ACCIDENT

Aircraft Type and Registration:	Piper PA-24-260 Comanche, G-ATIA
No & Type of Engines:	1 Lycoming IO-540-D4A5 piston engine
Year of Manufacture:	1964
Date & Time (UTC):	8 August 2007 at 1057 hrs
Location:	Approximately half a mile east of Leicester Airport
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Serious) Passengers - N/A
Nature of Damage:	Aircraft damaged beyond economic repair
Commander's Licence:	Private Pilot's Licence
Commander's Age:	74 years
Commander's Flying Experience:	1,222 hours (of which 200 were on type) Last 90 days - 37 hours Last 28 days - 4 hours
Information Source:	AAIB Field Investigation

Synopsis

On departing from Leicester, the pilot observed a low voltage indication and returned to make a precautionary landing. Whilst on short final for Runway 33, he became aware of vehicles near the runway threshold and accordingly, landed long. The aircraft bounced after touchdown and he decided to go around. During the climb out the engine began to lose power and he attempted to land downwind on another runway, but the aircraft was too high and too fast. After crossing the aerodrome eastern boundary, the aircraft stalled from a low height and impacted the ground heavily, following which a fire broke out. The pilot suffered back and facial injuries.

History of the flight

Three days before the accident, whilst preparing the aircraft for flight, the pilot found that the battery was discharged and requested for it to be changed by an engineer. On the day of the accident, he was able to start the aircraft on the first attempt and noted that the ammeter indicated that the battery was charging. The pre-flight and power checks were completed satisfactorily and the aircraft departed from Runway 33 at Leicester with full fuel tanks. As it climbed, the pilot noticed that the low voltage warning light had illuminated and he decided to carry out a circuit to land back on Runway 33. On the approach, he noticed a tractor and trailer combination that appeared to be moving towards the runway threshold, so he reduced the rate of descent to ensure that he cleared the vehicles

safely and landed further along the runway than he would usually. On touchdown, the aircraft bounced twice, prompting the pilot to execute a go-around. Whilst climbing back into the circuit he heard an "odd pop on the engine" and made a PAN call on the aerodrome air/ground radio frequency, stating that the engine was running roughly. The engine then began to run "very, very roughly" and the pilot radioed to say that he would land in the middle of the aerodrome. He was aware that the landing would be downwind and so began to descend early. An instructor in a helicopter operating nearby estimated that the aircraft completed a left turn from its north-westerly takeoff track onto an easterly heading at a height of approximately 100 ft.

An instructor in another aircraft had seen G-ATIA going around and judged that it had commenced the left turn onto an easterly heading at approximately 200 ft above the ground. It appeared to be approaching to land with its landing gear up, so the instructor called on the radio to advise the pilot, who immediately lowered the landing gear. The engine continued to run intermittently and make noises, which another witness on the ground described as "like shotgun fire". This witness saw the aircraft flying in an easterly direction at a speed and height that he considered too great for a landing on Runway 10. At a point south of the Runway 28 threshold, with the aircraft descending to within 50 ft of the ground, the pilot attempted to position the aircraft onto a right hand base leg for Runway 33. The aircraft was seen to climb very slowly then adopt a nose-down attitude and roll to the right. The pilot reported that at this point the engine had ceased to produce power. He responded by applying nose-up elevator control, which resulted in a nose-up attitude but no decrease in the rate of descent. This was followed almost immediately by the aircraft impacting the ground. Figure 1 depicts the aircraft's track following the go-around.

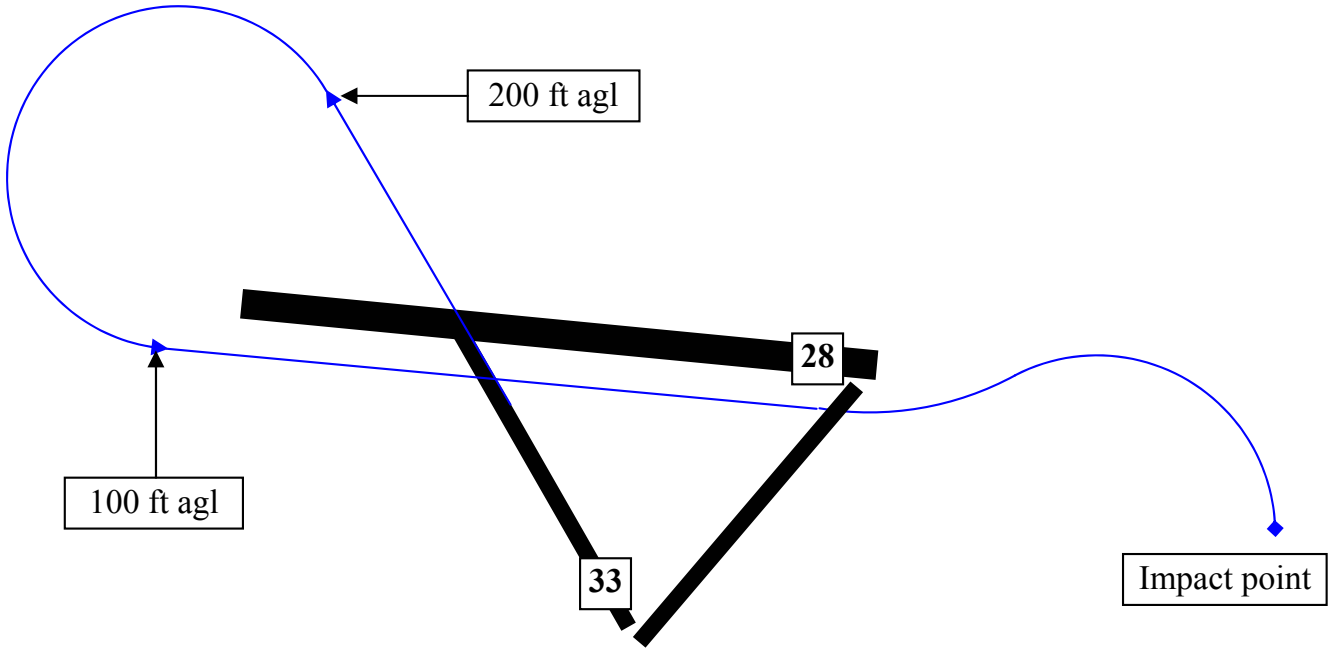

Figure 1

Leicester Aerodrome layout showing aircraft's track after go-around

The pilot suffered facial injuries when his head struck the control yoke during the impact and he was also aware of back pain. Shortly afterwards the helicopter landed nearby and its occupants went to assist the pilot. One of them used a fire extinguisher from the helicopter to attack a fire in the engine bay. The pilot, having considerable relevant medical experience, was concerned about the possibility of complicating any spinal injury and resisted their attempts to remove him from the aircraft wreckage. He vacated it without assistance, and recalled that he did not turn off the fuel supply or electrical power. He then walked over to the helicopter and used it to support himself in a standing position. The aerodrome fire and rescue service (AFRS) promptly attended the scene and put out the fire using one dry powder and two foam extinguishers. The pilot was later taken to hospital by the AFRS.

Aircraft information

The aircraft was a PA-24-260 Comanche powered by a 260 hp Lycoming IO-540-D4A5 engine, driving a 3-bladed constant-speed Hartzell propeller. It was of conventional design with mechanical flying controls and retractable tricycle landing gear (Figure 2). At the time of its last annual inspection on 4 May 2007, the airframe had accumulated 5,492 hours, the engine 81 hours, and the propeller 240 hours. The engine had been overhauled and rebuilt in the UK on 15 April 2006.

During the aircraft's last annual inspection, completed three months before the accident, oil pipes on the engine and the fuel hose between the injector and fuel flow manifold were replaced.

Accident site and wreckage examination

The accident site was located in a wheat field approximately 600 metres south-east of the end of Runway 10. The ground impact marks were consistent with the aircraft having struck the ground nose first, in a slight left bank. The aircraft had bounced after initial impact and travelled for 30 metres before coming to rest upright and orientated in the direction of 187°(M). The track of the aircraft at initial impact was approximately 245°(M). There was significant fire damage around the engine bay and to the engine, which had been forced to the right and was lying on

Figure 2

The aircraft, G-ATIA, before the accident

its left side. There was a 10 metre long narrow scorch mark in the wheat originating near the initial impact mark and leading up to a point about 20 metres short of the wreckage. There was an additional smaller and localised patch of burnt wheat at the edge of the initial impact mark.

All three landing gear legs were extended and had separated from the aircraft during impact. The flaps were in the retracted position. The majority of the damage to the aircraft was to the nose structure forward of the firewall. The wing skins and under-fuselage skin also exhibited crushing and wrinkling damage.

All three propeller blades exhibited significant leading edge gouges and chordwise scratches consistent with propeller rotation at impact. The blade tips were intact; one blade was bent forward at mid-span and the other two blades were bent aft.

The fuel tank selector was set to the right main tank. The electric fuel pump switch was in the ON position. The fuel recovered from the aircraft's left auxiliary tank, left main tank, right main tank and right auxiliary tank were 13, 23, 25 and 8 US gallons respectively, giving a total quantity recovered of 69 US gallons[1]. Fuel samples from all four tanks were tested and were found to be consistent with the properties of 100LL AVGAS. Small quantities of soil debris were found in the fuel samples, but they were otherwise free of contamination. A small amount of fuel was recovered from the fuel line to the engine firewall, but no fuel was found forward of the firewall due to the effects of the fire.

Footnote

[1] The aircraft total fuel capacity was 90 US gallons; 30 gallons in each of the main tanks and 15 gallons in each of the auxiliary tanks.

Recorded information

Track log data[2] covering the accident flight was downloaded from a GPS unit recovered from the aircraft. The frequency with which data was logged by the unit was set at once every 30 seconds, however, the track logs showed evidence that the satellite signals to the GPS antenna had occasionally been obscured, with missing sections of data or loss of altitude information.

The data for the accident flight showed the takeoff from Runway 33, a circuit of the airfield followed by an approach and aborted landing on Runway 33. The final two recorded data points showed the aircraft to be in a left turn. Following the aborted landing, a data point was recorded just beyond the end of Runway 33, at which point the recorded aircraft height was about 70 ft agl and the groundspeed 47 kt. The next point placed the aircraft about 200 metres to the south-west of the Runway 10 threshold, with a recorded track of 136° and ground speed of 75 kt. The final data point placed the aircraft about 200 metres beyond the end of Runway 10, within a few metres of the extended centreline, with a recorded ground speed of 72 kt. Neither of the final two data points included altitude information.

Powerplant examination

The engine was taken to an approved overhaul facility for strip examination. The engine internals were found to be in good condition with no evidence of heat distress. All mechanical components moved freely and were sufficiently lubricated. The cam lobes were in satisfactory condition. The oil filter and oil inlet screen

Footnote

[2] A track log contains a sequence of data points, with each point containing time, aircraft position, instantaneous groundspeed, track and altitude.

were free from any significant debris. The oil scavenge pump was free to rotate. All the spark plugs were in good condition. The plugs from cylinders 1, 3 and 5 were clean, whereas some of the plugs from cylinders 2, 4, and 6 were coated in oil. Oil was also found inside cylinders 2, 4 and 6. These cylinders are on the left side of the engine (as viewed from aft looking forward) and the aircraft had been lying on its left side at the accident site. The ignition lead to plug 5 was slightly loose, but all other connectors were tight.

The throttle and mixture control linkages had separated from the fuel injector, which was consistent with the impact damage in that area. The propeller speed control linkage was still connected to the governor. The propeller governor rotated freely, contained sufficient oil and its filter screen was clear.

The magnetos were found securely attached to the accessory gearbox and there was no evidence that these had rotated out of position. When tested, the left magneto operated normally down to 130 rpm whereas the right magneto fired irregularly below 230 rpm. This was above the specification of 150 rpm for a new or overhauled magneto, but was still well below normal engine idle rpm[3].

The electric fuel boost pump operated normally when tested.

The fuel manifold, flow dividers and nozzle injectors were rig tested. The manifold and flow dividers (without nozzles attached) produced a steady 161-162 pounds per hour flow at 4.5 psi, which was within specification. The low pressure test revealed that at 6 pounds per hour the flow rate increased suddenly, indicative of a sticking manifold valve. However, this would not have been apparent at high power settings and the sticking valve could be a result of heat from the post-impact fire. The injector nozzles were tested separately and all had flow rates within specification apart from nozzle No 4, which had a slightly low flow rate. After cleaning some oil from this nozzle its flow rate was within specification. The nozzle could have been contaminated by oil while the engine was lying on its side after impact.

The fuel hose between the engine-driven fuel pump and the fuel injector had separated from the fuel injector (Figure 3). This was not one of the hoses that was replaced during the previous annual inspection. The fuel injector had also separated from the oil sump. The injector fitting (circled) is part of the injector body and connects to a threaded hole (also circled). Four threads from this hole had been stripped and one of the stripped threads was wrapped around the separated injector fitting (Figure 4).

The injector fitting was confirmed to be of the correct type, with the correct number of threads. The silicone seal was missing, but could have been consumed by the post-impact fire. The fitting and injector body were examined by a metallurgist. Microscopic examination did not identify any material deficiencies. It was not possible to establish whether the fitting had been cross-threaded, nor was it possible to establish if the fitting had been tight when the separation occurred. The AAIB investigated a more recent accident to a Piper aircraft with a similar injector and injector fitting. In this accident, which did not involve suspicion of an engine problem, the injector fitting had pulled out and stripped the threads in a similar manner, probably due to impact forces.

Footnote

[3] Magneto rpm is equal to 1.5 x engine rpm for this engine.

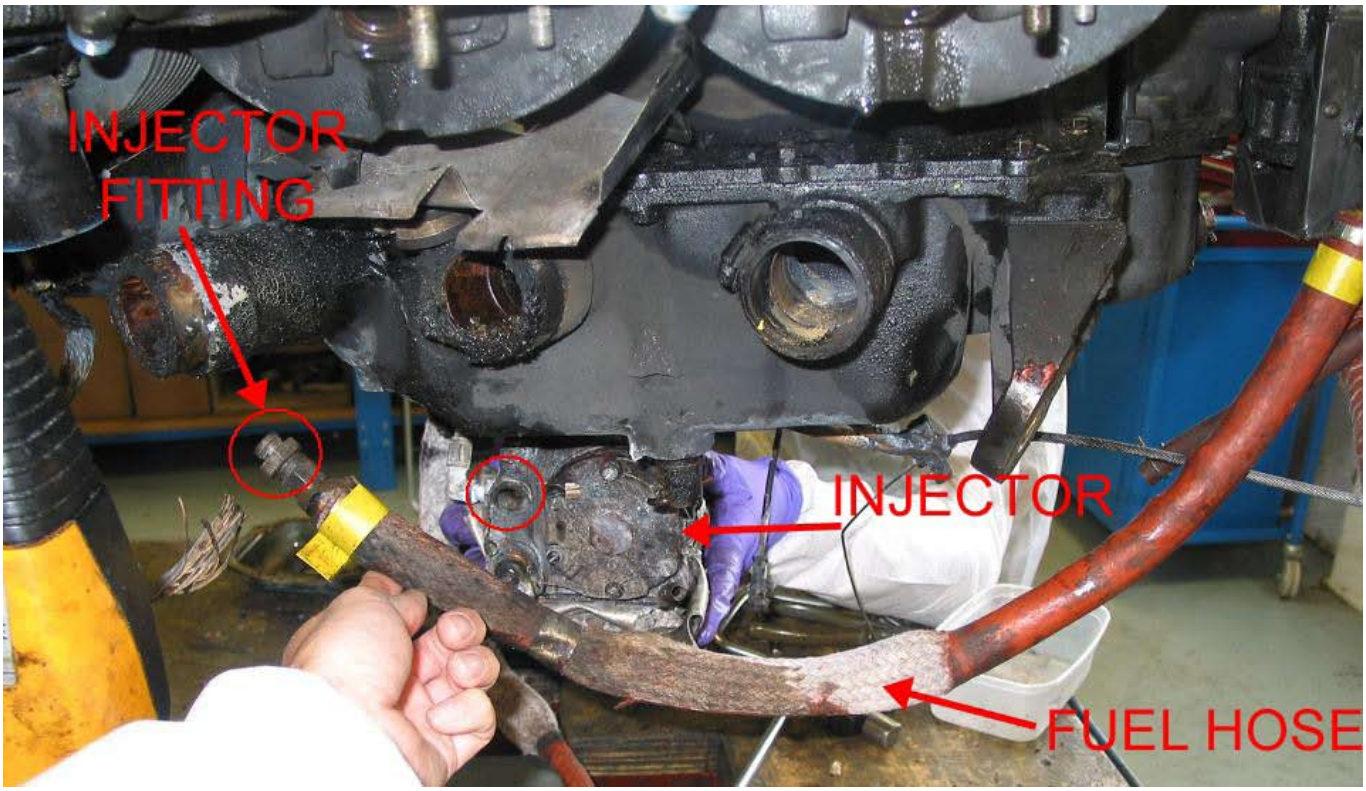

Figure 3

Fuel hose between the engine-driven fuel pump and the fuel injector.
It had separated from the injector at the injector fitting

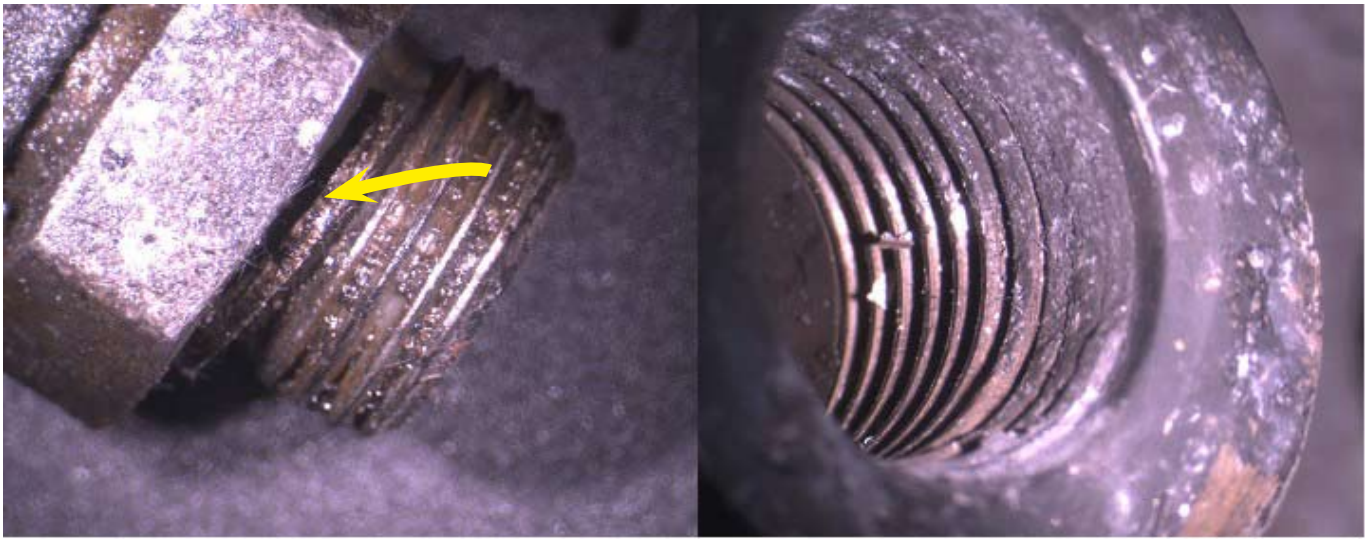

Figure 4

Left: close-up of injector fitting with separated thread (arrowed).
Right: close-up of threaded hole on the injector body showing the stripped threads

The fuel hoses were examined for leaks. The fuel hose between the engine-driven fuel pump and injector had a leak in the area where the hose had suffered fire damage. The inner lining exhibited clear evidence of heat damage. The fuel hose between the injector and fuel flow manifold did not leak at its rated pressure. The fuel hose from the firewall to the engine-driven fuel pump had a leak, again in a region where the inner lining had suffered heat damage from the fire.

The fuel injector was strip examined. No anomalies were discovered although heat damage to the membrane and seals precluded a full and conclusive examination. The engine-driven fuel pump had not suffered any mechanical damage.

Alternator test

Although the alternator had suffered fire damage, when tested it produced 80 amps at 17 volts which was within specification. The wires were securely attached but the fire had caused insulation damage.

Other information provided by the pilot

The pilot considered that when the aircraft was positioned south of the Runway 28 threshold, he should have attempted to turn left for a landing on that runway. He commented that it was not an ordinary engine failure in that it progressed from "a couple of pops" to a series of explosions associated with severe vibration. He recalled that the aircraft had been in a level attitude when the engine failed completely and judged that the aircraft had not stalled because it pitched up in response to nose-up elevator control. However, the subsequent change to a nose-down attitude was very rapid. He stated that the fuel boost pump had probably remained on throughout the flight. He recalled that when he checked prior to departure, the engine oil contents had been just below the 'Full' marking on the dipstick.

Techniques for handling engine failure after takeoff

Evidence from previous accidents and theoretical analysis both suggest that an attempt to return to the departure runway in the event of engine failure in a single engine aircraft is unlikely to be successful if the failure occurs shortly after takeoff. In this instance, after going around with what appeared to the pilot to be a partial engine failure, the aircraft turned through approximately 230º to approach Runway 10.

Transport Canada civil aviation document TP 13748E, *'An Evaluation of Stall/Spin Accidents in Canada 1999'*, which considered the altitude required before an "engine-out turn" was initiated, states in part:

> *'If an engine failure after takeoff results in an accident, the pilot is at least eight times more likely to be killed or seriously injured turning back than landing straight ahead.'*

Safety Sense Leaflet 1a – *'Good Airmanship'*, published by the CAA, includes the following advice:

> *'In the event of engine failure after take-off, if the runway remaining is long enough, re-land and if not, never attempt to turn back. Use areas ahead of you and go for the best site. It is a question of knowing your aircraft, your level of experience and practice and working out beforehand your best option at the aerodrome in use. (One day, at a safe height, and well away from the circuit, try a 180° turn at idle rpm and see how much height you lose!).'*

The 1994 paper *'The Possible "Impossible" Turn'*[4]

Footnote

[4] David F Rogers, United States Navy Academy, originally published in the AIAA Journal of Aircraft, Vol. 32 pp. 392-397, 1995

used a simplified analytical model to examine the ideal flight path of a single-engine aircraft turning back after engine failure during the takeoff phase of flight. It indicated that the optimum procedure involved a turn through approximately 190-220° using a 45° bank angle, flown at 5% above the stall speed.

The General Aviation Safety Information Leaflet (GASIL) 1 of 2006 stated:

> *'It is possible that in certain circumstances turning back to the aerodrome might be the option which minimises the risk of injury to the aircraft occupants, provided the pilot maintains a safe airspeed and sufficient height exists taking into account the extra drag from a windmilling propeller. However, in general, landing ahead is nearly always going to be the safest option in the event of an engine failure.'*

This issue has been explored in several previous AAIB reports. The report into the accident to G-BOIU[5] also considered the influence of a partial engine failure on a pilot's decision to return to the airfield:

> *'Although the principle of not turning back is well established in training, it is possible that some pilots are not sufficiently aware that a loss of power/performance can be insidious in nature and not always as easy to detect as the type of engine failure after takeoff generally practised at training organisations.'*

Analysis

The aircraft damage and the ground impact marks were consistent with a low speed, nose low impact with a slight left bank angle. The damage to the propeller blade leading edges indicated that the propeller had significant rotational energy at impact, consistent with either low power, or no power with a high windmilling speed. However, the low impact speed suggests that a high windmilling speed was unlikely; therefore, low power was more probable. The scorched wheat at the initial impact point and the narrow trail of scorched wheat emanating from it indicate that the fire ignited at or before initial impact. This fire spread after impact causing significant fire and heat damage forward of the engine firewall. The fire was probably fuelled by fuel being pumped into the engine bay by the electric fuel pump, as its switch was found in the ON position. This fuel would have flowed to the fuel hose which had separated from the injector, resulting in pooling below the injector – an area which was inside the area of most intense heat. It was the prompt arrival of the AFRS and the application of three fire extinguishers which prevented the fire from spreading beyond the engine bay.

The cause of the engine problems experienced by the pilot could not be established. There was sufficient fuel on-board and no evidence of fuel contamination was found. As the engine was fuel injected, carburettor icing can be ruled out as a cause. Satisfactory operation of the magnetos was verified and the spark plugs were in good condition. There were no mechanical defects with the engine and no evidence of an engine accessory defect. One possibility considered was a fuel leak from the fuel inlet fitting of the fuel injector. Insufficient fuel delivery could have caused rough running at a high power setting. Furthermore, if fuel had already been leaking from this fitting before impact, a fire would have more readily ignited at initial impact causing a narrow trail of scorched wheat. However, there were no records of this fitting having recently been disturbed;

Footnote

[5] AAIB Bulletin 12/2005, reference EW/C2004/08/05.

the fuel hose that was replaced during the annual check was a different hose. Furthermore, an examination of the stripped threads could not establish if the fitting had been loose or not before the fitting was pulled out. Evidence from another accident showed that impact forces can cause the fitting to be pulled out. Therefore, no definitive cause of the engine power loss could be established.

The cause of the low voltage warning after takeoff could not be explained. Low voltage is usually caused by an alternator failure, but the alternator operated normally when tested. Regardless of the cause of the low voltage light, it would not have had an impact on the engine operation, as the engine provides its own source of electrical generation via the magnetos and will continue to operate with a flat battery and a failed alternator.

Operational aspects

Engine failure shortly after takeoff requires the pilot of a single engine aircraft to decide very quickly where to land. Despite comprehensive advice to the contrary, the inclination to attempt to return to the departure airfield may be hard to resist, especially if the failure is partial and gives the impression of producing sufficient power to sustain flight. Although theoretically a return may be possible after the aircraft has climbed to several hundred feet, most single engine aircraft are unlikely to complete this manoeuvre successfully unless the failure occurs considerably higher. The aircraft would not have had sufficient height at the point it passed the threshold of Runway 28, to turn for landing on that runway.

Safety Sense Leaflet 1a suggests that '*at a safe height, and well away from the circuit'* pilots might '*try a 180° turn at idle rpm and see how much height'* is lost. This exercise would provide a gross estimate of the height lost during a turn to parallel the departure runway. However, in the absence of a crosswind the aircraft would need to turn through more than 180° to become realigned with the departure runway. Having sufficient height to complete the turn would not guarantee that the aircraft could land on the runway, because a tailwind during final approach might cause the aircraft to overshoot.

All the available evidence suggests that, following engine failure in a single engine aircraft, it is safest to land in open ground ahead. There is a risk of damage when landing on other than a prepared runway, but such damage is likely to be less severe if the pilot can accomplish a touchdown while still in control of the aircraft. In this case the aircraft stalled at a relatively low height above the ground. The ensuing high rate of descent, combined with a turn, resulted in touchdown at low forward speed. Had the aircraft stalled at a greater height, its speed on impact would have been higher, with possibly fatal consequences.