Australian Government
Australian Transport Safety Bureau

Engine power loss and departure from controlled flight involving Piper Seneca, VH-LCK

Near Broome Airport, Western Australia | 11 July 2012

Investigation

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Addendum

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Safety summary

What happened

Aircraft wreckage

Source: ATSB

On 11 July 2012, the pilot of a Piper Seneca I, registered VH-LCK, was conducting a freight-carrying flight between Broome and Port Hedland, Western Australia. The flight was conducted at night under the instrument flight rules. Witnesses who heard or saw the aircraft take-off reported hearing unusual noises from the engines during the climb. Other witnesses closer to the accident site reported hearing the engine sound suddenly cut out before the aircraft banked left and descended steeply towards the ground. The aircraft wreckage was located amongst sand dunes, about 880 m beyond the upwind runway threshold. The aircraft was destroyed and the pilot sustained fatal injuries.

What the ATSB found

The take-off towards the ocean was conducted in dark night conditions with limited external visual cues. An on-board global positioning system (GPS) recorded a reducing ground speed as the aircraft approached and passed overhead the upwind runway threshold, but without a significant increase in climb performance. That reduction in ground speed occurred about the same time witnesses heard unusual noises from the aircraft's engines.

In the absence of any identified environmental, airframe or structural factors, the witness reports and GPS data were consistent with the aircraft's performance being affected by a reduction in engine power. Following the likely loss of engine power, the aircraft speed reduced significantly, resulting in uncontrolled flight, a steep descent and collision with terrain.

Although not identified as a factor contributing to this occurrence, post-accident examination of the aircraft's fuel selector valves found the internal seals had deteriorated and allowed fuel to flow to the engines when the valves were in the OFF position. A review of the aircraft manufacturer's maintenance instructions revealed this type of internal leakage may not be evident during routine maintenance, although a non-scheduled valve leak procedure was available.

What's been done as a result

The aircraft manufacturer has been advised that their maintenance instructions may not identify deteriorated fuel selector internal seals during routine maintenance. Airworthiness bulletin AWB 28-105, published by the Civil Aviation Safety Authority, recommended that owners and operators of Piper Seneca, and other aircraft fitted with similar fuel selector valves, regularly check their function.

Safety message

This accident highlights the need for pilots to closely monitor their aircraft's airspeed and initial climb performance during take-off. The need for prompt identification of any performance degradation and optimisation of the aircraft's available climb performance is emphasised. The accident also highlights the elevated risk associated with dark night conditions, which increase pilot workload, particularly in the case of abnormal aircraft operations.

The investigation also identified the potential for inadvertent operation of the engine magneto switches due to their close proximity to the landing and taxi lights and auxiliary fuel pumps, potentially increasing risk if these switches are operated at a critical stage of flight.

Contents

The occurrence

On the evening of 11 July 2012, a Piper Aircraft Corporation Seneca I (PA-34-200), registered VH-LCK (LCK), was scheduled for a freight-carrying charter flight between Broome and Port Hedland, Western Australia. These flights were conducted Monday to Thursday nights and carried items of general freight outbound, before returning to Broome with the inbound freight.

Preparation for the flight

The aircraft was refuelled during the late afternoon with 80 L of aviation gasoline, distributed equally between the left and right fuel tanks. The pilot arrived at the airport about 1 hour prior to departure and completed activities that included flight planning, loading of the aircraft and the pre-flight inspection.

The aircraft's take-off weight at Broome was about 1,590 kg, which was below the maximum take-off weight of 1,909 kg; the centre of gravity was within the approved limits. The manifest indicated the freight weighed about 17 kg and did not include any dangerous goods. Operational documentation completed by the pilot indicated a total of 295 L of fuel was on board at engine start, sufficient for the planned flight to Port Hedland. The flight was to be conducted under the instrument flight rules (IFR).[1]

The aerodrome forecasts for Port Hedland and Broome indicated the possibility of reduced visibility in fog later in the evening. However, light winds, clear skies and fine weather conditions existed for the aircraft's departure from Broome. Last light in Broome was 1753 Western Standard Time[2] and the moon had set earlier during the day and would not rise again until after midnight.

In addition to the aircraft's navigation instruments, the pilot was also using a portable Global Positioning System (GPS) receiver which logged the position of the aircraft during the flight. The track log recovered from the GPS receiver commenced at the aerodrome's general aviation run-up bay at about 2002. The pilot reported to the Brisbane Centre air traffic controller at 2004 as he taxied towards runway 28 for departure. The controller advised the pilot to expect his clearance to operate in controlled airspace on departure from Broome.

Take-off

The pilot made routine broadcasts on the Broome common traffic advisory frequency[3] as he entered/backtracked along the runway and again lining up for departure. Although the GPS track log recorded the aircraft starting to backtrack along the runway, there was then a period of 56 seconds where there was no update to the aircraft's position. Consequently, the final stages of the runway backtrack, line-up and initial take-off were not discretely recorded by the GPS.

A company employee, who was familiar with the aircraft and was about 900 m south-east of the runway 28 threshold, heard the engines during the initial take-off roll and thought they sounded normal. Another nearby witness, about 1,200 m from the start of the take-off roll and 600 m south of the runway, heard the aircraft engines and thought that the 'plane did not sound mechanically right', that 'one or both of the engines were rough' and there was an 'intermittent sound from the engine, which was popping and not sounding smooth'. The witness advised that he lost sight of the aircraft behind trees and did not see the aircraft airborne.

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1 Instrument flight rules (IFR) permit an aircraft to operate in instrument meteorological conditions (IMC), which have much lower weather minimums than visual flight rules. Procedures and training are significantly more complex as a pilot must demonstrate competency in IMC conditions, while controlling the aircraft solely by reference to instruments. IFR-capable aircraft have greater equipment and maintenance requirements.

2 Western Standard Time was Coordinated Universal Time (UTC) + 8 hours.

3 The common traffic advisory frequency is the frequency on which pilots operating at a non-towered aerodrome should make positional radio broadcasts. This can include periods when control towers are not manned and the associated controlled airspace is not active.

Climb out

The next recorded position in the track log was at 2007:22, with the aircraft at a GPS-indicated altitude[4] of 83 m (272 ft), approximately 1,700 m from the start of the take-off roll. A witness close to this position had his attention drawn to the departing aircraft and commented that the engines 'did not sound good', not a normal engine sound but more like a 'popping' noise, before the noise faded as the aircraft flew further away.

At the time of take-off the surface wind was calm. The aircraft's GPS ground speed was represented as a derived average speed calculated between successive track log positions. Approaching the upwind runway threshold the ground speed was about 99 kt and the aircraft was continuing to climb, passing through 107 m (351 ft). The GPS point-to-point track data showed a slight divergence left of the runway centre-line and then a more noticeable divergence of about 13° to the right as the aircraft passed overhead the upwind threshold. Beyond the upwind threshold, although the aircraft's altitude had increased to 128 m (420 ft), the ground speed reduced to 89 kt and the ground track continued to diverge right of the extended runway centre-line.

The aircraft approached overhead a house upwind of the runway threshold with a ground speed of 80 kt and at an altitude of 147 m (482 ft). Several witnesses at the house saw the aircraft approach overhead, with one witness describing the engine(s) sounding as if they were 'chugging'. Another witness thought that the aircraft didn't sound right and the engine was spluttering and a third witness thought the engine(s) were not sounding right, making a rattling noise and sounding rough.

The aircraft reached an altitude of 161 m (528 ft) and a ground speed of 73 kt, then climbed slightly to 163 m (535 ft) and decelerated to 59 kt. The witnesses heard the engine(s) cut out then saw the left wing dip, the aircraft bank left and the nose of the aircraft drop steeply towards the ground, followed soon after by the sound of an impact. Those recounts of the aircraft's flight path were consistent with other witnesses who saw the final stages of the flight.

About 23 seconds elapsed between the aircraft passing overhead the upwind runway threshold and the commencement of the descent and about another 7 seconds before the collision with terrain. The GPS track log also recorded the aircraft descending steeply towards the ground. A short, 0.2 second radio transmission was recorded on the air traffic services area frequency at 2008:04. Although analysis of the audio spectrum of this transmission was consistent with speech, no discrete tones could be detected and it was not possible to identify the transmission source.

The track log information recovered from the GPS receiver relevant to the accident flight is depicted at Figure 1 and Appendix A. This data is represented as a series of individual GPS track points, joined together using a series of straight lines.

[4] GPS altitude is referenced to a simplified mathematical representation of the earth, known as an ellipsoid. Ellipsoid heights differ from heights referenced to mean sea level and, in this case, were about 16 m (52 ft) higher. For simplicity and comparability, the altitudes quoted in this section are ellipsoid.

Figure 1: GPS track log for the flight

Source: Google Earth with aircraft GPS track data overlaid by ATSB

Air traffic control initiated search and rescue alerting action when the controller did not receive the pilot's departure report. Local witnesses also notified emergency services in the belief that the aircraft had crashed. Searchers found the aircraft wreckage at about 2330, in sand dunes about 880 m beyond the upwind end of runway 28 and close to the extended runway centre-line (Figure 2).

The pilot sustained fatal injuries and the aircraft was destroyed by impact forces. There was no fire.

Figure 2: Aircraft wreckage

Source: ATSB

Context

Pilot information

The pilot held a Commercial Pilot (Aeroplane) Licence that was issued in September 2010 and a multi-engine command instrument rating. He had been employed by the operator since March 2011, initially flying single-engine aircraft, before progressing to multi-engine operations in early 2012 with endorsements on the Piper Seneca, Britten-Norman Islander and the Piper Chieftain. Operator records indicated the pilot's total flight time was 922 hours, with 423 hours logged on multi-engine aircraft and 99.5 hours flown on the Seneca. Those records also showed that the pilot had accrued about 213 hours of night flying, mostly in multi-engine aircraft.

The pilot was endorsed on the Piper Seneca in February 2012. His logbook indicated the endorsement flight was 0.3 hours day, 1.0 hours night and included a total of 1.0 hours instrument flight time. The endorsement flight was conducted in LCK and the pilot attained a satisfactory standard during the simulated engine failure after take-off, engine failure at altitude and asymmetric circuit.

The operator's chief pilot renewed the pilot's multi-engine command instrument rating on 27 February 2012. This test was conducted in LCK and included satisfactory completion by the pilot of simulated engine failures after take-off, during the instrument and missed approach procedures, including by reference to the aircraft's flight instruments. The chief pilot recalled that the simulation of the engine failure was accomplished by hiding the throttles from the pilot's view using a piece of paper and then closing the throttle of the selected engine.

A base check and a line check, each including a night sector, were conducted on 13 April 2012 and were completed at a satisfactory to good standard. The base check was completed in a Piper Chieftain and included a simulated engine failure after take-off, which was completed at a good standard, and a simulated engine failure on go-around, which was completed at a satisfactory standard. The pilot's logbook did not record any instrument flight time during those flights.

The operator also maintained a synthetic multi-engine flight trainer for pilots to retain instrument flying proficiency and to also practice their emergency procedure drills. A review of the pilot's flight records indicated he logged 0.6 hours on 29 June 2012, completing an instrument landing system (ILS) approach and steep turns. Prior to that, the pilot had last logged 0.3 hours in the synthetic trainer on 18 May 2012, also completing an ILS approach.

The pilot had regularly operated the night freight flight from Broome to Port Hedland and return since February 2012. His last nine rostered duties involved the night freight operation, all flown in LCK.

The pilot held a Class 1 Aviation Medical Certificate that was issued by the Civil Aviation Safety Authority (CASA) with nil restrictions. He was described by work colleagues and family as being health conscious and very fit. Family members recalled he was well rested prior to the flight and was experiencing the effects of a minor head cold. The operator's chief pilot reported to the ATSB that the pilot had not advised him that he had a cold or was otherwise unfit to conduct the flight.

Aircraft information

The aircraft was manufactured in the United States in 1973. It was exported to Australia and placed on the civil aircraft register in 1989. It was powered by two Lycoming counter-rotating, horizontally-opposed, four cylinder, fuel-injected engines. Each engine was rated at 200 horsepower.

Aircraft maintenance

General

The aircraft operator held a CASA-issued approval to carry out aircraft maintenance. The airframe was maintained in accordance with the maintenance requirements of CASA Schedule 5 and the engines in accordance with the requirements of the Piper PA34 Maintenance Manual.

The last scheduled maintenance was completed on the aircraft on 26 June 2012 and a maintenance release was issued for operations in the charter category under the IFR, valid until 26 June 2013 or 7,281.8 hours in service. The last daily flight entry on the maintenance release was on 10 July 2012 with 7,214.3 hours in service.

Recent maintenance

The pilot had reported to the operator that departing Broome the previous night, the landing gear did not retract on the first two attempts, but operated normally on the third attempt. The landing gear was reported to have operated normally on departure from Port Hedland for the return flight.

Maintenance documentation showed that earlier during the day of the accident, the operator's maintenance personnel moved the aircraft into the hangar, placed it on jacks and inspected and lubricated the landing gear system. Functional checks of the landing gear, including its retraction and extension were performed and with no defects evident, and the aircraft was returned to service. This maintenance did not require operation of the engines and there was no manipulation of any fuel-related systems.

Aircraft equipment and systems

Propellers

The engines were fitted with Hartzell two-bladed, constant speed, controllable pitch and fully-feathering propellers. The engines were counter-rotating, which balanced propeller thrust during take-off and climb and eliminated consideration of the 'critical engine'[5] during single-engine flight. Pilots used the propeller control lever to select the engine RPM and the propeller governor would automatically adjust the pressure of the engine oil supplied through the propeller shaft, controlling the propeller blade angle within the governing control range to maintain the selected engine speed.

To increase engine RPM, governed oil pressure increased and moved the blades of each propeller to a finer pitch setting. To reduce engine RPM, the governed oil pressure reduced and the blade counterweights and nitrogen pressure stored in the propeller dome coarsened the propeller pitch.

In event of an engine failure, the pilot could reduce drag by feathering[6] the propeller by moving the propeller control lever fully aft through the low RPM detent and into the feathering position. That action removed governed oil pressure from the propeller hub and the stored nitrogen pressure and counterweights moved the blades towards the feathered position. This took about 6 seconds. Operation of the propeller feathering system was checked by pilots as part of the pre-flight engine run-up checklist.

To prevent the propeller blades feathering during normal post-flight engine shutdown, each propeller was fitted with a feathering lock. As the engine slows down, this lock engages at about 800 RPM. With the feathering locks engaged, it is not possible to feather the propeller.

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5 The critical engine is the engine which, if it fails, will most adversely affect the performance or handling qualities of the aircraft, particularly at high power settings at low airspeeds/high angles of attack. For conventional multi-engine aircraft with clockwise rotating propellers, this is the left engine.

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

Flight controls

The aircraft was equipped with conventional cable-operated flight controls. The ailerons were lightly interconnected by springs with the rudder. When a pilot applied a roll input to the cockpit control column, the control interconnection also applied corresponding rudder input to help eliminate adverse yaw and reduce the amount of coordinating rudder required in normal turns.

Landing gear

The aircraft was equipped with hydraulically-operated retractable landing gear. Hydraulic pressure for operation of the landing gear actuators was provided by an electrically-powered hydraulic pump, controlled by a two-position gear selector switch in the cockpit. The pilot's operating manual indicated retraction or extension of the landing gear normally took 6 to 7 seconds. In the extended position, downlock hooks engaged on each gear leg assembly and springs maintained each hook in the locked position. Once selected up, hydraulic pressure disengaged the downlock hooks and the gear retracted. Hydraulic pressure then maintained the landing gear in the retracted position.

Fuel system

Each wing was equipped with two interconnected fuel tanks, filled from a single opening in the outboard tank of each wing. The total fuel capacity was 371 L, of which 352 L was useable.

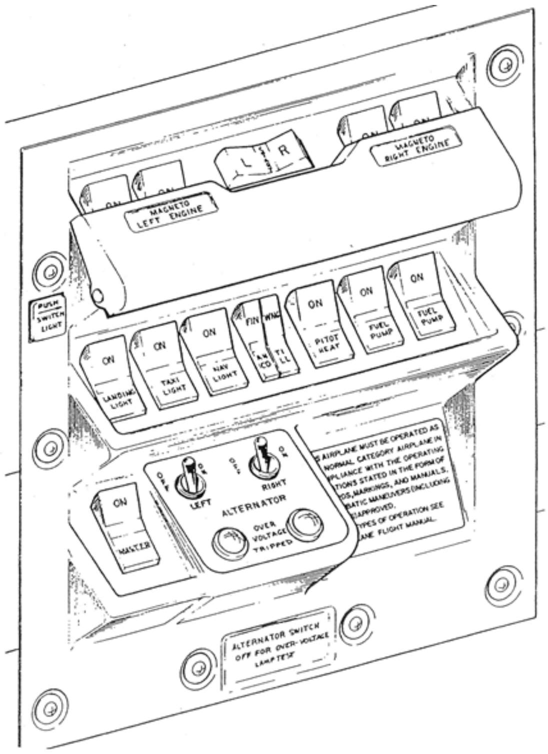
In normal operation, each engine operated with an independent fuel system, drawing fuel from the tanks in the same wing. In the event of single-engine operations, the pilot could manually select the opposite side tanks to extend range and laterally balance the fuel. The fuel selectors for each engine were located in a console between the pilot and copilot seats, with selector positions of ON, OFF and CROSSFEED to operate the fuel selector valve in each wing. The operator's normal checklist for the Seneca required the pilot to check the fuel selectors were ON during the pre-flight cockpit and before take-off checks.

An engine-driven fuel pump provided fuel to each engine. In addition, an electric fuel pump was mounted behind the firewall of each engine, providing fuel pressure for starting and in the event of a failure of the respective engine-driven pump. The electric pumps were used during take-off and landing, but normally selected to the OFF position as part of the climb checklist.

Electrical

Power for the aircraft electrical system was provided by an alternator mounted on each engine and a 12 volt battery. Most of the switches for the aircraft's electrical system were fitted to a panel on the left cockpit sidewall (Figures 3 and 4). This included the electrical master switch and switches for the engine magnetos, electric fuel pumps, starter motors, alternators, external aircraft lighting and pitot heat.

Figure 3: Electrical switch panel



Source: Piper Aircraft Corporation

Each engine was equipped with two magnetos, providing a duplicated ignition source to the cylinders of each engine and independently of the aircraft's electrical system. The switches for each engine's left and right magnetos were located on the top row of the switch panel. A hinged, spring-loaded cover closed over the front half of the magneto switches, guarding against inadvertent operation of the magnetos during flight. The top-row centre switch operated each engine's starter motor.

A pilot who had regularly flown the aircraft recalled that when closed, the guard cover for the magneto switches would remain in the closed position, but sometimes needed assistance to close the last 1‑2 cm. Another pilot who had also regularly flown the aircraft recalled the self-closing cover was effective at covering the magneto switches and needed to be held open when checking the magnetos during the engine run-ups, although it did not close with the same 'snap' as when new.

Inspection or examination for the correct operation and self-closing of the guard cover was not specifically included in the either the aircraft manufacturer's maintenance requirements or the CASA maintenance schedule.

Switches for the aircraft's external lighting, pitot heat and electric fuel pumps were on the second row of the switch panel.

The landing and taxi lights were mounted on the nose landing gear and were operated by the switches immediately below the magneto switches for the left engine. A microswitch was fitted to the lighting circuit for the nose landing gear, to switch off the lights when the landing gear was retracted. Irrespective of the microswitch, the operator's pilots would normally switch off the lights at some point after retracting the landing gear.[7]

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[7] That was to prevent the continued operation of the lights after retraction of the nose landing gear if the microswitch did not operate normally.

The switches for the electric fuel pumps were immediately below the magneto switches for the right engine.

Aircraft flight instruments

The aircraft was equipped with the relevant flight instruments for operations under the instrument flight rules.

The directional and attitude indicators operated using suction-powered gyroscopes, with suction provided by a vacuum pump on each engine. A vacuum gauge on the instrument panel provided a visual indication of the available suction for gyroscope operation. The aircraft was also fitted with an electrically-powered turn coordinator, which indicated the rate and direction of turn. The turn coordinator also incorporated a balance ball to provide information about the lateral balance of forces during flight.

White post lights and red overhead floodlighting provided instrument illumination for night operations.

Stall warning

The aircraft was equipped with a stall warning light and horn, operated by lift detectors installed on the leading edge of the left wing. The warning system was designed to operate not less than 5 kt before reaching the stalling airspeed. The actual stalling speed varied with aircraft configuration, weight, flap setting, engine power and bank angle.

Data contained in the Airplane Flight Manual (AFM) indicated that the landing gear down, wings-level, power-off stalling speed at 1,590 kg with flaps retracted was about 60 kt.

The AFM indicated that the 'loss of altitude during a power off stall with gear and flaps retracted may be as much as 450 feet … the loss of altitude during a power on stall with gear and flaps retracted may be as much as 550 feet'.

Noise attenuating headsets

The pilot was reported to have used a headset equipped with active noise reduction. This headset design electronically processes and helps reduce cockpit noise, particularly in the low audible frequency ranges. These frequency ranges are consistent with the typical frequency range of propeller, engine exhaust and airflow noises.

Meteorological information

The minute-by-minute data from the Broome Airport automatic weather station recorded calm wind conditions at the time of the aircraft's departure, a temperature of 18.3 °C and a relative humidity of 87 per cent. Witnesses reported that the sky was clear of cloud and that was consistent with recorded observations.

A post-accident analysis of the prevailing conditions by the Bureau of Meteorology indicated that winds in the lower levels (below 2,000 ft) were generally light, from a south-west to north-west direction.

Recorded information

The aircraft's GPS track log also retained records of other recent flights by the pilot between Broome and Port Hedland, two of which involved take-offs from runway 28 at Broome. On those departures and accounting for the recorded wind at Broome Airport at those times, as the aircraft approached the upwind threshold, the airspeed was generally about 100 kt and the altitude about 400 ft.

Wreckage and impact information

The accident site was approximately 880 m upwind from the end of the runway and about 55 m south of the extended runway centre-line. Although badly disrupted during the accident, the wreckage was substantially intact and in the immediate vicinity of the impact point.

Damage was consistent with the aircraft descending steeply into terrain in an upright, steep nose-down attitude, at low forward speed and with a high rate of descent. The force of the impact dislodged both engines at the firewall and the tail section was folded up and over the fuselage. The nose section was severely disrupted and the cockpit floor had been compressed upwards and rearwards.

All flight control surfaces were identified and their respective control continuity confirmed. The wing flaps and the landing gear were in the retracted position at the time of impact and there was no evidence of in-flight structural failure. Impact damage to all doors and hatches was consistent with them being securely closed. Both left and right propeller blades had the visual appearance of being in a fine pitch range at impact, were not feathered and exhibited low rotation signatures, consistent with low or nil engine power at impact.

No reliable information could be derived from the post-impact position of the engines' cockpit controls. Each of those controls was connected its respective engine via cables. The compression of the cockpit floor, disruption of the engine control pedestal and dislodgement of the engine at each firewall, all had potential to alter the position of the engine control levers during the impact sequence.

There was no evidence of leakage from the fuel tanks prior to impact with terrain and the caps of both fuel tanks were secure. All of the aircraft's fuel tanks ruptured on impact. It was not possible to obtain a fuel sample from either the ruptured tanks or other components from the aircraft's damaged fuel system. Droplet and rivulet impressions in the sand in a localised area forward of the wreckage were indicative of fuel spillage during rupture of the tanks.

The fuel selector levers were found in the most rearward crossfeed position, corresponding with the as-found position of the fuel selector valves in the wings. However, the selector levers could have been forced rearward by the severe nose/lower fuselage compression and distortion of the cockpit floor during the accident. Consequently, the position of the selector levers and valves was not a reliable indicator of their position immediately prior to impact.

Examination of the electrical switch panel on the left of the cockpit found the panel substantially intact, but dislodged from the sidewall of the cockpit (Figure 4).

The switches for the left engine's magnetos were in the OFF position. The right engine's magnetos switches were in the ON position. Photographs taken during the initial on-site response showed fine sand surrounding the magneto switches, consistent with them being in that position immediately after the accident. Those photographs also showed the guard cover for the magneto switches was intact, but had broken away from the switch panel at the forward hinge and was loosely attached at the rear hinge. Although this damage was consistent with the impact forces, the disruption of the guard cover meant that it was not possible to assess its pre-impact serviceability. All of the engines' magneto switches would normally be selected ON during flight.

The switches for the landing/taxi lights, navigation lights, anti-collision beacon and electric fuel pumps were all in the ON position and the switches for the wing strobes and pitot heat were in the OFF position. The master switch and the toggle switches for the left and right alternators were also in the ON position. Although potentially affected during the impact sequence, all of these switch positions were consistent with a night take-off.

Impact damage precluded functional testing of the aircraft's stall warning system.

Figure 4: Electrical switch panel

Source: ATSB

The aircraft's engines and propellers were recovered from the accident site for further examination, together with various aircraft instruments, fuel system components and the GPS receiver.

Medical and pathological information

A post-mortem examination and toxicological testing was conducted on the pilot by the relevant state authorities. Those examinations did not identify any pre-existing medical condition or factors with the potential to have incapacitated the pilot.

The toxicological testing revealed therapeutic levels of compounds and metabolites consistent with the pilot having recently used common over-the-counter medication, probably for the treatment of the pilot's reported minor head cold. However, the effect of those compounds on the pilot's performance was unable to be determined.

Any illness that affects the vestibular system, including the common cold, is likely to increase the risk of disorientation during flight. However the extent to which the pilot's vestibular system was affected by a cold, and the extent that his performance may have been affected by such a condition, could not be reliably determined.

Refuelling

A mobile tanker was used to refuel the aircraft prior to flight. Records indicated that the tanker refuelled 30 other aircraft that day, 27 before refuelling LCK and three after. There were no issues identified in relation to the quality of the fuel delivered to the other aircraft from the mobile tanker.

Routine post-accident testing of a fuel sample from the mobile tanker confirmed the sample complied with the relevant specifications for aviation gasoline.

Component examination and testing

GPS receiver

The GPS receiver was examined by ATSB technical specialists. Although some of the memory chips had dislodged, track log data was retained in the receiver's non-volatile memory and was able to be successfully downloaded. That data, as discussed in other sections of this report, included recent flights made by the pilot, including the accident flight.

Engines

The engines were disassembled and examined at a CASA-approved engine overhaul facility under ATSB supervision. Both had accumulated 1,117.7 hours since overhaul. Pre-impact mechanical continuity was established for both engines, from the crankshaft though to each engine's accessory drive.

Disassembly of both engines found evidence of some metal chipping (spalling) to some of the cast iron flat tappets (cam followers) and hard facing material had spalled from the corresponding camshaft lobe contact surfaces. During engine operation, contact is maintained between the camshaft lobe and the cam followers and the tappet transmits movement to the pushrod. In/out movement of the pushrod articulates the rocker arm about the rocker shaft such that the inlet and exhaust valves open or close in the cylinder head according to the particular stroke of the four-stroke engine.

Tappets are subject to high contact stresses and repetitive stress cycles. Identified modes of abnormal wear to these components include spalling as the consequence of inadequate lubrication and spalling as a consequence of corrosion of the ferrous tappet material. There was the potential for the wear identified on the camshaft lobes to affect engine efficiency, altering the valve opening, dwell and closing times. However, the spalling damage was assessed as being part of a long-term pattern of abnormal wear and did not preclude operation of either engine.

The magnetos and ignition harnesses were tested and found to be free of pre-impact damage and capable of normal operation. The lower spark plugs for both engines were destroyed by impact forces. The upper spark plugs for each engine were examined for electrode wear and gap and found to be within normal limits.

In summary, there was no evidence of mechanical abnormality or pre-existing conditions that could have significantly affected the operation of the engines.

Propellers

Examination of the propellers was conducted by technical specialists under ATSB supervision. The examination found that at the time of impact both propellers were latched, indicating the blade angles were between the 13.5° full-fine position and the 20.5° maximum latch angle. This was consistent with the engines being at low or nil engine power at impact.

Each propeller governor was tested before being disassembled/inspected and found to be capable of normal operation.

Fuel system components

Fuel system components that were tested included the left and right engine fuel injection servos, fuel manifolds, fuel lines and injectors. There were no anomalies identified in any of the engine fuel system components tested with the potential to affect either engine's ability to produce power.

Fuel selector valves

The X-ray examination of the left and right fuel selector valves showed that the position of each internal shuttle valve was consistent with the corresponding cockpit selector lever, being in the crossfeed position. However, as noted in *Wreckage and impact information*, the cockpit selector levers and shuttle valve positions were not considered a reliable indicator of their position immediately prior to impact. The X-ray examination did not identify defects affecting the operation or function of either valve. Functional testing of both selector valves was conducted under the supervision of the ATSB. The valves were leak tested in accordance with procedures detailed in the aircraft manufacturer's service manual. That testing identified that both fuel selector valves did not effectively seal and allowed the compressed air used to test the valves to bypass through the shuttle valve assembly when the selector was positioned to the OFF position.

In a simulation of the Seneca fuel-delivery system, with the selector valve under test positioned to the OFF position, both valves were confirmed to bypass fuel at a high rate to the corresponding engine's fuel outlet port. That is, both selector valves allowed fuel to flow via crossfeed lines when selected to the OFF position.

Disassembly of the valves identified deterioration of the O rings on the internal assembly of each shuttle valve. With each valve partially disassembled, both shuttle valves were able to move freely. A close examination of the O rings found that they had aged, and were either worn and cracked, or had slightly shrunk (Figure 5).

New O rings were fitted to each shuttle valve and the selectors retested. In this configuration, neither valve bypassed fuel in the OFF position.

Figure 5: O ring deterioration

Source: ATSB

Previous revisions of the manufacturer's service manual provided maintenance instructions for the overhaul of the fuel selector valve, including replacement of the O rings. However, a revision dated 30 October 2003 stated that 'maintenance is limited to removal and replacement of the whole unit'. Furthermore, the 2003 revision stated that:

> …The fuel selector valve need not be removed unless any of the following conditions exist:
>
> 1. Failure of selector lever to seat in detent.
> 2. Signs of leakage.
> 3. Difficultly in moving fuel selector lever.

Although the aircraft manufacturer's service manual did not identify the circumstances requiring application of the leak test procedure, it could reasonably be expected to be used to check the selector valve assembly for external leakage and in other circumstances, where maintenance personnel suspected the shuttle valve was allowing the internal bypass of fuel contrary to the valve's selected position. A review of the aircraft manufacturer's maintenance instructions revealed it was possible this type of internal leakage may not be evident during routine maintenance.

Maintenance records indicated that both fuel selector valves were refitted with new seals in accordance with the manufacturer's service manual during overhaul on 3 November 2003.

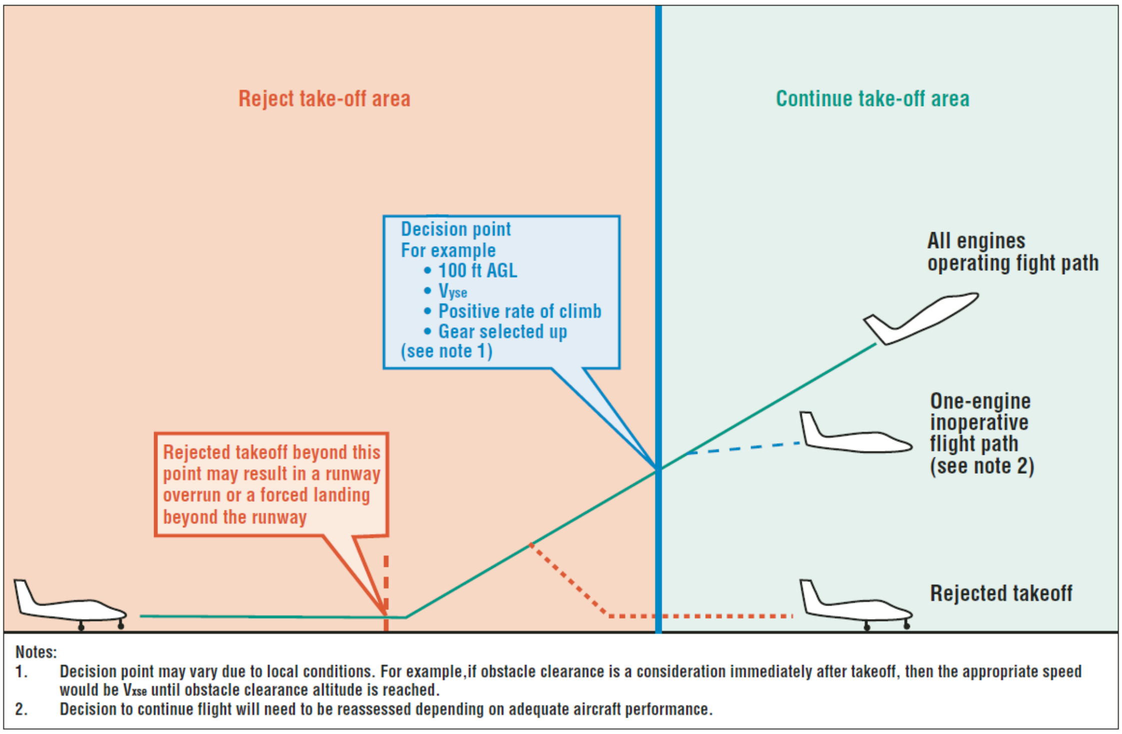
Operational procedures

Take-off procedure

The operator's procedures required the pilot to complete a before take-off safety briefing. This included the relevant speeds for the take-off and the actions to take in event of an engine failure during the take-off roll or during the initial climb.

The operator's standard procedure during take-off was consistent with the information contained in the aircraft manufacturer's aircraft flight manual. That procedure required the pilot to rotate[8] at an airspeed not less than 70 kt and establish the aircraft in the initial climb before retracting the landing gear when a safe landing could no longer be made on the remaining runway. The action of retracting the landing gear was used as a decision point to continue the take-off in event of a subsequent emergency (Figure 6). In the event of an emergency before this decision point, the operator's procedure was to discontinue the take-off and land on the remaining runway.

Figure 6: Typical considerations for take-off performance, multi-engine aircraft below 5,700 kg MTOW



At Broome, where the runway is about 2,400 m long, the decision point to continue/discontinue the take-off in the Seneca was typically reached about halfway along the runway. At this point, the aircraft would be accelerating towards the initial climb speed of 110 kt. After reaching this speed and being safely clear of obstacles or terrain, the operator's procedures called for engine power to be reduced to the climb setting and completion of the climb checklist.

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8 Positive, nose-up, rotation of the aircraft about the lateral (pitch) axis immediately before becoming airborne.

As stated previously, the operator's pilots would normally switch off the landing and taxi lights at some point after retracting the landing gear. The switching off of landing and taxi lights was not included as an item in the in the operator's written climb checklist. The chief pilot recalled that although there was no standard point at which the landing and taxi lights would be switched off, he expected that would occur some point after the landing gear had been retracted, the required airspeed for climb had been achieved and climb power had been set. However, the investigation was unable to establish the pilot's normal practice for operating the landing and taxi lights after take-off.

Soon after take-off from runway 28 and during the initial climb towards the ocean, the pilot would have lost sight of the runway lights. Due to the dark night conditions and limited external visual cues, the pilot would be expected to control the aircraft by reference to the flight instruments. The primary flight instrument, the attitude indicator, provided information that could be used by the pilot to maintain a wings-level, pitch attitude for the initial climb. In addition to the attitude indicator, the pilot would need to scan the other instruments, including the airspeed indicator, directional indicator, vertical speed indicator, altimeter and turn coordinator to monitor the aircraft's flight path and climb performance.

A review of two previous GPS-recorded departures made by the pilot from runway 28 at Broome, indicated he typically maintained runway heading until reaching a GPS-indicated altitude of between 750-850 ft, at which point he initiated a left turn onto crosswind to intercept the outbound track to Port Hedland.

Engine-out procedures

Immediately following an engine failure soon after take-off, there will be a change in engine noise and the aircraft nose will yaw in the direction of the inoperative engine. The largest effects will occur at high power settings and low airspeeds. This is due to the loss of thrust from the inoperative engine and the additional drag from the windmilling propeller. In addition to the yaw, the aircraft will also roll in the direction of the inoperative engine, mainly as a result of the secondary effect of the yaw and the loss of propeller slipstream over the inboard section of the wing.

To reduce the yaw, a pilot is required to make a correcting rudder input. That also reduces the rolling tendency and coordinated inputs of rudder, aileron and elevator can be used to maintain control of the aircraft. In visual conditions the yawing of the aircraft nose is detectable using external visual cues. Without external visual reference, that yaw is initially evident by a change in aircraft heading as displayed on the directional indicator and a roll towards the inoperative engine as indicated on the attitude indicator. The correlation between the change in aircraft heading and the roll towards the inoperative engine can be verified using the turn coordinator, with the balance ball displaced towards the operating engine. Reducing yaw helps maintain the required heading and provides the necessary rudder input to assist with correct identification of the inoperative engine. Importantly, to make the necessary rudder input, a pilot needs to associate the change in aircraft heading and roll towards the inoperative engine as a symptom of an engine failure.

If only aileron is used to control the roll, the aircraft can develop a large sideslip angle[9] and a relatively high bank angle will be required to maintain the intended heading. In this configuration, the increased drag and shielding of the wing on the same side as the failed engine, and large aileron deflection increase the risk of a loss of control.

If only rudder is used to control the yaw, the balance ball can be centralised and the aircraft flown wings-level. However, this configuration reduces single-engine performance for critical situations such as an engine failure after take-off.

To maximise the available aircraft performance a pilot needs to complete the relevant drills to maximise the available aircraft performance, verify the inoperative engine and feather the

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9 Displacement between the aircraft's longitudinal axis and the relative airflow.

propeller. The verification process used to confirm the inoperative engine, includes closing that engine's throttle to ensure the correct engine had been identified.

Single-engine climb performance

Optimal single-engine performance is typically achieved with 3-5° bank towards the operating engine and about half-displacement of the balance ball in the same direction. This configuration results in zero-sideslip flight that maximises aircraft control, minimises drag and achieves the maximum available single-engine performance.

To optimise the available climb performance, the aircraft must be flown at the airspeed for the best single-engine rate of climb (V_{yse}). The aircraft manufacturer stipulated 91 kt as the best single-engine rate of climb speed.

Single-engine climb performance data was established during the manufacturer's initial flight certification testing of the aircraft type. The testing was based on the aircraft being optimally configured for single-engine climb, with full power set on the operating engine, landing gear and flaps retracted, 5° of bank into the operating engine, the inoperative engine's cowl flaps closed and the propeller feathered. Allowing for a typical aircraft that is operating under normal effects of engine and airframe aging, the actual single-engine climb performance could reasonably be expected to be less than the manufacturer's indicated data.

In the case of the take-off from Broome, the single-engine climb performance data indicated that, for the ambient conditions at take-off and an aircraft weight of 1,590 kg, the aircraft's single-engine climb performance would have been about 370 ft/min.

Air minimum control speed

The air minimum control speed (V_{mca}) was also determined by the aircraft manufacturer during certification testing and was the minimum speed at which directional control of the aircraft could be maintained in an engine-out situation. Under the conditions used for certification, the demonstrated air minimum control speed was 69 kt. On any particular flight, the minimum actual control speed could vary due to a number of factors, including the power being produced by the operating engine, aircraft configuration, loading, atmospheric conditions and pilot technique.

The AFM indicated that if the aircraft's stall and minimum control speeds coincide, loss of directional control occurs at the same time the aircraft stalls and a spin could result. The AFM also noted that (practicing) stalls with one engine inoperative was not recommended.

Workload

Workload refers to the interaction between a specific individual and the demands associated with the tasks that they are performing. It varies as a function of the number and complexity of task demands and the capacity of the individual to meet those demands. For the same situation, different individuals will experience different levels of workload depending on their experience, skills and techniques, as well as factors such as fatigue.

High workload can result in an individual's performance on some tasks degrading, tasks being performed with simpler or less comprehensive strategies, or tasks being shed completely. In some cases tasks can be shed efficiently by not performing lower priority tasks or they can be shed inefficiently by abandoning tasks that should be performed (Wickens and Hollands 2000).

A range of factors can influence an individual's visual scanning performance. These include the salience of the items being searched for, the expectancy of finding relevant items, the value of identifying the items, and the amount of effort involved (Wickens and McCarley 2008). Workload and time pressure lead to a reduction in the number of information sources an individual will access, and the frequency or amount of time these sources are checked (Staal 2008).

Previous occurrences

A search of the ATSB database found two occurrences relating to PA-34 aircraft in which the magnetos for one engine were inadvertently selected off when the pilots were attempting to turn off the landing lights. In addition, there was a report in CASA's Flight Safety magazine[10] detailing another occurrence in which a pilot in a PA-34 selected what he thought were the landing lights off, and inadvertently turned off the magnetos for the left engine.

A search of the National Transportation Safety Board (NTSB) accident database identified two similar occurrences in the United States[11,12]. On 4 December 1997 a US-registered Piper Seneca was destroyed and the pilot seriously injured during a collision with the ground following an engine failure shortly after take-off on a dark night. The NTSB concluded that the probable cause of the engine failure was that, shortly after retracting the landing gear, the pilot inadvertently switched off the left engine's magnetos. Post-accident examination found that the left engine magnetos were in the OFF position and the landing light switches ON. The magneto switch guard cover's self-erecting springs were broken, allowing the guard cover to shield the landing light switches instead of the magneto switches.

Similarly, on 20 March 1984, another US-registered Piper Seneca collided with terrain soon after take-off on a dark night. That pilot reported that he felt the loss of engine power about the same time he turned off the landing lights. He believed that the manifold pressure gauge indicated the engine was still producing power and did not feather the propeller. An examination of the cockpit found the magneto switches for the left engine in the OFF position and the landing light switches in the ON position.

A review of the National Aeronautics and Space Administration's Aviation Safety Reporting System (ASRS) found an occurrence involving a PA-34[13] in which one magneto for the right engine was inadvertently switched off while the pilot in command was distracted.

10 Issue 90, January-February 2013
11 National Transportation Safety Board identification: CHI98LA054 available from www.ntsb.gov
12 National Transportation Safety Board identification: ATL84FA126 available from www.ntsb.gov
13 ASRS ACN: 569459 available from www.asrs.arc.nasa.gov

Safety analysis

Introduction

The aircraft's performance during the initial part of the take-off was similar to other recent departures by the pilot from that runway. The aircraft was still climbing as it passed overhead the upwind runway threshold, but the ground track was diverging right of the runway centre-line and the ground speed had started to reduce. Although the aircraft continued to climb over the next 23 seconds, ground speed continued to reduce before the aircraft abruptly descended steeply towards terrain.

The aircraft's abrupt final descent and collision with terrain at relatively low forward speed was not consistent with controlled flight. This analysis examines the factors associated with the flight leading up to, and ultimately resulting in, the departure from controlled flight.

Loss of control

The point-to-point speed recorded by the aircraft's global positioning system (GPS) receiver immediately before the aircraft started to descend was 59 kt, which in the calm wind conditions was close to the 60 kt aerodynamic stall speed derived from data published by the aircraft manufacturer.[14] An aerodynamic stall occurs when the wing exceeds the critical angle of attack, disrupting the smooth airflow over the aerofoil, rapidly reducing lift and resulting in a descent.

The abrupt departure from controlled flight could be consistent with an aerodynamic stall progressing to the incipient stages of a spin, with the consequent reduction in airspeed below the minimum control speed in an engine-out situation, or a combination of both. In any event, considering the abrupt nature of the loss of control, combined with the steep descent path towards the ground, it was unlikely the aircraft could be recovered to controlled flight in the height available.

A number of witnesses close to the site of the accident reported hearing the noise from the engines cut-out before the aircraft started to descend. The damage sustained by the blades of both propellers during the initial impact sequence was consistent with the engines operating at low or nil power. A reduction in engine noise at about the time the aircraft departed controlled flight could be consistent with both engines being inoperative, an attempt by the pilot to confirm an inoperative engine as part of his pre-feathering trouble-shooting procedure or a pilot-initiated reduction in engine power in response to a loss of directional control. The change in noise from the engines perceived by the witnesses could also have been a consequence of the sudden change in the direction of the aircraft and in its flight path turning the engine exhaust(s) away from the witnesses during the descent.

The severity of the departure from controlled flight would be increased by any asymmetry of thrust.

Aircraft performance upwind of the runway

Reduction in ground speed on climb out

The aircraft's GPS-recorded point-to-point speed had started to reduce as the aircraft approached and passed overhead the upwind runway threshold. Upwind of the runway, the point-to-point speed continued to reduce and the aircraft continued to climb.

The light wind conditions prevailing at Broome during the aircraft's departure made it unlikely the reduction in speed on climb out could be attributed to increasing headwinds as the aircraft

[14] Wing flaps up, landing gear down, wings level and no power.

climbed.[15] Similarly, there was no issue or failure identified with the airframe that could account for an abnormal increase in drag to result in such a significant reduction of speed. Although such a reduction in speed could also indicate the conduct of a steeper-than-normal climb by the pilot, the climb performance achieved was not consistent with a steepening climb gradient. In those circumstances, the only plausible explanation for the speed reduction was a significant reduction in engine power, without a corresponding adjustment in pitch attitude being made by the pilot.

Divergence to the right of the extended runway centre-line

There was no identified environmental factor nor any structural issue identified with the airframe that could account for the aircraft's divergence to the right of the extended runway centre-line as it tracked upwind. Whilst it was possible the divergence was the result of the heading selection for initial climb, the pilot's tracking of the extended runway centre-line was significantly less accurate than his other flights for which there was recorded data available.

Another potential influence on the upwind ground track was an asymmetry of thrust between the left and right engines and the associated control inputs made by the pilot. This could have resulted either from the left engine producing substantially more thrust than the right and the pilot flying wings-level using left rudder to centre the balance ball, or the right engine producing substantially more thrust than the left engine and the pilot banking towards the right engine with a smaller than required right rudder input. Both could result in the aircraft sideslipping and diverging right of the extended runway centre-line.

It was plausible that the aircraft's divergence from the extended runway centre-line and the reducing speed upwind were produced by the same initiating event.

Engine power reduction

There was sufficient fuel on board the aircraft for the flight and no indication that the quality of the fuel loaded that afternoon was a factor in the reduction in engine power. Similarly, the pilot had arrived at the airport with sufficient time to make normal preparations for his departure and there was no reason to believe he would not have conducted the requisite checks and pre-flight drains of the aircraft's fuel system.

Post-accident examination of the engines found no physical evidence of mechanical abnormality or pre-existing conditions to explain the witness reports of unusual and/or abnormal engine noises or that could have significantly affected the operation of the engines. However, the significant level of impact damage to the aircraft's systems meant that a component malfunction or failure, whether intermittent or complete, could not be categorically ruled out. Whilst the spalling of the tappets and the associated abnormal wear of the camshaft lobes had potential to affect the efficiency of both engines, that does not explain the significant and sudden reduction of power experienced by the pilot.

In the absence of a fuel-related anomaly, it was unlikely that both engines would malfunction at the same time. Although at test, both fuel selector valves allowed significant fuel to bypass to the opposite engine via the crossfeed lines when selected OFF, the ATSB did not identify a plausible circumstance where the pilot may have inadvertently attempted a take-off with the selector valves in that position. The fuel selectors were normally left in the ON position, they were reported to not have been moved during the aircraft maintenance activities that day, and the position of the fuel selectors were required to be checked ON as part of the pilot's pre-flight and before take-off checklists.

Although the take-off roll and initial climb were not recorded by the GPS, the first airborne data point was recorded as the aircraft approached the upwind runway threshold, indicating an initial climb profile that was comparable to the pilot's previous flights. Similarly, the GPS-recorded

[15] If at constant airspeed, an increasing headwind would result in a decrease in the aircraft's ground speed.

point-to-point speed between the first airborne position and the next data point was consistent with the aircraft exceeding the best single-engine rate of climb speed. Together, these data points would suggest a normal take-off to that point, which was consistent with the company employee's recollection that the aircraft sounded normal during the initial take-off roll, and also with the pilot continuing the take-off at the decision point, about half-way along the runway.

The pilot's training and recent check flights would have reinforced the aircraft's significantly reduced single-engine climb performance and therefore, the importance of the decision point and the go/no go decision. It was considered unlikely the pilot would have attempted to continue the take-off if he was concerned about the aircraft's take-off performance, or been aware of any engine malfunction or other anomaly prior to reaching the decision point. Although one witnesses along the aircraft's take-off path recounted that the 'plane did not sound mechanically right', that 'one or both of the engines were rough' and commented on the 'intermittent sound from the engine, which was popping and not sounding smooth', his location about 1,200 m along and 600 m south of the runway, together with the recollections from another witness nearby and the recorded GPS data, made it probable the aircraft was already airborne when those noises were heard.

The GPS-recorded data indicated the speed of the aircraft had started to reduce as the aircraft approached the upwind end of the runway. That is, the loss of engine power most likely occurred after the aircraft passed the decision point but before the aircraft reached the upwind runway threshold. This would explain the other witness reports of abnormal engine sounds.

Pilot response to probable reduction of power

The pilot's self-briefed, before take-off safety briefing should have covered the various elements for managing an engine failure after take-off, including the relevant speeds and pre-planned actions. That briefing should have helped the pilot with his recognition and response to an identified engine failure.

At the decision point, and if satisfied that the aircraft was performing normally, the pilot would have decided to continue the take-off and retracted the landing gear. With the runway lights disappearing from view, he likely would have referred to the aircraft's flight instruments for the initial climb. In the dark night conditions there would be a resulting lack of external visual reference. The pilot's workload would have increased with the loss of engine power, due to an asymmetry of thrust. The aircraft would have yawed and rolled, requiring various control inputs by the pilot to adjust and correct for this. As the pilot had limited time to respond to the power loss, the situation would have become increasingly critical as the aircraft's speed continued to reduce.

As pilots expect certain types of abnormal events to occur during training or check flights, they are generally well prepared to notice and respond to them. However, performance will generally be slower when the abnormal event is not expected. A recent study examined 18 air transport pilots' responses to expected and unexpected events during routine simulator training flights (Casner and others 2013). When an engine failure on take-off occurred, the majority of pilots responded correctly however two pilots made the incorrect decision to abort the take-off after the critical speed. Comments from these pilots indicated they had become momentarily confused due to the surprise or startle effect of the event and that this affected their performance.

While the pilot of VH-LCK (LCK) had already completed actions related to the latter stages of take-off (retracting the landing gear), it is probable that the unexpected nature of the power reduction adversely affected his reaction to this loss of power. Additionally, the possible confusion and likely increased stress of the situation would have further exacerbated the pilot's workload and reduced his ability to identify and respond to the event in the time available. The possibility that the reported head cold may have affected his performance could not be discounted.

Without external visual reference, the most apparent indication to the pilot of any thrust asymmetry was the tendency for the aircraft heading to change with yaw and then roll towards the engine producing less thrust. The yaw would initially be evident on the directional indicator as a change in heading and the roll would be apparent on the attitude indicator, both providing cues for the pilot to use and make correcting control inputs via the rudder and aileron controls. If the change in heading and roll was not identified as an asymmetry of thrust, the symptoms could equally have been interpreted as an issue with the aircraft's flight controls, autopilot or other system anomalies. The correct association by the pilot of the heading change and roll with differential engine thrust was an essential precursor to making a correcting rudder input and correctly identifying the affected engine.

Although the aircraft was still relatively close to the ground it was unlikely the pilot would have intentionally continued the climb while also allowing the aircraft's speed to reduce. That suggested the pilot either did not detect the reduction in speed, or did not adjust the aircraft's pitch attitude sufficiently to recover and/or maintain speed. Similarly, given both propellers were unfeathered, it was likely the pilot had not fully completed the relevant drills to optimise the aircraft's performance in the case of a loss of engine power. That could have been because, in the limited time available, his attention was increasingly focussed on maintaining lateral control of the aircraft. In that situation it is possible the pilot's attention was fixated on the attitude and heading indicators, which would have reduced his ability to identify the loss of speed and decreased climb performance of the aircraft. Alternately, it may have been because the nature of the malfunction, or the symptoms being encountered, were relatively poorly defined and therefore more difficult to identify and correctly interpret. Either scenario would require detailed troubleshooting, which may be difficult with limited information and time.

The propeller of an inoperative engine would initially have windmilled at a high enough RPM for the feathering locks to remain disengaged and, at that stage, it would have still been possible for the pilot to feather the propeller. As the aircraft's speed reduced, the RPM of the windmilling propeller would have also reduced and the feathering latches would have been progressively closer to engaging and thereby preventing the inoperative engine's propeller from feathering. The pilot held a multi-engine command instrument rating and had recently demonstrated proficiency by day in response to a simulated engine failure in instrument meteorological conditions and after take-off in visual meteorological conditions. However, he had limited exposure to simulated engine failures after take-off in dark night conditions.

Fuel selector valves

Although the deteriorated O ring seals did not contribute to the circumstances of this accident, the internal leak identified in both fuel selector valves may not be evident during routine maintenance activities. In such a circumstance, the undetermined level of engine operation in the event of a mis-selection of fuel selector levers to the OFF position or the inability to isolate an affected engine from the fuel system or make effective use of the crossfeed function, was considered a potential airworthiness issue.

Electrical switch panel

Examination of the aircraft's electrical switch panel found all switches in a position consistent with a night take-off, with the exception of the left engine's magneto switches, which were both in the OFF position. The position of the switches was not consistent with any published troubleshooting procedure in that phase of the take-off. However, the switch panel had detached from the cockpit sidewall during the accident and the hinged cover for the front half of the magneto switch panel had broken away at its forward hinge. The as-found position of the left engine's magneto switches can only have been a result of their selection to that position by the pilot at some point prior to the collision with terrain, or as a result of them being knocked to that position during the accident sequence.

With the minimal damage sustained to the guard cover for the magneto switches and the panel trim immediately surrounding the left engine's magneto switches, it was unlikely those switches could be knocked to the OFF position if the guard was closed, thereby protecting those switches from inadvertent operation.

The location of the magneto switches, immediately above the switches for the landing and taxi lights increased the risk of their inadvertent operation, particularly if the guard cover for the magneto switches did not fully close after the pilot had completed the magneto checks during the engine run-ups prior to take-off. If the left engine’s magnetos were inadvertently switched to the OFF position during flight, there would be no source of normal ignition for the fuel and air mixture in the cylinders of the left engine. The unburned fuel and air mixture would pass into the engine’s exhaust, where hot components could cause the fuel and air mixture to auto-ignite. Such after-firing of the fuel and air mixture could be consistent with the noises reported by some witnesses.

However, that outcome was contingent on the pilot not associating any reduction in engine power or noise from the engine after-firing with the operation of switches. If the pilot normally operated the landing and taxi light switches at that stage of the take-off, the dark night conditions and necessary transition to the aircraft flight instruments for the climb would have increased the pilot’s workload and may have reduced his ability to detect a change noise from the engines or to associate the switching of the landing and taxi lights with any loss of engine power. In addition, the pilot had completed the action of turning off the landing and taxi lights on many previous night take-offs with no adverse effect. The successful completion of this action over a period of time may have made it harder for him to identify that he had inadvertently selected the magnetos off in this instance. Although the damage sustained by the spring-loaded magneto cover precluded any assessment of the serviceability of its self-closing mechanism, one pilot who had recently operated the aircraft recalled that the guard cover did not always fully close. In such a circumstance, a partially open guard cover would have been less effective in preventing inadvertent operation of the magneto switches.

The ATSB identified a number of previous occurrences involving the inadvertent selection, in flight, of an engine’s magnetos to OFF in the Piper Seneca. Although this would explain the power loss at Broome involving LCK, there was insufficient evidence to find this was the case.

Findings

From the evidence available, the following findings are made with respect to the collision with terrain involving Piper PA34, registered VH-LCK, which occurred near Broome, Western Australia on 11 July 2012. They should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing factors

- The flight most likely proceeded normally until after the landing gear was retracted when, before the aircraft passed the upwind runway threshold, the total engine power available reduced to less than that required for a normal climb.
- Following the likely loss of engine power, the aircraft speed reduced significantly, resulting in uncontrolled flight, a steep descent and collision with terrain.

Other factors that increased risk

- Dark night conditions prevailed for the aircraft's take-off and initial climb, which could have adversely affected the pilot's response to the unexpected power loss in the short time available.
- The proximity of the switches for the landing lights and auxiliary fuel pumps to the aircraft engines' magnetos on the electrical switch panel increased the possibility of inadvertent switch operation.

Other findings

- Although not related to the circumstances of this occurrence, the investigation found deteriorated O ring internal seals within the fuel selector valve assembly.
- The reason for the power loss could not be determined.

Safety issues and actions

The ATSB did not identify any organisational or systemic issues that might adversely affect the future safety of aviation operations. However, the following proactive safety action was reported in response to this occurrence.

Proactive safety action

The Civil Aviation Safety Authority

The Civil Aviation Safety Authority (CASA) has advised the intention to publish airworthiness bulletin (AWB) 28-105, to alert operators and maintainers of Piper Seneca and other aircraft fitted with similar fuel selector valves, that undetected internal fuel selector leaks may result in a loss of fuel control to the engines and fuel imbalance due to deteriorated fuel selector seals, and recommending regular checks of selector valve function.

The aircraft operator

Following this occurrence, the aircraft operator amended their standard operating procedures, requiring aircraft to be above the lowest safe altitude before pilots operated switches associated with aircraft lighting and auxiliary fuel pumps.

General details

Occurrence details

Date and time:	11 July 2012 – 2008 WST	
Occurrence category:	Accident	
Primary occurrence type:	Loss of control	
Location:	Near Broome Airport, Western Australia	
	Latitude: 17° 56.6’ S	Longitude: 122° 12.5’ E

Aircraft details

Manufacturer and model:	Piper Aircraft Corporation PA-34-200 Seneca I	
Registration:	VH-LCK	
Serial number:	34-7350236	
Manufactured	1973 in the United States	
Type of operation:	Charter	
Persons on board:	Crew – 1	Passengers – 0
Injuries:	Crew – 1 (fatal)	Passengers – 0
Damage:	Destroyed	

Sources and submissions

Sources of information

The sources of information during the investigation included the:

- aircraft operator
- aircraft manufacturer
- Western Australia Police
- Bureau of Meteorology.

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Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003* (the Act), the Australian Transport Safety Bureau (ATSB) may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the aircraft operator, the aircraft manufacturer, the Civil Aviation Safety Authority and the pilot's next-of-kin. Submissions were received from all of these parties. The submissions were reviewed and, where considered appropriate, the text of the report was amended accordingly.

Appendix A

Global positioning system recorded data

Plan and side views of the aircraft's point-to-point global positioning system-recorded flight path are at figures A-1, A-2 and A-3.

Figure A-1: Plan view

Source: Google Earth with aircraft GPS track data overlaid by ATSB

Figure A-2: Side view

Source: Google Earth with aircraft GPS track data overlaid by ATSB

Figure A-3: Upwind plan view

Source: Google Earth with aircraft GPS track data overlaid by ATSB

Australian Transport Safety Bureau

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

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

It is not a function of the ATSB to apportion blame or determine liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

Australian Transport Safety Bureau

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Investigation

ATSB Transport Safety Report
Aviation Occurrence Investigation

Engine power loss and departure from controlled flight involving Piper Seneca, VH-LCK, near Broome Airport, Western Australia on 11 July 2012

AO-2012-093
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