ACCIDENT

Aircraft Type and Registration:	Pulsar, G-BULM
No & Type of Engines:	1 Rotax 582 piston engine
Year of Manufacture:	1994
Date & Time (UTC):	17 April 2007 at 1543 hrs
Location:	Dairy House Farm Airstrip, Aston Juxta Mondrum, near Nantwich, Cheshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Fatal) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	56 years
Commander's Flying Experience:	1,266 hours (of which 194 were on type) Last 90 days - 29 hours Last 28 days - 21 hours
Information Source:	AAIB Field Investigation

Synopsis

The pilot attempted to return the aircraft to the runway after it suffered a loss of power shortly after takeoff. The aircraft had insufficient performance to complete this manoeuvre and stalled before the pilot was able to make a controlled landing. The investigation did not determine the cause of the loss of power.

History of the flight

The pilot departed Lymm Dam, the airfield at which he kept the aircraft, for the short flight to Dairy House Farm airstrip (Figure 1) at Aston Juxta Mondrum, near Nantwich. A witness who flew regularly from the airstrip saw the aircraft circling overhead and drove the short distance from his home to welcome the visiting pilot. When he arrived, the aircraft had landed and was parked at the northwest end of the airstrip. He greeted the pilot, whom he remembered having met briefly at another airfield. During a conversation about flying and aircraft maintenance the pilot mentioned that previously he had had "problems with the electrics in his plane", but did not say if these problems persisted.

Before departure the pilot discussed his intended takeoff technique with the witness, who advised that if the aircraft had not become airborne before passing the intersection of the two runways the pilot should abort the takeoff. The pilot appeared to be "in good spirits". After a stay of approximately half an hour he boarded

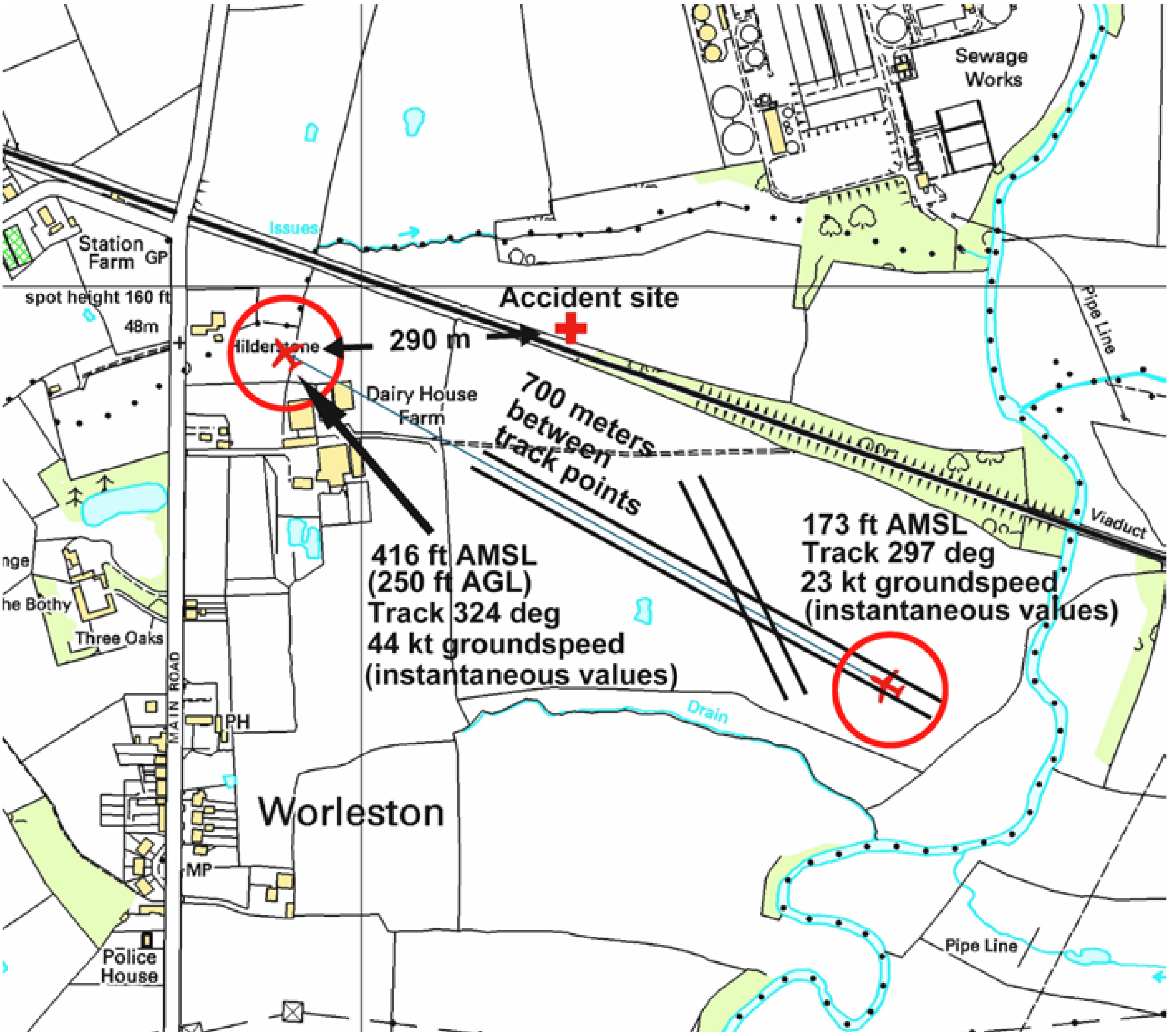

Figure 1

Accident at Dairy House Farm Airstrip

his aircraft and taxied to the south eastern end of the airstrip, in preparation for takeoff. He paused at the end of the main runway for approximately 2 minutes before lining up. The witness was unable to tell whether the pilot conducted engine power checks. The aircraft then lined up, commenced its takeoff and was airborne before the runway intersection.

Shortly before the takeoff the original witness, who stood beside the northwest end of the runway, was joined by three others who had been working at the farm. In their statements, each witness stated that the initial climb over the runway appeared normal but that, at a height of approximately 100 to 150 ft, the engine "coughed". The engine sound returned to normal briefly but, as the aircraft passed over the end of the runway, the engine coughed again. The aircraft then made what one witness described as a coordinated turn to the right until it was flying almost parallel to the runway in the opposite direction to takeoff, losing height as it did so. All of the witnesses reported that the propeller had stopped turning. At a height of approximately 60 ft the aircraft entered a tight turn to the right and impacted the ground in a field north of the airstrip, separated from it by a double railway line.

In order to access the crash site it was necessary for the witnesses to use a locked railway crossing. One witness, a worker at the farm who was familiar with crossing procedures, stayed at the gate to control access to the crossing. The other witnesses attempted to assist the pilot but determined that he had been fatally injured.

Aircraft description

The Pulsar is a two-seat, low-wing amateur-built aircraft with a fixed tricycle undercarriage, sliding canopy and side-by-side seating. The aircraft is equipped with conventional manual flying controls with the flaps, aileron and elevator operated by control rods and the rudder by control cables. G-BULM was powered by a Rotax 582 UL liquid-cooled, twin-cylinder two-stroke engine driving a two-blade fixed-pitch propeller through a reduction gearbox. A composite fuel tank, with a capacity of 16 Gal US, was mounted in the fuselage between the pilot and the stainless steel engine bulkhead. The manufacturer recommends that 2% of oil is mixed with the fuel to give a fuel/oil ratio of 50:1. G-BULM was not equipped with a stall warning system.

This engine is equipped with two BING carburettors and a diaphragm fuel pump which is operated by pressure pulses in the crankcase. The engine is also fitted with a 12v capacitor-discharge dual ignition system consisting of two magneto switches, flywheel magneto generator, two Electronic Units (EU) - containing the ignition coils and control circuits - and two external triggers. The flywheel incorporates 12 permanent magnets and the stator is equipped with 12 coils. Eight of the coils are connected in series and provide power to the aircraft electrical system, the remaining four coils are used for the dual ignition with two coils connected 'in series' to each ignition system.

Crash site examination

The aircraft crashed on a heading of 260°M in a small level field adjacent to the railway line. Both wings and the forward section of the fuselage were destroyed and the wreckage trail extended for 20 m from the initial impact point on a heading of 155°M. Damage to the aircraft, and ground marks, indicated that the right wing struck the ground first, when the aircraft was in a near vertical pitch attitude. The right wing spar failed close to the fuselage and the aircraft continued moving laterally before the propeller struck the ground and the engine broke away from the fuselage. The aircraft then 'cart-wheeled' and the tail section came to rest upside down on the broken left wing.

Both carburettors, which had come out of their rubber sockets, were still connected to the throttle cables and fuel feed pipe. The fuel bowl on one carburettor was half full and the fuel bowl on the second carburettor was empty. The gascolator was damaged and contained no fuel or evidence of debris. The fuel tank had disintegrated and there was a strong smell of fuel in the ground. The fuel cock was in the ON position. The propeller hub had bent backwards, allowing one of the blades to come out of the hub. The other blade had broken off close to the blade root. There was no damage to the leading edge of either propeller blade.

The control rod between the control column and the elevator was still connected and operated satisfactorily. The rudder pedals, which had broken away from the structure, were still connected to the control cables.

The flap and the aileron control rods and torque tubes all exhibited post-impact damage.

The aircraft master switch was found in the ON position, the Magneto 1 switch had bent to the left and was in the OFF position and the Magneto 2 switch was in the ON position. The pilot was sitting in the left hand seat secured by a four-point harness.

In the tail cone, and scattered around the cockpit, were a flight bag and a number of auxiliary items such as tools, oil, air compressor, battery, cleaning equipment and a stirrup pump.

Aircraft history

The last Certificate of Validity for the Permit to Fly, which was valid until 19/5/07, was issued by the Popular Flying Association (PFA) on 20/5/06. The last flight test was undertaken on 27/4/06, by the owner of the aircraft who recorded the stall buffet speed as 35 kt and the minimum airspeed achieved as 30kt. The owner also made a comment that the left wing dropped at the stall. A flight test undertaken a year previously by another pilot also recorded the same buffet and minimum airspeeds, though he made no comment on the wing dropping in the stall.

Friends of the pilot revealed that he had been experiencing engine problems, possibly involving the stator coil in the engine. Some believed that it involved the electrical charging circuit and others that he had been experiencing a large magneto drop. There were also reports that he had an intermittent ignition problem that would "appear during the pre-takeoff power checks". However, two other pilots who accompanied the owner, flying their own aircraft, on a 'fly out' two days prior to the accident, stated that whilst they were aware that he had been experiencing engine problems, he made no mention of any technical problems with his aircraft during the day of their outing.

A maintenance engineer, who had previously worked on the engine and gearbox from the aircraft, informed the AAIB that in the weeks before the accident the owner had visited him at his workshop and asked him to check the stator coil as he was experiencing problems with the electrical charging system. The engineer checked the charging coil resistance and found it to be satisfactory. It was also reported that the owner had obtained three stator coils over the previous four months.

The AAIB could find no evidence in the engine and aircraft log books, and other documents owned by the pilot, that he had been experiencing engine difficulties prior to the accident flight. The log book made no mention of the engine having been removed in the weeks prior to the flight, nor was there evidence that a duplicate inspection, required following the installation of an engine, had been carried out. The most recent work was the fitting of new upholstery and the painting of the instrument panel and interior of the aircraft 27 hours prior to the accident flight. The last documented work on the electrical system was carried out 46 hours prior to the accident flight when the stator coil, rectifier and battery were replaced and the earth cable cleaned.

Apart from a pencilled comment in the aircraft log book, there was no evidence of any formal documentation for the modification to fit the baggage compartment. The PFA were also unaware that this modification had been installed on the aircraft.

Detailed examination of the wreckage

Engine

The engine, complete with the controls and electrical leads still attached to the back of the instrument panel, was taken to a maintenance organisation where it was stripped and tested under AAIB supervision.

There was clean oil in the reduction gearbox and the magnetic plug was clean. It was established that the correct spark plugs had been fitted and, whilst they were slightly worn, the colour of the electrodes was considered to be typical of an engine that had been operating normally. Marks were found on one side of the electric start housing casing which had been caused by contact with the starter motor ring. These marks most probably occurred during the crash and indicate that the engine was not rotating. There was no evidence of a mechanical failure, seizure or of the engine having overheated.

The external trigger on the exhaust side of the engine and its associated EU at the front of the engine had been damaged in the crash. Both magneto switches and the continuity of the wiring between the magneto switches and the engine were tested and found to be satisfactory. The EUs, undamaged trigger and the spark plugs were also tested and found to be satisfactory.

There was no obvious damage to the stator, though it was noted that a repair had been carried out to one of the connections to the charging coil. A resistance check of the stator coil revealed that the resistance of both coils was approximately 27 Ω higher than the published limits.

The carburettor rubber sockets showed evidence of starting to perish, however given the colour of the deposits on the cylinder head and spark plug, it is assessed that the damage was not sufficient to affect the operation of the engine. The jets on both carburettors were clear. It was noted that the bottom of both float needle valves had worn dimples into the valve operating arms approximately 0.2 and 0.1 mm deep. The diaphragm on the fuel pump was found to be intact.

Controls

The damage to all the flying controls was consistent with the aircraft crashing. There was no evidence of a control restriction having occurred prior to the accident.

Baggage compartment

Aero Design, the designers of the Pulsar type, had produced a drawing for a baggage compartment for the Pulsar which is fitted behind the seats and above the flying controls. The compartment fitted to G-BULM did not conform to the Aero Design modification. The compartment sat 2 inches higher and extended 4.5 inches further down the tail cone than the specifications in the drawings. The drawings also stated that the maximum load in the baggage compartment was 20 lbs. Following the accident, equipment found in the tail cone and cockpit was weighed and it was calculated that between 48 to 58 lbs of equipment had been stowed in the baggage compartment.

The AAIB calculated that the effect of the deviation from the approved modification was that the moment arm for the equipment stored in the baggage compartment would have been 2.25 inches aft of the figure of 64 inches quoted in the aircraft operating manual. By using an incorrect moment arm the pilot would not be able to calculate an accurate CG position. There was also a risk, in exceeding the baggage compartment weight limit, that the compartment could collapse and interfere with the controls.

Fuel

With the fuel tank destroyed in the crash, it was not possible to establish either the quantity or quality of the fuel in the aircraft.

Three jerry cans, which are believed to have belonged to the owner, were found outside his hangar. The fuel in the cans, one full and two with residual amounts of fuel, were tested by QinetiQ and found to be of an acceptable standard with an oil/fuel ratio of between 2.2 and 2.6%.

Aircraft weight and balance information

It was assessed that the refurbishment of the cabin would have had a negligible effect on the aircraft weight and moment. The weight and balance of the aircraft, on the day of the accident, was calculated by the AAIB and found to be within acceptable limits.

Flight characteristics

According to several published flight tests and the statements of other pilots familiar with the type, the Pulsar is considered to have pleasant handling characteristics even at low airspeed. Though the type usually exhibits a left wing drop at the stall in the absence of additional pilot control inputs, one flight test noted a right wing drop. The behaviour of individual examples will differ.

Literature produced by the design organisation stated that the glide ratio was 12 to 1. If a loss of power occurred at 230 ft above ground level the aircraft could glide a maximum of 840 m with its wings level in still air conditions. The best angle of glide speed was approximately 55 mph (48 kt). A headwind of 7 kt would reduce the maximum straight line gliding distance by approximately 15%, to 717 m. The landing ground roll was estimated by this organisation to be approximately 800 ft (243 m), but the conditions in which this could be achieved were not stated.

Personnel information

The pilot's logbooks indicated that he started to learn to fly flex-wing microlight aeroplanes in 1991 and gained a Private Pilot's Licence, issued by the United Kingdom CAA, on 19 June 1992. His logbook shows that he first flew a fixed wing aeroplane, a Rans S6, on 24 January 2000. He flew only this aircraft type until 25 March 2005, when he first flew the accident aircraft.

Between March and June 2005 he conducted several flights under instruction in G-BULM and in a Cessna 150 for the issue of a National Private Pilot's Licence (NPPL), valid for single engine piston land planes. His NPPL was issued on 27 September 2005. From that date until the accident he only flew G-BULM. His licence was valid at the time of the accident.

Meteorological information

No official meteorological information was available for the accident location. The farm workers who witnessed the accident reported that the windsock indicated a wind blowing along the runway against the direction of takeoff. The witness who flew regularly from the airstrip estimated a surface wind speed of 5-8 mph (4-7 kt) and considered conditions to be, "mild, sunny" and "ideal" for flying.

Aerodrome information

The airstrip at Dairy House Farm had two intersecting grass runways. The runway used by G-BULM was the longer of the two, aligned west-north-west with a total length of 564 m and a slight upslope. The shorter runway crossed this runway approximately 190 m from the start of the available takeoff run. When inspected the day after the accident the runway surface appeared to have been mown recently, to be well drained and free of debris.

A row of low farm buildings crossed the takeoff flight path approximately 640 m from the start of the takeoff run. Beyond this there were several tall trees and further domestic and farm buildings. The nearest substantial area of open ground within an arc of 90º each side of the extended runway centreline was a rectangular field beyond the railway lines, 260 m northwest of the upwind end of the runway. Its maximum length was approximately 280 m. To the west of this field was another area of open ground, 245 m beyond the end of the runway, with a maximum length of approximately 260 m. The field containing the wreckage had a maximum length of approximately 390 m in a direction broadly parallel to the departure runway.

Recorded information

Introduction

The aircraft was not equipped with a flight data recorder (FDR) or cockpit voice recorder (CVR) and neither was required by legislation. However, a Global Positioning System (GPS)[1] was recovered from the aircraft. The GPS was successfully downloaded at the AAIB and a track log was found to have been recorded during the accident flight. A track log consists of a sequence of data points. For this model of GPS, each data point contained the time, aircraft position, its instantaneous groundspeed, track and altitude (amsl). The recording frequency of the data points could be manually adjusted from between 1 to 99 seconds. The unit was found in the default setting, which recorded a data point every 30 seconds.

GPS Data

The accident track log consisted of two data points, with the first data point recorded at 1541:18 hrs and the second at 1541:48 hrs. Figure 1 provides a plot of the two data points and the position of the accident site. The first data point was recorded when the aircraft was travelling at a ground speed of 23 kt on a track of 297º. Altitude was 173 ft amsl. From the low ground speed and terrain elevation, it can be assumed that the aircraft was on the ground when the first data point was recorded. The second data point was recorded after takeoff, at a height of approximately 250 ft agl. The aircraft's groundspeed was 44 kt and its track was 324º. The second data point position was about 290 meters from the accident site.

Video evidence of previous accident

The investigation of the accident to G-PULS[2], another Pulsar, used video evidence which showed the aircraft stalling from a height of approximately 200 ft. The impact sequence and distribution of the wreckage were similar to those identified in the case of G-BULM.

Medical and pathological information

The pilot held a valid NPPL declaration of medical fitness to fly countersigned by his general practitioner on 16 January 2003. His next medical assessment was due on 16 January 2008. Post-mortem examination confirmed that he died of multiple injuries sustained on impact. The pilot had no medical history of relevance to the accident. The accident was essentially non-survivable and it is unlikely that any additional or alternative restraint would have saved the pilot's life.

Techniques for handling a loss of power after takeoff

Evidence from previous accidents and theoretical analysis both suggest that an attempt to return to the departure runway in the event of a loss of power in a single-engine aircraft is unlikely to be successful if the failure occurs shortly after takeoff.

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:

Footnote

[1] Honeywell Bendix / King Skymap II.

Footnote

[2] AAIB Bulletin 9/95, reference EW/C95/7/3.

'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'*[3] used a simplified analytical model to examine the ideal flight path of a single-engine aircraft turning back after a loss of power during the takeoff phase of flight. It indicated that the optimum procedure involved a turn through approximately 190-220º using a 45º 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.'

Several AAIB Bulletins have explored this issue and can be viewed at www.aaib.gov.uk. The report of the investigation into the accident to G-BOIU[4] also considered the influence of a partial loss of power 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

Engineering aspects

The ground marks and damage to the aircraft indicated that the aircraft crashed in a near vertical pitch attitude whilst moving laterally to the left and turning around the longitudinal axis in a clockwise (to the right) direction. This attitude is consistent with the aircraft entering a spin to the right with left rudder applied. Damage to the engine and the propeller support the witness' observation that the engine stopped in flight. There was no evidence of a problem with the control system which would have caused the pilot to lose control of the aircraft.

Whilst the pilot had previously been experiencing problems with the electrical charging system, this would not have caused the engine to stop as the

Footnote

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

Footnote

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

twin ignition system is independent of the charging system. Examination of the stator coil revealed that the resistance of the ignition coils was slightly high; however the engine manufacturer informed the AAIB that these values would have no impact on the engine performance. Given the extent of the disruption to the instrument panel, the Magneto 1 switch could have moved to the OFF position during the impact. It is also possible that there could have been an electrical short in the ignition system or a temperature-related fault in the EU. However, failure of one of the independent ignition systems would not cause the engine to stop and it is highly unlikely that both ignition systems would fail at the same time.

Witnesses described the engine spluttering before it stopped. There was no obvious pre-crash damage to the induction or exhaust system, the throttle cables were still connected, the fuel cock was found switched ON and the fuel/oil ratio in the fuel cans was correct. There was no debris in the fuel cock, gascolator or carburettors; however, with the fuel tank having been destroyed, the possibility that fuel contamination or a blockage in the fuel tank had caused the engine to stop could not be eliminated. The possibility that the aircraft ran out of fuel could also not be eliminated, though the strong smell of fuel at the crash site suggests that this is unlikely. Consideration was given to the impact of the wear on the float needle valve operating arms allowing the fuel level in the carburettor fuel bowls to be slightly higher than normal; this would reduce the head of pressure required to draw fuel into the venturi thereby making the fuel/air mixture richer. The engine manufacturer's judgement was that the amount of wear would make little difference to the mixture ratio. This assessment was supported by the colour of the pistons, cylinder head and spark plugs which all indicated that the mixture was correct. Nevertheless the manufacturer did state that the dimples in the operating arms was unusual and was an indication of engine vibration emanating from the engine mounting installation.

There is no evidence that the baggage compartment modification, or any of the equipment stowed in the compartment, played any part in the accident.

In summary, the engine appeared to have been correctly installed in the aircraft, which appeared to have been in an airworthy condition at the time of the accident. Whilst there is evidence that the engine was not rotating under power when the aircraft crashed, the investigation could not determine the reason why the engine stopped in flight.

Operational aspects

The turn observed by the witnesses and the alignment of the wreckage trail indicated that the pilot attempted to return to the airstrip following the first indication of a loss of power. The pilot might have been encouraged to do so if he perceived the failure to be partial. Insufficient height remained to complete this manoeuvre, however, and the distribution of wreckage, and the impact sequence this suggests, indicate that the aircraft probably stalled before impact. This stall is consistent with the pilot attempting to stretch the glide.

The maximum length (390 m) of the field in which the aircraft crashed was greater than the landing ground roll (243 m) estimated by the design organisation but the approach would have been substantially downwind and, at the point the aircraft commenced its turn away from the takeoff direction, it could not have made use of the full length of this field. Though shorter, the two fields north-north-west of the airstrip would have presented a longer useable landing run and some headwind during the approach. The shorter turn required to line up for either of these fields would also have used less of the height available after the pilot identified the failure.

A loss of power 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 a 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. Whereas, 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.

Safety Sense Leaflet 1a suggests that '*at a safe height, and well away from the circuit*' pilots might '*try a 180º 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. In the absence of a crosswind the aircraft would need to turn through more than 180º to become realigned with the departure runway, however. Also, having sufficient height to complete the turn would not guarantee that the aircraft could land on the runway. If, for example, the takeoff was conducted in a strong headwind the aircraft might overshoot.

All of the available evidence suggests that, following a loss of power in a single-engine aircraft, it is safest to land in open ground ahead. In the case of G-BULM there were two areas of open ground ahead of the aircraft which might have been suitable for a forced landing. 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 appeared to depart from controlled flight approximately 60 feet above ground. The ensuing high rate of descent combined with a turn and touchdown on the wingtip resulted in impact forces which neither the aircraft nor the pilot could withstand.