Australian Government
Australian Transport Safety Bureau

Collision with terrain
Piper PA-31P-350 Mojave
VH-PGW

6 km north-west of Bankstown Airport, New South Wales | 15 June 2010

Photograph courtesy of Phil Vabre

Investigation

ATSB Transport Safety Report
Aviation Occurrence Investigation
AO-2010-043
Final

Australian Government

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ATSB TRANSPORT SAFETY REPORT

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15 June 2010
VH-PGW
Piper PA-31P-350 Mojave

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

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ISBN and formal report title: see 'Document retrieval information' on page viii

SAFETY SUMMARY

What happened

At about 0806 Eastern Standard Time on 15 June 2010 a Piper PA-31P-350 Mojave aircraft, registered VH-PGW, with a pilot and a flight nurse on board, collided with terrain in a suburban area about 6 km north-west of Bankstown Airport, New South Wales. At the time of the accident, the pilot was attempting to return to Bankstown following a reported in-flight engine shutdown. Both occupants were fatally injured and the aircraft was destroyed by the impact forces and an intense post-impact fire.

What the ATSB found

The Australian Transport Safety Bureau (ATSB) found that following the shut down of the right engine, the aircraft's airspeed and rate of descent were not optimised for one engine inoperative flight. In addition, spectral analysis indicated it was unlikely that the left engine was being operated at maximum continuous power as the aircraft descended. As a result, the aircraft descended to a low altitude over a suburban area and the pilot was then unable to maintain level flight, which led to the collision with terrain.

Examination of the engines, propellers and governors and other aircraft components found no evidence of any pre-impact faults. However, the engine surging identified by the spectral analysis of radio transmissions during the flight was consistent with uneven fuel distribution to the cylinders.

What has been done as a result

The Civil Aviation Safety Authority has started a project to amend advisory material relating to multi-engine aircraft training and operations to include guidance information about engine problems encountered during the climb and cruise phases of flight. This amended guidance material will include information about aircraft handling, engine management, and decision making during these phases of flight.

Safety message

This accident reinforces the importance when flying twin-engine aircraft with one engine shutdown that the optimal speed be selected, along with maximum continuous power on the operative engine, and that the aircraft's performance should be verified prior to conducting a descent. Pilots should also use the appropriate PAN or MAYDAY phraseology when advising air traffic control of non-normal or emergency situations.

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DOCUMENT RETRIEVAL INFORMATION

Report No.	Publication date	No. of pages	ISBN
AO-2010-043	20 December 2012	64	978-1-74251-304-1

Publication title

Collision with terrain – 6 km north-west of Bankstown Airport, New South Wales – 15 June 2010 – VH-PGW, Piper Aircraft Corporation PA-31P-350 Mojave

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Acknowledgements

Front cover photograph: Courtesy of Mr Phil Vabre
Figures 1 and 2: Airservices Australia
Figure 3: Courtesy of the NSW Police Force

THE AUSTRALIAN TRANSPORT SAFETY BUREAU

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

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

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

Purpose of safety investigations

The object of a safety investigation is to identify and reduce safety-related risk. ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated. The terms the ATSB uses to refer to key safety and risk concepts are set out in the next section: Terminology Used in this Report.

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 appropriate, or to raise general awareness of important safety information in the industry. 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 safety factor: a safety factor that, had it not occurred or existed at the time of an occurrence, then either: (a) the occurrence would probably not have occurred; or (b) the adverse consequences associated with the occurrence would probably not have occurred or have been as serious, or (c) another contributing safety factor would probably not have occurred or existed.

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

Other key finding: 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.

Safety issue: a safety factor that (a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and (b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operational environment at a specific point in time.

Risk level: the ATSB's assessment of the risk level associated with a safety issue is noted in the Findings section of the investigation report. It reflects the risk level as it existed at the time of the occurrence. That risk level may subsequently have been reduced as a result of safety actions taken by individuals or organisations during the course of an investigation.

Safety issues are broadly classified in terms of their level of risk as follows:

- **Critical** safety issue: associated with an intolerable level of risk and generally leading to the immediate issue of a safety recommendation unless corrective safety action has already been taken.
- **Significant** safety issue: associated with a risk level regarded as acceptable only if it is kept as low as reasonably practicable. The ATSB may issue a safety recommendation or a safety advisory notice if it assesses that further safety action may be practicable.
- **Minor** safety issue: associated with a broadly acceptable level of risk, although the ATSB may sometimes issue a safety advisory notice.

Safety action: the steps taken or proposed to be taken by a person, organisation or agency in response to a safety issue.

FACTUAL INFORMATION

History of the flight

On 15 June 2010, a Piper PA-31P-350 Mojave aircraft, registered VH-PGW (PGW), with a pilot and a flight nurse on board, was being operated by Skymaster Air Services[1] under the instrument flight rules (IFR) on a flight from Bankstown Airport, New South Wales (NSW) to Archerfield Airport, Queensland. The aircraft was being positioned to Archerfield for a medical patient transfer flight from Archerfield to Albury, NSW.

The aircraft departed Bankstown at 0740 Eastern Standard Time.[2] At 0752, the pilot reported to air traffic control (ATC) that he was turning the aircraft around as he was having ‘a few problems’. At about 0806, the aircraft collided with a powerline support pole located on the eastern side of the intersection of Sackville Street and Canley Vale Road, Canley Vale, NSW. The pilot and flight nurse sustained fatal injuries and the aircraft was destroyed by impact damage and a post-impact fire.

The following chronology of events leading up to the accident was constructed from information obtained from recordings of radio communication between the pilot and ATC, recordings of radar data, ATC documentation, meteorological data and post-accident witness interviews. The aircraft’s position and altitude were obtained from radar data recordings and plotted on an extract of the Sydney Visual Terminal Chart (Figures 1 and 2). The radar altitude data was recorded to the nearest 100 ft and was used to derive rates of climb and descent, which were rounded to the nearest 100 ft/min. The airspeed was derived from the radar data using the ambient meteorological conditions and was rounded to the nearest 5 kts.

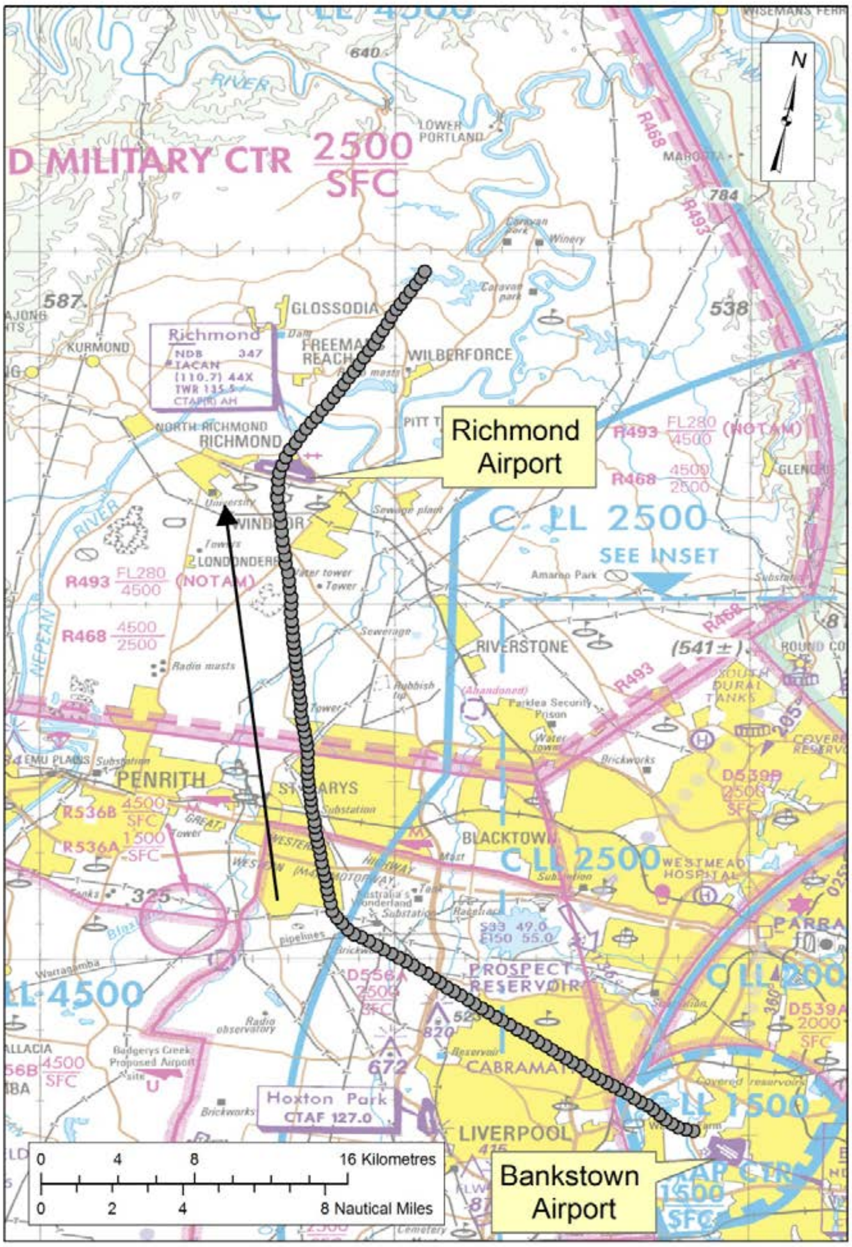
Time	Event
About 0720	The aircraft was refuelled with 660 L of aviation gasoline (Avgas) from a fuel tanker.
0740	The aircraft took off from runway 29 Centre (29C) at Bankstown Airport and tracked via the *Bankstown Three* standard instrument departure procedure towards Richmond Airport, NSW.
0749:45	The aircraft overflew Richmond Airport climbing to the cleared altitude of 7,000 ft above mean sea level (AMSL). Altitude: 6,100 ft Derived airspeed: 155 kts Derived rate of climb: 400 ft/min
0750:15	The pilot read back an ATC clearance to climb to 9,000 ft. *A spectral analysis of the pilot’s transmission showed signal frequencies within the transmission that indicated both propellers were rotating at about 2,400 RPM. This was consistent with the cruise climb power setting of 2,400 RPM specified in the operator’s operations manual.*

1 Skymaster Air Services Proprietary Limited was a part of the Airtex Aviation group of companies. ‘Skymaster Air Services’ will be used throughout this investigation report.

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

Time	Event
0752:20	The aircraft ceased climbing when it was about 6 NM (11 km) north of Richmond Airport (Figure 1). Altitude: 7,600 ft Derived airspeed: 135 kts

Figure 1: Aircraft flight path from takeoff to the cessation of the climb



Time	Event
0752:27	The pilot contacted ATC by transmitting the aircraft's call sign. Altitude: 7,600 ft Derived airspeed: 135 kts Derived rate of descent: 800 ft/min *The spectral analysis of the pilot's transmission showed that there were two frequency signals within the transmission that indicated the aircraft's propellers were operating at different RPM. The propeller RPM of one engine was varying from about 2,350 to greater than 2,600 RPM (the upper value of the RPM variation could not be positively determined). The RPM varied with about a 1.3 second cycle, which was consistent with the engine surging (see the subsequent discussion in the Tests and research section of this report).[3] A 'rasping' sound, varying in frequency and similar to a propeller operating at high power, was heard in the background. The propeller RPM of the other engine was constant at about 2,500 RPM until the final 0.5 seconds of the radio transmission when it reduced to about 2,050 RPM. The spectral analysis of this and the subsequent transmissions could not determine which engine had the fluctuating RPM.[4]*
	A number of witnesses who were located in the Wilberforce and East Kurrajong[5] area later reported that they observed the aircraft and heard a 'surging and roaring' engine noise with one engine 'revving then cutting out, then revving again'.
0752:31	The pilot reported to ATC that he was turning the aircraft around as he was having 'a few problems'. Altitude: 7,500 ft Derived airspeed: 135 kts Derived rate of descent: 900 ft/min *The high amplitude of the pilot's speech during the transmission made measurement of the background signals difficult. Spectral analysis indicated that the propeller RPM of one engine continued to vary and the low frequency 'rasping sound' remained present in the background. The propeller RPM of the other engine was constant at about 2,400 RPM.*
0752:37	In response to an ATC query as to whether 'everything [was] OK?' the pilot reported that he was '...turning back to Bankstown'. At that time, the aircraft was about 8 NM (15 km) north-east of Richmond Airport, in a left, descending turn. Altitude: 7,300 ft Derived airspeed: 135 kts Derived rate of descent: 1,200 ft/min *The spectral analysis of the pilot's transmission indicated that the propeller RPM of one engine was continuing to vary from about 2,300 RPM to greater than 2,600 RPM with about a 1.5 second cycle. The low frequency 'rasping' sound remained. The highest RPM derived from this and the following transmission could not be positively determined due to the frequency limitations of the recording. The propeller RPM of the other engine was constant at about 2,400 RPM.*

3 Piston-engine surging is an uncommanded variation in engine RPM.

4 The estimated propeller rotational speeds derived from the spectral analysis were rounded to the nearest 50 RPM (see the section titled *Spectral Analysis*).

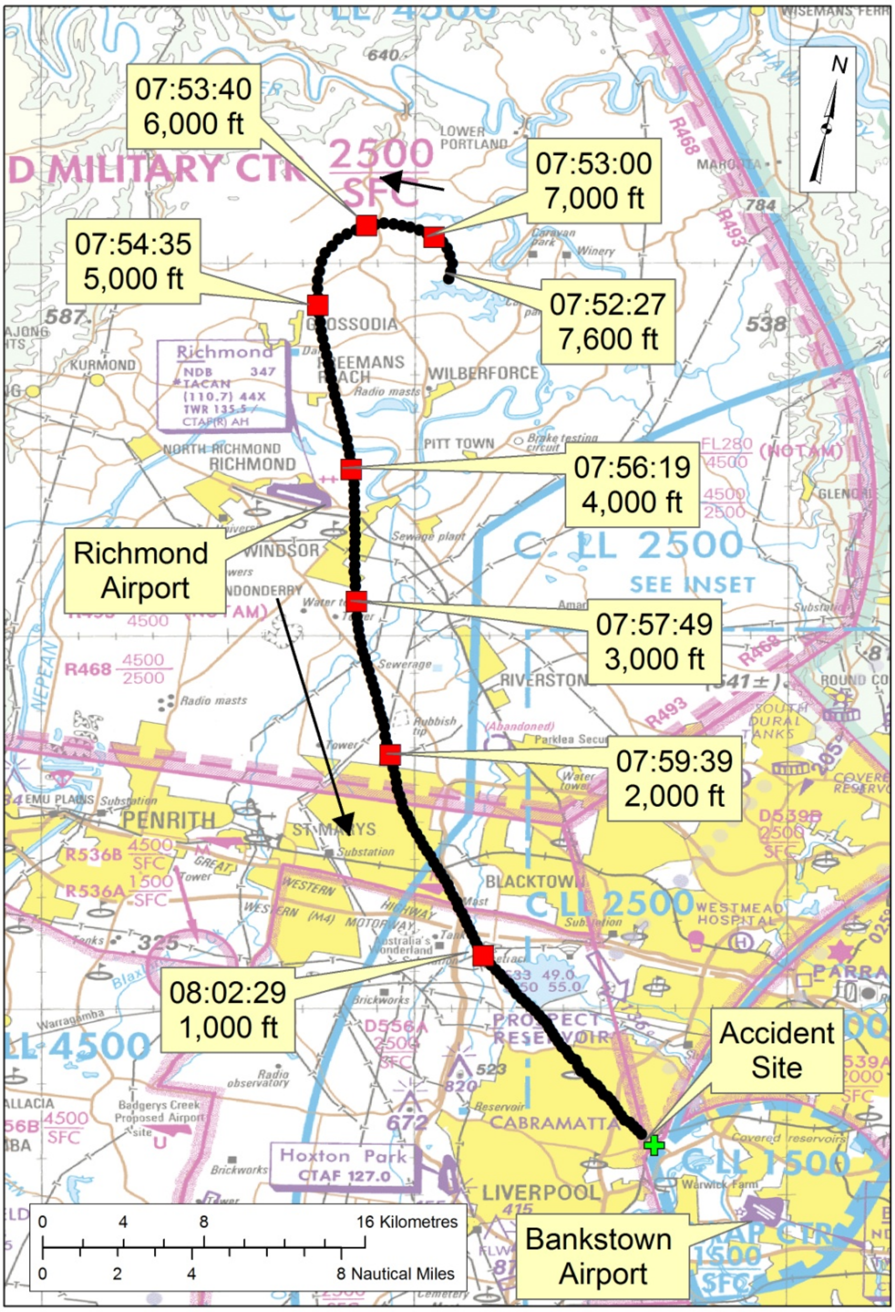
5 East Kurrajong is not shown in Figures 1 and 2 but is located about 10 km north-west of Wilberforce.

Time	Event
0752:46	The pilot reported understanding an ATC instruction to maintain 5,000 ft and advice that Richmond was available for landing if emergency conditions existed. The pilot acknowledged the advice and requested that ATC 'standby'. Altitude: 7,200 ft Derived airspeed: 135 kts Derived rate of descent: 1,000 ft/min *The spectral analysis of the pilot's transmission indicated that the propeller RPM of one engine was continuing to vary from about 2,300 RPM to greater than 2,600 RPM with about a 1.4 second cycle. The low frequency 'rasping' sound was no longer audible, indicating that the engine with the varying rpm was probably not developing the same power as in the previous transmissions. The propeller RPM of the other engine was constant at about 2,400 RPM.*
0753:00	The aircraft was 7.5 NM (13.9 km) north-north-east of Richmond Airport. Altitude: 7,000 ft Derived airspeed: 130 kts Derived rate of descent: 1,000 ft/min *Although ATC was not told about the nature of the problem, the departures controller contacted the Richmond Tower controller about the aircraft encountering a problem that could require a diversion to Richmond Airport. The departures controller also alerted the Sydney Terminal Control Unit Traffic Manager about the situation and an ALERT phase*[6] *was declared.*
0753:33	In response to an ATC request regarding the nature of the problem, the pilot replied that he had an 'engine issue', had shut down one engine and was intending to return to Bankstown. ATC cleared the aircraft to track direct to Bankstown Airport. Altitude: 6,100 ft Derived airspeed: 120 kts Derived rate of descent: 1,600 ft/min *The spectral analysis of this transmission indicated that one engine's propeller RPM was varying between about 2,500 and 2,600 RPM. This RPM was consistent with the maximum continuous power setting of 2,600 RPM specified in the PA-31P-350 Pilot's Operating Handbook for single-engine climb operations. The analysis did not detect any sounds from the other engine but did detect the background sound of the landing gear unsafe aural warning.*[7]
0753:40	The aircraft was 7.3 NM (13.5 km) north of Richmond Airport. Altitude: 6,000 ft Derived airspeed: 125 kts Derived rate of descent: 1,500 ft/min
0753:45	The pilot acknowledged the ATC clearance to track direct to Bankstown Airport. Altitude: 5,900 ft Derived airspeed: 130 kts Derived rate of descent: 1,500 ft/min *The spectral analysis of the pilot's transmission indicated one propeller rotating at between about 2,500 and 2,600 RPM. The sound of the landing gear unsafe aural warning remained audible.*

6 Defined in the Australian Aeronautical Information Publication as the emergency phase that is declared by ATC when certain situations occur, including '...apprehension exists as to the safety of the aircraft and its occupants...'.

7 The landing gear unsafe aural warning activated if a throttle lever was retarded to a position equivalent to less than 12 inches of manifold pressure with the landing gear in the retracted position.

Figure 2: Aircraft's flightpath from 7,600 ft to impact



Time	Event
0754:24	In response to an ATC query whether any emergency services (fire brigade and ambulance) would be required on arrival at Bankstown Airport, the pilot replied that he was not sure at that moment. Altitude: 5,300 ft Derived airspeed: 160 kts Derived rate of descent: 1,000 ft/min *The departures controller activated the Bankstown Airport Emergency Plan in response to a request from the Bankstown Tower controller as to what emergency services were required and the initial indication from the pilot that he was not sure.* *The spectral analysis of the pilot's transmission indicated one propeller rotating at about 2,600 RPM and the landing gear unsafe aural warning still sounding.*
0754:35	The aircraft was about 5 NM (9.3 km) north of Richmond Airport. Altitude: 5,000 ft Derived airspeed: 140 kts Derived rate of descent: 900 ft/min
0754:56	The pilot read back an ATC clearance to descend to 2,500 ft. Altitude: 4,800 ft Derived airspeed: 135 kts Derived rate of descent: 800 ft/min *The ATC clearance to descend to 2,500 ft was issued to track the aircraft to Bankstown Airport from the adjoining airspace.* *The spectral analysis of the pilot's transmission indicated that the propeller RPM of the operating engine was about 2,600 RPM with the landing gear unsafe aural warning continuing to sound.*
0755:13	The pilot stated that the aircraft was on a 'slow descent' in response to ATC advice that Richmond Airport was 2 NM (3.7 km) to the south of the aircraft if the pilot could not maintain height. Altitude: 4,800 ft Derived airspeed: 120kts Derived rate of descent: 600 ft/min *The spectral analysis of the pilot's transmission indicated that the propeller RPM of the operating engine continued at about 2,600 RPM with the landing gear unsafe aural warning continuing.*
0756:17	The pilot acknowledged an ATC transmission that the emergency services would be in attendance at Bankstown Airport. Altitude: 4,100 ft Derived airspeed: 120 kts Derived rate of descent: 600 ft/min *The spectral analysis of the pilot's transmission indicated that only those frequencies associated with the landing gear unsafe aural warning were present. The inability to detect an RPM-related signal during this transmission meant that either the RPM moved outside the audio bandwidth, or that the RPM signal was obscured by the aural warning.*
0756:19	The aircraft was 1.3 NM (2.4 km) north-east of Richmond Airport. Altitude: 4,000 ft Derived airspeed: 120 kts Derived rate of descent: 600 ft/min
0756:25	The pilot queried the availability of runway 11C at Bankstown Airport and ATC cleared the pilot for a direct track to runway 11C. Altitude: 3,900 ft Derived airspeed: 120 kts Derived rate of descent: 600 ft/min *The spectral analysis of the pilot's transmission indicated that the landing gear unsafe aural warning was still active and that the signal used to determine the propeller RPM of the operating engine was not detected.*
0756:56	The pilot requested heading guidance to Bankstown Airport, which was provided by ATC. The aircraft was 1.6 NM (3km) south-east of Richmond Airport and 20.5 NM (38km) north-north-west of Bankstown Airport. Altitude: 3,600 ft Derived airspeed: 120 kts Derived rate of descent: 700 ft/min *The spectral analysis of the pilot's transmission indicated that the landing gear unsafe aural warning was still active and that the signal used to determine the propeller RPM of the operating engine was not detected.*

Time	Event
About 0757	*The flight nurse contacted the operator's Operations Manager by mobile phone advising that the aircraft had sustained an engine failure. The call duration was about 30 seconds before dropping out.*
0757:45	ATC advised the pilot that the aircraft's current heading would take it about 10 NM (19 km) to the west of Bankstown Airport and suggested that the pilot make a further left turn. Altitude: 3,100 ft Derived airspeed: 125 kts Derived rate of descent: 600 ft/min
0757:49	The aircraft was at 3.2 NM (5.9 km) south-east of Richmond Airport and 18.8 NM (34.9 km) north of Bankstown Airport. Altitude: 3,000 ft Derived airspeed: 125 kts Derived rate of descent: 600 ft/min
0758:27	ATC cleared the pilot to continue descent as required and asked if the aircraft was in visual conditions. The pilot replied that he was flying in visual conditions 'on top' (that is, there was a cloud layer between the aircraft and the ground). Altitude: 2,600 ft Derived airspeed: 125 kts Derived rate of descent: 600 ft/min *The spectral analysis of the pilot's transmission indicated that the landing gear unsafe aural warning was still active and that the signal used to determine the propeller RPM of the operating engine was not detected.*
0759:26	ATC advised the pilot that by radar there were no other aircraft in the Prospect Reservoir area.[8] At that time, the aircraft was about 6.5 NM (12 km) south of Richmond Airport and about 16 NM (30 km) north-west of Bankstown Airport. Altitude: 2,100 ft Derived airspeed: 130 kts Derived rate of descent: 500 ft/min
0759:39	The aircraft was at 7.4 NM (13.7 km) south-south east of Richmond Airport and 14.9 NM (27.6 km) north-north-west of Bankstown Airport. Altitude: 2,000 ft Derived airspeed: 120 kts Derived rate of descent: 500 ft/min
0800:41	The pilot contacted Bankstown ATC, advising that the aircraft was 12 NM (22.2 km) from Bankstown Airport at 1,500 ft. ATC instructed the pilot to join a straight-in approach for runway 11C and advised the pilot of the wind conditions at the airport. Altitude: 1,600 ft Derived airspeed: 120 kts Derived rate of descent: 400 ft/min *The spectral analysis of the pilot's transmission indicated that the landing gear unsafe aural warning was still active and that the signal used to determine the propeller RPM of the operating engine was not detected.*
0802:29	The aircraft was near Prospect Reservoir at 9.4 NM (17.4 km) north-west of Bankstown Airport. Altitude: 1,000 ft Derived airspeed: 105 kts Derived rate of descent: 400 ft/min
0802:50	The pilot asked ATC how far the aircraft was from Richmond Airport. ATC advised that the aircraft was closer to Bankstown Airport than to Richmond. At that time, the aircraft was about 13.7 NM (25.4 km) south of Richmond Airport and 8.7 NM (16.1 km) north-west of Bankstown Airport. Altitude: 900 ft Derived airspeed: 105 kts Derived rate of descent: 300 ft/min *The spectral analysis of the pilot's transmission indicated that the landing gear unsafe aural warning was still active and that the signal used to determine the propeller RPM of the operating engine was not detected.* *Reports from people who knew the pilot and heard a replay of these radio transmissions suggested that he sounded 'stressed' during his communication with ATC from this time until the final transmission at 0805:49.*

8 Prospect Reservoir is located 7.4 NM (13.9 km) north-west of Bankstown Airport and is a visual flight rules approach point for arrival to Bankstown.

Time	Event
About 0803	*The flight nurse attempted unsuccessfully to contact the Operations Manager again by mobile phone. She then contacted a friend by mobile phone and the friend reported that the call dropped out. On a second attempt, the flight nurse was reported to have advised the friend that the flight was in 'a lot of trouble'. The second call was reported to have dropped out in less than 30 seconds.*
0803:41	The pilot sought confirmation from ATC that the aircraft was heading straight towards Bankstown Airport and advised that the aircraft was 'struggling on height a little bit'. Altitude: 600 ft Derived airspeed: 100 kts Derived rate of descent: 200 ft/min *The spectral analysis of the pilot's transmission indicated that the landing gear unsafe aural warning was still active and that the signal used to determine the propeller RPM of the operating engine was not detected.*
0805:03	The pilot asked ATC whether the controller was able to see the aircraft. The controller replied that he was unable to see the aircraft due to haze. The pilot advised that the aircraft was not maintaining height and asked ATC for 'any ideas of any good roads around'. ATC advised that the M7 motorway 'should be in your vicinity' and that the aircraft was approaching 3 NM (5.6 km) from Bankstown Airport. Altitude: 300 ft Derived airspeed: 90 kts Derived rate of descent: 200 ft/min *The spectral analysis of the pilot's transmission indicated that the landing gear unsafe aural warning was still active and that the signal used to determine the propeller RPM of the operating engine was not detected.*
0805:37	The pilot advised ATC that 'we got no height here'. Altitude: 200 ft Derived airspeed: 95 kts Derived rate of descent: 100 ft/min *The spectral analysis of the pilot's transmission indicated that, while the landing gear unsafe aural warning continued, a second signal was detected, which was consistent with the propeller RPM of the operating engine reducing to about 2,350 RPM.*
0805:49	The pilot advised ATC that he was about to land the aircraft on a road. ATC suggested the Warwick Farm Racecourse[9] as a landing area but the pilot replied that he could not see the racecourse. Altitude: 200 ft Derived airspeed: 95 kts Rate of descent: could not be derived *The spectral analysis of the pilot's transmission indicated that the propeller RPM of the operating engine was reducing from about 2,350 to 2,250 RPM with the landing gear unsafe aural warning continuing.*
0806:00	The sound of an open microphone with background noise was recorded for 1 second. The detection in this recording of the same signals relating to engine operation and the landing gear unsafe aural warning were consistent with its transmission from PGW. *The spectral analysis of the radio transmission indicated that the propeller RPM of the operating engine was reducing from about 2,250 to 2,050 RPM. The landing gear unsafe aural warning continued to be recorded.*
	Witnesses who were located in the area and observed the aircraft were generally consistent in recalling that the aircraft's right propeller was not rotating. Several witnesses reported hearing a 'spluttering' engine sound. A witness near the accident site reported observing the landing gear extending immediately prior to the initial impact.
About 0806	The aircraft collided with a powerline support pole.

9 Warwick Farm racecourse is located about 2 NM (3.7 km) west of Bankstown Airport.

Witnesses who were located near the impact point reported that the aircraft was travelling in an easterly direction and appeared to be lining up to land on Canley Vale Road before the right wing collided with a powerline support pole (Figure 3). The aircraft then collided with the road and was engulfed in flames. Firefighting services arrived shortly after and extinguished the fire.

There were no reported injuries to any person on the ground. Damage was sustained by the powerline infrastructure, the front fence of a dwelling, several motor vehicles and the road tarmac.

Figure 3: Accident site

Courtesy of the NSW Police Force

Pilot information

The pilot obtained a Commercial Pilot (Aeroplane) Licence (CPL(A)) on 18 April 2007[10] and an Airline Transport Pilot (Aeroplane) Licence (ATPL(A)) on 29 April 2009 and held a Class I Medical Certificate that was valid until 11 January 2011. He commenced flying for Airtex Aviation[11] on 20 May 2008. The pilot transferred to Skymaster Air Services, which was part of the Airtex Aviation group of companies, and commenced flying for that operator on 14 July 2008. The pilot's qualifications and experience are summarised at Table 1.

10 Although the pilot passed the flight test for the issue of the CPL(A) on 4 February 2007, the issue date was recorded as 18 April 2007.

11 Airtex Aviation was the trading name for Avtex Air Services Pty Ltd which was part of the Airtex group of companies. 'Airtex Aviation' will be used throughout this investigation report.

Table 1: Pilot information

Type of licence	ATPL(A)
Total flying hours	2,435.3
Total flying hours on multi-engine aircraft	1,700.2
Total flying hours on PA-31P-350	779.1
Total flying in the last 90 days	166.5 hours
Total flying in the last 30 days	70.2 hours
Total flying in the last 7 days	16.0 hours
Total flying in the last 90 days on PA-31P-350	120.9 hours
Total flying in the last 30 days on PA-31P-350	29.9 hours
Total flying in the last 7 days on PA-31P-350	0.5 hours
Last proficiency check	12 April 2010
Medical certificate	Class 1 – valid to 11 January 2011 with nil restrictions

Multi-engine aircraft endorsement and instrument rating training

The pilot underwent flight training for an initial multi-engine aircraft endorsement from 25 August to 6 October 2006. This training was carried out by a flight training organisation in Victoria in a Piper PA-34-200 Seneca aircraft (PA-34). The pilot's training file and logbook indicated that there were seven separate flights, totalling 10.5 hours during this period. These flights included some training for the initial issue of a command (multi-engine aeroplane) instrument rating.

The pilot's training file showed that the total time with one engine simulated inoperative during the flights was about 2.4 hours. Civil Aviation Safety Authority (CASA) Civil Aviation Advisory Publication (CAAP) 5.23 1(0), *Syllabus of training Initial issue of multi-engine aeroplane type endorsement (rating)*[12], advised that there should be at least 3.5 hours of asymmetric training[13] and 7 hours total of dual instruction for the issue of an initial multi-engine aircraft endorsement.[14] The pilot successfully completed a 0.4 hour flight check in the PA-34 on 7 October 2006 and was issued with a PA-34 endorsement.

The pilot continued flight training for an instrument rating with an additional three flights being conducted in the PA-34 aircraft until December 2006. On 18 December 2006, the pilot underwent 1.3 hours of training for a multi-engine endorsement on the Vulcanair P68C (P68C) aircraft and the remaining 10 flights of the instrument rating training course were conducted in that aircraft type. A review of the pilot's training file indicated that the pilot encountered some difficulties with handling engine failures, particularly during his instrument rating training following the issue of the initial multi-engine endorsement.

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[12] Issued in September 2006.

[13] Involves one engine inoperative operation.

[14] CAAPs provide guidance on how operators and pilots might satisfy the requirements of the relevant regulations and orders.

On 3 February 2007, the pilot passed a 3-hour flight test in the P68C, which included simulated engine failures and asymmetric operations, and was issued with a multi-engine command instrument rating.

Commercial pilot licence training

On 4 February 2007, the day following the instrument rating flight test, the pilot passed another flight test of 3.1 hours duration in a Cessna R172K single-engine aircraft. This test was conducted for the issue of a CPL(A).

Prior to this flight test, the pilot had logged a total of 269.1 hours aeronautical experience while holding a private pilot licence. As this experience had not been gained as a student on a CASA-approved CPL(A) training course, the pilot was required, prior to attempting the flight test, to undertake an assessment flight with a Grade One Flight Instructor in accordance with the CASA *Day VFR*[15] *Syllabus – Aeroplanes.*[16]

The syllabus required the instructor to '... recommend as appropriate, that the candidate either is ready to undertake the CPL(A) flight test, or should undertake, in accordance with the relevant parts of the Day VFR Syllabus, a tailored course of training designed to prepare the candidate for the flight test'. The syllabus also required that when '... a tailored course is recommended, the Chief Flying Instructor is to provide in writing a detailed training programme consistent with the sequences listed in the Day VFR Syllabus, as recommended by the assessment flight instructor'.

The pilot's training file did not contain any details or documentation relating to the conduct of an assessment flight or of a detailed training programme. The pilot met all other requirements for the issue of a CPL(A).

PA-31 aircraft endorsement and post-endorsement training

The Piper PA-31 endorsement was a class endorsement that included all piston-engine models of the PA-31 aircraft type, including the PA-31P-350 Mojave. The aircraft types in this class endorsement were listed in Civil Aviation Order (CAO) 40.1.0 *Aircraft endorsements - aeroplanes*.

The pilot's PA-31 endorsement training was conducted by the then chief pilot of Airtex Aviation. Two endorsement flights were recorded in the pilot's logbook on 6 and 7 May 2008 respectively and totalled 2.8 hours.

No training records relating to the pilot's PA-31 endorsement were available to the Australian Transport Safety Bureau (ATSB) and the operator's file on the pilot did not contain an *Engineering, data and performance questionnaire* for that aircraft. During an audit in June 2008, CASA identified anomalies with the PA-31 endorsement training conducted by the chief pilot of Airtex Aviation (see the section of this report titled *Organisational and Management information*).

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

16 The applicable syllabus was Issue 3.1 of 1 April 2004.

The pilot's logbook showed that he flew 11.2 hours in command under supervision (ICUS) after his endorsement flying, prior to logging any command flight hours on the PA-31-350 aircraft. The ICUS was conducted with a supervising pilot who had been nominated by the chief pilot. Contrary to the requirements of the operations manual, the pilot was not checked by the Airtex Aviation chief pilot prior to commencing line operations for that company.

Special design feature endorsement training

In order to operate the PA-31P-350 Mojave aircraft type, the pilot was required to hold a special design feature endorsement for the pressurisation system fitted to the aircraft.[17]

The operator's pilot file included a PA-31P-350 pressurisation endorsement examination on 31 October 2008 and an undated supporting engineering examination. The special design feature endorsement flight training of 0.8 hour was conducted in one of the operator's PA-31P-350 aircraft on 13 November 2008 by an independent approved testing officer (ATO).

The pilot's logbook recorded three flights ICUS on the PA-31P-350 aircraft on 19 and 21 November 2008, totalling 12.4 hours. He subsequently underwent a flight operations check in a PA-31P-350-aircraft with Skymaster's chief pilot on 2 December 2008 before flying the PA-31P-350 aircraft on line operations. The chief pilot's flight check form for that flight included the comment that the pilot's '... system knowledge and aircraft handling is good ... [and] he has many reasons to be proud of his work'.

Other multi-engine aircraft endorsement training

The pilot underwent training and was endorsed on the Cessna 310/340 piston multi-engine aircraft in October 2007. In September 2009, the pilot was endorsed on the Piper PA-42-1000 turboprop multi-engine aircraft.

Proficiency checks

Table 2 is a summary of proficiency checks conducted during the pilot's employment with Skymaster, as recorded in his logbook and the operator's pilot file.

Table 2: Pilot proficiency checks

Date	Check
12 July 2008	Flight operations check conducted by the chief pilot
13 July 2008	Flight operations check conducted by the chief pilot
13 July 2008	CAO 20.11 emergency procedures check
2 September 2008	Flight operations check conducted by the chief pilot
2 December 2008	Flight operations check conducted by the chief pilot
21 March 2009	Command instrument rating renewal flight test

17 Civil Aviation Regulation 5.01 and 5.06 outlined the requirements for the issue of special design feature endorsements, including in respect of aircraft pressurisation systems.

Date	Check
18 May 2009	CAO 20.11 emergency procedures check
21 May 2009	Flight operations check conducted by the chief pilot
25 May 2009	Flight operations check conducted by the chief pilot
13 March 2010	Command instrument rating renewal flight test
12 April 2010	Flight operations check conducted by the chief pilot
12 April 2010	CAO 20.11 emergency procedures check

Skymaster Air Service's *Operations Manual*, Part A - Appendices, contained a *Flight Check* form, the second page of which allowed for qualitative comments about pilots' flight operations checks. The pilot's file contained the second page for all seven flight checks undertaken by the pilot from 2008 to 2010. Comments from those checks are discussed in the following paragraphs.

The previous chief pilot noted on the check form for the 12 July 2008 flight that the pilot's 'systems knowledge and use of checklists and emergencies was not adequate enough'. The pilot underwent further training the following day and the chief pilot then conducted a further check before clearing him to conduct line operations. The subsequent chief pilot conducted two check flights with the pilot in September and December 2008, commenting that the pilot had shown 'good work on today's flight' and achieved a 'good standard' respectively.

Following the fifth check flight on 21 May 2009, the chief pilot decided to conduct another check flight due, in part, to an inaccurately flown instrument approach by the pilot. The subsequent check flight was flown 4 days later and the chief pilot noted on the check form that the pilot's ' performance was excellent' and he considered that the pilot's 'performance the other day was out of character possibly due nerves or cockpit gradient[18]'.

The pilot underwent a flight test in a Piper PA-31-350 aircraft on 13 March 2010 to renew his multi-engine command instrument rating. The ATO who conducted that test recorded on the CASA *Instrument Rating Application* form that the pilot was at a satisfactory standard for the items tested, including three simulated engine failures. These simulated engine failures were not required to be conducted during the climb/cruise phase of flight.

At the request of the chief pilot, the ATO made some notes regarding the pilot's performance during the flight test. The testing officer commented that the pilot was:

> ...a bit behind the aircraft at times. Radio procedures not in accord[ance] with AIP.[19] Struggled with the ILS [instrument landing system].[20] Did not ident[ify] LLZ [localiser]. Did not call OM HT [outer marker height]. NDB app [non-directional radio beacon approach] satisfactory. Landing at YSBK [Bankstown] unsatisfactory'.

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18 The term 'cockpit gradient' can variously refer to the difference between involved pilots in terms of age, experience levels and position held in the organisation.

19 A package of documents that provides the operational information necessary for the safe and efficient conduct of national (civil) and international air navigation throughout Australia and its Territories.

20 A standard ground aid to landing, comprising two directional radio transmitters: the localizer, which provides direction in the horizontal plane; and the glideslope, for vertical plane direction,

The chief pilot advised that he requested these additional notes from the testing officer to assist in the development of a future staff training course that was intended to standardise procedures and improve pilot general flying proficiency. That course had not been conducted at the time of the accident.

The testing officer reported that his evaluation of the pilot's standard during the flight test was based on what he considered to be the standard of an exemplary pilot. The testing officer stated that any comments about an unsatisfactory standard were to be considered in relation to '... what an exemplary pilot would be like [as opposed to] to CASA's standard or minimum standard to pass the test'. The testing officer also stated that during the ILS approach at Richmond he queried the pilot as to whether he had 'forgotten anything?'. He did not specifically draw the pilot's attention to his omitting to aurally identify the ILS and his not calling out the aircraft's height when overflying the outer marker.[21] Each of these actions was anticipated by the testing officer but not carried out by the pilot until prompted by the testing officer.

On 12 April 2010, the pilot underwent a CAO 20.11 emergency procedures check and a flight operations check with the chief pilot on a flight from Bankstown to Dubbo, NSW and return. The chief pilot reported that the pre-flight briefing of this check included a discussion about engine failures during the cruise and the need to attempt to 'fix' the problem before shutting down an engine. The chief pilot stated that during the subsequent flight an engine failure scenario was discussed and the pilot simulated (without manipulating the controls or switches) what actions were required to manage the situation. The chief pilot recalled the pilot indicating during the in-flight discussion that he would shut down the failed engine without attempting to rectify the problem. That contrasted with the reported statement by the pilot during the pre-flight briefing that he would carry out rectification checks prior to shutting down the engine. The pilot subsequently wrote some notes about what had occurred during the check flight, including the comment '... Engine failure – not clear on instructions'. The pilot also submitted an internal safety report on the conduct of the flight (see the *Safety management* section of this report).

In response to the standard achieved by the pilot in this check flight, the chief pilot 'Recommend[ed] some ICUS and another check in 3 – 6 months'. The chief pilot later reported that the intention was for the pilot to fly with one of his peers to show him that his standard of flying had not improved to the same extent as reached by the peer. There was no record that these ICUS flights were undertaken prior to the accident.

Operating practices

Several pilots who had flown with the pilot described him as having a relaxed attitude to flying and a tendency to avoid interpersonal conflict. Flight instructors reported that during his initial multi-engine endorsement training, the pilot's pre-flight preparation was well organised and his general flight handling was of a good standard.

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usually at an inclination of 3°. Distance measuring equipment or marker beacons along the approach provide distance information.

21 A beacon that forms part of the ILS and is normally located on the approach centreline about 3.9 NM (7.2 km) from the runway threshold.

The flight instructor who conducted the pilot's initial multi-engine endorsement and command instrument rating training reported that the pilot was '... very professional about the way he went about things' and that, when he commenced training, the pilot's knowledge, skill and ability were '... pretty good' and that the pilot '... was no different from any other student'.

The ATO who conducted the flight tests for the issue of the pilot's instrument rating and CPL(A) considered the pilot to be 'very mature, capable'.

Several pilots reported that, in their opinion, the pilot did not have adequate knowledge in instrument flying procedures when he commenced flying with Skymaster Air Services. They also reported that the pilot's response to non-normal and simulated emergency situations appeared reactive and that he encountered difficulties in formulating a plan to manage the situation. Other pilots who had flown with him stated that, in their opinion, the pilot's behavioural response to emerging non-normal situations or circumstances was less than optimal and that his decision-making, situation awareness and problem solving skills in these situations were not at the level of other pilots. There is no evidence of these opinions or observations being brought to the attention of the chief pilot of Skymaster Air Services.

Some pilots who flew with the pilot during line operations at Skymaster Air Services stated that the manner in which he accomplished procedural items appeared to be unstructured and his checklist usage was non-standard. Several pilots commented on the pilot's approach to making radio transmissions, including that he made 'casual or non-standard' calls. The ATO who conducted the multi-engine command instrument rating flight test on 13 March 2010 also commented on the pilot's 'sloppy' radio procedures.

In January 2009, the pilot was flying a PA-31P-350 at flight level (FL) 140[22] when the right propeller speed reduced by 100 RPM, resulting in the two engines becoming unsynchronised. The pilot contacted ATC to request a clearance to return to Bankstown. ATC provided a clearance and tracking instructions and on completion of the turn back, the pilot carried out the emergency checks and determined that the problem was due to the right engine propeller lever moving back from the required setting. The pilot then notified ATC that operations were normal and requested a clearance to return to the original flight plan track. The pilot later stated in a report to the chief pilot that the situation had occurred suddenly, he did not realise what had happened, and he did not immediately attempt to correct the problem. The chief pilot stated that he discussed the incident with the pilot and advised him that he should have attempted to rectify the engine problem before initiating a diversion. The chief pilot reported having emphasised the need for the pilot to manage tasks in the cockpit, with control of the aircraft being the highest priority.

Recent history

The pilot had returned to Bankstown 3 days before the accident flight following a 6-day rostered duty period where he had flown a PA-31-350 aircraft on a series of flights in South Australia and Queensland. It was reported that the pilot was out to

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22 At altitudes above 10,000 ft in Australia, an aircraft's height above mean sea level is referred to as a flight level (FL). FL 140 equates to 14,000 ft.

dinner until about 2100 on the night before the accident. On his return home, the pilot contacted a family member who said that the pilot seemed to be his normal self. The pilot was observed leaving his residence at about 0615 on the morning of the accident.

Aircraft information

The aircraft was a twin piston-engine, propeller-driven, low-wing aircraft that was certified to seat up to seven occupants in a pressurised cabin. The aircraft was configured with two seats in the cockpit and three passenger seats and a patient stretcher in the cabin. Details of the aircraft and its engines and propellers are provided in Tables 3 to 5.

Table 3: Aircraft data

Manufacturer	Piper Aircraft Corporation
Model	PA-31P-350 Mojave
Serial Number	31P-8414036
Registration	VH-PGW
Year of manufacture	1984
Certificate of airworthiness	Issued 27 October 2006
Certificate of registration	Issued 19 September 2006
Maintenance Release	Valid until 6,310.6 hours or 28 May 2011
Total airframe hours	6,266.8 (prior to the accident flight)

Table 4: Engine data

Manufacturer	Lycoming Engines (Avco Corporation)	
Model	Left engine	TIO-540-V2AD
	Right engine	LTIO-540-V2AD
Type	Turbocharged, fuel-injected, horizontally-opposed, six-cylinder piston engine	
Serial Numbers	Left engine	L-8525-61A
	Right engine	L-2819-68A
Time since overhaul	Left engine	491.3 hours (overhauled 10 May 2007)
	Right engine	273.3 hours (overhauled 4 February 2010)

Table 5: Propeller data

Manufacturer	Hartzell Propeller Inc.	
Model	Left engine	HC-I3YR-2CUF
	Right engine	HC-I3YR-2LUF
Type	3-blade variable pitch constant speed propeller	
Serial Numbers	Left engine	FS107
	Right engine	FS75
Time since overhaul	Left engine	990.6 hours
	Right engine	894.3 hours

The *Piper PA-31P-350 Mojave Pilot's Operating Handbook*, *Section 2 Limitations*, specified a maximum engine speed of 2,600 RPM.

Aircraft airworthiness and maintenance

The aircraft was maintained in accordance with the aircraft's logbook statement. A review of the maintenance records for the aircraft showed that all scheduled maintenance was done in accordance with that statement. All applicable engine and airframe airworthiness directives were carried out. A review of the PA-31P-350 service bulletins indicated that most of the bulletins had been completed for the aircraft. However, there was no record of compliance for service bulletins 1125 of 15 April 2003 relating to the elevator trim wheel, and 1174 of 15 February 2007 relating to the aircraft door lock assemblies.

There was no evidence found in the aircraft maintenance documentation of any pre-existing defects that may have contributed to the accident.

A review of the aircraft's maintenance records showed that the aircraft last underwent maintenance on 11 June 2010, consisting of a scheduled 50-hourly maintenance inspection. The last 100-hourly maintenance inspection was conducted on 28 May 2010 at 6,210.6 airframe hours and the aircraft was issued with a maintenance release on that date. The maintenance release was valid until 28 May 2011 or 6,310.6 hours, whichever came first.

The operator's *Daily Flight Sheet*, which was carried onboard the aircraft, was completed by flight crew whenever there was a maintenance issue with the aircraft. Any engineering work done on the aircraft was also recorded on this sheet and copies of the completed sheets were normally forwarded to the operator's engineering section at the completion of each day's operations. The last recorded entry relating to unscheduled maintenance work being carried out on the aircraft was in a *Daily Flight Sheet* dated 7 June 2010 regarding the changing of the left magneto on the right engine after a magneto problem earlier that day.

It was reported that about 4 to 5 months prior to the accident, another pilot experienced surging of the aircraft's right engine during climb from Bankstown and again on descent to Taree, NSW. The aircraft's maintenance records showed that the right engine was changed on 19 February 2010 for scheduled maintenance, about 4 months prior to the accident. The replacement engine had been overhauled prior to it being installed on PGW. The maintenance records, including the *Daily Flight Sheets*, were examined for the 9 months preceding the accident but there were no entries relating to surging of either of the aircraft's engines, or maintenance work being carried out to rectify a surging problem.

The *Daily Flight Sheet* for the accident flight was not recovered from the site due to the post-impact fire.

Weight and balance

The aircraft's weight and balance was calculated using the aircraft's load sheet, the empty weight of the aircraft and estimates of the occupants' weights and position, and the weight and position of the onboard equipment and fuel. The aircraft's weight at the time of the accident was estimated to be 3,266 kg, which was less than the aircraft's maximum approved take-off weight of 3,368 kg.[23] Similarly, the aircraft's centre of gravity was within limits at that time.

Refuelling

The aircraft was refuelled at about 0720 on the morning of the accident with 660 L of Avgas from a fuel truck. A review of the refueller's records determined that the aircraft was the fifth of 25 aircraft that were refuelled from that fuel truck on the day of the accident. During that time, 5,929 L of fuel were dispensed from the truck to those aircraft. There were no reports of any of the other aircraft experiencing engine or fuel related problems.

Due to the impact and subsequent fire, no fuel from the aircraft was available for examination and testing. Subsequent testing of samples taken from the fuel truck indicated their compliance with the specification for Avgas 100LL fuel, which was the correct type and grade for the aircraft's engines.

On the day prior to the accident, the aircraft was refuelled at Dubbo with 80 L of fuel prior to its return to Bankstown. A review of the Dubbo refuelling records determined that five other aircraft refuelled from the same supply that day and that a total of 1,179 L of fuel was supplied to those aircraft. There were no reports of any of those aircraft experiencing engine or fuel related problems.

An aviation turbine fuel (Avtur) truck was also operated by the same refuelling supplier at Bankstown that supplied the Avgas to PGW on the day of the accident. Examination of the fuel records for the Avtur truck showed that it was not used between 0550 and 0930 that day, which encompassed the time that PGW was refuelled.

Meteorological information

Aerodrome forecasts

The Bureau of Meteorology (BoM) issued an aerodrome forecast (TAF)[24] for Bankstown Airport at 0244 on 15 June 2010 that was valid from 0400 to 2200[25] that day. During the aircraft's planned takeoff and climb in the Bankstown area, the forecast wind was variable in direction at 3 kts, the visibility was forecast to be greater than 10 km with Few clouds[26] at 3,500 ft above the aerodrome elevation, the temperature was forecast to be 4 °C and the QNH[27] 1032 hPa.

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23 The aircraft had been modified in accordance with a supplemental type certificate, which resulted in an increase in the maximum approved take-off weight from 3,265 kg to 3,368 kg.

24 Aerodrome Forecasts are a statement of meteorological conditions expected for a specific period of time, in the airspace within a radius of 5 NM (9 km) of the aerodrome.

25 Meteorological forecasts and reports are issued reference UTC. Here, for ease of reference all forecasts and reports are discussed with reference to EST.

26 Cloud cover is normally reported using expressions that denote the extent of the cover. The expression Few indicates that up to a quarter of the sky was covered.

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

The BoM also issued a TAF for Richmond Airport at 0303 on 15 June that was valid from 0400 to 2200 that day. During the time the aircraft was planned to overfly Richmond, the forecast wind was variable in direction at 3 kts, the visibility was forecast to be 400 m in fog until 0900, the temperature was forecast to be 2 °C and the QNH 1032 hPa.

Weather observations

A BoM Automatic Weather Station (AWS) located at Bankstown Airport generated routine aerodrome weather reports (METAR).[28] The METAR issued at 0800 indicated that the wind at that time was from 340 °(T) at 4 kts, the temperature was 6 °C, the dewpoint[29] was 5 °C, the visibility was 8 km with no cloud detected and the QNH was 1033 hPa.

The Bankstown Airport automatic terminal information service (ATIS)[30] 'Bravo' was broadcast during the period encompassing the aircraft's departure and subsequent return flight. The ATIS information included a variable wind of 5 kts, a temperature of 6 °C, CAVOK[31] and a QNH of 1033 hPa. The pilot reported that he had received 'Bravo' when contacting the Bankstown Surface Movement Controller at 0734, 6 minutes prior to reporting ready for departure.

An AWS was also located at Richmond Airport and the METAR issued at 0800 indicated that the wind was calm, the temperature was 4 °C, the dewpoint was 4 °C, the visibility was 200 m with vertical visibility information being unavailable, and the QNH was 1033 hPa. An air traffic controller who was on duty in the Richmond control tower later stated that the weather conditions at the airport when the aircraft was flying over the Richmond area included a clear sky with a shallow fog that was below the level of the control tower cabin. The fog reduced visibility at ground level to 300 m.

Communications

Relevant communications between the pilot and various air traffic controllers are included in the *History of the flight* section of this report. The pilot did not use the PAN and MAYDAY phraseology provided in the Aeronautical Information Publication (AIP) En Route Supplement Australia for notifying ATC of abnormal and emergency operations. The term PAN is used for urgency situations such as 'for the purpose of giving notice of difficulties which compel it [the aircraft] to land without requiring immediate assistance',[32] for example flight with one engine

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[28] Routine aerodrome weather report issued at fixed times, hourly or half-hourly.

[29] Dewpoint is the temperature at which water vapour in the air starts to condense as the air cools. It is used among other things to monitor the risk of aircraft carburettor icing or likelihood of fog at an aerodrome.

[30] An automated pre-recorded transmission indicating the prevailing weather conditions at the aerodrome and other relevant operational information for arriving and departing aircraft.

[31] Ceiling and visibility OK, meaning that the visibility, cloud and present weather are better than prescribed conditions. For an aerodrome weather report, those conditions are visibility 10 km or more, no significant cloud below 5,000 ft or cumulonimbus cloud and no other significant weather within 9 km of the aerodrome.

[32] Civil Aviation Regulation (CAR) 193.

inoperative. The term MAYDAY is used for distress situations where ‘the aircraft is threatened with grave and immediate danger and requires immediate assistance’.[33]

Aerodrome information

Bankstown Airport

Bankstown Airport is located about 22 km south-west of the Sydney central business district (CBD) at an elevation of 29 ft. The airport has three parallel runways aligned in the 11/29 direction (111/291 °(M)). The central runway, runway 11/29C, is constructed of asphalt and is 1,416 m long and 30 m wide. The airport is serviced by a non-directional radio beacon (NDB).[34]

Richmond Airport

Richmond Airport is located about 50 km north-west of the Sydney CBD and 40 km north-west of Bankstown Airport. The airport is at an elevation of 67 ft and is an Australian Defence Force facility located within Royal Australian Air Force Base Richmond. The airport has a single runway aligned in the 10/28 direction (095/275 °(M)) that is constructed of asphalt and is 2,134 m long and 45 m wide. The runway is suitable for operations by PA-31 aircraft and is available for civil aircraft in an emergency. The airport is serviced by an ILS for runway 28 and an NDB.

Recorded information

Flight recorders

The aircraft was not fitted with a flight data recorder or a cockpit voice recorder, nor were those recorders required by the relevant aviation regulations.

Recorded radar data

The pilot was provided with a discrete transponder[35] code as part of the airways clearance that was issued to him while he was taxiing the aircraft to runway 29C prior to departing Bankstown Airport. Transponder information from the aircraft was recorded by ATC.

The system track data relating to the aircraft’s position, groundspeed and altitude was logged every 5 seconds. The logged data was used to determine the radar track and altitude following the aircraft’s departure from Bankstown Airport. Figures 1 and 2 depict the recorded track of the aircraft relative to Richmond and Bankstown Airports.

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33 CAR 192.

34 A non-directional (radio) beacon (NDB) is a radio transmitter at a known location, used as a navigational aid. The signal transmitted does not include inherent directional information.

35 A transponder provides aircraft information such as identity and altitude to ATC.

Radar data for other flights

Radar data for the period 3 June to 1 July 2010 was also examined to derive the descent profiles of previous flights in PGW and other PA-31P-350 aircraft operated by Skymaster Air Services, to compare these profiles with the accident flight. None of these flights were flown by the accident pilot.

The rate of descent of six flights into Bankstown Airport was compared with the rate of descent adopted by the pilot during the accident flight. Four of these flights showed a rate of descent of between 500 and 600 ft/min from top of descent to about 5,000 ft. The rate of descent of PGW on 7 June during a return to Bankstown as a result of a magneto problem was about 800 ft/min. The highest rate of descent was about 1,000 ft/min from FL130.

The accident flight radar data showed that, apart from the initial descent following the reported engine shutdown, the rate of descent adopted by the pilot was consistent with the rate of descent flown in five of the six other flights examined.

Recorded audio data

All communications between the relevant air traffic controllers and the pilot were recorded by ground-based automatic voice recording equipment. The sound quality of these very high frequency (VHF) transmissions between the controllers and the pilot was good.

Wreckage and impact information

Accident site description

The accident site was located in a suburban area at a distance of 6.3 km on a bearing of 299 °(M) from Bankstown Airport. The right wing of the aircraft initially hit a powerline support pole on the southern side of Canley Vale Road about 40 m east of the intersection with Sackville Street, Canley Vale. Marks on the pole indicated that the impact was about 10 m above ground level.[36] Witness reports and damage to tree foliage indicated that fuel from the right wing tank ignited after the impact with the pole.

The aircraft continued in an easterly direction for about 75 m along Canley Vale Road, descending and rolling to the right before the right wing struck the ground. The aircraft then collided with two power support poles and travelled for a further 60 m along the street with the outboard sections of the left and right wings separating from the aircraft. The aircraft came to rest inverted in the driveway of a residential property (Figure 4).

[36] This equated to about 60 ft above mean sea level.

Figure 4: Main wreckage

The fuselage, inboard sections of the left and right wings and the engines and propellers were destroyed by the impact forces and post–impact, fuel-fed fire. The structural damage to the aircraft was consistent with the application of excessive structural loads during the impact sequence, and the effects of the subsequent fire. No pre-existing structural defects likely to have contributed to the accident were found. All aircraft control surfaces were located at the site. The flaps were retracted and the landing gear was probably extended at impact.

The aircraft engines, propellers and some other components were removed for further examination.

Examination of removed components

Engines and ancillary systems

Disassembly and examination of both engines revealed no evidence of any internal mechanical malfunction or catastrophic failure. There was no evidence of detonation, pre-ignition, piston/combustion chamber melting or oil starvation.

Examination of the turbocharger units and control components from both engines revealed damage due to the impact and post-impact fire but found no indications of pre-impact unserviceability. Examination of the engine oil pumps also revealed damage due to the post-impact fire but found no indications of pre-impact unserviceability.

There were no indications of pre-impact failure of the engine-driven fuel pumps, the distributer valves, the fuel injection lines from the left and right engines or the left engine fuel control unit. Due to post-impact fire damage, the serviceability of the right engine fuel control unit could not be determined. Testing of the fuel injector nozzles found that the spray patterns were erratic and the number six nozzle from the right engine was completely blocked. The ATSB was unable to determine whether the erratic nozzle spray patterns and blockage of the number six nozzle were due to pre-impact contamination.

Most of both engines' ignition system components, including the magnetos and ignition harnesses, were either severely damaged or destroyed by the post-impact fire. As a result only the spark plugs could be tested. The results of this testing were inconclusive due to contamination of some of the plugs by fire-fighting foam, water and engine oil.

An examination of the cowl flap actuators was inconclusive, due to the extent of damage to these components, and the position of the cowl flaps of both engines at impact could not be positively determined.

Propellers

Examination of the propellers from both engines found no evidence of any pre-impact faults. The damage sustained by the propeller blades from the left engine was consistent with the blades being in the fine pitch position with the engine at a low power setting at impact. The propeller blades from the right engine were in the feathered[37] position, which was consistent with witness reports that the right propeller was not rotating prior to impact. Examination of both propellers' governors did not find any pre-impact faults.

Cockpit instruments and switches

Only a small number of the cockpit controls, instruments and switches were recovered for further examination as most were severely damaged by the impact and intense post-impact fire. Nothing was found during these examinations that might have precluded normal operation.

Medical and pathological information

A post-mortem examination of the pilot by state authorities found that the injuries sustained were consistent with the accident and that the pilot did not exhibit any physiological condition that would have affected the performance of his duties. Toxicological examinations found no evidence of drugs or alcohol in the samples taken from the pilot.

Fire

Evidence from the accident site indicated that the right wing fuel tank was breached early in the impact sequence, most likely at the initial impact with the top of the powerline support pole. There was scorching damage to trees after this point. Witnesses also reported that they felt heat from a fire as the aircraft passed above them. Following impact with the ground, an intense, fuel-fed fire caused significant damage to the aircraft and its systems.

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37 The term used to describe the propeller blades being rotated to an edge-on angle to the airflow that minimises aircraft drag following an engine failure or shutdown in flight.

Survival aspects

The accident sequence was not considered survivable.

Tests and research

In an effort to understand the nature of the emergency and any actions by the pilot, the pilot's recorded radio transmissions were examined using spectrographic analysis software to determine the frequency spectrum of each transmission. These transmissions provided information on the operation of PGW at the time the communications were made.

In support of this analysis, a recording flight was carried out in an exemplar Piper PA-31P-350 Mojave aircraft to obtain a comparative record of signals generated by the aircraft and its systems during normal operation. The recorded signals from the exemplar aircraft were then compared with those from the aircraft on the day of the accident.

Recording flight

Conduct of the flight

The recording flight was carried out on 1 September 2011. Audio recording, global positioning system (GPS) and video equipment were carried on board to record the flight. In addition, automated voice recordings of radio transmissions from the recording flight were obtained from the ATC service provider.

The video equipment recorded the aural environment in the aircraft's cabin and the visual images of the instrument panel. This information provided a baseline that correlated propeller sounds with the aircraft's engine speed instruments. Audio equipment recorded electrical interference signals from the aircraft's alternators via the intercommunication headphone system. The GPS unit logged the aircraft's position and altitude, allowing the aircraft's flight profile to be examined in conjunction with ATC-recorded radar information.

The aircraft was loaded to a similar weight as PGW on the day of accident and the flight was conducted at a density altitude[38] that corresponded to that of PGW when the radar data indicated that the pilot had ceased the climb. During the flight, the aircraft was slowed to various airspeeds with the power setting of the right engine reduced to various combinations of RPM and manifold pressure to simulate single engine zero thrust as specified in the *Piper PA31P-350 Mojave Pilot's Operating Handbook*. The left engine was maintained at the climb power setting used by the operator of the recording aircraft. While the aircraft was being flown with the power reduced on the right engine, the position of the right cowl flap was varied.

The exercise was then repeated with the power setting on the left engine reduced to various combinations of RPM and manifold pressure to again simulate single engine zero thrust, and the right engine maintained at a constant power setting.

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38 The altitude in the International Standard Atmosphere (ISA) at which the air density is equal to the actual air density at the specific location. Also defined as the pressure altitude corrected for non-ISA temperature.

As the aircraft was to be operated in a manner that simulated single engine operation, although at a lower power setting than specified in the POH for operation following an engine failure, the rate of climb, or descent exhibited during the recording flight was documented.

The electrical interference signals from the alternators that were generated at the various power settings were present in the recordings of the recording aircraft's intercommunication system but not in the video camera recording. The aircraft's performance in these configurations was documented. The variation in the right engine power settings resulted in differing rotational speeds being recorded and allowed the changes in frequency of the propeller and alternator signals to be tracked. The signals were analysed and variations in frequency were correlated with video images of the engine instrument indications.

Aircraft performance

During the recording flight, the aircraft was unable to maintain altitude in the following configuration:

- wings level
- airspeed greater than 101 kts
- either the left or right engine powers set at 2,400 RPM and 36 inches (in.) of manifold pressure[39]
- either the left or right engine power set at the simulated zero thrust setting
- having the operating engine's cowl flap in the open position and the cowl flap on the engine that was simulating zero thrust in the closed position.

In the above configuration, the rate of descent varied between 50 ft/min and 300 ft/min depending on the airspeed.

In the same configuration, the rate of descent reduced to about 0 ft/min when the airspeed was reduced to about 101 kts, which was the nominated one-engine inoperative best rate-of-climb speed (V_{YSE}).[40]

The rate of descent increased by approximately 50 ft/min with the airspeed at about V_{YSE} when the right engine cowl flap was selected to the open position.

Spectral analysis of the pilot's radio transmissions

Analysis of the pilot's radio transmissions identified signals from the aircraft's propellers and engine-driven alternators (a separate signal from each engine's alternator was discernable). Signals relating to the operation of the aircraft's aural alerting system were also recorded, and related to the operation of the landing gear configuration warning.

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39 The operator of the recording aircraft used a climb power setting of 2,400 RPM and 36 in. manifold pressure. The *Piper PA-31P-350 Mojave Pilot's Operating Handbook* and the *Skymaster Air Services Operations Manual* specified 2,400 RPM and 40 in. manifold pressure as the climb power setting, which was also the maximum normal operating power setting.

40 The aircraft manufacturer defined the one-engine inoperative best rate-of-climb speed (V_{YSE}) as the airspeed which '… delivers the greatest gain in altitude in the shortest possible time …' with one engine inoperative.

Aircraft propellers

The aircraft's propellers were directly driven from the respective engine crankshaft, which meant that the sound of each propeller was directly related to the operating speed of the corresponding engine. No propeller sound was detected in the radio transmission made during the climb by the recording flight pilot. However, analysis of the audio environment of the cabin, which was recorded by the video camera during the recording flight, clearly showed propeller sounds. This confirmed the effectiveness of the flight crew noise cancelling microphones at nulling the propeller sound at normal climb power operation.

The low frequency and varying 'rasping' sound in the background of the three transmissions made by the pilot of PGW commencing at 0752:27 (after the aircraft ceased climbing - see the previous section titled *History of the flight*) was consistent with engine surging but was not heard in the pilot's earlier transmissions made during the climb. This indicated that, after the aircraft was levelled off, one of the engines was intermittently developing significantly more than climb power , driving the affected propeller to a higher than normal RPM and causing a low frequency 'rasping' sound. The spectral analysis could not determine whether the 'rasping' sound originated from the left or right engine.

Engine-driven alternators

The aircraft was fitted with two engine-driven alternators that provided electrical power to the instruments, avionics equipment and other aircraft systems. The frequency characteristics of a residual alternating signal are dependent on the construction of the alternator and its rotational speed. Each alternator was driven from the respective engine's crankshaft through a pulley system via a flexible vee-belt. This meant that the residual alternating signal frequency was generally related to the operating speed of the engine.

The frequency of the signals originating from the engine driven alternators from the recording flight were similar to the signals detected in the radio transmissions from the pilot of PGW.

Cause of the engine surging

The engine manufacturer advised that the surging identified by the spectral analysis of radio transmissions during the accident flight was 'consistent with uneven fuel distribution to the cylinders'. The propeller manufacturer advised that it had 'yet to find a causal factor in surging that was clearly identified as being from the propeller or governor, especially for a report of a large RPM excursion'.

Organisational and management information

Operator overview

Skymaster Air Services was incorporated as a proprietary limited company in NSW on 30 May 2001. CASA issued an initial Air Operator's Certificate (AOC) on 19 June 2002 that authorised the company to conduct charter operations in Cessna 337 aircraft. This AOC was subsequently varied to authorise the operation of other types of aircraft. In about November 2006, the owner of Airtex Aviation purchased Skymaster Air Services, which then formed part of a group of four companies.

The AOC was varied on 18 August 2008 so that Skymaster Air Services could conduct aerial work ambulance operations in addition to charter and other aerial work operations. The chief executive officer (CEO) of the Airtex group reported that the majority of the Skymaster Air Services flying activities were associated with patient transport operations in conjunction with an associated company, which was part of the Airtex Aviation group of companies. While this associated company did not hold an AOC, it had a contract with the NSW State Government Department of Health for the provision of non-emergency medical patient transport services.

The Skymaster Air Services main base and head office was at Bankstown Airport with an ancillary base at Dubbo Airport. In June 2010 there was one line pilot employed on a full-time basis at the Dubbo base and 15 line pilots employed on a casual basis at the Bankstown base. At that time Skymaster Air Services operated eight Piper PA-31-350 Chieftain aircraft, four Piper PA-31P-350 Mojave aircraft and three Ted Smith Aerostar 600 series aircraft.

Chief pilot

The position 'head of the flying operations' was defined in Section 28(3) of the *Civil Aviation Act 1988* as being a key position within an AOC holder's organisational structure. The chief pilot of an organisation was responsible for carrying out the duties of that key position. CAO 82.0, Appendix 1 outlined the responsibilities of a chief pilot, which included monitoring operational standards and supervising the training and checking of flight crew.

The incumbent chief pilot of Skymaster Air Services was approved by CASA on 6 August 2008. He had previously been chief pilot with five other operators. The chief pilot had 9,061.7 hours total aeronautical experience with 7,429.2 hours on multi-engine aircraft.

Flight crew training and checking processes

The operator required pilots to undergo induction training when commencing employment. Section A2.3 of the Skymaster Air Service's Operations Manual titled *Induction and Training Requirements* provided information on the induction training requirements. This included the requirement to achieve a 100% pass in a written examination that was based on the *Multi-Engine Aeroplane Endorsement – Engineering, Data and Performance Questionnaire* in Appendix D to CASA Civil Aviation Advisory Publication 5.23-2(0), *Multi-engine Aeroplane Operations and Training*, dated July 2007.

The operator also required new pilots to complete a series of ICUS flights and be line checked before they were cleared to undertake flights as a pilot in command (PIC). [41] The operations manual stated that:

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[41] Civil Aviation Order (CAO) 82.1 sub-paragraph 4.1(b) specified that PICs of multi-engined aeroplanes not exceeding 5,700 kg maximum take-off weight that were engaged in charter operations under the IFR, had to have at least 10 hours experience as PIC of the aircraft type. This could include flight time spent ICUS.

> Pilots supervising ICUS flights shall utilise the time allotted to reinforce SOP [standard operating procedures] and systems management training by providing, when operationally acceptable, scenario and situation based discussions which amplify and examine emergency, abnormal and normal operations.

There was no evidence that the pilots who supervised the ICUS flights had undergone formal training to conduct these flights, including the management of actual emergencies from the right cockpit seat. There was no information in the operations manual regarding the training of ICUS supervisory pilots or the conduct of the flight operations checks conducted by the chief pilot prior to a new pilot being cleared to conduct line operations.

The chief pilot stated that any flight operations checks conducted by him included discussions about various emergency scenarios, including engine failures, but did not include simulated engine failures in flight. The chief pilot reported that he did not hold a flight instructor rating or any delegations from CASA under CAR 5.19 or CAR 5.20 (1).[42] As a result, the chief pilot was not authorised to conduct simulated in-flight engine failure training and he was, therefore, unable to assess the skill-based performance of the operator's pilots in one-engine inoperative situations.

Recurrent proficiency checks of the operator's pilots comprised either flight operations checks conducted by the operator's chief pilot or command instrument rating renewal flight tests conducted by an independent ATO. As the operator used piston-engine aircraft with a gross weight of less than 5,700 kg and did not conduct regular public transport operations, the operator was not required to provide a training and checking organisation in accordance with the provisions of Civil Aviation Regulation (CAR) 217. Furthermore, the operator's AOC did not contain any authorisation to conduct any training and checking operations.

The chief pilot reported that he carried out a minimum of one check flight on each pilot every 12 months. Information about the flight operations check was not provided in the operations manual but the content of the check was listed in Appendix 4 to Part A of the operations manual, the *Flight Operations Check* form. This form listed 52 items that were to be assessed by the chief pilot as having been evaluated to a satisfactory or unsatisfactory standard or having not been observed. The items included systems knowledge and the conduct of cockpit checks. Simulated engine failures were not included in the list.

The chief pilot reported that a check flight would also include a review of any issues identified during previous check flights and in any electronic safety incident reports[43] involving the pilot being checked.

The pilots' multi-engine command instrument rating flight tests were carried out by independent ATOs. Depending on the number of navigation aids to be tested, the applicant had to demonstrate competency in up to 65 items that were assessed as either satisfactory or unsatisfactory by the ATO. CASA *Instrument Rating Flight Test Report* form number 645 dated December 2005 specified that simulated engine

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42 CAR 5.19 related to the conduct of flight crew flight tests and CAR 5.20 to approval to give flight training.

43 Electronic safety incident reports formed part of the air traffic service provider's safety management system and enabled air traffic controllers to electronically submit reports about safety occurrences.

failures were to be conducted during or after a takeoff, prior to or during an instrument approach and during a missed approach from the instrument approach. Form 645 also stated that:

> Simulated engine failures should be introduced at random times in an effort to make the simulated emergency and associated actions more difficult to predict. The simulation need not involve the feathering of a propeller.

CAO 40.2.1 *Instrument Ratings* specified various requirements for pilot proficiency on multi-engine aircraft in asymmetric flight conditions during an instrument flight test. These requirements included:

- where the simulated failures were to be introduced during the various manoeuvres
- flight tolerances to be demonstrated by the instrument rating candidate in terms of aircraft heading, indicated airspeed and height during asymmetric flight.

As a result, the operator's pilots were checked on their proficiency in engine power loss situations once in a 12-month period during the multi-engine command instrument rating flight tests. There was no regulatory requirement for the operator's pilots to undergo any recurrent in-flight training relating to engine power loss situations and the flight management of these situations, nor was such training provided by the operator.

PA-31 endorsement training

During 2007 and 2008, the chief pilot of Airtex Aviation provided PA-31 endorsement training to a number of pilots, including the pilot of PGW.

The Airtex Aviation chief pilot reported that he had been provided by CASA with a CAR 5.21(1) delegation that approved him to give aircraft conversion training (that is, endorsement training). The chief pilot also indicated that he had held a Flight Instructor (Aeroplane) Rating Grade 3.

An instrument of delegation that was issued by CASA on 26 July 2007 limited the chief pilot to conducting conversion training on Fairchild Aerospace Metro III (Metro III) aircraft. The delegation did not permit the chief pilot to conduct conversion training on PA-31 aircraft, which at that time were operated by Airtex Aviation.

The holder of a Grade 3 instructor rating was authorised to give flying training under supervision of the chief flying instructor (CFI) or an approved Flight Instructor Grade 1 of a training organisation that was authorised to conduct flying school operations. The Airtex Aviation AOC did not contain that authorisation.

Following a fatal accident involving an Airtex Aviation Metro III aircraft in April 2008,[44] CASA conducted a risk-based special audit[45] of that operator in June that year. During that audit, CASA inspectors determined that they had 'significant

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[44] ATSB Transport Safety Report AO-2008-026, *Loss of control 19 km SE Sydney Airport NSW, 9 April 2008, VH-OZA, Fairchild Industries SA227 AC Metro III*. A copy of the report can be obtained from the ATSB website at http://www.atsb.gov.au/media/3422407/ao2008026.pdf

[45] CASA conducted special audits of an operator in response to information that indicated there was an increased level of risk associated with that operator.

safety concerns over the standard of training received by any pilots endorsed [by the Airtex chief pilot] on piston engined aircraft'. This included 26 pilots who underwent PA-31 endorsement training during 2007 and 2008. The pilot of PGW was one of the pilots identified in that group.

CASA inspectors contacted the identified 26 pilots and 11 of them advised that they had not done any simulated engine failure training during their endorsement training flights. Ten pilots stated that they had done one or two simulated engine failures, four pilots stated that they had done one simulated engine failure and one pilot was unsure how many he might have carried out. The inspectors noted that the pilots who responded that they had done one or two failures '... were not definite in their answer and appeared not to want to make waves'. The pilot of PGW reported to the inspectors that he did 'a couple' of simulated engine failures during endorsement training and that he considered the training he underwent to be 'quite a good endorsement'.

On 1 July 2008, CASA issued a request for corrective action (RCA)[46] in response to the inspectors' concerns about the standard of endorsement training. This RCA was accompanied by a Safety Alert[47] that required Airtex Aviation to take immediate action to ensure that the legislative breaches relating to the training were rectified '...before continuing any activity under your Air Operator's Certificate in piston engine aircraft using pilots endorsed by [name of the chief pilot]'.

On 2 July 2008, Airtex Aviation's General Manager provided CASA with a letter that contained an undertaking to retrain eight of its pilots who had undergone PA-31 endorsement training with the chief pilot. The letter further stated that 'All other candidates listed are either independent endorsements [that is, not employees of Avtex Aviation], whilst other candidates can be identified as having gone to the airlines'.

On 8 July 2008, the CEO of Airtex Aviation forwarded an additional letter to CASA in response to the Safety Alert. The CEO advised that the relevant pilots would be retrained by an independent ATO and that the other pilots would be provided with a 'retraining and recertification programme conducted by a third-party training provider'. A review of CASA surveillance files indicated that this action was accepted by CASA who also placed eight conditions on Airtex Aviation's AOC. These conditions included the prohibition of passenger-carrying charter or aerial work operations while the chief pilot remained in that position.

The pilot of PGW was not included in the list of pilots that was submitted by Airtex Aviation to CASA and indicated who were to be retrained, although he was flying for Airtex Aviation at that time. The pilot's logbook indicated that he had conducted 25 flights in Airtex Aviation's PA-31aircraft from 20 May to 2 July 2008, including the three flights ICUS. The logbook was also stamped and signed by a company pilot who was acting as the chief pilot's delegate. This action certified that the flying times that were recorded by the pilot to 24 June 2008 were

46 CASA issued requests for corrective action (RCA) when there was a failure to comply with the regulatory requirements. Affected operators were required to take corrective or preventive action to address deficiencies. Such operators were required to address any deficiencies and provide CASA with details of corrective and remedial actions by an agreed date.

47 A safety alert was a type of RCA that was issued to an operator in the case of a serious breach of the regulatory requirements. A safety alert required immediate action by the affected operator to rectify the breach.

correct. Furthermore, the logbook recorded that the pilot flew PA-31 aircraft for Airtex Aviation on six occasions from 3 July until 12 July 2008 when he recorded being checked by the chief pilot of Skymaster Air Services and commenced flying for that company. There was no record in the pilot's logbook of any subsequent PA-31 endorsement retraining.

The ATSB conducted a review of incidents from November 2006 to June 2010 that had been reported by the Airtex Group of companies. This review identified 27 incidents involving PA-31 or PA-31P aircraft that sustained in-flight engine problems and, in nine events, resulted in an engine being shut down.

The ATSB was able to interview three pilots involved in three separate incidents, all of whom had undergone their initial PA-31 endorsement training with the Airtex chief pilot. One incident involved an engine failure in the cruise and another a power loss during climb with the engine subsequently failing. Both pilots conducted an in-flight engine shutdown and landed without incident at the nearest suitable aerodrome.

The third incident involved an engine surging shortly after takeoff. The pilot, who was also an engineer, considered that the engine could operate safely at a reduced power setting and subsequently conducted a landing in that configuration.

Of these three pilots, only one had received the re-training required by CASA following the special audit of Airtex in June 2008.

The chief pilot of Skymaster Air Services at the time of the accident reported that he was not aware of the specific problems that the chief pilot of Airtex Aviation had encountered with CASA about PA-31 endorsement training. The Skymaster chief pilot also stated that he was unaware that the pilot of PGW had been identified as one of the pilots requiring retraining, of the undertaking given by the CEO about providing retraining, or that the pilot of PGW had not received this retraining.

Operational documentation

Information on the operation of the operator's PA-31P-350 aircraft was contained in two manuals. These manuals were, in order of precedence:

- the CASA-approved Flight Manual
- the operator's Operations Manual.

The accident aircraft's flight manual consisted of the *Piper PA-31P-350 Mojave Pilot's Operating Handbook and FAA Approved Airplane Flight Manual*[48], which included sections on operating limitations, emergency procedures, normal procedures, performance data and aircraft systems.

Part A of the *Skymaster Air Services Operations Manual* stated that 'company pilots are responsible to the chief pilot for ensuring that company aircraft operations are conducted in accordance with the provisions of the Act [*Civil Aviation Act 1988*], CAR, CAO, AIP, Aircraft Flight Manual and the COM [Company Operations Manual]'. Part B of the operations manual contained information and procedures relating to the operation of the operator's aircraft. The manual stated that 'actions to be taken by a pilot following an emergency or abnormal situation

[48] The US Federal Aviation Administration (FAA).

are contained in the applicable aircraft's Emergency checklists and the Aircraft Flight Manual'.

Procedures for engine malfunctions and one engine inoperative flight

The aircraft manufacturer specified the emergency procedures for the aircraft in the *Piper PA-31P-350 Mojave Pilot's Operating Handbook, Section 3 Emergency Procedures*. This included procedures for engine roughness, propeller/governor malfunctions and engine failures. The handbook did not contain a specific procedure for engine surging.

The manual described engine roughness as a condition where 'an engine falters or runs erratically' and advised that it may be caused by '... fuel flow interruption, fuel contamination, icing or air starvation or ignition problems'. A procedure was included for determining the cause of any engine roughness, including changing the selection of various engine controls to troubleshoot the rough running engine. If a decision was made to shut down the engine, the manual provided a procedure for configuring the various systems appropriately, including feathering the propeller and closing the cowl flap of the inoperative engine to reduce drag.

Safety management

As part of the operator's response to the safety alert that was issued by CASA on 1 July 2008, the CEO of Airtex Aviation applied to vary its AOC to include eight conditions. These conditions included the implementation of a safety management system and a confidential reporting system, and the engagement of an independent auditor to conduct quality and aviation safety systems audits on a 6-monthly schedule.

The Skymaster Air Services safety management program was documented in its *Safety Management System* manual, which was initially issued in November 2008 and amended in November 2009. The amended manual built on the initial issue and covered the Airtex Aviation group of companies. It included information about the responsibilities of the safety manager, the operation of the various safety committees and meetings, the hazard and incident reporting process, risk management, incident investigation and auditing. Skymaster Air Services line pilots were also advised about the safety program activities by email.

A safety manager was appointed in 2009 and carried out the safety program-related activities that mostly involved dealing with hazard and incident reports and conducting investigations and safety meetings. Six safety meetings were held on an irregular basis averaging about every 3 months during 2009 and 2010 with the Skymaster Air Services chief pilot attending each meeting. Other attendees varied between meetings and included the CEO for the three meetings preceding the accident.

Between the commencement of the safety program and the accident, 33 reports were submitted about various hazards and incidents within the group's activities. These reports were reviewed and actioned by the company. There was no evidence that this action included detailed investigations being carried out to identify any systemic factors or trends. Three of the reports related to PGW and separately reported an issue with the locking of the main cabin door, deterioration of the cabin floor carpet, and a pilot inadvertently entering controlled airspace without clearance from ATC.

The pilot of PGW submitted a report on 19 April 2010 expressing concerns about the conduct of his check flight with the chief pilot the previous week (see the *Pilot information* section earlier in this report). The pilot's concerns related to 'not knowing what is to be expected' during the flight and the conduct of the post-flight debrief. The chief pilot forwarded a response to the safety manager on 27 April 2010 refuting the pilot's concerns about the check flight.

In accordance with the condition on the Airtex Aviation AOC relating to independent auditing of the group's operations, an external auditor was engaged in August 2008, March 2009 and September 2009 to conduct an assessment of 'operator organisation and accountability'. Skymaster Air Services operations were not examined during those three assessments and there was no evidence that Skymaster management had implemented a formal internal audit program.

Maintenance processes

The maintenance work on the aircraft operated by Skymaster Air Services was performed by Airtex Aviation, which held a Certificate of Approval to conduct that maintenance. A review of PGW's maintenance documentation indicated that the aircraft was maintained in accordance with the aircraft's logbook statement.

Following the purchase of Skymaster Air Services in November 2006, the Airtex group of companies was the registered operator of 17 twin piston-engine aircraft that were maintained by Airtex Aviation's maintenance facility. During the period from November 2006 to June 2010, the twin piston-engine fleet had nine in-flight engine failures or shutdowns. Two of the engine failures involved PGW, in July 2007 and February 2008.

A number of deficiencies in Airtex Aviation's maintenance processes were identified and commented on by CASA during surveillance and regulatory action was taken against the company in 2006 (see the following discussion titled *Regulatory oversight*).

Regulatory oversight

CASA surveillance of Skymaster Air Services

CASA surveillance of Skymaster Air Services operational activities from late 2006, when the company became part of the Airtex Aviation group, until the accident on 15 June 2010 included a series of safety trend assessments, functional surveillance activities and a scheduled audit. This surveillance activity did not identify any significant issues relating to the operation of the company.

A scheduled audit in July 2009 found that:

> This audit snapshot indicated that the company is maintaining compliance. The chief pilot is aware the operations manual requires review and will be amending it where appropriate.

No RCAs were issued to the company as a result of this audit. CASA inspectors later stated that Skymaster Air Services was operating at an 'alright' standard and was comparable to other operators at Bankstown and other general aviation piston-engine aircraft operators. As a result, they considered the level of surveillance to be appropriate for the perceived level of risk. They also reported that the level of surveillance activity on an operator was dependent on both the operator's risk profile and the resources available in the CASA Bankstown office.

Following the accident involving PGW, CASA inspectors conducted a special audit of Skymaster Air Services in June 2010. The audit included an examination of flight operations, aircraft airworthiness and maintenance control, the drug and alcohol management plan, and safety management system.

The inspectors found that ICUS flights were often training flights rather than being flights to expose new pilots to flight operations under ICUS conditions. The audit found no evidence that the pilots supervising these ICUS flights had been given any instruction on how to conduct the flights.

The audit resulted in 19 RCAs and two audit observations (AOs) [49] being issued to the company. CASA considered that the legislative non-compliance identified in three of the RCAs was sufficiently serious for them to be classified as Safety Alerts.

The inspectors found that the company was not monitoring and recording compliance with aircraft manufacturer service bulletins. A Safety Alert, accompanied by a direction under CAR 38[50], directed the company's Head of Maintenance to identify all manufacturer's service bulletins applicable to aircraft operated by the company and to ensure these services bulletins were complied with and certified in each aircraft's maintenance records.

Three Skymaster Air Services pilots were found to have not undergone the PA-31 endorsement retraining required by CASA in July 2008. A Safety Alert was issued that required the operator to develop a plan of action to address this training deficiency, which had not been identified during previous CASA audits.

The third Safety Alert was issued in relation to a multi-engine command instrument rating flight test undertaken by a company pilot. CASA inspectors concluded from a review of the ATO's comments about the pilot's performance that the pilot had not met the proficiency standard for the renewal of the rating. The pilot's flight test was conducted on the same day (13 March 2010) as the flight test undertaken by the pilot of PGW and was conducted by the same ATO. The Safety Alert required that the pilot be suspended from flying duties involving IFR or multi-engine operations until he undertook another flight test with a different ATO.

The remaining 16 RCAs identified legislative non-compliance with regards to crew scheduling, operational support systems, operational standards and airworthiness control. The two AOs related to minor deficiencies in operational support systems and airworthiness control.

The special audit report contained five recommendations regarding the:

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49 CASA issued audit observations (AOs) to draw an operator's attention to latent conditions or minor deficiencies in the operator's systems or processes that could not be attributed to current regulatory requirements.

50 CAR 38 (1) enabled CASA to 'give directions relating to the maintenance of Australian aircraft for the purpose of ensuring the safety of air navigation'.

- provision of in-house or external training of company pilots to ensure operational standards were achieved and verified
- provision of appropriate support to address the issue of chief pilot workload
- improvement of the company fatigue risk management system
- training of pilots selected to conduct ICUS flights with new pilots
- examination of pilots to ensure that they had memorised emergency procedure recall items.

On 23 July 2010, CASA suspended Skymaster Air Services' AOC and on 20 August 2010 CASA cancelled the AOC. This action was taken under section 30DI of the *Civil Aviation Act 1988* on the grounds that CASA was satisfied that a serious and imminent risk to air safety existed if the AOC was not cancelled.

CASA surveillance of the Airtex Aviation maintenance facility

CASA surveillance of Airtex Aviation's maintenance activities included a series of safety trend assessments, functional surveillance activities, scheduled audits and special audits. A review of CASA's surveillance files found that following an in-flight engine failure in a company PA-31P-350 in May 2005, CASA inspectors expressed concerns about the adequacy of Airtex Aviation's maintenance infrastructure and staffing levels. In July 2005, CASA inspectors conducted a special audit, which found that 'the prime reason for all the deficiencies noted at Airtex is the lack of well documented procedures'. Six RCAs relating to deficiencies in procedures were issued and subsequently acquitted by the company.

CASA inspectors conducted another special audit of Airtex Aviation's maintenance activities in August 2006 and found that there had been 'substantial improvement' in the company's maintenance activities. One RCA was issued in relation to a documentation error and, soon after the audit, the company took corrective action and CASA acquitted the RCA.

In October 2006, CASA contacted Airtex Aviation's maintenance controller regarding concerns about key personnel changes in the company's engine overhaul shop. CASA sought details about the person responsible for performing, supervising and certifying the work performed in the engine shop. On the basis of those details, CASA recommended that Airtex Aviation should be issued a direction:

> ... to cease all engine overhauls, bulk strips and component overhauls until such time as the appointed persons responsible for these activities meet a satisfactory standard of training and experience in the works being performed.

On 22 November 2006, CASA issued a direction under CAR 38 directing that Airtex Aviation cease engine and electrical component overhauls as the company had not ensured that appointed persons were adequately trained in the work they were to perform. In December 2006, CASA lifted the CAR 38 direction in relation to the Airtex Aviation component shop and in April 2007 in relation to the engine overhaul shop following the approval of persons to control the overhaul activities.

During July 2007, there were engine problems in three of the company's aircraft, including PGW, which had an in-flight failure of the right engine. During the following 12 months, CASA inspectors conducted three functional surveillance activity audits of the company and issued five RCAs relating to deficiencies in the control of documentation, of equipment and components, and in respect of a lack of guidance to staff in the company quality manual.

In September 2008, CASA conducted a scheduled audit of the maintenance facility that concluded:

> The company is assessed as reasonably compliant, with a capability to continue to meet the standards of the regulatory requirements as prescribed by regulation 30 of the Civil Aviation Regulations 1988 to hold a certificate of approval.

Five RCAs were issued during the audit regarding issues with documentation, the calibration of testing equipment, and the packaging, storage and documentation relating to components. The RCAs were acquitted in October 2008.

During a functional surveillance activity audit in July 2009, CASA inspectors found that there '... was a lack of diligence by personnel in documenting and following procedures'. Three RCAs were issued relating to deficiencies in procedures and document control that were acquitted in October 2009. As a result of a risk-based audit in February 2010, CASA inspectors issued a number of RCAs including one relating to a company Metro III aircraft not having a current Certificate of Airworthiness during the period from January 2008 to January 2010.

While conducting the special audit of Skymaster Air Services after the accident involving PGW, CASA also carried out a special audit of Airtex Aviation's maintenance activities. The audit summary noted that:

> The findings of this audit were not exceptional and none are of immediate safety concern. A total of 5 Requests for Corrective Action (RCA's) and 8 Audit Observations (AO's) are being issued as a result of the audit.

The five RCAs identified legislative non-compliance with regards to data and documents, maintenance activities, and tooling and equipment. The two AOs related to minor deficiencies in the same areas as the RCAs. The audit report recommended that the company respond to the RCAs, review the AOs and consider whether action should be taken to address the deficiencies identified by the observations.

Additional information

Flight with one engine inoperative

Certification standard

The accident aircraft was manufactured in the United States (US) in 1984 and was certificated as a normal category aircraft[51] in accordance with US *Civil Air Regulations Part 3 – Airplane Airworthiness – Normal, Utility, Acrobatic, and Restricted Purpose Categories.* Additional certification requirements were contained in *Title 14 Code of Federal Regulations Aeronautics and Space Part*

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[51] Aircraft 'intended for non-acrobatic, non-scheduled passenger, and non-scheduled cargo operation.'

23 Airworthiness Standards: Normal, Utility Acrobatic, and Commuter Category Airplanes.

Under these design standards, the PA-31P-350 aircraft was required to achieve, with one-engine inoperative, '…a steady rate of climb…'. The one engine inoperative rate of climb was expressed in the US Civil Air Regulation as being '…at least 0.02 Vso^2 in feet per minute at an altitude of 5,000 feet with the critical engine inoperative...'.[52,53] To achieve this climb performance, the aircraft manufacturer specified in the *Piper PA-31P-350 Mojave Pilot's Operating Handbook* that aircraft should to be flown in the following configuration:

- 101 kts indicated airspeed (V_{YSE})
- operating engine power setting of 2,600 RPM and 42 in. of manifold pressure with full rich mixture
- cowl flap on the inoperative engine CLOSED and on the operating engine OPEN
- landing gear and wing flaps retracted
- aircraft banked 5º toward the operative engine.

When PGW was imported into Australia in 2006, CASA accepted the US certification as the basis for certification in Australia.

En route climb performance

CAO 20.7.4, *Aeroplane weight and performance limitations – aeroplanes not above 5 700 kg – private, aerial work (excluding agricultural) and charter operations*, placed additional requirements on multi-engine aeroplane charter and aerial work operations under the IFR. These aeroplanes had to be capable of climbing with the critical engine inoperative at a gradient of 1% at all heights up to 5,000 ft.

Application of the performance data in the *Piper PA-31P-350 Mojave Pilot's Operating Handbook* to PGW indicated that, given the conditions of the day, the aircraft was capable of achieving the specified en route climb gradient.

Factors affecting aircraft performance with one engine inoperative

Aerodynamic drag

An important consideration for multi-engine aircraft performance is to minimise aerodynamic drag in the event of an engine failure. Drag can be caused by a number of factors, including:

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[52] Vso was 'the stalling speed or minimum steady flight speed in the landing configuration.'

[53] The critical engine is that engine which, if it fails, will most adversely affect the performance or handling qualities of the aircraft. The PA-31P-350 was fitted with contra-rotating engines, which meant that the aircraft did not have a critical engine.

- flying the aircraft in a wings-level attitude, resulting in a sideslip and an estimated reduction in the one engine inoperative rate of climb of about 10 to 20 ft/min[54]
- opening the engine cowl flaps, resulting in an estimated reduction in the one engine inoperative rate of climb by about 25 to 50 ft/min[55]
- airframe ageing effects such as chipped paint, mis-fitting doors and hatches, and small dents. In combination, these ageing effects can result in an estimated reduction in the one engine inoperative rate of climb of about 100 to 150 ft/min.[56]

Airspeed

An aircraft with one engine inoperative should be flown at the manufacturer's nominated airspeed, usually V_{YSE}, to minimise drag. With an increase in airspeed, aerodynamic drag will also increase, requiring more power to maintain the higher airspeed at a given altitude. Therefore, during one engine inoperative flight, flying above V_{YSE} will result in a reduction in the aircraft's capability to maintain height or climb. This reduced climb performance can amount to 30 to 40 ft/min when operating 10 kts above V_{YSE}.[57]

Power available from the operating engine

In order for a twin piston-engine aircraft to maintain height with one engine inoperative, the power available from the operating engine/propeller needs to be able to overcome aerodynamic drag.

Weight

Aircraft weight affects the power required to maintain height. For a specific airspeed, more power is required to overcome the increased induced aerodynamic drag at a higher gross weight.

Aircraft performance for the accident flight

The *Piper PA-31P-350 Mojave Pilot's Operating Handbook* included a chart for determining the aircraft's rate of climb with one engine inoperative. Applying the

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54 Banking up to 5° toward the operating engine reduces drag by reducing the sideslip and the amount of rudder required to counteract yaw. (see Department of Transport (1979) *One down and one to go – the facts about engine failure in a light twin*, Aviation Safety Digest number 105, Melbourne Victoria and Evans, R. (1993) *Understanding Light Twin Engine Aeroplanes*, self published, Maitland, NSW).

55 Evans, R. (1993) *Understanding Light Twin Engine Aeroplanes*, self published, Maitland, NSW.

56 An estimate of 100 ft/min was made for a Piper PA-31-350 Chieftain with about 3,400 hours total time in service (see Department of Transport (1979) *Single-engine performance of a light twin?*, Aviation Safety Digest number 108, Melbourne Victoria) and up to 150 ft/min for typical light general aviation multi-engine aircraft (see Evans, R. (1993) *Understanding Light Twin Engine Aeroplanes*, self published, Maitland, NSW).

57 Department of Transport (1979) *One down and one to go – the facts about engine failure in a light twin*, Aviation Safety Digest Number 105, Melbourne Victoria.

ambient conditions on the day of the accident and PGW's estimated gross weight of 3,266 kg to this chart indicated that, with one engine inoperative, the aircraft was capable of climbing at about 270 ft/min at sea level, 250 ft/min at 1,000 ft and 170 ft/ min at 7,600 ft.

The handbook also included a *Single Engine Service Ceiling* chart for determining the maximum altitude at which the aircraft type would have been capable of maintaining height[58] with one engine inoperative. Using the ambient conditions on the day of the accident and PGW's estimated gross weight, the chart indicated that the aircraft had a single engine service ceiling of about 12,750 ft.

Guidance material for pilots regarding engine failure in the cruise

During the 1970s, the aircraft manufacturer provided information regarding flight with one engine inoperative during the cruise phase of flight in a training publication titled *Piper Multi-Engine Manual*[59]. This manual included the following information:

> Normally, an engine failure enroute is not as critical as one occurring during takeoff or climb. The pilot should have more than ample time to analyse the reason for the engine failure and correct the problem, if possible. Even if the situation is not critical, it is good practice to apply full power, or maximum continuous power to the good engine to conserve altitude while trying to correct the engine failure.

and stated that:

> During the descent, V_{YSE} airspeed should be used to obtain the minimum rate of descent and conserve altitude as long as possible. The airspeed should never be reduced below V_{YSE} in an attempt to hold altitude.

Similar information was identified by the ATSB in four other publications.[60]

In 2004, the FAA published updated guidance on flight with one engine inoperative during the cruise. The FAA publication, titled FAA-H-8083-3A *Airplane Flying Handbook* stated that:

> Engine failures well above the ground are handled differently than those occurring at lower speeds and altitudes. Cruise airspeed allows better airplane control, and altitude may permit time for a possible diagnosis and remedy of the failure. Maintaining airplane control, however, is still paramount. Airplanes have been lost at altitude due to apparent fixation on the engine problem to the detriment of flying the airplane. ....

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58 Maintaining height is defined as having a maximum rate of climb of less than 50 ft/min in smooth air.

59 Published 1974 and 1979.

60 Campbell, R. D. (1986), *Flying Training for the Private Pilot Licence: Multi Engine Rating*, Collins Professional and Technical Books, London, UK; *Cessna integrated flight training system, Multi-engine/clt* [centre-line thrust] *manual of flight*, Jeppesen & Co., Englewood, 1975; *Multi-Engine Pilot Manual*, Jeppesen Sanderson, Inc., Englewood, 1989; and Robson, D. (2000), *Multi-Engine Piston*, Aviation Theory Centre Pty Ltd, South Melbourne, Australia.

> ...Although it is a natural desire among pilots to save an ailing engine with a precautionary shutdown, the engine should be left running if there is any doubt as to needing it for further safe flight. Catastrophic failure accompanied by heavy vibration, smoke, blistering paint, or large trails of oil, on the other hand, indicate a critical situation. The affected engine should be feathered and the "securing failed engine" checklist completed. The pilot should divert to the nearest suitable airport and declare an emergency with ATC for priority handling.

Further information was provided in a 2008 FAA safety pamphlet titled FAA-P-9740-66 AFS-8 *Flying Light Twins Safely*, which stated:

> An in-flight engine failure generally allows more time for diagnosis of the problem with a view toward remedying the situation, if possible. A logical and orderly check of gauges, switches, and systems may rectify the problem without resorting to engine feathering. As with any single-engine operation, declare an emergency with Air Traffic Control.

In September 1996 CASA issued CAAP 5.23-1(0) *Syllabus of training – Initial issue of a multi-engine aeroplane type endorsement (rating)*. CAAPs were intended to '... provide guidance and information in a designated subject area, or show a method acceptable to an authorised person or CASA for complying with a related Civil Aviation Regulation'. CAAP 5.23-1(0) was amended in July 2007 and issued as CAAP 5.23-2(0) *Multi-engine Aeroplane Operations and Training*. The amended CAAP included information about:

> ...threats and errors associated with multi-engine operations and provide advice on multi-engine training. In addition this CAAP includes competency standards for multi-engine operations, suggested multi-engine and flight instructor training syllabi and a questionnaire to assist pilots to learn and assess their aircraft systems knowledge.

Appendix A of CAAP 5.23-2(0) contained a suggested standard to be demonstrated by a candidate during flight training in relation to engine failure during the cruise as follows:

> *Engine failure during cruise*
>
> - [The candidate] Determines asymmetric performance for the cruise phase of flight, analyses weather and terrain conditions, and formulates a plan that can be implemented following and [sic] engine failure during any stage of cruise flight to achieve the <u>safest outcome</u>.

Neither version of CAAP 5.23-2(0) included any more specific guidance on managing engine problems or failures during the cruise in multi-engine aircraft.

Regulatory requirements relating to the management of engine problems or failures during the en route phase of flight in multi-engine aircraft were contained in CAO 20.6, *Continuation of flight by multi-engine aircraft with 1 or more engines inoperative*. This included a listing of the factors to be considered by the pilot in command when selecting an aerodrome for landing following an engine failure or shutdown.

One engine inoperative training and testing

In order to develop and maintain proficiency in handling emergency situations, including partial or complete engine failures, pilots need to continually practice and review these situations. Engine failures are not usually simulated during the en route climb or cruise phases of flight, reducing pilots’ exposure to situations that may allow time to troubleshoot and possibly rectify the simulated problem. Furthermore, the aircraft is usually flown during the flight test at a weight significantly less than its maximum take-off weight.

For the operator’s pilots, the opportunity to practice in-flight engine failures was limited to command instrument rating flight tests. Due to the flight test requirements, engine failures were usually only simulated after takeoff, during an instrument approach and during a go-around with the pilot being aware that the simulation would occur during one of these phases, thereby reducing the element of surprise. Furthermore, these engine failures were usually simulated by ‘...slowly closing the throttle to idle or zero thrust [which] is unlikely to harm the engine and allows for immediate restoration of power’ as outlined in CAAP 5.23-2(0).

Human factors and one engine inoperative flight

Skill-based, rule-based and knowledge-based performance

Research has identified three levels of human information processing and performance that are descriptive of individual actions and reactions.[61] These levels of performance can be applied to pilots and how they react to, and manage normal and non-normal situations.

When an individual is very familiar with a task or action, and can perform the task automatically, that is, without conscious oversight, it is indicative of skill-based performance.

When an individual is less familiar with a task or situation, they are more likely to rely on rules or procedures to complete an action. In the case of pilots, most responses to non-normal situations rely on checklists and procedures, which is classified as rule-based performance. Rule-based performance occurs when the individual is not familiar enough with the task to conduct it automatically, but they are aware of which procedure or rule they need to follow to complete the task successfully.

Knowledge-based performance occurs when an individual is faced with a novel, unexpected and unfamiliar task or situation. This level of performance requires significant conscious oversight, cognition and planning by the individual and is typical of student pilots at the beginning of their training. Knowledge-based performance is slower than rule- and skill-based performance and uses significant attentional resources.

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[61] Rasmussen, J. (1983). Skills, Rules, and Knowledge; Signals, Signs, and Symbols, and Other Distinctions in Human Performance Models. *IEEE Transactions on Systems, Man & Cybernetics, SMC*; 13(3).

Situation awareness and decision making

The role of situation awareness (SA) in decision making is documented in human factors research (for example see Endsley, 1997) [62]. There are three levels of SA: perception of elements in the environment (level 1), comprehension of the current situation (level 2), and projection of future status (level 3). Research has shown that a novice decision maker may be capable of achieving the same level 1 SA (perception) as more experienced decision makers but may not be able to achieve level 2 (comprehension). SA becomes the 'driving factor' in decision making for novices, '...who may operate using very different decision strategies, understanding the situation frequently poses the major portion of their task' (Endsley, 1997, p. 269). The role of SA in 'poor' decision making is also clarified by Endsley, namely that a poor decision may not be the result of the decision maker's choice of action, rather of their SA. That is, novices are not accurately perceiving the situation, rather than reacting incorrectly.

The development of SA and the subsequent decision making process is reliant on attention and working memory, a limitation that is particularly applicable to novices or anyone facing novel situations. A function of complex, dynamic environments is that any form of information overload, task complexity and/or multiple tasks may easily exceed an individual's capacity and capability for SA. As such, they may accurately perceive only part of the situation, which can adversely affect any subsequent decision making.

Working memory will also influence an individual's ability for levels 2 and 3 SA, as comprehension and projection relies on information being perceived and combined with existing knowledge and experiences to determine a course of action. The difference between novices and experts in this regard is that experts have developed mental models or schemas, which guide their actions during most known or learned situations. This allows the experts to make decisions with incomplete information or in times of uncertainty. As such, they do not need to exactly match a situation to a mental model. Rather, the model gets modified over time as the individual gains experience.

Research has also shown that the context in which a problem occurs is an important part of determining how an individual will respond, in particular their ability to choose an effective strategy to solve the problem. Cues from the environment will lead individuals to choose a strategy, and if an appropriate mental model is not available, the individual may not solve the problem correctly. As noted by Endsley, 'In the absence of an appropriate model, people often fail in solving a problem correctly, even when it requires the same logical processes as others they can solve' (Endsley, 1997, p. 280).

An important part of the context of a problem is the presentation of the problem, which will often determine the strategy used by an individual based upon their comprehension of the situation. In this sense, the individual is using level 1 and 2 SA to direct their decision making. Therefore any limitation in either of these levels will affect the decision making and reaction of the individual.

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[62] Endsley, M.R. (1997). The Role of Situation Awareness in Naturalistic Decision Making. In C.E. Zsambok, & G. Klein (Eds.), *Naturalistic Decision Making* (pp.269-283). Lawrence Erlbaum Associates, Mahwah NJ.

In discussing emergency decision making, Martin *et al* (1997)[63] explored decision making frameworks and the effect of decision making in changing situations. It was noted that elements beyond just the task in focus can influence the choice of decision strategy, 'namely organisational norms and culture and individuals' expertise' (Martin *et al*, 1997, p. 285).

The authors also noted previous research showing that 'pilots use a variety of decision strategies depending on the specific problem conditions' (Martin *et al*, 1997, p. 281). They also noted that the decision making framework selected by the decision maker was 'determined to an extent by the situation and their response being dependent on the way [the decision maker] interprets these conditions – in terms of situation assessment and their implementation of response procedures' (Martin *et al*, 1997, p. 282).[64]

Martin *et al* also highlighted that during dynamic events, individuals may switch between strategies according to the demands of the situation. This was also observed with pilots, where 'a pilot's choice of decision strategy is fundamentally based on his/her estimation of risk and [the] available time' (Martin *et al*, 1997, p. 282). The authors also discussed how individuals use a certain decision style 'until their situation awareness indicates the situation has changed to a point which requires reassessment' and described how 'the individual's characteristics will play a part in this maintenance of situation awareness, with, for example, experience influencing the individual's ability to recognise the dynamics of the situation' (Martin *et al*, 1997, p. 285).

Stress and pilot performance

In general, attention appears to channel or tunnel when an individual is experiencing stress. This reduces the individual's focus on peripheral information and tasks and centralises focus on the individual's understanding of the main tasks. What determines a main task from a peripheral task appears to depend on whichever stimuli is perceived to be of greatest importance or the most salient.

When environmental cues are threat-related, the individual often considers such stimuli to be the most salient. This can result in a tunnelling of attention that can either enhance or reduce performance, depending on the nature of the task and the situation. For instance, when peripheral cues are irrelevant to task completion the ability to 'tune them out' is likely to improve performance. On the other hand, when these peripheral cues are related to the task and their incorporation would otherwise facilitate success on the task, performance deteriorates when they are unattended.[65]

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[63] Martin, L., Flin, R. & Skriver, J. (1997). Emergency decision making – A wider decision framework? In R. Flin, E. Salas, M. Strub, & L. Martin (Eds.), *Decision Making Under Stress* (pp.233-242). Ashgate, Aldershot, UK.

[64] While this referred to a study with Fire Commanders, the study is equally applicable to pilots as they also operate in a changing, dynamic environment, especially in an emergency situation.

[65] Staal, M. A. (2004), *Stress, Cognition, and Human Performance: A Literature Review and Conceptual Framework*, Report NASA/TM—2004–212824, National Aeronautics and Space Administration, Ames Research Center, Moffett Field, California.

ANALYSIS

Introduction

The accident occurred during a non-normal return to Bankstown Airport with one engine inoperative. Examination of the aircraft and associated systems did not identify any engineering defect or failure that contributed to the shutdown of the right engine in-flight. However, the engine surging identified by the spectral analysis of radio transmissions during the flight was consistent with uneven fuel distribution to the cylinders.

While the evidence was consistent with engine surging affecting the flight and the right engine being shut down in-flight, the published performance data indicates that the aircraft should have been able to maintain height on one engine to enable a return to Bankstown Airport. Examination of the left engine did not identify any engineering defect or failure that would have affected the engine’s capability to produce maximum continuous power.

The return to Bankstown was not flown in accordance with the available guidance material for flying with one engine inoperative, including the need to conserve altitude and to operate at the optimal airspeed for one-engine flight (V_{YSE}). As such, the aircraft continued to descend and the pilot subsequently attempted a forced landing into an unsuitable area, which led to a collision with a powerline support pole on the eastern side of the intersection of Sackville Street and Canley Vale Road, Canley Vale, about 6 km north-west of Bankstown Airport.

In-flight engine problem

Nature of the problem

At 0752:27, shortly after the aircraft ceased climbing and levelled out at 7,600 ft, the pilot contacted air traffic control (ATC) and, in the background of this transmission, a noise consistent with engine surging was recorded. Spectral analysis of the recording indicated that the propeller RPM of the affected engine was varying from about 2,350 RPM to greater than 2,600 RPM, which exceeded the specified maximum rotational speed of 2,600 RPM. This variation in RPM was consistent with recollections from witnesses in the area, who reported hearing engine surging noises from the aircraft during this time.

During further transmissions until 0753:45, the surging remained audible. Spectral analysis of the transmissions after this time indicated that there was only one signal recorded, suggesting that one engine was not operating. This was consistent with witness reports of the right propeller not rotating and with the subsequent examination of the right propeller, which indicated that the propeller was feathered at the time of impact.

Source of the problem

The examination of the aircraft’s engines and ancillary systems was hampered by the extent of the damage to the aircraft during the collision with terrain and the severe post-impact fire. Accordingly, the reason for the engine surging recorded during the pilot's transmissions could not be determined from the available physical evidence.

However, the engine manufacturer advised that the surging RPM that was audible in the background to the pilot's transmissions was 'consistent with uneven fuel distribution to the cylinders'. The propeller manufacturer advised that it had 'yet to find a causal factor in surging that was clearly identified as being from the propeller or governor, especially for a report of a large RPM excursion'. On that basis, the Australian Transport Safety Bureau (ATSB) concluded that it was likely that the surging was related to an uneven fuel distribution problem, rather than to a propeller/governor problem.

Pilot's initial response to the engine problem

The engine surging would have resulted in the aircraft yawing from side to side and an increased noise level in the cockpit. This would have presented the pilot with a confusing and distracting problem to identify and manage, and would have increased the difficulty of the pilot's initial response to the situation. This situation was novel and unexpected and it was likely that the pilot's response would have required the use of significant attentional resources and conscious oversight, consistent with knowledge-based performance. This probably resulted in the reduced level of information being provided by the pilot during his initial communication with ATC.

The spectral analysis showed that the pilot varied the power on the engine that had a stable propeller RPM and probably also varied power on the malfunctioning engine, although this could not be confirmed. This was consistent with an attempt to identify the nature of the problem. The as-found feathered right engine propeller and pilot report of having shut down an engine showed that the pilot intended to manage the engine surging problem by isolating that engine.

While the pilot could have reduced power on the engine and attempted to fly the aircraft with both engines operating, the ongoing surging in that case could have affected the handling of the aircraft during the return to Bankstown and may have posed a distraction during a critical phase of flight. As the engine malfunction was most likely related to an uneven fuel distribution problem, the pilot's actions in shutting down the right engine were consistent with an attempt to manage the handling/distraction risk.

Similarly, the pilot's decision to return to Bankstown Airport was appropriate given the relative distance from Bankstown and, while Richmond Airport was closer, the fog there probably precluded a landing. In addition, pilot decision making can be influenced by their estimation of risk and of the available time, and it is probable that the pilot considered the return to Bankstown to be a lower risk option. However, the commencement of a descent during the initial stages of the return resulted in the aircraft losing 2,600 ft in about 2 minutes. This action was in contrast to the guidance material available on flying with one engine inoperative, which emphasised the need to conserve altitude for as long as possible, and resulted in increased risk to the flight.

Flight management during the return to Bankstown

Effective flight management during one-engine inoperative flight relies on the pilot conserving altitude, maintaining the nominated airspeed for optimal performance on one engine (typically V_{YSE}), appropriately configuring the aircraft, and advising ATC about the non-normal situation.

The radar data showed that during the return to Bankstown, the pilot did not appear to attempt to verify the aircraft's one-engine inoperative performance prior to initiating a descent. Subsequently, the pilot accepted an ATC instruction to maintain 5,000 ft and then to descend to 2,500 ft. The pilot could have verified the aircraft's performance by levelling out soon after the engine shutdown and assessing the aircraft's capability for maintaining height with one engine inoperative. If the pilot had conducted this evaluation, he may have become aware earlier during the return of the need to change the aircraft's configuration and flightpath, and to plan for the possibility of landing at an alternative site, including a forced landing in a non-urban area. The apparent lack of a performance evaluation may have been due to the pilot's workload during the initial phase of the return to Bankstown. However, he also did not appear to assess the aircraft's performance during the remainder of the flight, which may have been due to the aircraft's performance being consistent with the intended descent profile.

The radar data showed a continuous descent from the time the pilot notified ATC of his intention to return until the collision with terrain. When queried by ATC as to his ability to maintain height, the pilot reported being on a 'slow descent'. This appeared to be consistent with the pilot conducting the return at a rate of descent that was similar to a 'normal' arrival into Bankstown and that he anticipated reaching the runway.

The aircraft's derived airspeed and rate of descent showed that the airspeed varied between about 120 kts and 160 kts as the aircraft descended from 7,600 ft to 1,600 ft, with the rate of descent varying between about 400 and 1,600 ft/min. The aircraft's airspeed only reduced to around V_{YSE} of 101 kts after the aircraft descended below 1,000 ft, with the effect that the rate of descent reduced to between about 100 ft/min and 400 ft/min.

The pilot's appraisal of the non-normal situation, including his possible expectation about the aircraft's one-engine inoperative performance capability, probably led him to accept the ATC instructions to descend to 5,000 ft and then 2,500 ft. His actions in flying a 'normal' descent were probably influenced by his mental model of the required flightpath for an arrival into Bankstown, but did not take account of the effect on performance of not maintaining V_{YSE}.

The spectral analysis showed that after the right engine was shut down, the propeller RPM of the operative left engine was set at 2,600 RPM until the aircraft descended to below 4,100 ft. The left propeller RPM was then reduced to about 2,400 RPM, which was consistent with the cruise climb power setting. This propeller RPM was maintained until the aircraft was below 200 ft. While the pilot may have increased the throttle in an attempt to maintain height, the spectral analysis did not detect a change in propeller RPM, and it was unlikely that the left engine was delivering maximum continuous power as the aircraft descended. The reduction in the left propeller RPM to about 2,100 RPM as the aircraft descended below 200 ft was consistent with the pilot reducing power for the approach to Canley Vale Road.

The noise of the landing gear unsafe aural warning from the time the engine was shut down may have affected the pilot's workload by creating an additional distraction, at least during the initial stage of the return flight. However, given the events during the later stages of the flight, and the pilot's focus of attention on these events, it is unlikely the warning would have influenced the pilot's reaction to the situation at that time.

Examination of the aircraft wreckage could not positively determine the position of the engine cowl flaps. However, the derived performance of the aircraft below 1,000 ft was consistent with the data collected during the ATSB's recording flight in a similar PA-31P-350 Mojave aircraft with both engine cowl flaps in the open position. Therefore, it is possible that the pilot did not appropriately configure the aircraft's cowl flaps for the situation. The published performance data indicated that the aircraft should have been able to at least maintain height if it was appropriately configured with the right engine cowl flap in the closed position and the left engine at the maximum continuous power setting, and was being flown at the V_{YSE} of 101 kts.

The probable incorrect configuration and power setting, combined with the speed and descent profile, contributed to the aircraft being too low and the pilot being unable to maintain height once he became aware that the aircraft's current performance was insufficient to reach the airport.

The pilot reported being visual 'on top' (above cloud) during the return to Bankstown and it is likely that he did not make visual contact with the ground until the area around Prospect Reservoir. It was from this point that the pilot's communications with ATC were reported by those that knew him to be indicative of him sounding stressed. His questions to ATC regarding his location and proximity to Bankstown indicate that his focus was probably on identifying and reaching the airport and, following his realisation that he 'did not have any height', his focus switched to selecting an alternative landing site.

The pilot indicated to ATC that he was looking for a road to land on once he realised he could not reach the airport. It is likely that under the stress of the situation, his attention narrowed and his focus on landing on a road may have hampered his ability to identify other suitable landing sites. It is also possible that due to the stress of the situation, he did not increase the power on the operative engine or check the configuration of the aircraft when he realised the aircraft was not maintaining height.[66]

Despite the pilot's frequent communication with ATC, he did not advise of the non-normal and then emergency situation with a PAN and/or MAYDAY call. Although ATC initiated an ALERT phase, the pilot was issued with a descent clearance that did not indicate to him that he could descend as required to achieve optimal one-engine inoperative performance. It is possible that during most of the return flight, the pilot believed he was going to reach Bankstown Airport and did not consider it necessary to either request approval to delay descent or to broadcast

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[66] An ATSB investigation into an accident involving a Brasilia aircraft found that the flight crew did not restore power during a simulated engine failure despite the imminent loss of control of the aircraft. ATSB Transport Safety Report AO-2010-019, *Loss of control – Embraer S.A. EMB-120ER Brasilia, VH-ANB, Darwin Airport, Northern Territory, 22 March 2010*. A copy of the report can be obtained from the ATSB website at http://www.atsb.gov.au/media/3546615/ao-2010-019.pdf

an urgency transmission. However, pilots should consider the benefits of using the correct phraseology specified in the Aeronautical Information Publication during non-normal and emergency situations to ensure that ATC is aware of their situation.

The pilot's PA-31 endorsement training

The lack of evidence that the pilot of PGW and other affected pilots underwent retraining in support of their initial endorsements on the PA-31 aircraft type that was stipulated by the Civil Aviation Safety Authority (CASA) in 2008 suggested that this training did not take place. However, following the initial endorsement, the pilot had logged over 1,500 hours in PA-31-350 and PA-31P-350 aircraft until the time of the accident. He had also passed two multi-engine command instrument rating renewals and successfully completed a PA-42-1000 aircraft endorsement. In light of this subsequent experience and testing, and the further endorsement training on a high performance turboprop multi-engine aircraft, the ATSB concluded that it was unlikely that any deficiencies in the pilot's PA-31 endorsement training contributed to the accident.

Civil Aviation Advisory Publication (CAAP) 5.23-2(0) *Syllabus of training – Initial issue of a multi-engine aeroplane type endorsement (rating)* included a suggested standard to be demonstrated by a candidate during flight training in relation to engine failure during the cruise. However, there was no specific guidance in the CAAP on managing engine problems or failures during the climb and cruise phases of flight. While there was no evidence to indicate that this deficiency contributed to the accident, the availability of this information to pilots of multi-engine aircraft, flight instructors and approved testing officers would provide for an ongoing ready reference. Ease of reference would increase the likelihood of wider access by pilots and enhance safety in the case of engine problems or failures during the climb and cruise phases of flight.

Regulatory oversight

The regulatory oversight of Skymaster Air Services after it became part of the Airtex Aviation group of companies until the time of the accident did not find any significant issues with the operation. In addition, given that CASA inspectors rated the standard of Skymaster's operations as similar to other comparable operators, the level of surveillance was considered by CASA inspectors to be appropriate for the perceived risk that Skymaster posed and the resources available at the oversighting CASA Bankstown office.

However, during oversight of Airtex Aviation, CASA found issues relating to Airtex's maintenance organisation and pilot endorsement training. In November 2006, CASA issued a direction under Civil Aviation Regulation 38 directing Airtex to cease all engine overhauls after a series of engine failures to engines that were overhauled by the facility and fitted to aircraft flown by the operator. This direction was subsequently withdrawn in April 2007, and in an audit conducted in August 2008, CASA inspectors found that the standard of work at the maintenance facility had improved and was satisfactory. The ATSB found no evidence that the maintenance activities of Airtex Aviation contributed to the accident.

The non-detection by CASA until after the accident that the pilot and a number of other pilots were not retrained in the PA-31 aircraft type was probably due to the two companies having separate Air Operator’s Certificates, with different CASA inspectors being assigned to the surveillance of each company. As previously determined, it was unlikely that any deficiencies in the pilot’s PA-31 endorsement training contributed to the accident.

FINDINGS

From the evidence available, the following findings are made with respect to the collision with terrain involving Piper Aircraft Corporation PA-31P-350 Mojave aircraft, registered VH-PGW, at Canley Vale, New South Wales on 15 June 2010. The findings should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing safety factors

- While the aircraft was climbing to 9,000 ft the right engine sustained a power problem and the pilot subsequently shut down that engine.
- Following the shutdown of the right engine, the aircraft's descent profile was not optimised for one engine inoperative flight.
- The pilot conducted a descent towards Bankstown Airport that was consistent with a normal arrival profile without first verifying that the aircraft was capable of achieving adequate performance with one engine inoperative.
- Following the engine problem, the aircraft's flightpath and the pilot's communication with air traffic control indicated that the pilot's situation awareness was less than optimal.
- The aircraft collided with a powerline support pole on the eastern side of the intersection of Sackville Street and Canley Vale Road, Canley Vale, about 6 km north-west of Bankstown Airport.

Other safety factors

- The pilot did not broadcast a PAN following the engine shutdown and did not provide air traffic control with further information about the nature of the problem in order for the controller to positively establish the severity of the situation.
- Section 4 of Civil Aviation Advisory Publication (CAAP) 5.23-2(0), *Multi-engine Aeroplane Operations and Training* of July 2007 did not contain sufficient guidance material to support the flight standard in Appendix A subsection 1.2 of the CAAP relating to Engine Failure in the Cruise. *[Minor safety issue]*

Other key finding

- Given the pilot's extensive experience and testing in the PA-31 aircraft type, and subsequent endorsement training on a high performance turboprop multi-engine aircraft since the issue by CASA in 2008 of a safety alert in respect of the pilot's PA-31 endorsement, it was unlikely that any deficiencies in that endorsement training contributed to the accident.

SAFETY ACTION

The safety issue identified during this investigation is listed in the Findings and Safety Actions sections of this report. The Australian Transport Safety Bureau (ATSB) expects that all safety issues identified by the investigation should be addressed by the relevant organisation(s). In addressing those issues, the ATSB prefers to encourage relevant organisation(s) to proactively initiate safety action, rather than to issue formal safety recommendations or safety advisory notices.

All of the responsible organisations for the safety issues identified during this investigation were given a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

Civil Aviation Safety Authority

Pilot guidance material

Minor safety issue

Section 4 of Civil Aviation Advisory Publication (CAAP) 5.23-2(0), *Multi-engine Aeroplane Operations and Training* of July 2007, did not contain sufficient guidance material to support the flight standard in Appendix A subsection 1.2 of the CAAP relating to Engine Failure in the Cruise.

Action taken by the Civil Aviation Safety Authority

The Civil Aviation Safety Authority (CASA) has advised the ATSB that it has started a project to amend advisory material relating to multi-engine aircraft training and operations to include guidance information about engine problems encountered during the climb and cruise phases of flight. This amended guidance material will include information about aircraft handling, engine management, and decision making during these phases of flight.

CASA audit and surveillance

No organisational or systemic issue was identified in respect of CASA's surveillance that might adversely affect the future safety of aviation operations. However, during the investigation CASA advised that, in September 2010, it had commenced a Certificate Management Team approach to its audit and surveillance activities. This change was intended to improve the evaluation capability across CASA, allow the more effective assignment of resources, increase knowledge sharing, clarify defined roles and responsibilities, and foster standardisation and consistency.

The implementation program was completed in August 2012.

APPENDIX A: SOURCES AND SUBMISSIONS

Sources of information

The sources of information during the investigation included:

- the aircraft operator
- the operator's chief pilot and flight crew
- a number of the operator's former flight crew
- the aircraft manufacturer
- the engine manufacturer
- the NSW Police Force and Coroner
- the Bureau of Meteorology (BoM)
- the Civil Aviation Safety Authority (CASA)
- Airservices Australia (Airservices).

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 CASA, Airservices, the aircraft operator, the chief pilot, the approved testing officer (ATO), a number of the pilot's flying instructors, the National Transportation Safety Board, the aircraft and engine manufacturers and the BoM.

Submissions were received from CASA, the operator, the chief pilot, Airservices, the ATO and the flying instructors. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

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Investigation

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Aviation Occurrence Investigation
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AO-2010-043
Final