that the Gipsy Major engine runs better on lower octane fuel more suited to automotive specifications rather than the higher octane aviation fuel. Therefore, utilising automotive fuel was not unusual. The ATSB did not find any documentation that the use of a fuel additive, while common industry practice, was approved. However, there was no evidence that the use of Mogas or the fuel additive was linked to the partial power loss.

The total fuel on board prior to the flight was reported to be about 60 L, sufficient for the planned flight. This equated to about three-quarters of the fuel tank's capacity. The pilot indicated that he generally departed with the fuel tank about three-quarters full and returned with the tank about half full.

Meteorological conditions

The ATSB gathered weather information from a number of sources to get an accurate representation of the weather at the time of the occurrence.

Bureau of Meteorology

The Bureau of Meteorology provided the ATSB with a report on the weather conditions in the vicinity of the occurrence location. For the period between 0900 and 0930 on 28 December 2015, the following was noted:

- From exposed maritime locations (The Seaway and Banana Bank), winds were from the south-southeast and about 20 kt, gusting to 25-27 kt.
- From locations on the Moreton Bay coast (Redland and Brisbane Airport), the winds were from the south-east at 10-12 kt gusting to 17 kt.
- From the inland location of Beaudesert, the winds were from the south-southwest at 12 kt gusting to 15 kt.
- At 0900, the recorded temperature at Beaudesert was 23.7°C

Private weather representations

A private weather station about 4 km north of Pimpama Airstrip provided an unverified representation of the likely wind conditions on the morning of the accident. Between 0840 and 1000, it recorded winds between 8-13 kt, gusting up to 15 kt, and coming generally from the south-southeast.

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13 Mogas is an aviation term used to describe unleaded automobile fuel.

The website Windyty.com[14] provided an unverified representation of the wind conditions experienced in the vicinity of the accident site. At 0900, the wind was recorded as 19 kt from a south-south-easterly direction

Observed weather

The pilot reported that there was about 10-15 kt of wind and it would gust every now and then, but overall was relatively constant. The wind direction was from the south-east, 'down the cross strip'. The wind speed was consistent with a brief view of the windsock, recorded by the video camera during the take-off roll.

The Westpac Lifesaver helicopter was first to arrive on scene at about 1002. The pilot of the helicopter reported that it was very windy and gusty, with gusts to 30-35 kt from about a southerly direction. The helicopter pilot also stated that, when on the ground at the accident site, it did not feel as windy compared with the conditions above tree level and that it was 'certainly' less than 30 kt.

Summary of weather conditions

The proximity of the personal weather station and its consistency with the pilot's weather observations suggest it provided a more accurate representation of the weather than the Bureau of Meteorology observations. Based on these sources, the wind at ground level at the time of the flight was probably 8-19 kt coming from the south-east and gusty. It is likely that the wind above tree level was stronger.

Recorded information

The aircraft was fitted with a Garmin portable video recorder mounted underneath the upper right wing and facing rearwards. The video recorder separated from the aircraft during the accident sequence and was subsequently located near the accident site.

The recorded files were downloaded. The memory card contained a flight on 16 December 2015, a damaged file and a file that contained a recording for approximately 1 hour after the accident. The accident flight file did not record correctly to the memory card, probably due to a power disruption during the impact, and had to be repaired. The accident flight video file was 6 minutes and 43 seconds long and ended a few seconds prior to the impact. It is likely the recording of the last few seconds of the flight was stored in random access memory prior to being recorded onto the memory card and was lost with the power disruption during the impact.

A summary of the events in the accident flight recording is detailed in Table 2.

Table 2: Summary of the accident flight recordings

Time (EST)	Event
0900	Recording starts – Engine running, pilot returns chocks to hangar and then takes his seat in aircraft
0901:40	Taxi commences
0903:15	Aircraft lines up for take-off – about 100 m in from the runway threshold (Figure 1)
0905:55	Take-off roll commences – windsock visible during ground roll, indicates a southerly wind of 10-15 kt
0906:11	Lift-off
0906:13	Left turn commences
0906:23	Right turn commences
0906:36	Aircraft heading towards the south-east

14 Windyty.com used different weather data sources, mainly Global Forecast System (GFS) forecast models, produced by the National Oceanic and Atmospheric Administration (NOAA) and modelling produced by employees from Meteoblue.com (https://forum.windyty.com/topic/12/what-source-of-weather-data-windyty-use).

	Pilot observed looking outside the cockpit.
0906:38	Engine RPM starts to reduce After the reduction in engine RPM, the video shows the pilot looking inside the cockpit in the direction of the instrument panel. The pilot's and passenger's hand and any movements of the controls could not be observed in the video.
0906:43	End of flight recording – height between 200-300 ft

A frequency analysis of the recorded engine and propeller noise indicated that the engine was operating at around normal take-off RPM of 2,010 RPM until 0906:38 when RPM reduced to 1,740 over the last 4 seconds of the recording. The RPM did not appear to have stabilised at the time the video recording stopped. The reason for the reduction in engine RPM could not be determined from the video and frequency analysis.

Site and wreckage information

The accident site was located about 850 m east of where the aircraft began the take-off and about 7 m west of a group of tall trees (Figure 3). The initial ground impact mark was about 2 m east of the aircraft nose and co-located with propeller slash marks. The aircraft was orientated to the east, and was upright.

Impact marks were identified on the underside of the upper left wing (Figure 4) and significant tree debris were located in the vicinity of the left wing. There was evidence of freshly broken branches in the trees to the east of the accident site. There was minimal damage to the right wing.

The examination of the aircraft identified:

- all parts of the aircraft were present at the accident site
- there were no observable pre-accident defects to the airframe
- propeller slash marks and the damage to the propellers indicative of the engine driving the propeller at the time of impact (Figure 5)
- the aircraft impacted the ground in a steep nose-down attitude with little forward velocity
- the damage to aircraft, the trees and location of the aircraft wreckage was consistent with a collision with terrain while spinning to the left.

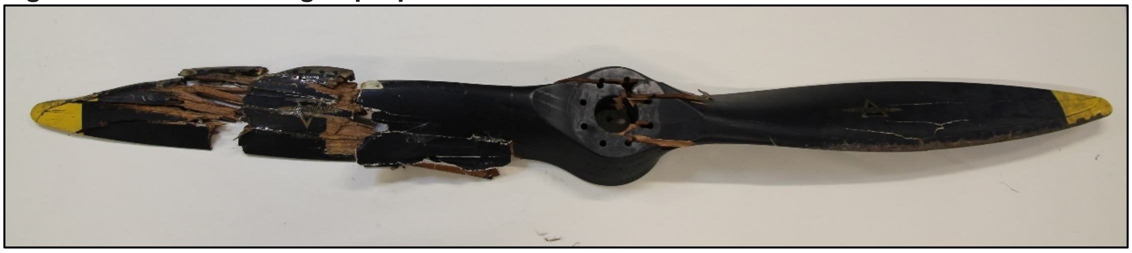
Figure 3: Accident site

Source: ATSB

Figure 4: Tree impact marks on underside of upper left wing

Source: ATSB

Figure 5: VH-UZB damaged propeller



Source: ATSB

Fuel system

The fuel tank was located between the upper wings and had a capacity of 86 L. Fuel was gravity-fed from the tank to the engine. The fuel exiting the tank passed through a matrix of 21 - 1/8 inch (3 mm) diameter holes to trap larger contaminates. Any finer contaminates were captured by the fuel filter. The filters were examined and found to be relatively clear from debris.

The fuel tank ruptured during the accident and there was evidence of post-accident fuel leakage. A fuel sample was recovered from the fuel tank and found to be visually contaminant free. A water contamination test was conducted on-site and returned a negative result.

A vent with a ball mechanism was installed on the upper surface of the fuel tank to allow air to enter the tank as fuel was used. The vent and ball mechanism was examined on-site and found to be clear of debris and serviceable.

A cork float connected to a visual fuel quantity gauge was located within the fuel tank. The float was inspected and found to be intact and in good condition.

A fuel shut-off valve was located immediately below the fuel tank. The valve was mechanically connected to a lever located in the pilot compartment. The video of the flight showed the flight shut-off valve was open throughout the flight up to and including in the last frame of the recording.

Previous testing identified that if the engine was operating at 2,050 RPM and the valve was turned off, the engine would stop in about 16 seconds.

Engine and engine systems examination

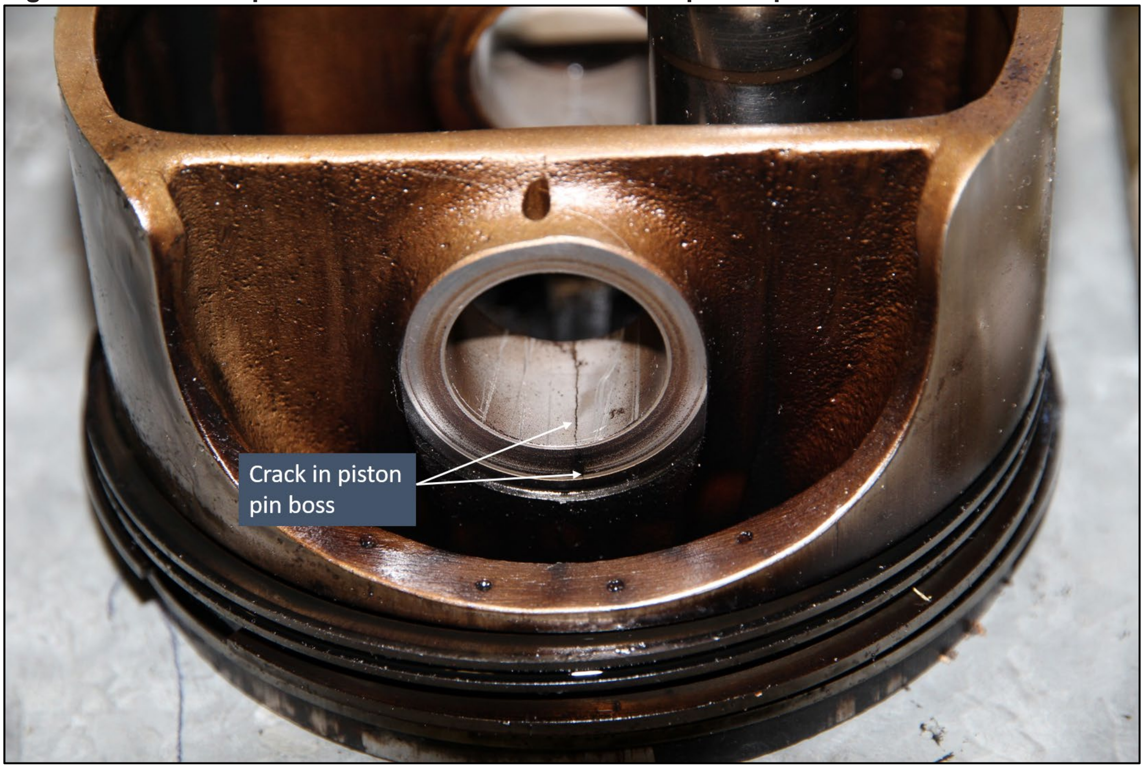
Engine

The engine was disassembled and examined at an engineering facility under the supervision of the ATSB. The examination found that there was no evidence of a catastrophic engine failure. In addition, the examination identified:

- impact damage to the rocker covers and exhaust system
- the number 1 cylinder exhaust valve was bent and stuck, most likely due to impact damage
- the engine rotated freely by hand with all cylinders (apart from number 1) having correct compression
- the number 4 piston had a full thickness crack through the piston pin boss (Figure 6). The crack may have been pre-existing or a result of the impact. As the crack had not propagated to the point of failure, it did not lead to the power loss.
- the spark plugs appeared normal
- the engine carburettor in line filter was clean
- the valve guide clearances were within the documented tolerance. The cylinder number 4 exhaust valve was stiff in comparison to the other valves, although still free to move.

There were no mechanical defects identified that would have led to a sudden reduction in engine power.

Figure 6: Number 4 piston with full thickness crack in piston pin boss.



Source: ATSB

Component examination

The magnetos were bench-tested, under the supervision of the ATSB. Both magnetos were found to be serviceable for normal engine operation.

The carburettor was disassembled and inspected. The float chamber was refilled with fuel and the fuel level was measured and found to be within limits. The freedom of movement of the mechanism was also checked and found to be serviceable. Some cracks in the varnish of the cork float were identified (Figure 7). Such cracking can allow the ingress of fuel into the float and affect both the dimensions and buoyancy of the float within the carburettor. Fuel-affected cork floats have been found to be a contributing factor in a number of other engine malfunctions involving Gipsy Major engines.

Consequently, the ATSB conducted testing of the float to determine if the cracks allowed fuel to penetrate the float. The cork float dimensions and weight were measured and recorded. The float was then immersed in unleaded petrol for a total of 26 hours. There were minor changes in the float dimensions and a minor increase in weight, however, these changes were not considered significant enough to have resulted in the observed power loss.

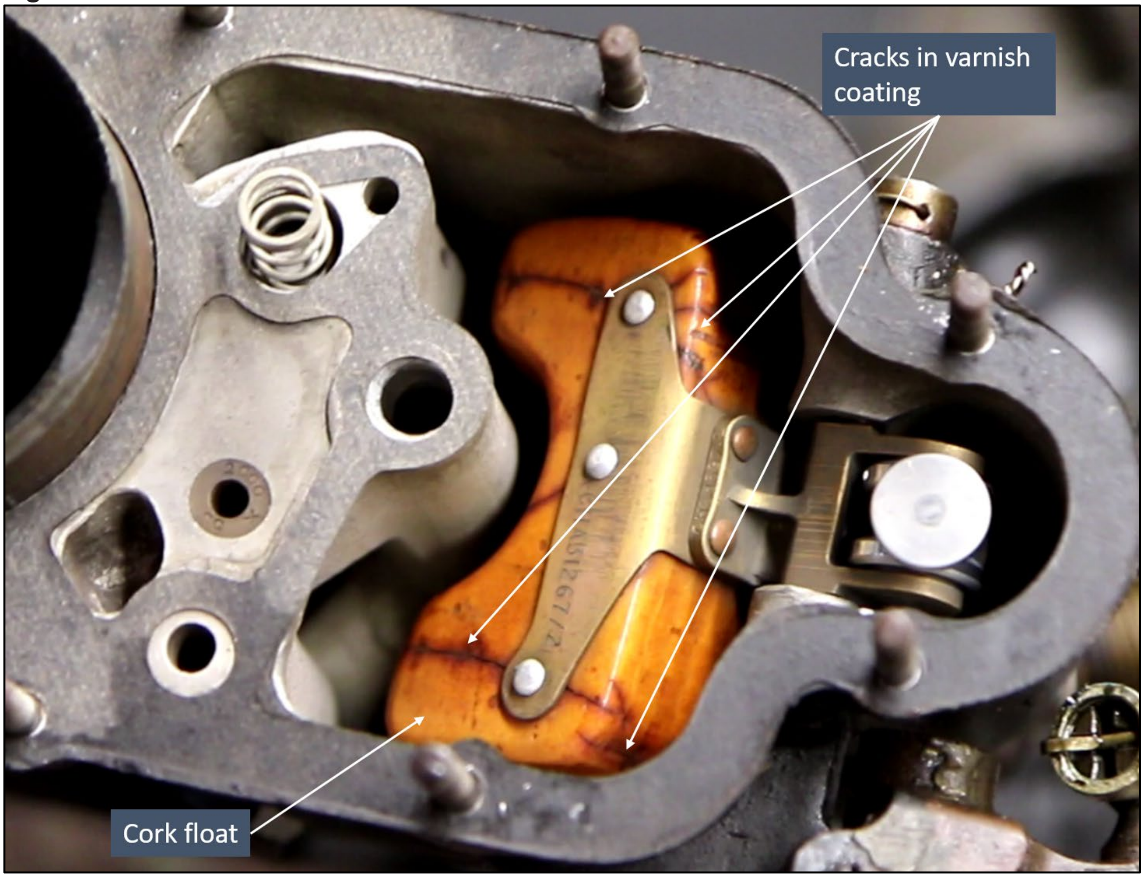
Following review of the draft report, de Havilland Support Ltd (the aircraft type certificate holder, provided advice that it could take many months for the cork to become impregnated with fuel to a point where engine performance was affected. As a result of this new information, the ATSB conducted additional testing on the float, in consultation with de Havilland Support (Figure 8).

The ATSB found that over a period of 101 days the float increased in weight by about 0.89 grams (from 39.41 to 40.30 grams), a 2.4 per cent increase in weight. When the cork float was re-weighed approximately 16 months after the beginning of the test it weighed about 40.55 grams (a 2.91 per cent increase in weight). This final weight could not be verified, as a portion of the fuel had evaporated, and the cork had not been submerged for a period of time.

As part of the initial draft report review process, de Havilland Support advised that from practical experience cork floats with aluminium alloy rivets, such as the one in VH-UZB, will generally weigh between 36 and 40 grams. The final weight of the tested float was 0.55 grams more than the upper weight range.

The aircraft type certificate holder and the ATSB assessed that the increase in weight, while low, had the potential to affect the buoyancy of the float. However, the degree of any resultant effect on carburettor operation could not be determined.

Figure 7: Carburettor float chamber and cracked cork float



Source: ATSB

Figure 8: Carburettor cork float testing

Source: ATSB

Survival aspects

Examination of the aircraft, first responder observations and witness statements confirmed the correct function of the safety harnesses. Video footage of the flight showed that the pilot, seated in the rear, was wearing a helmet made of hard material and a 4-point harness. The passenger, seated in the front, was wearing a soft leather helmet and a 4-point harness.

The impact forces sustained to the forward section of the aircraft and passenger compartment were not considered survivable.

The aircraft was not fitted with an emergency locator transmitter (ELT) nor was a portable ELT carried. Carriage of an ELT was not required under *Civil Aviation Regulation 1998* Section 252A, subsection 2.[15]

Managing partial power loss in single engine aircraft

The ATSB report *Managing partial power loss after take-off in single-engine aircraft* identified 242 reported occurrences (between 1 January 2000 and 31 December 2010) involving single-engine aircraft sustaining a partial engine power loss after take-off. In two-thirds of these, the pilot turned back toward the aerodrome. Four fatal accidents and one serious injury accident involved loss of control after a turn back due to the aircraft entering an aerodynamic stall and spin, followed by a collision with the ground. The report highlighted that a turn back requires accurate flying during a period of high stress to prevent a stall and possibly a spin. If a stall or spin does occur, there is little likelihood of recovery before collision with the terrain.

The research suggested that the following initial actions should be performed when responding to a partial loss in power:

- lower the nose to maintain the aircraft's glide speed
- time permitting, conduct basic initial engine trouble checks as per a total engine failure in accordance with the aircraft manufacturer's advice
- Fly the aircraft to make a landing. If a turn is conducted, be mindful that an increase in elevator input to maintain a desired descent path will reduce the margin to the stall. Also, keep the aircraft in balance to minimise the rate of descent in the turn. Having a planned minimum turning height is recommended; CASA suggests a minimum height of 200 ft above ground level. Below your planned minimum turning height, if continued climb to a safer altitude is possible, it should be done with level wings. With insufficient remaining power to climb, landing ahead is the only option.
- re-assess landing options throughout any manoeuvres
- land the aircraft.

Unintentional spins

The CAA of New Zealand's publication *Spin Avoidance and Recovery*[16] states: 'The majority of unintentional spins occur at altitudes too low for recovery.' The publication discusses how aircraft enter unintentional spins and methods to recover from a spin.

When in *a low-speed climbing turn*, the aircraft is already vulnerable by being at low speed with a nose-up attitude and therefore close to the stall. Low-energy, low-powered aeroplanes, such as the Tiger Moth, in this situation will suffer some performance loss during a turn. To compensate, the nose of the aircraft should be lowered, otherwise the speed will further diminish.

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15 An aircraft is not required to be fitted with an approved ELT if the flight is to take place wholly within a 50 NM (93 km) radius of the departure aerodrome (https://www.legislation.gov.au/Details/F2015C00993/Download).

16 Civil Aviation Authority (CAA) of New Zealand (NZ) publication *Spin Avoidance and Recovery* (2014)

Increased rudder application in the direction of the turn without increasing bank will result in a *skidding turn*. This coupled with a reducing or low airspeed can provide the conditions to start a spin.

With a high nose-up attitude, high power setting and low speed, the immediate priority following an *engine failure after take-off* is to lower the nose and preserve existing airspeed. In most cases, there is little option but to land ahead. Attempting to turn back to the runway or to a limited landing area will increase the risk of a loss of control.

In the event of a *spin*, pilots must immediately recognise the spin, its direction, know what to do in the correct order and correctly execute the procedure the first time. In most cases, there is only about 3 seconds to do all this. The minimum altitude loss for a text-book recovery will be about 1,000 to 1,500 ft. At low heights above ground level, there will be little opportunity to recover.

Similar occurrences

ATSB investigation 199805459 (VH-AQN)

Shortly after take-off, and at a height of about 150 ft above the ground, the Tiger Moth's engine began to run rough and lose power. The pilot banked the aircraft to the right towards a clear area to avoid the residential area directly ahead. During the landing roll, the aircraft came into contact with a number of trees and was substantially damaged. The pilot and two passengers were uninjured.

Examination of the carburettor found that the carburettor's cork float had two large blisters in the fuel proof varnish. Further examination indicated that the larger of these blisters was binding against the float chamber housing walls. This could have resulted in either an excessively rich or lean mixture, leading the engine to run rough and stop.

During the investigation, several experienced Tiger Moth operators were contacted to ascertain their experience with this type of problem. These operators advised that they were aware of several incidents where the varnish surrounding the cork float had cracked and the cork float had then absorbed fuel. However, none had any previous experience of the varnish blistering in this manner.

ATSB investigation AO-2012-017 (VH-GVA)

Immediately after take-off, the Tiger Moth was observed to have a partial, intermittent power loss. When at the upwind end of the runway, a climbing left turn was made. The aircraft then stalled and descended. The aircraft collided with terrain and both occupants were fatally injured. The aircraft was destroyed by the impact forces and a post-impact fire.

Examination found the varnish coating on the carburettor float was darker than normal and had blistered away from the float, allowing the blister to contact the float bowl and interfere with the free movement of the float. Tests on exemplar floats found that the coating blistered when exposed to elevated temperatures, which may have been similar to temperatures inside the carburettor during the post-impact fire.

The investigation determined that the partial engine power loss was probably the result of a partial blockage of the aircraft's fuel cock.

ATSB occurrence 200806008 (VH-FBO)

The pilot reported that the airstrip was experiencing 'powerful' standing waves[17] with ground winds appearing to be strong. While on approach, the aircraft appeared 'out of wind' and turbulence and

[17] Also known as mountain waves; are oscillations to the lee side (downwind) of high ground resulting from the disturbance in the horizontal airflow caused by the high ground.

control difficulties were experienced. As a result, the pilot aborted the landing and commenced a go-around, with less than full power being applied. During this time, the pilot was reportedly focusing on the ground winds and it was possible that the control column was moved rearward. With likely windshear also being experienced, the aircraft's airspeed diminished and the aircraft entered a spin. The aircraft collided with terrain and the pilot received serious injuries.

Civil Aviation Authority (CAA) of NZ 06/4477 (ZK-BAR)

While in level flight, between 500 and 800 ft above ground level, the Tiger Moth entered a left climbing turn and then stalled and spun towards the ground. No unusual engine noise was reported and if such had occurred, a pilot's first visible and expected reaction would be to lower the nose to maintain airspeed and establish a glide. The aircraft impacted the ground and caught fire.

The examination of the wreckage indicated that the impact was in a steep nose-down attitude with the right main-planes striking the ground first following by the left main-planes. The aircraft then rebounded backwards pivoting around the right main-plane tips.

Examination of the CAA of NZ database showed that there had been three fatal Tiger Moth accidents in the previous 12 years resulting from a low altitude stall/spin. These were:

Registration	Injuries	Pilot experience on type	Details
ZK-BGP	2 fatal	33 hours	Stalled from less than 500 ft, spun, then caught fire.
ZK-DHA	2 fatal	24 hours	Stalled while turning on climb out at about 500 ft, spun, then caught fire.
ZK-BAR	2 fatal	27 hours	Stalled in climbing turn at 500-800 ft, spun, then caught fire.

Safety analysis

Introduction

Shortly after take-off, the aircraft had a partial engine power loss. In response, the pilot elected to return to the landing area. During the subsequent left turn, the aircraft stalled and entered a spin, at a height from which recovery was not possible before the collision with terrain.

The ATSB established that the pilot was appropriately qualified to be conducting the flight. The pilot had limited experience on the aircraft type, however, it was not possible to determine whether that contributed to the development of the accident as the management of this emergency would have challenged most pilots. While there was 8-19 kt of wind and gusty conditions, it did not exceed any aircraft- or industry-accepted limitations.

This analysis will examine the power loss and the potential reasons for the subsequent loss of control.

Engine power loss

The video audio analysis corroborated the pilot's account that at a height of about 200 ft above ground level (AGL), the engine RPM began to reduce. The pilot reported that in an attempt to recover engine power, he retarded the throttle to idle and then advanced the lever back to full power. There was no apparent change to the reduced power level after the throttle was advanced.

The reported continued low power level after the pilot advanced the throttle indicated that the throttle had not 'rolled back' and had not been inadvertently interfered with by the passenger. The aircraft was refuelled prior to the flight and there was no evidence of fuel contamination. The engine, its components and fuel system were examined.

Observed cracking of the carburettor cork float varnish raised the possibility of the float being impregnated with fuel to the extent that the performance of the carburettor may have been affected. Testing of the carburettor mechanism and additional submersion testing of the float conducted during the investigation indicated that this was possible, however the likelihood was difficult to assess.

There was an anomaly with the number four exhaust valve clearance, however it was within the manufacturer's specifications and there was insufficient evidence to determine if it contributed to the partial power loss. There were no other defects identified that would explain the partial power loss.

Loss of control

A partial engine power loss presents a more complex scenario to a pilot than a complete engine power loss. Following a complete engine failure, a forced landing is the only option whereas in a partial power loss, pilots are faced with making the difficult decision of whether to continue flight or to conduct an immediate forced landing. ATSB research found that the two-thirds of pilots who experience a partial power loss after take-off elect to return to the landing area. The pilot of VH-UZB (UZB) similarly elected to return to the airfield.

In the event of a complete power loss, CASA suggests keeping wings level below 200 ft AGL and landing ahead. At the time of the partial power loss, UZB was just above this height and the pilot assessed that he had the option to return to the airfield. This accident highlights the decision-making challenges during critical stages of flight, especially when faced with an unusual problem and the importance of pre-briefing the intended actions if faced with a power loss during take-off.

A number of scenarios could have led to the loss of control in the turn, these include:

- The higher winds above tree height may have resulted in an illusion of slipping when the pilot turned the aircraft downwind. This may have resulted in the pilot increasing the rudder input, leading to an out-of-balance turn and entry to the spin.
- The wind was reported to be gusting (gusts during the turn could have increased the angle of attack sufficiently to result in a stall/spin).
- There may have been a sufficient loss of airspeed due to the power loss and turn to reduce the airspeed below the stall speed. The design of the Tiger Moth as a biplane with struts and wires creates higher drag than a monoplane.
- The speed reduced below the stall speed as the nose may not have been lowered sufficiently after the partial loss of power.

Previous tests, research and accident data indicates that recovery from a spin is difficult to achieve below 1,000 ft. The aircraft was about 200-300 ft above ground level when the spin occurred and therefore recovery was not considered possible.

Immediately after take-off, the pilot conducted two low-level turns, despite the requirement to maintain the take-off track until 500 ft above terrain. These turns were reportedly to provide additional time to climb out over clear terrain prior to overflying trees. However, banking during the climb resulted in a reduced climb rate. It was not possible to determine whether the increased altitude that could have been obtained by climbing straight ahead would have assisted in managing the power loss. However, even without the manoeuvring, the aircraft could not have gained sufficient height in 23 seconds (flight time prior to the power reduction) to recover from the spin.

While the pilot’s initial actions in deciding to return to the airfield were understandable, they introduced an additional risk of a loss of control. The best survivability outcome if an emergency landing is required for any reason is by flying:

- the aircraft in a controlled manner
- with wings level
- at the recommended glide speed
- using available headwinds, to reduce the touchdown speed.

Findings

From the evidence available, the following findings are made with respect to the loss of control and collision with terrain involving a DH82A Tiger Moth aircraft, VH-UZB, near Pimpama, Queensland, on 28 December 2015. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing factors

- Shortly after take-off, for reasons that could not be determined, the aircraft experienced a partial engine power loss at low altitude.
- In response to the partial power loss, the pilot elected to return to the airfield. During the subsequent manoeuvring, the aircraft stalled and entered a spin that was unrecoverable in the available height.

General details

Occurrence details

Date and time:	28 December 2015 – 0907 EST	
Occurrence category:	Accident	
Primary occurrence type:	Loss of control and collision with terrain	
Location:	Near Pimpama, Queensland	
	Latitude: 27°48.99' S	Longitude: 153° 21.40' E

Pilot details

Licence details:	Commercial Pilot (Aeroplane) Licence, issued April 2010
Endorsements:	Multi-engine aeroplane, Single-engine aeroplane, Manual Propeller Pitch Control, Retractable Undercarriage,
Ratings:	Instrument rating
Medical certificate:	Class 1, valid to 30 January 2016
Aeronautical experience:	1,111 hours
Last flight review:	December 2014

Aircraft details

Manufacturer and model:	de Havilland Aircraft DH82A, Tiger Moth	
Year of manufacture:	1941	
Registration:	VH-UZB	
Operator:	Gold Coast Aerobatic Adventures	
Serial number:	291	
Total Time In Service	7,986.4 hours	
Type of operation:	Adventure flight	
Persons on board:	Crew – 1	Passengers – 1
Injuries:	Crew – 1 (serious)	Passengers – 1 (fatal)
Damage:	Substantially damaged	

Sources and submissions

Sources of information

The sources of information during the investigation included the:

- Air Accidents Investigation Branch (AAIB) UK
- Australian Warbirds Association
- Bureau of Meteorology
- Civil Aviation Authority of New Zealand
- Civil Aviation Safety Authority (CASA)
- Flight crew
- Operator
- Witnesses

Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003* (the Act), the 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 AAIB, Australian Warbirds Association, CASA, de Havilland Support, the owner/operator of Gold Coast Aerobatic Adventures, the pilot, the airstrip maintenance provider and the next of kin of the passenger.

Submissions were received from the AAIB, Australian Warbirds Association, CASA, de Havilland Support, the owner/operator of Gold Coast Aerobatic Adventures, the pilot and the airstrip maintenance provider. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

Australian Transport Safety Bureau

The 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 operations involving the travelling public.

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.

Terminology used in this report

Occurrence: accident or incident.

Safety factor: an event or condition that increases safety risk. In other words, it is something that, if it occurred in the future, would increase the likelihood of an occurrence, and/or the severity of the adverse consequences associated with an occurrence. Safety factors include the occurrence events (e.g. engine failure, signal passed at danger, grounding), individual actions (e.g. errors and violations), local conditions, current risk controls and organisational influences. A 'safety factor' is an event or condition that increases risk.

Contributing safety factor: a safety factor that, had it not occurred or existed at the time of an occurrence, then either:

(a) the occurrence would probably not have occurred; or

(b) the adverse consequences associated with the occurrence would probably not have occurred or have been as serious, or

(c) another contributing safety factor would probably not have occurred or existed.

Other factors that increased risk: a safety factor identified during an occurrence investigation, which did not meet the definition of contributing safety factor but was still considered to be important to communicate in an investigation report in the interest of improved transport safety.

Other findings: any finding, other than that associated with safety factors, considered important to include in an investigation report. Such findings may resolve ambiguity or controversy, describe possible scenarios or safety factors when firm safety factor findings were not able to be made, or note events or conditions which 'saved the day' or played an important role in reducing the risk associated with an occurrence.