Australian Government
Australian Transport Safety Bureau

Loss of control and collision with terrain involving Cessna 172, VH-EWE

near Moorabbin Airport, Victoria, on 8 June 2018

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Addendum

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Safety summary

What happened

At about 1710 on 8 June 2018, the pilot of a Cessna Aircraft Company 172S, registered VH-EWE, was returning to Moorabbin Airport, Victoria, following a one-hour private flight. While on final approach, and shortly after receiving clearance to land, the pilot transmitted 'we've got engine failure'. Shortly after, witnesses observed the aircraft's left wing and nose drop, consistent with an aerodynamic stall. The aircraft collided with terrain in a residential street about 680 m from the airport. The pilot was fatally injured and a post-impact fuel-fed fire destroyed the aircraft.

There was minor damage to one residence and a vehicle, there were no injuries to persons on the ground.

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 reported engine power loss. The investigation also found that when control of the aircraft was lost, there was insufficient height to recover.

Safety message

The loss of engine power while on final approach presents a scenario where there may be limited forced landing options, especially when there is insufficient height to glide to the airport. This is particularly relevant where the approach is over built-up areas, such as at Moorabbin Airport. The ATSB publication, Avoidable Accidents No. 3 - Managing partial power loss after take-off in single-engine aircraft provides guidance that is also applicable to an engine failure occurring at low-level during an approach. Taking positive action and ensuring that control is maintained has a much better survivability potential than when control of the aircraft is lost. In addition, using the aircraft structure and surroundings to absorb energy and decelerate the aircraft can assist in minimising injury.

Having a clear, defined emergency plan prior to the critical stages of the flight, such as approach, removes indecision and reduces pressure on the pilot while in a high stress situation. Further, flying the approach as per manufacturer and airport procedures places the aircraft in the optimum configuration and position.

Proficiency in in-flight emergencies can be improved by regularly practicing these emergencies. The United States Federal Aviation Administration *safety briefing September/October 2010* described this as 'imbuing the quantity of all your flying, however limited, with quality'.

Contents

The occurrence

What happened

On 8 June 2018, a Cessna Aircraft Company C172S, registered VH-EWE (EWE), was being operated on a private flight from Moorabbin Airport, Victoria. The flight was the first one after scheduled maintenance and the pilot, an employee of the maintenance organisation, was the sole occupant.

The aircraft departed Moorabbin Airport at 1604 Eastern Standard Time.[1] Flight tracking data showed that it climbed to an altitude of 3,000 ft above mean sea level and tracked towards Tyabb, Victoria. EWE then tracked south toward Hastings, south-east to Inverloch, and north-east toward Leongatha, before heading north-west to return to Moorabbin Airport (Figure 1 inset).

Figure 1: VH-EWE flight path

Source: Flight Aware flight data and Google Earth, modified by ATSB

At 1706, the pilot advised Moorabbin Air Traffic Control (ATC)[2] that EWE was at reporting point GMH,[3] at 1,500 ft and inbound to Moorabbin. ATC acknowledged and instructed the pilot to join base (see the section titled *Circuit operations*) for runway 35 Right (35R), the expected arrival runway when tracking from GMH. At 1711, due to the number of aircraft tracking for 35R, ATC subsequently requested EWE change runways to 35 Left (35L), which the pilot accepted.

At 1712:41, EWE was cleared to land on runway 35L and this was acknowledged by the pilot. ATC's observation of EWE during the approach was that the aircraft was a little low, but not unusually so, with flaps extended and a slight nose-up attitude.

At about the time the aircraft was cleared to land, witnesses on the ground observed EWE heading toward Moorabbin and described hearing the engine 'spluttering', 'struggling' and that it

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

2 Moorabbin ATC had a tower controller and a surface movement controller (SMC) on duty at the time of the occurrence. ATC, for the remainder of the report, refers to the tower controller.

3 GMH is an identifiable landmark 7 nm east of Moorabbin used as an entry point for aircraft visually approaching the airport.

'sounded like a lawn mower struggling to start'. Some witnesses also reported the aircraft was quite low and slower than expected. Witnesses located 120 m from the accident site reported EWE was heading in a westerly direction, at a height of about 25 m (82 ft) above the ground, with no engine noise.

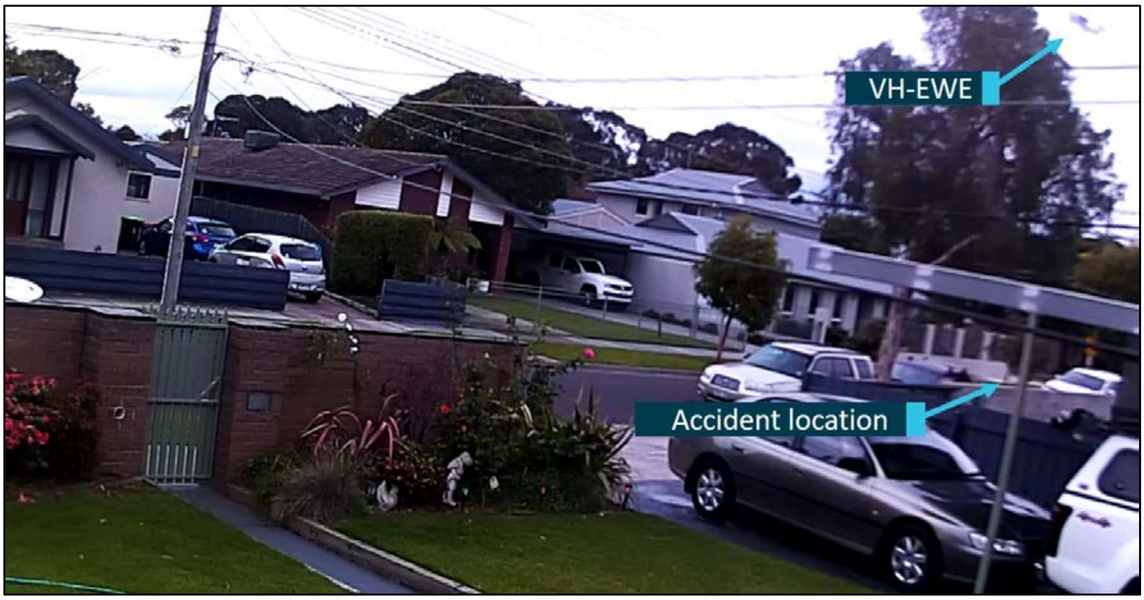
At 1713:05, the pilot of EWE broadcast MAYDAY[4] and stated 'we've got engine failure'. In response, the tower controller directed his attention to EWE and observed that the aircraft was 'low' and the nose had 'started to pitch up' before the MAYDAY call was finished. At the completion of the MAYDAY transmission, the surface movement controller looked toward EWE and also noticed the aircraft was in a nose-up attitude. About 2–3 seconds later, they both observed the left wing and nose drop, before they lost sight of the aircraft below the tree line.

The MAYDAY broadcast also prompted several pilots to look toward EWE.[5] These pilots reported observing that EWE was:

- initially in a shallow left turn, with increased angle of bank, prior to a left wing drop
- in 'a sharp left turn', then the left wing dropped
- 'near to a 30˚ bank to the west…the aircraft lost considerable height in this manoeuvre and continued in this state' [before he lost sight]
- 'banked in an uncontrolled state at about 150–200 ft…heading toward the ground'.

A security camera located two houses to the west of the accident site captured the accident sequence. The footage showed EWE enter the frame in a slight left bank and initially on about a westerly heading. The aircraft was descending with a nose attitude appearing higher than that for a normal glide (Figure 2). As the aircraft passed behind a tree, the aircraft appeared to stall, indicated by the sharp reduction in pitch attitude and left wing drop (see the section titled *Stall characteristics and recovery*). The left wing subsequently clipped the power service line[6] to a corner property. The footage showed that the wing flaps were in the retracted position.

Figure 2: Security camera footage



Source: Supplied, modified by ATSB

[4] MAYDAY: an internationally recognised radio call announcing a distress condition where an aircraft or its occupants are being threatened by serious and/or imminent danger and the flight crew require immediate assistance.

[5] Two pilots were located on the ground at Moorabbin, the others were on final to 35R at about the same time EWE was tracking to 35L.

[6] The service wire connects a property to the power distribution lines.

EWE collided with the top of a concrete column and tubular steel fence located at the front of a property. The propeller and nose wheel impacted the grass verge with the aircraft stopping behind a parked vehicle on the southern side of the street (Figure 3). A severe post-impact fuel-fed fire commenced immediately. Witnesses reported that ignited aircraft fuel leaked from EWE and flowed along the street gutter.

The pilot was fatally injured and a post-impact fuel-fed fire destroyed the aircraft. There was also some damage to a residential property and the parked car. There were no injuries to members of the public.

Figure 3: Accident site

Source: ATSB

Context

Pilot information

The pilot held a Commercial Pilot Licence (Aeroplane), issued in January 1989, with single- and multi-engine aeroplane ratings and had accrued about 1,400 hours of total flight experience. The pilot held the appropriate licences and qualifications, and met all currency requirements to operate VH-EWE (EWE).

The pilot conducted his last flight review in a Cessna 182 on 14 July 2017, 11 months prior to the accident. Competencies demonstrated at this time included:

- entry and recovery from stall
- recovery from incipient spin
- management of engine failure after takeoff and in the circuit area (simulated)
- performance of forced landing (simulated).

The pilot's training records showed he conducted a 'recurrency' flight with an instructor, in a Cessna 172, on 25 August 2017. Comments from that flight included that the approach speed was 'initially a little slow' and the pilot had 'a tendency to use aileron in an approach stall recovery'. Normal, flapless and glide approaches to Moorabbin were also practiced. The instructor noted that they worked on power settings and attitudes on the approach, resulting in subsequent approaches being 'much improved' and that pilot flew to a 'safe standard'.

The pilot's logbook did not record any additional stall and/or engine failure training, either formal or informal. It was possible, however, that this practice had been conducted without being documented. The pilot had flown once in the preceding 30 days and had flown less than 2 hours in the preceding 90 days, all in the Cessna 172.

Medical information

The pilot held a current Class 1 aviation medical certificate, with restrictions. These restrictions had been successfully managed by the pilot and the Civil Aviation Safety Authority (CASA), for several years.

Post-mortem and toxicological examinations of the pilot did not reveal any medical issues that may have contributed to the accident. Additionally, there were no indicators that the pilot was experiencing a level of fatigue known to affect performance.

Aircraft information

General

EWE was a Cessna Aircraft Company 172S all-metal, four-seat, high-wing aircraft designed for general utility and training purposes (Figure 4). EWE was powered by a Lycoming IO-360-L2A fuel-injected piston engine and fitted with a McCauley two-blade, fixed-pitch propeller. The aircraft was manufactured in the United States in 2006 and first registered in Australia the same year. EWE had been owned and operated by the same flight training organisation since 2007 and had accumulated 6,348 hours in service prior to the accident flight.

A Garmin G1000 (G1000) integrated flight deck system was installed in EWE. The G1000 system consists of two display units, presenting flight instruments, position, navigation, communication and identification information to the pilot. Each display had two slots for secure digital (SD) memory cards, one for the navigation database and one for flight plans, software updates and flight data logging. SD cards were installed in the slots of at least one of the display units at the time of the accident.

EWE was fitted with a standard stall warning system, which consisted of a stall warning horn and scoop assembly. The warning system was designed to activate the horn between 5–10 knots above the stall speed in all configurations.

Weight and balance calculations showed that the aircraft was well within the weight and centre-of-gravity limits at all stages of the flight.

Figure 4: VH-EWE

Source: Phil Vabre

Fuel system information

The Cessna 172 fuel system has a total capacity of 212 litres (of which 200 litres is useable) and consists of two vented integral fuel tanks, one in each wing. The tank is located in the inboard section of each wing and has two fuel pick-ups, forward and aft. Surrounding each pick-up is a baffle, to reduce any sloshing affecting fuel flow downstream.

A fuel selector valve lever (Figure 5), operated by the pilot, allows fuel to gravity flow from either the left or right, or both wing tanks to a reservoir (feeder) tank. The handle is indexed and therefore cannot be fitted incorrectly. The Cessna 172 pilot operating handbook (POH) recommends checking the fuel selector is in the BOTH position prior to engine start, prior to takeoff, and before landing.

An auxiliary pump[7] draws fuel from the reservoir and delivers it, under pressure, to the engine-driven pump and fuel injector unit.[8] The fuel injector unit meters the fuel/air ratio that is delivered to the flow divider, which distributes the fuel to each cylinder nozzle, for combustion.

A fuel shut-off valve is located between the auxiliary and engine driven pumps. The POH requires the fuel shut-off valve to be selected to 'off' (closed) in the event of a forced landing due to engine failure.[9] The fuel shut-off valve is located separate to the fuel selector valve to prevent inadvertent

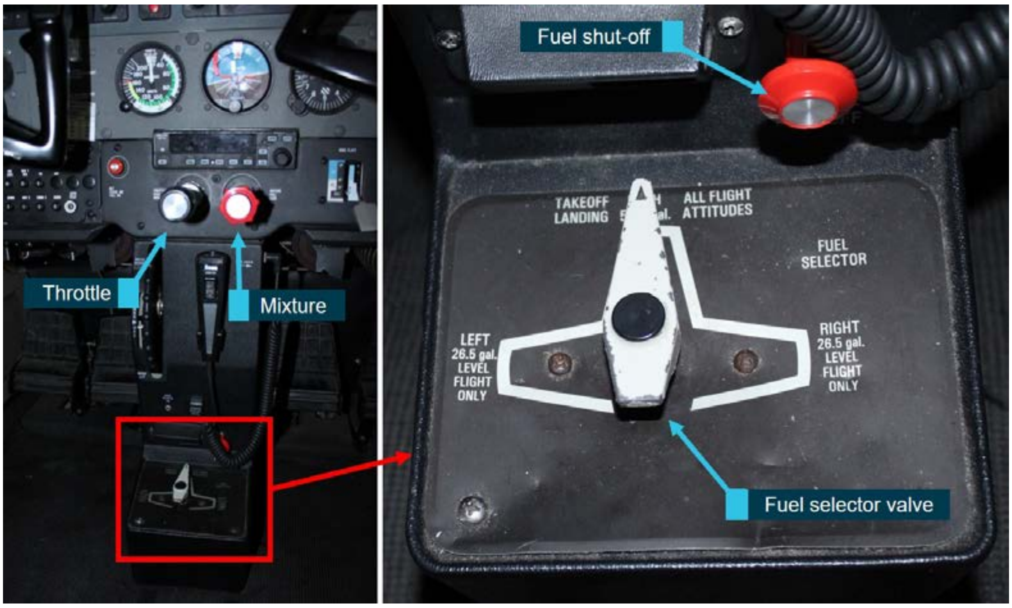
7 The auxiliary pump is operated by the pilot and primarily used for engine starting and in the event of an engine-driven pump failure.

8 The fuel injector is referred to as the fuel/air control unit in the airframe documentation.

9 Closing the fuel shut-off valve prevents fuel from flowing to the 'hot' engine and spark plugs, removing a potential ignition source.

shutting of the fuel system when selecting between tanks. Fuel shut-off valve operation, via mechanical linkage, is achieved by pulling the knob full out (rearward).

Figure 5: Typical Cessna 172 fuel and engine control locations



Source: ATSB

The throttle is configured so that it is open in the forward position and closed in the full aft position. The throttle also has a friction lock to hold it at the selected position. The mixture control allows the pilot to vary the fuel/air mixture entering the engine. The 'rich' position is fully forward. Moving the control aft leans the mixture and full aft is idle-cutoff (engine shutdown).

Each tank has a low fuel sensor that indicates when the tank quantity drops below about 18 L for 60 seconds. The POH states that in this condition, a LOW FUEL amber message will flash on the annunciator panel for about 10 seconds, then remain steady. There is no aural warning for low fuel. In addition, the POH recommends that if the selected tank is less than one-quarter full (28L), uncoordinated/unbalanced flight with respect to rudder input should be avoided for periods longer than 30 seconds.

Maintenance information and history

EWE was maintained in accordance with a CASA-approved System of Maintenance, which required a periodic check to be conducted every 105 hours or 6 months, whichever came first. A review of the aircraft logbooks did not identify any significant incidents, accidents or major repairs in the aircraft's maintenance history. EWE was last flown on 3 June 2018, with no reports of concern about its serviceability prior to it entering routine maintenance.

Maintenance prior to accident flight

EWE underwent scheduled maintenance during the week of 4-8 June 2018 at the flight training organisation's maintenance facility at Moorabbin Airport. This included a periodic inspection, other scheduled maintenance, and minor additional maintenance/rectifications. A scheduled engine change was also completed. In addition, the fuel selector handle was removed, painted and reinstalled, and the stall warning air scoop was replaced and tested.

The accident pilot, who was also a licenced aircraft maintenance engineer (LAME), worked on the airframe and was assisted by an apprentice. The engine change was conducted by another LAME.

At the completion of the maintenance, the aircraft was washed and readied for engine runs. An initial ground run was carried out, for about 5–10 minutes. The LAME who had conducted the engine change reported that he conducted a leak check and adjusted the idle mixture, with satisfactory results. A second engine run, of about 20–30 minutes, was then conducted and included checks of the magnetos, fuel flow, cylinder head temperatures, exhaust gas temperatures and oil pressure. Once the engine oil reached operating temperature, the idle RPM was noted to be a little low and was adjusted accordingly. EWE was then returned to the hangar, engine cowls were fitted, and a new maintenance release issued.

While there was no formal requirement for a test flight, the chief engineer advised it was standard procedure for LAME's holding pilot licences to conduct an 'acceptance flight' in the aircraft at the completion of major work. Several pilot-licenced LAMEs took it in turns to conduct these flights with the knowledge of the flight training organisation.

The acceptance flights were generally about 60 minutes duration and operated at about 65-75 per cent power, to help bed the piston rings, when an overhauled engine had been installed. A visual inspection and leak check was then conducted after landing. The chief engineer surmised the pilot had 'done about 50' of these flights during the approximate 20 years he had been working for the company.

Engine history and overhaul information

The Lycoming IO-360-L2A is a four-cylinder, direct drive, horizontally opposed, air-cooled, fuel-injected piston engine. Engine serial number L-32890-51E was installed new in one of the flight school's aircraft in 2006 and removed twice for 3,000 hour scheduled overhaul. After each overhaul, the engine was installed in a different aircraft. The second installation was in EWE.

The engine was inspected and overhauled at an authorised maintenance and overhaul facility in Victoria. The facility received the engine on 10 April 2018 and the engine inspection worksheets did not indicate any issue with the engine strip and inspection.

The scheduled maintenance included replacement of the engine hoses, baffles and mount components. Two overhauled magnetos were fitted at this time. In addition, inspection of the fuel injection supply lines was conducted in accordance with the United States Federal Aviation Administration (FAA) airworthiness directive (AD) 2015-19-07. The flow divider was replaced with an overhauled item. The fuel injector and fuel nozzles were disassembled, cleaned and inspected. The flow divider, fuel injector and fuel nozzles were bench tested with satisfactory results.[10] They were then fitted to the engine for the engine post-maintenance test-bed runs.

Following overhaul, the engine was run on the overhaul facility's test bed on 25 May 2018 with satisfactory results. The engine test schedule included two runs, for a total of 75 minutes, with a shutdown and oil level check in between runs.

Additional maintenance carried out during the engine change included:

- idle mixture and idle RPM adjustment[11]
- replacement of two engine control rod ends due to wear.

Site and wreckage information

The accident site was located on a residential street in the Melbourne suburb of Mordialloc, about 680 m south of the runway 35L threshold. A school oval (210 m long by 120 m wide) was situated about 50 m south of the accident site (Figure 6).

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10 The fuel injector had been previously overhauled by the same facility in August 2013. The test sheet from this overhaul was compared with the most recent. In both cases, all parameters were within limits. In addition, there was little difference in actual figures between the two bench tests.

11 The idle adjustments made at overhaul are within manufacturer's limitations. Minor adjustments may then be conducted at fitment, to suit the airframe characteristics.

Figure 6: Accident site location

Source: Victoria Police, modified by ATSB

Security camera footage, along with statements from two nearby witnesses, were used to calculate the height of the aircraft at the time of the apparent stall. From this, EWE was estimated to be about 85 ft above ground level at the commencement of the loss of control.

The security footage showed the landing light was in operation immediately prior to the collision with terrain, which was consistent with the aircraft electrical system being energised. The fire initiation point could not be determined. However it was likely the energised electrical system or hot engine components ignited the fuel on board.

The post-impact fire destroyed the cabin section of the fuselage and most of the left wing, which precluded a complete examination of those sections of the aircraft. The on-site examination of the wreckage identified:

- no evidence of in-flight break-up
- no evidence of pre-existing damage or anomalies in the flight control system that may have contributed to a loss of control
- at the point of impact the propeller was not rotating and the flaps were retracted.

The engine assembly and fuel selector valve were retained for further examination. One of the G1000 units was identified in the wreckage, however the SD cards were destroyed in the fire and no data was able to be retrieved.

Engine and fuel systems examination

Engine examination

The engine was disassembled and examined at a CASA-approved engine overhaul facility under the supervision of the ATSB. The engine condition was consistent with the operated life of the engine and limited run time (bedding in) following the recent overhaul.

Fire and heat damage prevented functional testing of the engine ancillary components. However, visual examination of the engine-driven fuel pump did not identify any anomalies that may have affected its operation. Disassembly and examination of the magnetos, vacuum pump, oil pump and associated oil system components, and drivetrain similarly did not identify any failure or condition that may have affected engine operation.

The throttle and mixture controls were identified in the forward positions. The fuel injector was found in the open (full power) condition, consistent with throttle being fully forward, and the throttle valve had full and free movement. The fuel metering section of the injector was severely damaged by fire and heat, however it was noted there was no evidence of oil contamination. Engine fuel system component disassembly and inspection did not identify any failure, seizure or blockage that may have prevented fuel flow to the engine cylinders.

The spark plugs were noted to be a darker colour than standard, this could be due to:

- an engine running rich
- the 'bedding in' phase, for up to 25 hours after the overhaul
- the engine being flooded during an attempted restart.

It is unlikely that the engine was running excessively rich, as this was the first flight after the overhaul and the engine and fuel components had been tested prior to reinstallation. In addition, the pilot probably adjusted the mixture control for each phase of flight in accordance with normal operating procedure and should have identified if there was a higher than usual fuel flow. Witness reports of the engine spluttering or struggling to start may be indicative of the pilot attempting an engine restart.

In summary, examination of the engine did not identify any failures or issues that may have contributed to the loss of engine power.

Fuel system examination

Examination of the fuel system identified that:

- both fuel tank filler caps were secure[12]
- the inboard section of the left wing, including fuel tank, was destroyed by the fire
- the right wing, including fuel tank, had minor heat damage, to the inboard section only
- a small fracture to the right tank inboard skin upper half that was likely a result of impact forces
- about 2 litres of fuel drained from the right tank when the wing was inverted
- the fuel shut-off valve was in the off (closed) selection
- the fuel selector valve was mid-travel between the 'left' and 'both' ports.

It was standard practice to fuel the flight school aircraft to 'full', however an accurate 'fuel on board' figure was not recorded. Fuel delivery records showed the EWE was fueled after its last flight, prior to entering maintenance and the amount of fuel uplifted was consistent with completely filling the tanks.

Fuel usage calculations (including on-ground engine runs) indicated there should have been about 121–146 L on board EWE at the time of the accident, of which between 109–134 L was usable.[13] Considering a worst-case scenario, with the aircraft being operated solely on one tank for the engine runs and flight, fuel calculations indicated that there should have been 17 L (11 L useable) remaining in the selected tank. Additionally, flight with the left tank full and the right nearly empty would likely have induced noticeable flight handling characteristics.

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[12] The right filler cap was secure on the right wing. The left filler cap was located in the fire-damaged remains of the left wing, in a closed and secure configuration.

[13] Fuel calculations considered the 'maximum' and 'reasonably expected' fuel burn for various phases of ground operations and flight.

Given the duration of the accident flight, it was considered unlikely that there was any problem with the fuel quality. That assessment is supported by the fact that a number of other aircraft used the same fuel source, with no reported issues.

Meteorological information

The Bureau of Meteorology's Moorabbin Airport automatic weather station recorded a temperature of 13˚C and a 13 kt northerly wind at 1700 on 8 June 2018. This corresponded with the conditions recorded on the Moorabbin Airport automatic terminal information service, which the pilot acknowledged receiving.

Sunset occurred at 1706, 7 minutes prior to the accident. After the pilot declared MAYDAY, EWE was observed in a left turn toward the west. Calculations and recorded video showed that sun glare and lighting conditions would not have reduced visibility at the time of the accident.

Approach profile considerations

Standard approach and glide profiles

The Cessna 172 POH does not provide approach profile guidance, however, it does contain the following information regarding landing approaches:

> Normal landing approaches can be made with power on or power off with any flap setting within the flap airspeed limits. Surface winds and air turbulence are usually the primary factors in determining the most comfortable approach speeds.

The glide distance capability of aircraft varies with the effect of ambient wind, reducing with a headwind component. A headwind is most commonly experienced during an approach to land and was present during the accident approach.

The glide distance capability of the aircraft also reduces with flap extension and an increase in bank angle. The best gliding distance capability of the Cessna 172 is achieved with wings level and the flaps fully retracted. However, an approach is typically conducted with flaps extended. Retracting the flaps to increase gliding distance results in an initial reduction in lift and associated loss of height. Furthermore, the POH instructs that FULL flap be used for a forced landing without power to facilitate the lowest possible touchdown groundspeed. Multiple configuration changes at low level however, may distract a pilot and make it more difficult to maintain control of the aircraft.

Forced landing

Forced landing without engine power

The Cessna 172 POH provided guidance on restart procedures for an engine failure during flight should sufficient height and time be available. The POH also included guidance for 'engine failure after take-off'. While not directly related to this occurrence, the guidance was relevant to an engine failure on approach as it occurs at low-level, with limited options and time to effect a successful landing.

> ENGINE FAILURE IMMEDIATELY AFTER TAKEOFF
>
> 1. Airspeed - 70 KIAS - Flaps UP
>
>   - 65 KIAS - Flaps 10° - FULL
>
> 2. Mixture Control - IDLE CUTOFF (pull full out)
>
> 3. FUEL SHUTOFF Valve - OFF (pull full out)
>
> 4. MAGNETOS Switch - OFF
>
> 5. Wing Flaps - AS REQUIRED (FULL recommended)

6. STBY BATT Switch - OFF
7. MASTER Switch (ALT and BAT) - OFF
8. Cabin Door - UNLATCH
9. Land - STRAIGHT AHEAD

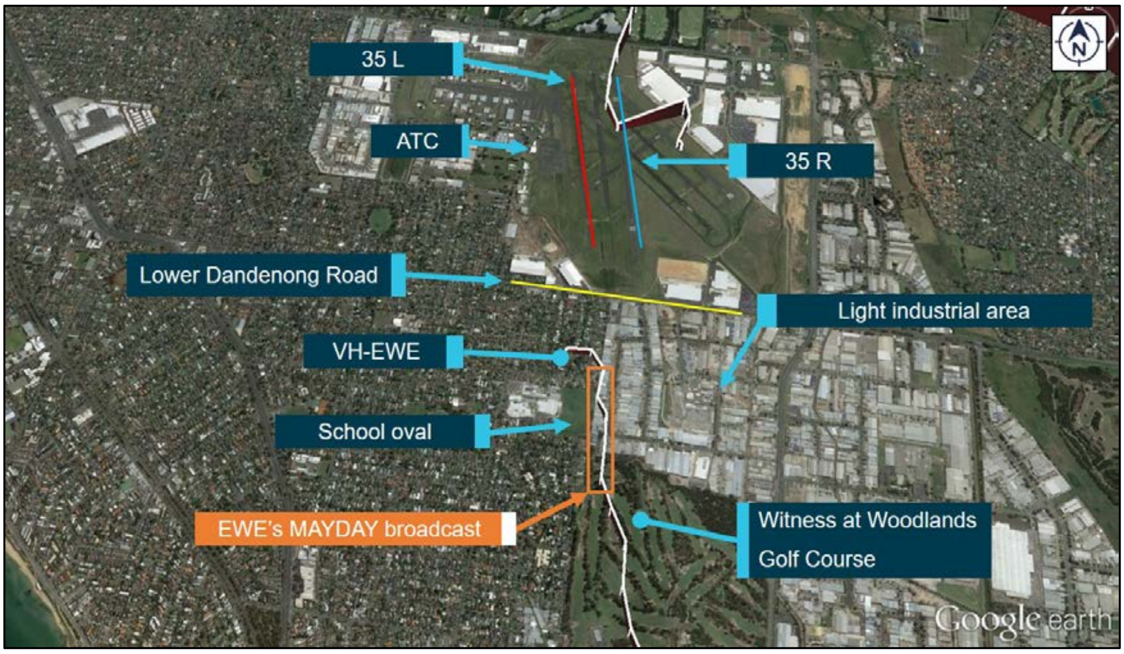
The ATSB publication Avoidable Accidents No. 3 - Managing partial power loss after take-off in single-engine aircraft outlined the hazards associated with engine power loss at low height and strategies to minimise the associated risk. In addition, the guidance included ‘knowing that you have planned your action under non-stressful and controlled circumstances should give you the confidence to carry out the actions in an emergency situation’.

Moorabbin Airport

Moorabbin Airport is located 21 km south-east of Melbourne, Victoria at an elevation of 55 ft above means sea level. The airport is home to a range of general aviation activities including flying training, flight charter, aviation maintenance, and general and recreation aviation operations. The published circuit altitude is 1,000 ft.

The standard approach to runway 35 left (35L) and runway 35 right (35R) involves flight over a nature reserve, a residential area, the Woodlands Golf Course and a light industrial area (Figure 7). Lower Dandenong Road forms the southern boundary of the airport and has powerlines running along its southern edge and the airport perimeter chain-link fence to the north. The area from the fence to the start of 35L, about 240 m, consists of undulating, clear grass ground and two internal airport service roads.

Figure 7: Overview of Moorabbin Airport vicinity showing VH-EWE departure and approach track



Source: Google Earth, modified by ATSB

Options for forced landing

Theoretical glide distances were calculated for three points (last radio call, midway between last radio call and MAYDAY call, and the MAYDAY call location) using ATC recorded audio, radar data, flight tracking data and witness reports. At each point, it was theoretically possible to make the edge of the airport with a perfect glide. However, accounting for the effects of wind, flap configuration, tolerances on the data and reaction time of the pilot, this may not have been achievable.

The school oval and Woodlands Golf Course were possible landing options for the pilot if he believed he could not glide to the runway. The golf course as a landing option was deemed impractical as EWE was calculated to be at, or near, overhead the golf course at a height above the ground of around 300 ft at the time of the MAYDAY.

The security footage and witness reports indicate that EWE may have turned left and been heading in a westerly direction shortly after the MAYDAY call. Based on this, it was possible that the pilot was attempting to conduct a forced landing on the school oval. EWE's estimated location during the MAYDAY call would have required a 180˚ left turn in order to conduct a southerly, downwind landing on the oval. The oval was about 210 m at its longest point, which is shorter than the approximately 375 m required for the Cessna 172 to land and come to rest.

Engine power loss during approach and forced landing guidance

FAA guidance

The United States Federal Aviation Administration publication Airplane Flying Handbook, Chapter 17 *Emergency Procedures* advises that when an emergency landing in terrain makes extensive aeroplane damage inevitable, pilots should keep in mind that keeping the cabin area relatively intact will help minimise injuries. This can be accomplished by using dispensable structure (wings, landing gear, fuselage bottom) to absorb the impact before it affects the occupants. In addition, vegetation, including brush and small trees, can provide considerable cushioning and braking effect without destroying the aeroplane.

> Most pilots instinctively—and correctly—look for the largest available flat and open field for an emergency landing. If beyond gliding distance of a suitable open area, the pilot should judge the available terrain for its energy absorbing capability.

It was noted that EWE's final approach was slightly lower than usual, prior to the MAYDAY broadcast. Chapter 8 *Approaches and Landings* includes accident statistics that show that a pilot is at more risk of an accident during the approach and landing than in any other phase of a flight. Further, following established procedures reduces the likelihood of an accident or mishap.

In addition, the guidance advised that in an emergency, such as an engine failure, elevator back pressure should not be applied to stretch a glide back to the runway. This will likely lead to the airplane landing short and may even result in a loss of control if the airplane stalls.

Other guidance

Flight Safety Australia published the article *Your one and only: mitigating the risk of engine failure in singles* in March 2019. This article highlighted that, while rare, engine failures should still be considered in the pre-flight planning.

> Although reassuring, the statistics on engine failure don't give licence to assume engine failure in a single won't happen to you. Rather than passively waiting for power loss and falling back on trained responses, pilots must actively defend their aircraft against the consequences of engine failure. Know your aircraft and procedures. Fly as high as practical, keep your options open and have a clear plan rehearsed for engine failure during every sequence of flight.

CASA developed 'a ten-part video series providing tips and advice from experts about keeping safe and legal' titled *Out-n-Back*. Episode 8 *Emergency procedures* recommended that 'the more you practise forced landings, the more readily those immediate vital actions will kick in, and the less daunting and intimidating your task will seem'.

Stall characteristics and recovery

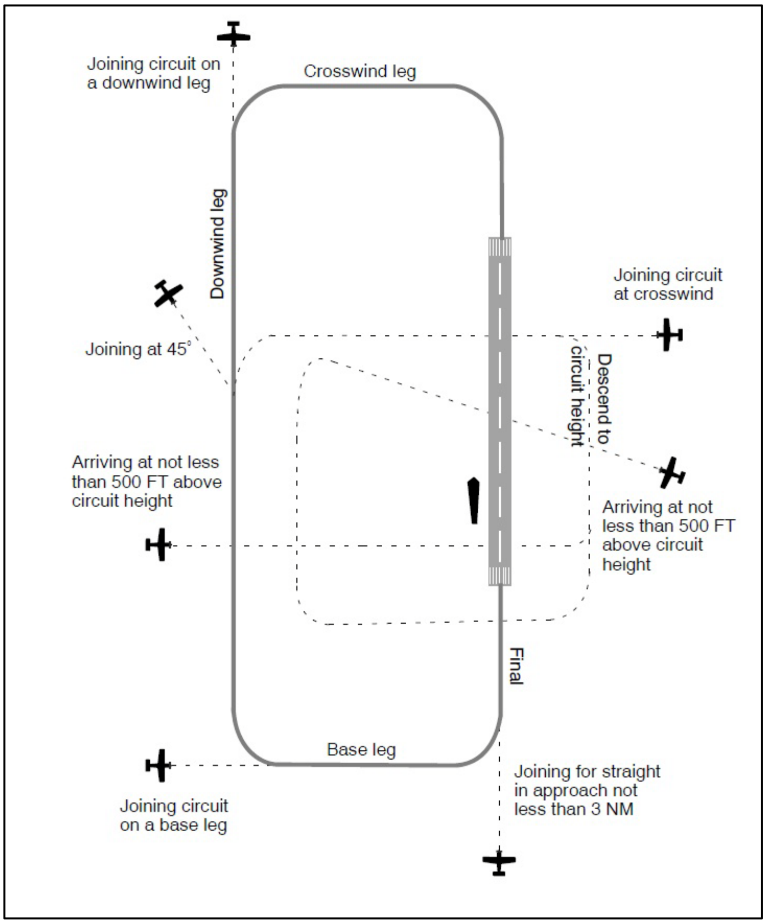
An aerodynamic stall occurs when airflow separates from the wing's upper surface and becomes turbulent, resulting in reduced lift and increased drag. In addition to any stall warning devices, pilots are trained to recognise an impending stall via sight, sound and feel.

A stall can be identified by an increasing descent rate, often accompanied by a rapid reduction in pitch attitude. An uncommanded roll or 'wing drop' may also occur when one wing stalls earlier than the other. Stall recovery practically involves lowering the nose of the aircraft and, if available, applying power to increase airspeed. Pilots are trained and assessed in stall identification and recovery during initial flight training and also during regular ongoing flight reviews. The POH stated that altitude loss of a C172, during a stall recovery, may be as much as 230 ft.

Circuit operations

In order to assure a safe and orderly traffic flow into and out of an airport, a standard circuit traffic pattern is used. The circuit consists of four legs: crosswind, downwind, base and final as shown in Figure 8, with standardised methods for joining the pattern to avoid traffic conflicts.

Figure 8: Standard circuit pattern



Source: Airservices Australia

Similar occurrences/research

A review of the ATSB national aviation occurrence database for single-engine piston-powered aeroplanes was conducted for the period January 2009 to January 2019. In total, out of 1,346 engine failure occurrences, 103 resulted in a loss of control. Engine failure or malfunction is not common, however there is increased pressure on the pilot when it occurs at critical stages of a flight, such as take-off and during final approach.

ATSB investigations

AO-2018-050

On 3 July 2018, the pilot, and sole occupant, of a Cessna 172RG aircraft, registered VH-LCZ, was conducting circuit operations at Parafield Airport, South Australia. At about 1758 Central Standard Time,[14] while under the night VFR[15] operations, the engine failed, likely due to carburetor icing. The engine failed at a position during the final approach that did not permit the aircraft to glide to the runway, and afforded limited alternative landing area options. While descending during the forced landing at night, the aircraft struck a power line and then collided with terrain, resulting in minor injury to the pilot and substantial damage to the aircraft.

While a successful landing was not achieved in this instance, the pilot's actions after realising he would not reach the runway closely followed the guidance in the Federal Aviation Authority pilot's handbook (*Airplane Flying Handbook*). The pilot's actions in maintaining control of the aircraft maximised the likelihood of a successful forced landing.

AO-2015-079

Late in the afternoon on Sunday 19 July 2015, an amateur-built Stoddard Hamilton Glasair SH-2FT two-seat aeroplane, registered VH-HRG and operated in the Experimental category, was seen flying due north, consistent with the downwind leg of a circuit for landing at Wedderburn Airport, New South Wales. Witnesses stated that they heard the aircraft's engine surge twice and then silence, prior to hearing the aircraft collide with wooded terrain about 900 m north of the runway threshold. No witness reported seeing the aircraft turn onto the base leg or final approach, nor the aircraft collide with terrain. The pilot sustained serious injuries, the passenger was fatally injured and the aircraft was destroyed.

The ATSB found that during the turn onto final approach to land, the aeroplane's engine ceased operating, probably due to carburetor icing. Following the loss of power, the pilot was unable to control the aircraft's descent to an appropriate forced landing area before colliding with the ground.

AO-2014-149

On the morning of 14 September 2014, the pilot and passenger of an amateur-built Van's Aircraft RV-6, a two-seat aeroplane, registered VH-TXF, approached Mudgee Airport, following a 25-minute flight. Witnesses stated that the pilot conducted a tight left turn onto final approach at a slow speed and low height. The witnesses also recalled hearing the aeroplane's engine 'splutter' and then silence during the turn. The aeroplane continued its high-angle-of-bank left turn until it collided with terrain about 300 m south-west and short of the runway threshold. The pilot and passenger were fatally injured and the aeroplane was substantially damaged.

The ATSB found that during the turn onto final approach to land, the aeroplane's engine ceased operating, likely due to carburetor icing. Analysis of the aeroplane's global positioning system data showed that it was common for this pilot to fly approaches at lower than recommended circuit heights and at speeds close to the aircraft's stall speed. The aeroplane's airspeed before the engine failure was within about 0.5 kt of the estimated stall speed during the high-bank turn. After the engine failure, it is likely the aeroplane entered an aerodynamic stall. The associated loss of control was not recovered and the aircraft continued in the turn until it collided with terrain.

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[14] Central Standard Time (CST): Universal Coordinated Time (UTC) + 9.5 hours.

[15] Visual flight rules (VFR): a set of regulations that permit a pilot to operate an aircraft only in weather conditions generally clear enough to allow the pilot to see where the aircraft is going.

Safety analysis

VH-EWE (EWE) experienced an engine power loss while on final approach to land at Moorabbin Airport. The pilot transmitted a MAYDAY distress message, which was shortly followed by a loss of control and subsequent collision with terrain. The analysis will examine the factors involved in the engine power loss and subsequent loss of control.

Engine power loss

The pilot had been in contact with Moorabbin air traffic control for over 6 minutes with no indication of any engine issues. The pilot transmitted MAYDAY, stating ‘engine failure’, about 20 seconds after acknowledging his clearance to land, consistent with the engine issue developing relatively rapidly.

The engine had been operated, during testing and in the aircraft, for about 4 hours, with no indication of abnormalities. Further, the engine examination did not identify a mechanical reason for the loss of power. In the absence of an identified mechanical failure, the ATSB considered the possibility of a fuel-related issue.

Fuel calculations indicated there should have been over 100 L on board EWE at the time of the accident. In addition, the intense post-impact fire was consistent with there being a substantial quantity of fuel on board.

Wreckage examination identified that the right wing had minor heat damage whereas the forward fuselage and left wing were almost entirely consumed by the fire. In addition, the engine issue occurred shortly after EWE turned right onto final. The investigation therefore explored the possibility that EWE had been operated solely on the right fuel tank during maintenance runs and flight, resulting in fuel starvation that was potentially influenced by un-porting of the fuel tank outlet. The fuel selector valve position prior to the accident could not be determined. However, fuel tank selection should be checked prior to start, prior to takeoff and before landing to ensure that fuel is drawn from both fuel tanks simultaneously. Further, the fuel quantity in both tanks would normally be monitored by the pilot throughout the flight to identify any fuel consumption variation.

In addition, the following factors opposed this hypothesis:

- there should have been at least 17 L (11 L useable) remaining in the right tank at the time of the accident, even if the entire flight was conducted using fuel from the right wing tank
- conducting a coordinated turn should avoid un-porting of the fuel tank outlet in low-fuel quantity conditions
- the LOW FUEL warning should have indicated if the fuel quantity was less than 18 L for 60 seconds however, as there is no aural warning for low fuel, the pilot may have missed any activation of the warning light during the relatively high workload period setting up for landing
- flight with the left tank full and right nearly empty would likely induce flight characteristics that would be noticed by the pilot.

Therefore, while the uneven fire damage was unusual, there was insufficient evidence to determine that fuel starvation occurred following operation solely on the right tank. Further, there was insufficient evidence to determine if a temporary interruption to fuel flow or other intermittent fuel starvation event occurred.

Witness reports of unusual engine sounds of an engine struggling to start could be indicative of the pilot attempting to restore power. However, it was also likely that the pilot closed the fuel shut off valve, which was consistent with a decision to conduct a forced landing without engine power.

In summary, the reason for the engine power loss could not be determined.

Loss of control

The final approach path was situated over residential and light industrial areas, with few options for an off-airport landing. The pilot had worked at, and flown out of, Moorabbin Airport for many years, so was presumably aware that the departure and approach paths offered limited options for off-airport forced landings. Air traffic control's observation of EWE's approach was that the aircraft was a little low but not unusually so. In normal circumstances, the lower than normal height would not have affected the landing. In this occurrence, however, it reduced the likelihood of being able to safely glide to the airfield following the engine failure.

After the pilot's MAYDAY transmission, both air traffic controllers noted that EWE's nose attitude increased. This may have been indicative of the pilot attempting to extend the glide to the airport. Acknowledging that such an action would be instinctive when faced with the potential of a forced landing over an unsuitable area, the most important actions are to 'continue flying the aircraft' and achieve best glide speed. Raising the nose, without the addition of power, reduces airspeed, which can lead to loss of control if the aircraft slows excessively. The pilot also retracted the flaps, consistent with attempting to achieve the best glide distance. However, with the flaps retracted, the aircraft's stall speed also increased.

The theoretical glide distance from the approximate location of the MAYDAY call, in ideal conditions, indicated it may have been possible to reach the airport property short of runway 35L. However, given the headwind and time required for the pilot to identify and react to the situation, had he attempted to conduct a forced landing straight ahead it is likely the aircraft would have landed just short of the airport.

Notwithstanding the chance of the touchdown occurring on a relatively busy road, landing short of, and passing through, the perimeter fence would have reduced the aircraft's forward momentum. In addition, the open grassed area between the fence and runway threshold was relatively energy-absorbent and free of obstacles. As such, and consistent with advice provided by the United States Federal Aviation Administration, a forced landing in these conditions was conducive to increased survivability.

The ATSB considered whether the school oval may have appeared more desirable to the pilot than a forced landing straight ahead, which presented buildings, roads, power lines and the airport perimeter fence. This may have prompted the reported left turn shortly after the MAYDAY broadcast. However, the act of turning increases the angle of bank and, in turn, the stall speed if back pressure is applied.

Ultimately, the left wing drop and sharp nose drop were consistent with an aerodynamic stall. In addition, the aircraft was calculated to be at about 85 ft when the stall occurred, considerably lower than the published minimum height required for stall recovery.

The pilot's last flight review, 11 months prior to the accident, included practice engine failures. While the pilot may have conducted additional practice in the intervening time, there was no documented evidence of any additional practice, either formal or informal, having been conducted. The extent to which the pilot's recency in management of emergencies influenced the development of the accident could not be determined. However, regularly practicing the appropriate emergency response improves readiness and proficiency, should an engine power loss occur.

When faced with in-flight emergencies such as a loss of engine power, pilots needs to make decisions on how to manage the situation under conditions of stress, uncertainty, high workload, and time pressure.

During pre-landing planning, considering factors such as wind direction and landing options on and off the airfield will likely reduce the pilot's mental workload if an engine power loss occurs. While it was not possible to determine the degree to which the pilot considered the potential for an engine power loss, pre-planning generally mitigates the detrimental effects of decision-making under stress.

Findings

From the evidence available, the following findings are made with respect to the loss of control and collision with terrain involving a Cessna Aircraft Company 172S, registered VH-EWE that occurred near Moorabbin Airport, Victoria on 8 June 2018. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing factors

- During final approach, for reasons that could not be determined, VH-EWE experienced an engine power loss, at a position that afforded limited clear landing area options.
- Following the engine power loss, control of the aircraft was lost at a height insufficient for recovery prior to collision with terrain.

General details

Occurrence details

Date and time:	8 June 2018 – 1713 EST	
Occurrence category:	Accident	
Primary occurrence type:	Loss of control and collision with terrain	
Location:	680 m south-south-west Moorabbin Airport, Victoria	
	Latitude: 37° 59.344' S	Longitude: 145° 5.775' E

Pilot details

Licence details:	Commercial Pilot (Aeroplane) Licence, issued January 1989
Endorsements:	Manual propeller pitch control; retractable undercarriage; tail-wheel undercarriage, single- and multi-engine Aeroplanes
Ratings:	Nil
Medical certificate:	Class 1, valid to 17 July 2018
Aeronautical experience:	Approximately 1,400 hours
Last flight review:	July 2017

Aircraft details

Manufacturer and model:	Cessna Aircraft Company 172S	
Registration:	VH-EWE	
Serial number:	172S10361	
Type of operation:	Private	
Departure:	Moorabbin Airport	
Destination:	Moorabbin Airport	
Persons on board:	Crew – 1	Passengers – Nil
Injuries:	Crew – 1	Passengers – Nil
Aircraft damage:	Destroyed	

Sources and submissions

Sources of information

The sources of information during the investigation included:

- the Civil Aviation Safety Authority
- Airservices Australia
- Cessna Aircraft Company (manufacturer)
- the flight training organisation

References

Australian Transport Safety Bureau Avoidable Accidents No. 3 - Managing partial power loss after takeoff in single-engine aircraft

United States Federal Aviation Administration (FAA) *Airplane Flying Handbook.* Available on the FAA website www.faa.gov

FAA *Safety briefing September/October 2010*

Civil Aviation Safety Authority (Australia) *Out-n-back.* Available via www.casa.gov.au

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 Civil Aviation Safety Authority, Airservices Australia, the United States National Transportation Safety Board, the aircraft and engine manufacturers, the aircraft maintainer, and the flight-training organisation.

Submissions were received from the Civil Aviation Safety Authority, Airservices Australia, the United States National Transportation Safety Board, the aircraft and engine manufacturers, the aircraft maintainer, and the flight training organisation. 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 ATSB's 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.

Contributing factor: a 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 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 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.