

Australian Government Australian Tr<u>ansport Safety Bureau</u>

Loss of control and collision with terrain involving Cessna T310R, VH-JMW

40 km south-south-west of Port Macquarie, NSW | 28 October 2017



Investigation

ATSB Transport Safety Report

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Postal address:	PO Box 967, Civic Square ACT 2608	
Office:	62 Northbourne Avenue Canberra, Australian Capital Territory 2601	
Telephone:	1800 020 616, from overseas +61 2 6257 2463 (24 hours)	
	Accident and incident notification: 1800 011 034 (24 hours)	
Email:	atsbinfo@atsb.gov.au	
Internet:	www.atsb.gov.au	

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Addendum

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Safety summary

What happened

During the afternoon of 28 October 2017, a Cessna Aircraft Company T310R, registered VH-JMW (JMW) was conducting a return flight from The Lakes airstrip, New South Wales to Toowoomba Airport, Queensland with the pilot and one passenger on board.

On the return flight from Toowoomba, during descent to The Lakes, and while about 8 km from the runway, a witness recalled hearing the sound of what he thought was a single-engine aircraft 'cough' and then stop. Shortly afterwards, JMW was seen descending slowly with the landing gear extended. The aircraft then 'jerked' suddenly, rolled to the left and descended rapidly to the ground.

The pilot and passenger were fatally injured and the aircraft was destroyed.

What the ATSB found

The ATSB identified that during the final descent towards the Lakes airstrip runway, the left engine was not producing power and the right engine was operating at low or intermittent power.

Following the loss of engine power a safe flying speed was not maintained resulting in a loss of control and collision with terrain due to either an aerodynamic stall, asymmetric power effects or a combination of both.

The loss of engine power was probably the result of either insufficient fuel for the flight or an in-flight fuel management error.

Safety message

A loss of power in an aeroplane requires different responses depending on whether the aircraft has single or multiple engines. However, regardless of the configuration, in order to maximise the survivability outcome it is imperative that the pilot retains control of the aircraft and maintains a safe airspeed. Where the aircraft's performance degrades to the point that continued safe flight is not possible, the pilot must shift focus to conducting a forced landing.

Pilots also need to routinely exercise good fuel-management practices in order to maintain the highest level of safety and avoid fuel exhaustion or starvation events. <u>*Civil Aviation Advisory*</u> <u>*Publication 234-1(2)*</u> provides guidance on the current fuel requirements and good fuel-management practices.

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The occurrence

What happened

At about 1000 Eastern Daylight-saving Time¹ on 28 October 2017, a Cessna Aircraft Company² T310R, registered VH-JMW (JMW), departed The Lakes airstrip, New South Wales, for a private flight to Toowoomba Airport, Queensland with the pilot and one passenger on board. The aircraft arrived in Toowoomba at about 1130 and remained on the ground for a few hours.

At about 1437, the pilot and passenger departed for the return flight to The Lakes. The aircraft was not refuelled at Toowoomba and weather forecasts and reports indicated that conditions were suitable for flight under the Visual Flight Rules.³ There was a light westerly crosswind at the cruising altitude of 9,500 ft and a light easterly wind at lower altitudes near the destination.

At about 1541, the passenger sent a cheerful text message to a friend, which indicated that all on board the aircraft was normal. A short time later, the pilot began the descent from 9,500 ft and continued tracking towards The Lakes.

At about 1554, a witness located close to JMW's track heard a low-flying aircraft to the west of his position travelling south (Figure 1, 'Witness 1'). He described the aircraft as sounding like a single-engine aircraft and recalled hearing the engine 'cough' and then stop as the aircraft flew past him.



Figure 1: Flight path of VH-JMW

Source: Google Earth modified by the ATSB

A minute later, two other witnesses, both driving south along the Pacific Highway, saw JMW to the west of the highway at low altitude (Figure 1, 'witnesses 2 & 3'). One witness recalled the aircraft was descending slowly at first with the landing gear extended. Soon after, the witness saw the aircraft 'jerk' then roll to the left, pitch down and descend rapidly to the ground.

¹ Eastern Daylight-saving Time (EDT): Coordinated Universal Time (UTC) + 11 hours.

² On 29 July 2015, the Type Certificate Holder transferred from the Cessna Aircraft Company to Textron Aviation. All information related to the aircraft manufacturer in this report pre-dates that transfer.

³ Visual flight rules (VFR): a set of regulations that permit a pilot to operate an aircraft only in weather conditions clear enough to allow the pilot to control and navigate the aircraft visually.

At about 1555, JMW impacted trees and then collided with terrain. The aircraft came to rest in a narrow wooded strip of land between the highway and the main northern railway line (Figure 2). The wreckage was about 800 m (0.4 NM) from The Lakes runway 16 threshold.

One of the witnesses driving on the Pacific Highway was the first to arrive at the accident site. He recalled smelling fuel on arrival, and the ground around the aircraft's wreckage being wet. He also noticed a momentary wisp of smoke from sparking electrical components behind one of the wings however, there was no fire. Emergency services personnel arrived at the accident site shortly afterwards. A couple of the first responders reported a fuel smell near the aircraft, but others did not recall smelling fuel.

The pilot and the passenger were fatally injured and the aircraft was destroyed in the accident.



Figure 2: Accident site

Source: ATSB

Context

Pilot information

The pilot held a:

- Private Pilot (Aeroplane) Licence issued on 10 October 2000
- current Class 2 aviation medical certificate issued in 2017 without restriction
- Night Visual Flight Rules rating and a Private Instrument Flight Rules rating.⁴

The pilot had owned a number of single- and multi-engine aircraft, and was endorsed for the Cessna 310 in December 2001.

Extracts from the pilot's logbook showed that he had in excess of 3,200 hours total flying experience on aeroplanes, with more than 300 hours experience on multi-engine aircraft. He last completed a multi-engine flight review with a flight instructor in May 2017. As part of that review, the pilot demonstrated his ability to manage asymmetric power conditions and simulated one-engine inoperative exercises at various phases of the flight. The instructor recorded the pilot's response to these exercises as 'normal'.

Aircraft information

The Cessna Aircraft Company T310R is a low-wing, twin-engine aircraft equipped with retractable landing gear. In 1988, VH-JMW was modified under supplementary type certificates to replace the original Continental IO-520-MB engines with turbocharged engines (TSIO-520-NB) and fit new three-bladed propellers (Figure 3).





Source: Flightaware.com

In December 2016, a periodic inspection was conducted. The maintenance release did not identify any defects. The release was valid for 100 hours or until 14 December 2017. The only scheduled maintenance task carried out during this release period was an engine oil change. Documentation for the aircraft's prior maintenance history, including fuel gauge calibration, was not available.

⁴ Instrument flight rules (IFR): a set of regulations that permit the pilot to operate an aircraft to operate in instrument meteorological conditions (IMC), which have much lower weather minimums than flights conducted using the visual flight rules (VFR). Procedures and training are more complex as a pilot must demonstrate competency in IMC conditions while controlling and navigating the aircraft solely by reference to instruments. IFR-capable aircraft have greater equipment and maintenance requirements.

At the time of the accident, the aircraft's optional equipment included:

- a multifunction display
- a digital fuel flow indicator and totaliser (digital fuel system), which had replaced the standard Cessna analogue fuel flow gauge
- an electronic primary navigation display.

Fuel system

The aircraft's fuel system consisted of two main tanks located on the tip of each wing, two auxiliary tanks and two wing locker tanks. The dual indicating fuel quantity gauge provided a continuous indication of the fuel remaining in the selected tanks based on fuel weight, for both the left and right sides of the aircraft. The aircraft was not equipped with optional low fuel level indicator lights. The total capacity of the main tanks and the auxiliary tanks was 628 L, with 617 L being usable. The total capacity of the wing locker tanks was 155 L with 151 L of usable fuel.

The main tanks were integrally sealed aluminium tanks, which were vented to atmospheric pressure by a flush vent located on the lower aft portion of each main tank. Each auxiliary fuel tank consisted of two interconnected bladder-type fuel cells located between the wing spars in the outboard section of each wing. The wing locker fuel tanks were located in the forward part of each wing locker baggage area and were also bladder-type cells that supplemented the main tank fuel quantity. The wing locker fuel could not be fed directly to the engines; instead it was transferred to the main tanks by manually-selected wing locker fuel transfer pumps.

Two fuel selectors, one for each engine, were located on the floor between the pilot and co-pilot seats. The fuel selectors controlled the wing selector valves to enable switching between the main and auxiliary fuel tanks.

The fuel system comprised the following pumps (for each side to the aircraft):

- engine-driven fuel pump (to transfer fuel from the centre sump to the engine)
- auxiliary boost fuel pump (to provide fuel pressure for priming during engine starting, and to supply fuel to the engine in an emergency)
- main fuel tank transfer pump (to transfer fuel from the nose of the main tank to the centre sump and allow steep descent with low fuel quantity)
- wing locker fuel tank transfer pump (to transfer fuel from the wing locker tank to the main tank).

Fuel tank selection

The Cessna T310R Pilot's Operating Handbook (POH) (Revision 3, 1982) stated:

If auxiliary fuel tanks are to be used, select main fuel for ... 90 minutes of flight. This is necessary to provide space in the main tanks for vapour and fuel returned from the engine-driven fuel pumps when operating on auxiliary fuel. If sufficient space is not available in the main tanks for this diverted fuel, the tanks can overflow through the overboard fuel vents.

The POH also stated that in the event of an engine failure, the fuel in the auxiliary tank on the side of the failed engine would become unusable.

The Cessna Aircraft Company's *Pilot Safety and Warning Supplements* (1 June 1998) also included this important fuel tank selection sequence. If auxiliary tanks were to be used, this sequence would ensure excess fuel supplied to the engine was collected in the main tanks, and not vented overboard. The incorrect sequence could result in venting fuel, reducing the fuel available to complete the planned flight.

The potential for accidental venting of fuel overboard described above and guidance on correct tank sequence had been widely promulgated for a many years. As such, it was considered unlikely that an experienced pilot would make such an incorrect selection.

Digital fuel system

The aircraft was equipped with a digital fuel system that measured the instantaneous fuel flow to each engine and calculated the aircraft's endurance based on current fuel flow and the system-totalised quantity of fuel remaining.

The system did not measure the actual fuel quantity on board the aircraft, instead it relied on a manually entered starting quantity and the system-calculated quantity of fuel consumed. Additionally, the data presented did not provide the pilot with the quantity of fuel in individual fuel tanks. The pilot had the following manual data entry options:

- input the quantity of fuel added
- update the system's computation of fuel remaining
- selection of a 'full' fuel default.

The ATSB examined the digital fuel system and found that it was correctly configured for the aircraft and operational at the time of the accident. The default 'full' value was set to 616 L in the system settings, which closely corresponded with the usable capacity in the main and auxiliary tanks. The system was set to display 'Lo FUEL' when the pre-programmed fuel level of 100 L was reached. Once 'Lo FUEL' was displayed, the fuel flow information would not display until the pilot acknowledged the warning by pressing 'enter'.

The system was also configured to display a warning for the flying time remaining (endurance time). When the endurance time reduced below the pre-programmed endurance time of 45 minutes, the data in the right half of the display flashed. This warning required the pilot to acknowledge the warning by pressing 'enter'.

Operational information

Fuel management

At the time of the accident, the Civil Aviation Advisory Publication, *CAAP 234-1(1) Guidelines for Aircraft Fuel Requirements*, was in effect.⁵ The CAAP recommended a 45-minute fixed fuel reserve⁶ and that pilots use at least two independent fuel check methods to establish the quantity of fuel.

Fuel quantity

The last known fuel uplift by JMW was recorded on 12 September 2017. The number of flights undertaken between 12 September and the accident flight meant that the aircraft must have been refuelled during that time. However, no records were found to indicate where, when and how much fuel was uplifted. Consequently, it was not possible to determine the fuel quantity on board the aircraft on departure from either The Lakes or Toowoomba.

There was some indication that the pilot considered the runway length at The Lakes was weight limiting on take-off. While this could suggest JMW did not depart from there with full fuel, that could not be verified. The aircraft was not refuelled in Toowoomba prior to the return flight.

⁵ In November 2018, CASA 29/18 – Civil Aviation Fuel Requirement Instrument was released which re-introduced a fixed fuel reserve requirement (30 minutes for daytime VFR pilots) and required pilots to conduct in-flight fuel management with regular fuel quantity checks, and, if required, declare MAYDAY fuel. At the same time, the advisory publication was updated to include the new requirements.

⁶ For visual flight rules flights in an aircraft with piston engines.

The ATSB found the refuelling facility at The Lakes airstrip had appropriate maintenance placards affixed to the bowser indicating that it was in use. The facility's fuel tank was about one-third full, and a test of the fuel indicated no fuel quality issues. The facility was not required keep fuel records.

The supplemental type certificate for JMW under which the turbocharged engines were installed did not provide revised fuel consumption rates. No other documents, such as pilot calculations for the aircraft's fuel consumption or similar records, were found. In the absence of that information, the ATSB used the fuel consumption rates of a Cessna aircraft (of similar size to JMW and fitted with the same engines) to estimate fuel consumption for the accident flight. This calculation indicated that fuel consumption for the round trip from The Lakes to Toowoomba would be in the order of 425 L.

The on board digital fuel system recorded a consumption of 563 L (based on the pilot's last entry and system calculations) and displayed 53 L remaining. If the starting fuel quantity was accurate, there should have been 53 L (616 - 563 L) of usable fuel based on calculations remaining at the time of the accident. However, this could not be verified by independent calculations or physical evidence.

Asymmetric operations

The Cessna 310 has two wing-mounted engines that produce symmetrical propeller thrust during normal operation. When one engine is inoperative, the resulting asymmetric forces will cause the aircraft to yaw in the direction of the inoperative engine, which can be countered through the application of rudder and aileron control inputs. The minimum control speed (V_{mca}^7) of 84 KIAS⁸ must be maintained to ensure that the rudder and aileron retain sufficient control authority to maintain directional control of the aircraft. The value of the minimum control speed will vary from the published value with engine power level on the operable engine and aircraft configuration. With the operable engine at low power, the minimum control speed will reduce to a value close to the stall speed.

The intentional one engine inoperative section of the Cessna T310R POH stated that while the aircraft is controllable at V_{mca} , the performance is so far below optimum that continued flight near the ground is improbable. Therefore, the handbook recommended that a more suitable safe single-engine speed was 92 KIAS. At this speed, altitude could be maintained more easily while the landing gear is being retracted and the propeller is being feathered.⁹

A single inoperative engine on a twin-engine aircraft may not always result in controllability issues that are immediately obvious to the pilot. This point was highlighted in the United States Federal Aviation Administration (FAA) *Airplane Flying Handbook*:

An engine failure in a descent or other low power setting can be deceiving. The dramatic yaw and performance loss will be absent. At very low power settings, the pilot may not even be aware of a failure.

Aircraft handling following engine failure

The Cessna 310 POH stated that, following an engine failure, the pilot's first consideration is to maintain control of the aircraft and ensure the airspeed remains above the minimum control speed. It then stated that the pilot needed to identify the inoperative engine, adjust the operative engine as required, and perform a number of checks relating to fuel flow, tank selection and quantity; engine oil pressure and temperatures; magneto switches and mixture. If the engine could

⁷ V_{mca} is defined as the indicated airspeed at which it is possible to maintain control of the aeroplane when the critical engine is suddenly made inoperative, and thereafter to maintain straight and level flight at the same speed with an angle of bank of not more than 5° towards the operative engine.

⁸ Minimum control speed taken from STC.

⁹ Rotation of propeller blades to an edge-on angle to the airflow to minimise aircraft drag following an in-flight engine failure or shutdown.

not be re-started, the pilot must 'secure' or shutdown the engine, which includes feathering the propeller.

The FAA *Airplane Flying Handbook* provides further practical guidance for managing such a situation. Importantly, the handbook stated that completely securing a failed engine may not be necessary or even desirable depending upon the failure mode, altitude, and time available.

It is recognised that if both engines lose power, the best gliding range will be achieved when the aircraft is flown at the optimum gliding speed and configured for the minimum aerodynamic drag. Guidance for configuring an aircraft following engine failure is provided in the *Multi-Engine Pilot Manual* by Jeppesen Sanderson (1992):

It is important that the pilot be familiar with the correct order for drag reduction following an engine failure. Normally, a windmilling propeller contributes the greatest amount of drag, followed by full flaps, extended landing gear, and the control deflections required to stop the airplane from turning. Since it is considered unwise to immediately feather an engine before it has been positively identified, drag is normally reduced by first retracting flaps and gear. Next, the failed engine is identified and the propeller is feathered. However, the specific order of drag reduction may vary between types of twin-engine airplanes, so the manufacturer's recommendations should be followed.

Based on the estimated weight of JMW, its best glide speed was about 102 KIAS at a glide angle of 4°. Any variation from that target airspeed would have reduced the gliding range. Shortly before the collision, the aircraft's airspeed was about 67 kt, 35 kt less than the best glide speed.

Aircraft performance degradation

In relation to a previous Cessna 310 accident, the aircraft manufacturer provided information that an unmodified Cessna 310 at maximum landing weight has a single-engine climb rate of about 375 feet per minute at sea level. However, the drag penalties of an unfeathered windmilling¹⁰ propeller, extended landing gear and full flap significantly degrade single-engine climb performance. Under these conditions with one engine inoperative, a penalty to the climb rate of about 850 feet per minute could be expected.

In comparison to standard engines for its aircraft type, JMW's engines were higher performing. At the time of the accident, JMW had its landing gear extended, propellers unfeathered and flaps at 15° (see the section titled *Aircraft configuration*). In this configuration, the aircraft descended about 1,100 ft during the last minute of its flight (see the section titled *Recorded data*).

Recorded data

The aircraft was fitted with an electronic primary navigation display. The recorded data on the navigation system included aircraft pitch, roll and ground speed.

ATSB analysis of the recorded data (partly illustrated in Figure 4) determined that:

- About 140 seconds before the collision, the aircraft rolled to the left and then to the right. The
 aircraft was travelling at about 150 kt at an altitude of 1,600 ft and was approximately 4.5 NM
 from the The Lakes runway threshold. There was a corresponding heading change to the left
 of approximately 4° followed by a change to the right of approximately 6°. This sequence could
 be consistent with asymmetric forces on the aircraft due to the loss of left engine power or a
 course correction onto the final approach path.
- Shortly after, the speed of the aircraft decreased below the maximum flap extension speed (158 KIAS) and the maximum landing gear extension speed (138 KIAS) indicating the pilot did not configure the aircraft into its final configuration until the last 100 seconds of the flight.

¹⁰ Windmilling: a rotating propeller being driven by the airflow rather than by engine power; this results in increased drag at normal propeller blade angles.

- From about 1554 (60 seconds before control of the aircraft was lost) the pitch of the aircraft trends upwards from -5° (nose down) to a maximum of 6.5° nose up just before the loss of control.
- Just after 1554, the aircraft's altitude was about 1,100 ft¹¹ (last known altitude). The aircraft was approximately 2 NM from the runway threshold.
- About 30 seconds before the collision and again about 10 seconds before the collision, the aircraft rolled to the left and pitched down with a heading change to the left (Figure 4). This sequence was consistent with asymmetric forces on the aircraft due to the loss of left engine power.
- Over the last 30 seconds of the flight, the rate of speed decay increased with the aircraft's speed reducing to below the published (and likely actual) V_{mca}, and into the stall speed range (68–74 kt).¹² Constant variations in pitch and roll were evident throughout this stage of the flight, with a continual upward trend in pitch (Figure 4).
- Just before 1555, the aircraft's speed decayed to 67 kt¹³ (ground speed). The nose continued to pitch up, attaining a maximum pitch of about 6.5 degrees. Shortly after, the left wing dropped and the nose pitched towards the ground.



Figure 4: Last 280 seconds of recorded flight data

Source: ATSB

¹¹ The aircraft's altitude was sourced from the flightradar24 website.

¹² A range for the stall speed has been specified because the stall speed will vary with a number of parameters including weight, which was unknown at the time of the accident. The range has been estimated assuming the aircraft was lightly loaded and had less than 20 degrees angle of bank.

¹³ The aircraft's system recorded ground speed of the aircraft. The weather reports for the area around the time of the accident indicate that the winds were light and therefore the groundspeed closely represents what the indicated airspeed would have been.

Wreckage and impact information

The ATSB's examination of the accident site confirmed that the aircraft was in a left-wing, nose-down attitude when it collided with terrain. It came to rest between a railway line and the Pacific Highway in a thicket of gumtrees and coastal scrub. The distribution of the wreckage and the damage to the trees indicated that the aircraft had little forward momentum on impact (Figure 2). The impact forces from the collision destroyed the aircraft.

Aircraft structure

All of the aircraft structure was identified at the accident site. There was no evidence of inflight break-up or post-impact fire. Continuity of the flight control cables and aircraft control surfaces were confirmed as secure or fractured due to overstress, consistent with the ground collision.

There were no pre-existing mechanical defects identified during the examination that would have prevented normal operation of the aircraft. However, there was severe disruption to the aircraft pitot tubes, seats and fuel selector system, making it impossible to determine their serviceability.

The aircraft's occupant restraint system had been in use during the flight and was working normally.

Aircraft configuration

The wreckage examination showed that the aircraft was configured with the landing gear down and locked, and the flaps extended to 15°. Both the left and right engine propellers were towards the fine pitch, and not feathered.

The position of the flight controls, engine controls and fuel tank selectors immediately prior to the loss of control could not be determined due to the severe disruption of the cockpit and fuselage.

Engines

Continuity of the right engine propeller pitch control was established by visual inspection. The left engine propeller pitch control cable had separated at the governor connecting rod, consistent with overstress failure from impact forces.

The left propeller blades showed no evidence of bending, twisting or chord-wise (that is, across the width of the blade) scratching. This indicated that the left engine was not producing power on impact. On the other hand, one blade of the right propeller showed evidence of forward compound bending, and chord-wise scratching across its face. The spinner and propeller hub were partially buried in the ground with evidence of corkscrewing of the propeller pressure dome cover attached to the spinner. The propeller hub fractured at the crankshaft. Examination of the fracture surface showed that dominant failure load was bending, consistent with no significant power on the right engine at the time of impact with terrain.

An external visual inspection of the left and right engine and engine controls did not identify any pre-existing damage or defects. All of the damage identified (including to the left engine fuel pump and oil sump) was consistent with impact damage from the collision.

The cylinders, sparkplugs, crankcase and external accessories were confirmed secure on both the left and right engine. All of the fuel supply and return lines between the engine firewall and the engine were disconnected and inspected. Negligible fuel was found in the lines (they should contain fuel under normal operating conditions). No blockages in the lines that would have prevented fuel reaching either engine were found.

The left engine oil sump was breached during the impact and a quantity of oil had leaked out and been absorbed in the soil. However, the oil cap was secure and some oil was noted on the graduated dipstick. Oil was also identified in the right engine.

The spark plugs, fuel pump, vacuum pump and all cylinder rocker covers on both engines were removed and inspected. Rotation of the crankshaft on each engine demonstrated continuity of the

major engine components. During rotation, the pistons, cylinder rocker arms, vacuum pump drive, fuel pump drive and magneto gears were found to move through their normal range. An endoscope was used to determine that the pistons, valves and cylinders were in normal operational condition.

The left and right engine turbo charger inlet and outlet impellors were inspected and nil damage identified. The absence of damage provided inconclusive evidence to indicate whether the turbo chargers were powered at the time of impact.

There was no evidence found during examination of the engines to indicate that either engine was incapable of normal operation.

The fuel system

Both the left and right main fuel tanks separated from the wings following overstress failure at the spar attachments, and were found between 5 and 10 m from the main wreckage. Impact forces from the accident breached both the tanks, but their fuel caps were found in place and secured.

The left and right auxiliary fuel tanks were holed and crushed during the accident. There was some evidence of discolouration under the left wing resulting from fuel weeping from the left auxiliary tank. This weep was assessed as minor and therefore considered to have had a negligible impact on the usable fuel quantity.

The left and right wing locker tanks were intact but the interconnecting pipes had fractured during the accident. There was no evidence of fuel in either tank.

There was no fuel-fed post-impact fire or evidence of fuel tank deformation resulting from a large quantity of fuel impacting the internal walls of the fuel tank during the accident. While the first persons to arrive at the accident site reported smelling fuel, others who arrived shortly afterwards did not smell fuel. This could be indicative of the smell of fuel vapour from ruptured tanks, which then dissipated. Further, ATSB investigators found a negligible quantity of fuel in any of the tanks or around the wreckage. They also observed no dieback of vegetation at the accident site in the days following the accident that is typical of a fuel spill.

The main fuel tank transfer pumps were tested and found to be operational; therefore, even with the aircraft in a steep descent all of the usable fuel in the main fuel tank was available for use. The left engine fuel pump could not be tested due to severe impact damage, while the right engine fuel pump was not tested as it was evident that the right engine was producing some power at the time of the collision. A small amount of fuel was found in each of the fuel distributors, indicating that both of the engine fuel pumps were operational prior to the accident. The small quantity of fuel may have been due to a low fuel volume in the tanks.

Related occurrences

The ATSB research report, *Power loss related accidents involving twin-engine aircraft* (Research and analysis report B2005/0085), found that:

- Power loss accident rates in twin-engine aircraft were almost half that for single-engine aircraft.¹⁴ However, a power loss accident in a twin-engine aircraft was more likely to be fatal and overwhelmingly the result of in-flight loss of control.
- Of the 58 accidents identified between 1993 and 2002 that resulted in damage following the power loss, seven occurred during the approach phase of flight. Three of these involved a loss of control, including one fatal accident. When compared to the take-off phase, the approach phase is considered to be equally risky, with low altitude and only a little more energy available than during the take-off phase.

¹⁴ Only aircraft below 5,700 kg maximum take-off weight were included in the analysis.

• Just over one-third of power loss accidents in twin-engine aircraft occurred during a non-asymmetric power loss. The majority of these were related to fuel management, and no benefit was derived from the presence of a second engine.

Another ATSB research report, <u>Starved and Exhausted: Fuel management aviation accidents</u> (AR-2011-112) summarised key occurrences related to fuel management and outlined procedures pilots can use before and during the flight to ensure they land with reserve fuel intact.

This report includes the following key safety messages.

- Accurate fuel management starts with knowing exactly how much fuel is being carried at the commencement of a flight. If the tanks are not filled to a known setting, then a different approach is needed to determine an accurate quantity of usable fuel.
- Keeping fuel supplied to the engines during flight relies on the pilot's knowledge of the aircraft's fuel supply system and being familiar and proficient in its use. Adhering to procedures, maintaining a record of the fuel selections during flight, and ensuring the appropriate tank selections are made before descending towards your destination will lessen the likelihood of fuel starvation at what may be a critical stage of the flight.

Safety analysis

Physical evidence at the accident site allowed the ATSB to establish, that VH-JMW (JMW) was operating in a low engine power state when it collided with terrain. Similarly, recorded flight data and witness reports enabled analysis of the sequence of the aircraft's loss of control in the lead up to the collision. The following analysis details the factors that contributed to the development of the accident.

Engine power loss

Examination of the wreckage identified that the aircraft was configured for a powered approach, in a high-drag configuration - left and right engine propellers unfeathered, landing gear down and the flaps partially extended. Based on the recorded data, the landing gear and flaps were extended within the last 100 seconds of the flight and the airspeed reduced significantly over the same time period. Maintenance of a high-drag configuration while the aircraft's performance declined indicated that either the pilot did not recognise any engine abnormalities until late in the approach, or he assessed that sufficient engine power remained to reach the runway.

The nature, type and extent of damage to the propellers (bending, twisting and scratching to each), and examination of the fractured right propeller flange showed that, at the time of collision:

- the left engine was not producing power
- the right engine was not producing significant power.

No evidence was found to indicate a mechanical defect that would have prevented either engine from developing full power.

The ATSB considered whether the assessed low engine power levels at the time of the collision also existed immediately before the loss of control. While it is possible that the pilot may have reduced the engine power in the final moments, given the significant recorded decline in aircraft performance over the last two minutes of the flight, the low power state probably existed immediately prior to the accident. Distortion of the engine controls during the collision prevented identification of the selected power setting.

The positive nature of the text message sent about 14 minutes before the collision, indicated that the aircraft was performing as expected at that point in the flight. However, about 2 minutes and 20 seconds before the collision, at an altitude of 1,600 ft, the recorded data showed a large deviation in the aircraft roll and heading. Those deviations were consistent with a left engine power loss. Control of the aircraft's pitch, roll, heading and speed declined from this point on (Figure 4).

In the last minute of flight, JMW's descent rate was higher than expected for the aircraft type when operating on one engine in a high drag configuration. That indicated that the operative right engine was likely producing reduced power. Based on witness observations, it is possible that the right engine had intermittent power rather than a consistently low output.

In summary, the ATSB assessed that, shortly before the collision, the left engine had stopped producing power and the right engine was operating at low or intermittent power.

Loss of control

From the available evidence, it could not be determined when the pilot became aware of the left engine power loss. Consistent with the guidance in the United States Federal Aviation Administration *Airplane Flying Handbook*, it is possible that the power loss may not have been obvious as the aircraft was descending. Similarly, apart from extension of the landing gear and flap, it was impossible to determine the pilot's response to the power loss and his subsequent actions. However, it is relevant to note that he had started an apparently normal descent minutes earlier (soon after 1541). He was also flying over thickly-wooded terrain, and was very close to the destination before control was lost.

Recorded data enabled the loss of control to be better explained (Figure 4). The low engine power combined with the high-drag configuration meant that the aircraft's speed and altitude could not be maintained. This in turn led to the airspeed declining to below the published V_{mca} and into the stall speed range. As the right engine was likely not operating at full power, the actual V_{mca} was less than the published figure and likely in the region of the aircraft's stall speed. As the speed continued to decline, the nose was progressively pitched up to about 6.5°. The left wing and nose then dropped towards the ground resulting in a collision with terrain. That flight behaviour with the airspeed in the region of both the stall speed and V_{mca} , indicated a loss of control due to either a low-speed stall, asymmetric effects or a combination of both.

Fuel-related factors

There was no evidence of a mechanical defect to explain the apparent engine power losses. However, the absence of fuel in the supply and return lines indicated that sufficient fuel was not reaching either engine at the time of the collision. This, and other fuel-related evidence, resulted in the ATSB exploring potential fuel starvation and exhaustion scenarios, and related factors.

As no fuel uplift occurred in Toowoomba before the accident flight, JMW departed The Lakes with a fuel quantity that the pilot considered sufficient for the return flight. However, with no fuel records or other evidence available, that quantity could not be determined. It is possible that there was sufficient fuel for the return flight as anticipated by the pilot and the wreckage examination did not identify any pre-existing fuel tank leaks that could have affected the storage capacity.

After the aircraft began its descent to The Lakes, recorded roll and heading deviations indicated that the left engine lost power first due to insufficient fuel supply. The right engine's loss of power, some time later, was consistent with the expected slight variation in fuel consumption and tank fuel quantities between the left and right systems.

The on board digital fuel flow indicator and totaliser indicated there were 53 L of usable fuel in the tanks at the time of the collision. However, this was not a measured quantity but a system-calculated figure based on consumption, and relied on an accurate starting quantity. While the system was correctly set up, the ATSB could not verify this figure because there were no fuel records or fuel consumption rates. The absence of fuel damage to vegetation at the accident site, no post-impact fire and no strong, persistent fuel smell, supported a conclusion of minimal fuel on board. The ruptured fuel tanks made it impossible to determine (or estimate) the fuel quantity that they had contained.

The investigation considered the possibility of inadvertent venting of fuel overboard due to the incorrect sequence of selecting fuel tanks (auxiliary before main tanks). However, given the pilot's significant experience and familiarity with the aircraft type, and the well-known tank selection sequence, it is unlikely that he would have made such an error.

The investigation also considered a scenario where the pilot attempted using all usable fuel in the auxiliary tanks before switching the fuel selector to main tanks for landing (to avoid having unusable fuel in the auxiliary tanks in the event of an engine failure on approach). Mis-timing the switchover could interrupt the fuel supply if the auxiliary tanks were exhausted. This would introduce air into the fuel lines, and manifest as struggling engines, such as observed by the witness. There was insufficient evidence to determine the likelihood that occurred.

In summary, based on the scenarios and fuel-related factors considered, it is possible to state that:

• the fuel quantity when the aircraft departed either The Lakes or Toowoomba could not be determined but may have been sufficient to complete the return flight

- the left engine lost power after its fuel supply was interrupted when approaching The Lakes
- the right engine lost power due to a restriction to its fuel supply (it could not be determined if this was due to control inputs or otherwise)
- at the end of the flight, there was probably less than 53 L usable fuel
- it is unlikely that fuel was vented overboard due to incorrect tank selection sequence
- it is possible that a fuel tank switchover was intended and mis-timed.

Therefore, the ATSB concluded that the loss of engine power was probably the result of either insufficient fuel for the flight or an in-flight fuel management error.

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 T310R, registered VH-JMW that occurred 40 km south-south-west of Port Macquarie, New South Wales on 28 October 2017. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing factors

- During the final descent towards The Lakes airstrip runway, the left engine was not producing power and the right engine was operating at low or intermittent power.
- After losing engine power at low altitude, a safe flying speed was not maintained resulting in a loss of control and collision with terrain due to either an aerodynamic stall, asymmetric power effects or a combination of both.
- The loss of engine power was probably the result of either insufficient fuel for the flight or an inflight fuel management error.

General details

Occurrence details

Date and time:	28 October 2017 – 1555 EDT		
Occurrence category:	Accident		
Primary occurrence type:	Loss of control		
Location:	40km SSW Port Macquarie, New South Wales		
	Latitude: 31° 42.418' S	Longitude: 152° 43.38' E	

Pilot details

Licence details:	Private Pilot Licence (Aeroplane) and (Helicopter)	
Endorsements:	Tail wheel undercarriage, retractable undercarriage, manual propeller pitch control, Pressurisation system, gas turbine engine	
Ratings:	Multi-engine, Private IFR, Night VFR	
Medical certificate:	Class 2, valid to March 2019	
Aeronautical experience:	Approximately 3,200 fixed wing hours	
Last flight review:	4 May 2017	

Aircraft details

Manufacturer and model:	Cessna Aircraft Company T310R		
Registration:	VH-JMW		
Serial number:	310R1802		
Type of operation:	Private		
Departure:	Toowoomba, Queensland		
Destination:	The Lakes, New South Wales		
Persons on board:	Crew – 1	Passengers – 1	
Injuries:	Crew – 1	Passengers – 1	
Aircraft damage:	Destroyed		

Sources and submissions

Sources of information

The sources of information during the investigation included:

- a number of witnesses
- the aircraft manufacturer (Cessna)
- aircraft refuellers
- Textron Aviation
- The Civil Aviation Safety Authority
- The United States Federal Aviation Administration.

References

- Jeppesen Sanderson Inc 1992, Multi-Engine Pilot Manual, Jeppesen Sanderson, Colorado.
- ATSB aviation research investigation report B2005/0085, Power loss related accidents involving twin-engine aircraft.
- ATSB aviation research investigation report AR-2011-112, *Starved and exhausted: Fuel management aviation accidents.*

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 representatives of the aircraft's occupants, the United States National Transportation Safety Board, the Civil Aviation Safety Authority, and the aircraft manufacturer.

Any submissions from those parties will be reviewed and where considered appropriate, the text of the draft report will be 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.

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.

Australian Transport Safety Bureau

Enquiries 1800 020 616 Notifications 1800 011 034 REPCON 1800 020 505 Web www.atsb.gov.au Twitter @ATSBinfo Email atsbinfo@atsb.gov.au Facebook atsbgovau Linkedin Australian Transport Safety Bureau

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ATSB Transport Safety Report Aviation Occurrence Investigation

Loss of control and collision with terrain involving Cessna T310R, VH-JMW, 40 km south-south-west of Port Macquarie, New South Wales, on 28 October 20179

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