



Australian Government

Australian Transport Safety Bureau

Fuel exhaustion and forced landing involving Cessna 172M, VH-TUX

72 km south of Kalgoorlie Boulder Aerodrome, Western Australia, on 5 January 2018

ATSB Transport Safety Report
Aviation Occurrence Investigation
AO-2018-005
Final – 17 March 2019

Released in accordance with section 25 of the *Transport Safety Investigation Act 2003*

Publishing information

Published by: Australian Transport Safety Bureau
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

© Commonwealth of Australia 2019



Ownership of intellectual property rights in this publication

Unless otherwise noted, copyright (and any other intellectual property rights, if any) in this publication is owned by the Commonwealth of Australia.

Creative Commons licence

With the exception of the Coat of Arms, ATSB logo, and photos and graphics in which a third party holds copyright, this publication is licensed under a Creative Commons Attribution 3.0 Australia licence.

Creative Commons Attribution 3.0 Australia Licence is a standard form license agreement that allows you to copy, distribute, transmit and adapt this publication provided that you attribute the work.

The ATSB's preference is that you attribute this publication (and any material sourced from it) using the following wording: *Source:* Australian Transport Safety Bureau

Copyright in material obtained from other agencies, private individuals or organisations, belongs to those agencies, individuals or organisations. Where you want to use their material you will need to contact them directly.

Addendum

Page	Change	Date

The occurrence

What happened

On 5 January 2018, at about 1600 Western Standard Time¹ the pilot of a Cessna 172M, aircraft registered VH-TUX (TUX) operated by Goldfields Air Services conducted a forced landing into scrubland about 72 km south-south-west of Kalgoorlie Airport, Western Australia. The pilot and one fire spotter were uninjured. The aircraft sustained minor damage.

On 4 January 2018, TUX returned to service following repairs due to significant damage sustained during a storm in January 2017. The repairs involved a bulk strip of the engine, and replacement of the propeller and both wings.

On the morning of 5 January 2018, the pilot returned from a flight in another Cessna 172 around the Kalgoorlie area. The pilot's next scheduled flight was to conduct fire-spotting operations in the Lake Johnstone area to the south-west of Kalgoorlie (Figure 1).

Figure 1: Location of Kalgoorlie – Boulder airport and overlay of flight paths to fire fronts



Source: Hema- Australia map, flight path overlay by Goldfields Air Services. Annotated by ATSB

The pilot anticipated fire-spotting operations would typically run for two to three hours. The pilot was familiar with TUX and had flown it on numerous occasions over a period of about 18 months prior to its repair and return to service.

At about 1100, the pilot performed a daily inspection and checked the aircraft's maintenance release. This was the first revenue flight following the repairs and the pilot noted two previous entries from when the aircraft was signed out by the Chief Pilot for check flights prior to its return to service. Apart from the installation of a new propeller, the pilot reported that the aircraft appeared largely unchanged.

During the daily inspection, the pilot dipped the right hand tank noting the fuel dipstick was graduated in fractions (1/4, 1/2, 3/4 and F) rather than decimal increments in litres as it was when the pilot had flown TUX prior to its return to service. For this flight, the calibration of the dipstick

¹ Western Standard Time (WST): Coordinated Universal Time (UTC) + 8 hours.

was not important as the pilot had decided to take a full fuel load due to there being only one other person on-board. The pilot recorded a total fuel quantity of 180 litres on board at the start of the flight.

After refuelling, the pilot met with the fire spotter to discuss the flight. During this briefing, the fire spotter identified a second fire front located north-east of Fraser Range that would also require an inspection. The pilot reported that they planned the flight using the OzRunways, electronic flight bag application however, the flight planning requirements detailed in the operations manual were not conducted.

At about 1217, TUX departed Kalgoorlie aerodrome heading east-south-east for the first leg. The aircraft climbed to a cruising altitude of 7,500 ft above mean sea level and continued to a location 232 km from Kalgoorlie. At this location, the pilot descended TUX to between 500 and 1,000 ft above ground level to inspect an active fire front. The pilot circled at that location for approximately 20 minutes before departing to the second location.

The second location was approximately 289 km south-west from the first. The pilot departed the first location and climbed to a cruising altitude of 8,500 ft. Upon arrival at the second location the pilot again descended TUX to between 500 and 1,000 ft above ground level, spending approximately 15 minutes inspecting the second fire front.

The pilot departed the second fire front, climbing to 7,500 ft for the final leg of the flight northward toward the Kalgoorlie aerodrome. At about 1555 at 7,500 ft, the engine speed began to steadily reduce toward idle. The pilot switched between fuel tanks and adjusted the mixture and throttle settings. This resulted in the engine speed momentarily increasing before returning to idle.

The aircraft was about 72 km from Kalgoorlie aerodrome over scrubland. The pilot noticed a dirt road (Burra Rock Road) to the north-west of his current track and prepared TUX and the fire spotter for a forced landing on the road. The pilot made a MAYDAY² call at about 5,000 ft and shortly after activated the Emergency Locator Transmitter (ELT).

As TUX descended below 2,000 ft, the pilot realised the aircraft glide range would be insufficient to land on the road. The pilot identified an area of less dense scrub and landed TUX, coming to a stop approximately 30 m from the Burra Rock Road with minimal damage. Both pilot and fire spotter exited the aircraft with no injury. The pilot was unable to make contact by VHF radio³ or mobile phone at the landing site so they walked about 1 km to Burra Rock Main Dam where mobile phone reception was possible.

At about 1600, the Australian Maritime Safety Authority contacted the operator and requested their assistance to undertake a search and rescue flight to the ELT location. Shortly after, the search aircraft arrived at the location and held overhead until emergency services attended the site at about 1700.

Fuel management

Fuel system

The Cessna 172M utilises a gravity feed fuel system from a fuel tank mounted in each wing. Both wings on TUX had been replaced during the recent repairs, with wings from another Cessna 172M. However, the replacement wings were fitted with smaller capacity tanks, which reduced the useable fuel capacity from the original 182 litres to 144 litres. A fuel gauge calibration check was performed on 21 December 2017 and a fuel calibration placard was affixed to the centre of the instrument panel. Fuel quantity labels were also placed adjacent to the fuel filler caps indicating the respective tank's fuel capacity (Figure 2).

² 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.

³ Very High Frequency - radiophone

Figure 2: Fuel placard and label installed on VH-TUX



Source: Goldfields Air Services

A hand written entry dated 22 December 2017 adjacent section 1.3 Fuel in the Pilots Operating Handbook recorded ‘Wings replaced, fuel capacity 144 litres, Refer PenYan Supplement⁴ for fuel consumption data.’

Accurate fuel determination

Prior to the fire spotting flight in TUX, the pilot dipped the right tank which indicated about 3/4 full on the dipstick. The pilot did not dip the left tank, as the intention was to fill the tanks before departing for the flight. The pilot uploaded a total of 45.9 litres of fuel between the two tanks. The pilot stated the fuel quantity uploaded was consistent with his expectation, based on previous experience with TUX, to fill the tanks on this aircraft.

The pilot did note that the dipstick was graduated in quarters, rather than in decimal increments (litres). He considered that these markings when used to determine the fuel quantity remaining was not optimal as it potentially made it more difficult for a pilot to check actual fuel (in litres) remaining in the aircraft, if departing with less than full tanks (Figure 3).

Because TUX had just returned to line following evaluation flights post repair, no Trip Sheet⁵ was available in the aircraft to indicate recent fuel usage history. The pilot raised a new Trip Sheet and recorded a fuel upload of 46 litres and that the total fuel on board at start-up was 180 litres.

⁴ Prior to the January 2017 storm damage, the aircraft was fitted with an upgraded Penn Yann Aero 180 HP engine.

⁵ Operator’s document carried with the aircraft to record pre-flight details of flight date, pilot, tachometer/VDO time out/in and quantities of fuel on board at start-up and shutdown, together with any fuel uploaded to the aircraft.

Figure 3: Fuel dip sticks from Cessna aircraft TUX and CAL

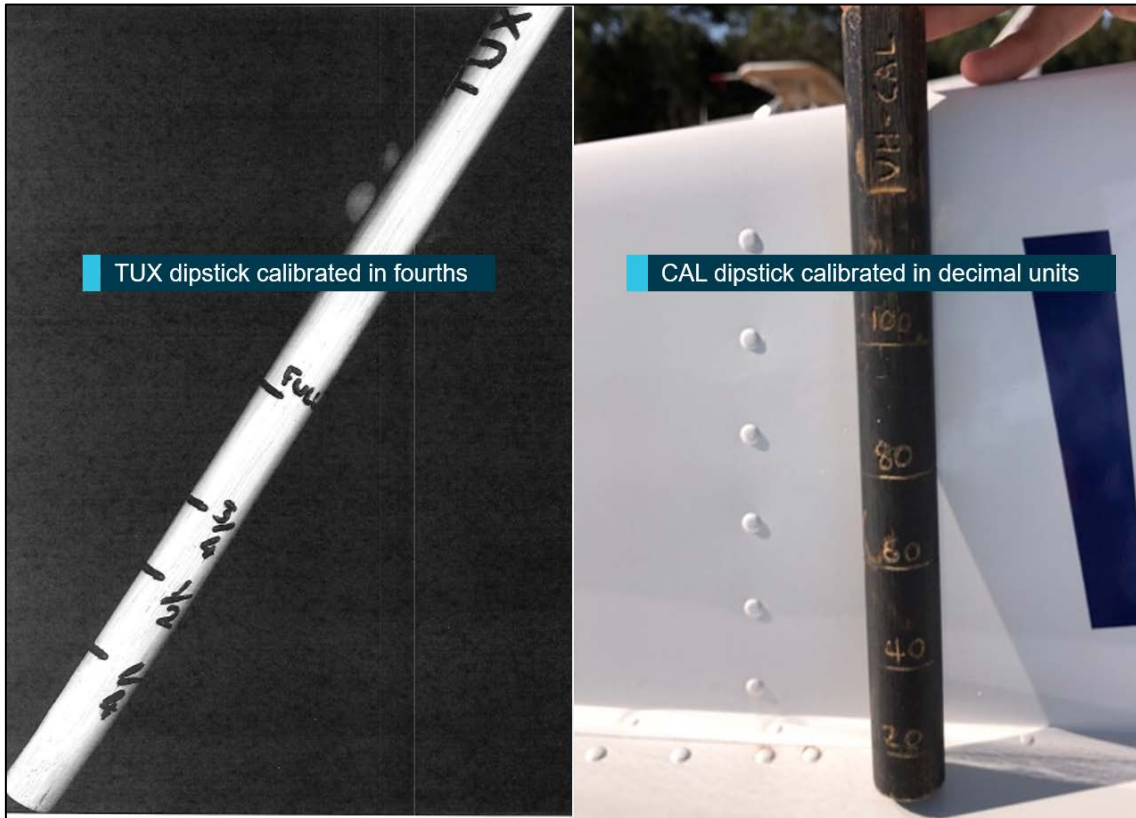


Image of fuel dipsticks from the incident aircraft VH-TUX (left) and the aircraft VH-CAL (right) flown by the pilot earlier on the morning of 5 January 2018. Source: Goldfields Air Services, annotated by ATSB

Flight planning

The pilot checked weather conditions for the flight which were ideal (CAVOK)⁶ for the rest of the day. To determine the time available at each location, the planned flight paths to the fire front locations were calculated using the OzRunways application and Jeppesen circular slide rule. Based on previous experience in flying TUX, the pilot determined that with full fuel tanks, there was a flight time of 4 hours available from when they took off, which would give about 15-20 minutes at each fire location for the inspections. The pilot’s methods for planning the flight were inconsistent with the operator’s standard operating procedures and instructions.

In-flight fuel management

The cruise sections of the flight were undertaken at 2,500 RPM, to run the engine in following the rebuild. The pilot climbed to 7,500 and 8,500 ft and leaned the mixture. The pilot had noted the departure time and estimated time of arrival to ensure the flight could be completed within the calculated fuel endurance. The pilot periodically checked the fuel gauges⁷ during the flight, which were indicating a steady decrease as the flight progressed. As TUX approached the second fire front located in the Lake Johnston area, the pilot noticed the gauges were indicating lower than he would have expected but discounted the lower than expected indication on the basis of his calculated fuel endurance.

The pilot reported that he had one fuel gauge indicating around 5 US gallons and the other around 2 US gallons when the engine reduced to idle and ceased producing power. The pilot did not recall which gauge provided the respective indications.

⁶ Ceiling and visibility OK for Visual Flight Rules.

⁷ Fuel gauges of TUX indicated quantity in both the fraction of tank capacity and US Gallon increments.

Operator's report

The operator conducted their own investigation of the occurrence circumstances. Their investigation report listed a number of applicable standard operational procedures that specified the minimum requirements for pre-flight preparation, planning and in-flight fuel management for the intended operation type. These procedures required a pilot to ensure the documentation of flight plans, weather briefings and other information prior to departure. With the exception of the Trim and Trip sheets, there was no evidence of a documented flight plan, weather information, or a navigation log completed by the pilot.

The operator utilised flight planning software, which contained the approved performance data for each aircraft, including fuel consumption. As part of their internal investigation, post-incident flight planning calculations were undertaken using this software as well as the actual fuel consumption during the occurrence flight. Those calculations indicated that TUX did not have the available fuel capacity, even if fitted with the original larger fuel tanks, to complete the intended flight with the operator-required fixed fuel reserve of 45 minutes⁸.

Aircraft inspection

On 6 January 2018, the operator's maintenance personnel inspected and commenced recovery of TUX from the landing site. The aircraft was powered-up and the gauge for the left wing tank was observed to indicate a reading equating to approximately 10 litres of fuel in the tank. There was no record in the operator's report of the indication on the right tank gauge. The fuel was drained from the wing tanks and fuel system strainer yielding about 200 mL in total (around 25 mL from the tanks and 150 mL from the fuel strainer).

On 9 January 2018 following the recovery of TUX, the operator's maintenance personnel reconnected the fuel gauges and found both gauges indicated empty. Although the wing was not fitted to the fuselage, 30 litres of fuel was added and drained from the left wing tank to check the correspondence of indications on the left tank gauge. With fuel added, the gauge indicated just under the half-full mark. After draining the fuel, while tapping the wing to simulate normal vibrations during flight, the gauge returned to indicate just below empty. Although this test did not take into account unusable fuel, the operator considered these indications were within expectation for the quantity of fuel added, and the fuel transmitter was found to operate smoothly across the full range checked.

On the 12 January 2018 the engine of TUX was started with no roughness at idle evident. After warming, the engine was accelerated up to maximum ground RPM. The engine accelerated smoothly with no abnormal sounds and oil pressure and exhaust gas temperature indicated a normal reading.

Operator communication with pilots

The operator's chief pilot communicated to line pilots either verbally, by e-mail, or through the Alerts feature of the operator's Air Maestro Safety Management System software. The Air Maestro system was primarily used to formally disseminate information related to scheduling, rosters, safety reports and new operational alerts or notifications. The operator acknowledged an omission occurred in the dissemination of information, which resulted in no operational alert/notification being published on Air Maestro in relation to the change in the useable fuel capacity or upgraded engine for TUX.

The aircraft was equipped with a folder containing the maintenance release, the manufacturer's pilot operating handbook, weight and balance data and aircraft supplements. The pilot's operating handbook for TUX included handwritten amendments by the chief pilot in the fuel section. The amendments were dated 22 December 2017, recording the aircraft wings had been replaced and

⁸ Civil Aviation Advisory Publication 234-1 (1)

the fuel capacity of 144 litres. Reference was also included to refer to the Pen Yan flight manual supplement for fuel consumption data associated with the newly-installed engine.

Safety analysis

While the pilot conducted his pre-flight planning activity, it was not consistent with the regulatory requirements for flight planning and preparation, or the operator's electronic flight bag administration and in-flight fuel management procedures. Consequently, the pilot did not identify that, even if it had been fitted with the original larger fuel tanks, the aircraft had insufficient endurance to safely conduct the flight.

The pilot's pre-flight planning was based on the expectation that the aircraft's endurance would be 4 hours after departing Kalgoorlie. This was consistent with the pilot's belief that the useable fuel capacity and fuel consumption of TUX was unchanged from the 182 litres available when the pilot operated the aircraft before its removal from line in January 2017. The pilot did not detect the change to the flight manual or the fuel tank capacity displayed on the cockpit fuel calibration card or tank placards installed following the installation of the new wings and calibration of the fuel system. Additionally, because this was the first flight of TUX following return to service, there was no available information available from a Trip Sheet, to provide an indication to the pilot that the fuel capacity had reduced.

During the flight, the pilot observed a steady decrease in the indications on the fuel gauge. Although the indications appeared lower than expected at the second fire front location, the pilot discounted the accuracy of the indications. The pilot's in-flight fuel management was likely also based on the expectation of the aircraft's endurance, rather than crosschecking the expected fuel burn against the fuel burn achieved during flight at the 30-minute intervals required under the operator's standard operating procedures.

The change to the aircraft's total fuel tank capacity (and corresponding reduction in the aircraft's endurance) was not formally published in the operators Air Maestro Safety Management System to alert line pilots of the significant modification to the aircraft prior to its return to line on the 5 January 2018.

The absence of information alerting pilots to the change in the aircraft's endurance and the pilot's pre-flight fuel management planning (based on an expectation), meant that there was insufficient fuel available for the intended flight. Furthermore, pilot's in-flight fuel management resulted in the aircraft exhausting its useable fuel supply about 3 hours and 38 minutes into the flight with the aircraft about 72 km from the intended landing point.

When the engine began to reduce power, the pilot's experience from instructing student pilots on the protocols for an engine restart and practice forced landings likely aided in managing workload during the emergency and led to the successful forced landing.

Findings

These findings should not be read as apportioning blame or liability to any particular organisation or individual.

- The pilot's fuel management practices resulted in a complete loss of engine power due to fuel exhaustion that led to a forced landing in scrubland.
- The aircraft's reduced fuel capacity was not adequately communicated to the pilot in accordance with the operator's standard practices.

Safety action

Whether or not the ATSB identifies safety issues in the course of an investigation, relevant organisations may proactively initiate safety action in order to reduce their safety risk. The ATSB has been advised of the following proactive safety action in response to this occurrence.

Goldfield Air Service conducted an internal review to: -

- determine incidence of deviation within the pilot group from the implementation of standard operating procedures
- examine the operator’s change management plan to determine, at an organisational level, why the effect of the changes to the aircraft configuration were not fully captured and broadcast to all operating crews.

Safety message

Fuel starvation and exhaustion events continue to be reported to the ATSB. It is therefore important for pilots to continue to educate themselves on the risks and controls associated with fuel management.

Methods for cross-checking fuel on board before flight are published by the [Civil Aviation Safety Authority in Civil Aviation Advisory Publication 234-1\(2\): Guidelines for aircraft fuel requirements](#).

Case studies for pilots to learn about fuel management related accidents have been published by the ATSB in [Avoidable Accidents No. 5 – Starved and exhausted: Fuel management aviation accidents](#).

General details

Occurrence details

Date and time:	5 January 2018 – 1600 WST	
Occurrence category:	Serious incident	
Primary occurrence type:	Fuel exhaustion	
Location:	72 km S of Kalgoorlie	
	Latitude: 31° 23.22' S	Longitude: 121° 12.684' E

Aircraft details

Manufacturer and model:	Cessna 172M	
Registration:	VH - TUX	
Operator:	Goldfield Air Services Pty. Ltd.	
Serial number:	17263713	
Type of operation:	Charter	
Persons on board:	Crew – 1	Passengers – 1
Injuries:	Crew – 0	Passengers – 0
Aircraft damage:	Minor	

About the ATSB

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; and 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.

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

About this report

Decisions regarding whether to conduct an investigation, and the scope of an investigation, are based on many factors, including the level of safety benefit likely to be obtained from an investigation. For this occurrence, a limited-scope, fact-gathering investigation was conducted in order to produce a short summary report, and allow for greater industry awareness of potential safety issues and possible safety actions.