ACCIDENT

Aircraft Type and Registration:	Piper PA-28-140 Cherokee, G-AVRP
No & Type of Engines:	1 Lycoming O-320-E2A piston engine
Year of Manufacture:	1967
Date & Time (UTC):	5 August 2007 at 1100 hrs
Location:	0.5 nm south-west of Isle of Wight/Sandown Airport
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 3
Injuries:	Crew - 1 (Fatal) Passengers - 3 (Fatal)
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	48 years
Commander's Flying Experience:	687 hours (of which 143 were on type) Last 90 days - 12 hours Last 28 days - 6 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft departed from Runway 23, with four people on board, on a flight to Pontivy, France. Its takeoff ground roll was noticeably long and, having lifted off, G-AVRP climbed to about 50 ft agl and maintained that height as it flew over rising ground beyond the end of the runway. As it approached trees at the top of the rising ground, the aircraft was seen to pitch up and clear the trees before its nose dropped and it descended out of sight. The aircraft struck another line of trees and crashed into a field. The aircraft rapidly caught fire. The fire was extinguished by the Airport Fire-fighting and Rescue Service (FFRS). All the occupants of the aircraft died in the accident and the aircraft was destroyed.

It was established that the aircraft's predicted performance, at its estimated takeoff weight and in the prevailing conditions, should have enabled a successful departure. Its failure to do so may have been the result of reduced engine power, a tailwind component, a greater takeoff weight than estimated, an incorrect piloting technique during takeoff or a combination of some or all of these factors.

Two Safety Recommendations are made.

History of the flight

The aircraft's initial point of departure on the day of the accident was a private airstrip in Staffordshire, 7 nm south of Tatenhill Airfield. The pilot flew from there to Tatenhill, where he picked up three passengers, one of whom had recently bought the aircraft from the pilot and another co-owner. Then, without refuelling or any other delay, G-AVRP departed for Isle of Wight/Sandown Airport (referred to as Sandown Airport), arriving there at 0942 hrs after a flight lasting 1 hour 55 minutes. The aircraft was seen to touch down about halfway along Runway 05 and use most of the remaining runway to stop. With the surface wind from the south-east at 5 to 10 kt and the reciprocal Runway 23 providing an upslope, which favoured landing aircraft, the direction of the runway in use was changed.

While on the ground, the pilot completed a flight plan for an outbound flight to Pontivy, France (Brittany), and a customs declaration form for a return flight from Pontivy later that afternoon. He also enquired about refuelling but was told that there was no fuel available. When the pilot received confirmation that his flight plan had been filed, he and his passengers re-boarded the aircraft for their flight to France.

When the pilot of G-AVRP requested clearance to taxi he also requested a departure from Runway 05, stating that he had a full load. He was advised by the airfield air/ground radio operator that a number of aircraft were inbound to land on Runway 23 and that movements were restricted to that runway. G-AVRP taxied to the holding point for Runway 23, via the airfield's northern taxiway; it is probable that the pilot carried out a power check while awaiting the opportunity to take off. After being advised by the airfield radio operator that there was nothing to affect their departure, the aircraft lined up at the end of the runway and at 1059 hrs the pilot called "rolling".

G-AVRP was seen by various witnesses to continue its takeoff ground roll until it had travelled beyond a public footpath which crossed the runway 584 metres from the start of Runway 23. The aircraft then became airborne and climbed to a height of about 50 ft, maintaining that height as it flew over rising ground towards a wooded copse, 660 metres beyond the upwind end of the runway, in which the tops of some trees reached an elevation of 199 ft amsl. A local pilot estimated that the aircraft's pitch attitude after takeoff was 10-15° nose-up. He also commented that the engine sounded normal.

Just before reaching the copse, which was 150 metres deep, the aircraft was seen to pitch up and clear the tops of the uppermost branches of its trees by about 10 ft. Witnesses at the airfield then saw it disappear from view as it descended behind the trees, with the wings level but the nose down. At about the same time, another witness, who was located 550 metres to the west-south-west of the copse, heard an aircraft taking off from the airfield and, as it came into his view, he saw the aircraft clear the trees by about 20 ft in a nose-down attitude. He thought that it might be attempting to land in the field towards which it was heading. He then heard a "crack" and saw the aircraft descend rapidly. He did not see it strike the ground because his view was blocked by a nearby tree, but he realised that it had crashed and told a nearby householder to call the emergency services while he ran across the field to render assistance.

At approximately 1100 hrs, a member of the public was walking along a path in a thin line of trees that run south from the copse which the aircraft was seen to clear. He recalled hearing the noise of an aircraft engine, which initially sounded normal but then spluttered, as if being "throttled back", and seemed to stop. Two or three seconds later there was a thump. He had not seen the aircraft but concluded that it had crashed in the field to his left and made his way in that direction. Within a few seconds he emerged from the trees and saw an aircraft nose-down in the field with its tail almost vertical, wings level, facing in a northerly-easterly direction. The left side of the fuselage was on fire.

Another member of the public had also arrived on the scene and was standing in front of the right wing next to the aircraft's door. Together they attempted to extricate the heavily built male occupant from what was considered to be the front right seat of the aircraft. He had head injuries and did not respond to their efforts; they were unable to move him more than a few inches before being beaten back by the intensifying fire. During these attempts, one of the two witnesses noticed signs of life in a younger occupant, who was further back on the left side of the cabin and in a seat that had moved into a higher, upright position. This occupant then became silent and the fire suddenly intensified. The right arm of a third person was visible below and between the first two occupants that they had encountered.

These two witnesses retreated 30 to 40 metres and, about a minute after the crash, a private Jet Ranger helicopter arrived from Sandown Airport. On arrival, the crew of the helicopter observed flames on the crashed aircraft's left wing, and other flames rising from the engine cowling up into the cabin. One of the crew disembarked and went over to the two walkers, thinking that they were survivors of the crash. They advised him that there were at least three people in the aircraft. He then attempted to approach G-AVRP but, at a distance of 5 metres, had to shield his face from the intense heat. He could not see the occupants and, as the fire worsened, he observed the tail of the aircraft twist and fall into the cabin. Before re-embarking in the helicopter he called the emergency services.

The emergency services had also been contacted by the aerodrome air/ground radio operator when he had observed smoke emerging from behind the trees which he had just seen the aircraft fly over, before disappearing from view. In addition, the smoke had alerted the aerodrome FFRS, who immediately departed for the scene of the accident.

Between three and five minutes after being alerted, the aerodrome fire vehicle arrived at the accident site and the two fire crew personnel immediately began to fight the fire with a combination of 675 litres of aqueous film forming foam (AFFF), two 9 kg monex powder extinguishers and a 9 kg foam extinguisher. Using all their fire fighting media they extinguished the fire. As their extinguishants ran out, the local fire brigade vehicles arrived and continued to dampen down the aircraft and surrounding area.

Following post-mortems, it was reported that three of the occupants had died as a result of their injuries and that the fourth, the youngest, who had shown some signs of life immediately after the crash, had died as a result of the effects of fire. There was no evidence of any medical condition that could have contributed to the accident.

Accident site details

The aircraft had struck the upper branches of a line of trees approximately 1 km from Sandown Airport and on the extended centreline of Runway 23. It had then crashed, in an inverted attitude, into a wheat field some 60 m beyond the trees. An intense, post-impact fire occurred, which consumed the cabin and fuselage before being extinguished by the Airfield and local Fire Services.

A number of small branches and twigs had been dislodged from the trees, together with a substantial bough of approximately 150 mm in diameter. It was considered that the latter was responsible for causing a large indentation in the left wing leading edge immediately outboard of the main landing gear, which had detached and fallen in the field between the trees and the main wreckage. It is probable that the collision with the tree imparted a significant left yaw, which led to the aircraft becoming inverted before it struck the ground.

The first marks on the ground were two propeller slashes, followed, some 1.3 metres further on, by a shallow impression made by the forward edge of the top of the engine cowling. Windscreen fragments were found close by, together with the propeller. There was an absence of significant damage to the wing tips, with the main force of the ground impact being sustained by the nose/engine. The combination of the ground marks and the disposition of the wreckage indicated that the aircraft had struck the ground with a roll angle of 180° (ie inverted) and with a flight path inclined at approximately 30° to the horizontal. It slid for around 4 metres before coming to rest with the tail, according to witnesses, pointing vertically upwards. As the fire developed, the aircraft settled back into an inverted attitude.

Following an on-site assessment, the wreckage was recovered to AAIB's facility at Farnborough for a detailed examination.

Aircraft history

The aircraft was built in July 1967 and had achieved 9,983 flying hours up to 3 June 2007, the last date for which there was a flight recorded in the aircraft log book. The most recent maintenance was an Annual Check, which was signed for on 10 July 2007, with the same flight hours as the 3 June entry. Prior to this was a 50-Hour Check, on 20 April 2007, with a Star Annual Inspection (ie Certificate of Airworthiness (C of A) renewal) conducted on 3 August 2006.

On 14 July 2007, the aircraft was sold by its two co-owners to the new owner. The log book of the new owner was not recovered, but it is thought that he flew no more than about two familiarisation flights between acquiring the aircraft and the day of the accident. In addition, the log books of the previous co-owners indicated that four flights, totalling 2 hrs 35 mins, were flown since 3 June. The last of these, on 14 July, was likely to have been a familiarisation flight for the new owner. It is thus probable that on the morning of the accident, fewer than 5 hours would have been flown on the aircraft since the Annual Check.

The engine was a Textron Lycoming, factory overhauled unit, sourced from a UK agent in March 1997 and fitted to G-AVRP in May 1997. In its first year of operation, the aircraft flew only 25 hours. Over the next 5 years, it averaged approximately 150 hours per annum, reducing to around 53 hours per annum for the last 4 years. It had achieved in excess of 980 hours at the time of the accident.

In July 1999, at approximately 240 operating hours, the engine was removed and disassembled in order to conduct a shock load inspection, although the log books did not record the reason for this. The work included polishing the main and connecting rod journals, honing the cylinder bores and re-facing and lapping the valves and seats. In addition, a log book entry in January 2002 recorded the repair of some minor propeller damage.

The aircraft documentation did not include any recent refuelling records although there were some old receipts for Avgas. Although the aircraft is likely to have started the day of the accident with full tanks, there was no fuel taken on at Tatenhill; nor was there any record of any recent sale of fuel to the aircraft from that airfield. During the investigation there was some anecdotal evidence that a private supply of Avgas was available, with the possibility of motor gasoline being used on occasions.

Examination of the aircraft

The extensive fire damage to the cockpit area meant that the remains of the instruments yielded little useful information. However, the throttle control was identified, and was found pushed fully forward, ie at the full power position. The flap operating lever, located on the floor between the front seats, was found in its lowest detent, indicating that the flaps were retracted at impact.

The extremities of the aircraft were all accounted for and the flying control operating cables had remained intact. The single cabin entry door, located on the right side of the aircraft, was largely consumed in the fire. However, part of the door frame was recovered, which contained the door latch engagement slot; this was damaged in a manner that suggested that the door had burst open in the impact. The aircraft was not equipped with a baggage door.

Examination of the engine

The engine had been affected by the fire to the extent that the magnetos had been badly damaged and the ignition harness had been destroyed. The carburettor had broken off its mounting on the underside of the engine but had remained attached to the aircraft by its control cables. The carburettor air box had been badly distorted in the impact, but it was possible to establish that the heat control lever was in the COLD position.

Burnt residues within the carburettor float chamber, together with a sample of oil sludge, were analysed in a laboratory. Traces of lead were found in the carburettor residue, indicating that leaded gasoline had been used recently, although it did not necessarily prove that it was being used at the time of the accident. No evidence of lead was found in the oil sludge sample, although this might simply be due to the recent oil change.

The engine itself was subjected to a strip examination at a UK overhaul agent for Textron Lycoming, under the supervision of the AAIB. During this process, it was noted that the camshaft was correctly timed to the crankshaft and that the oil pump, main and big end bearings were all in good condition. The spark plugs were normal in appearance, with a lead nodule being evident on one of them, indicating the recent use of leaded gasoline.

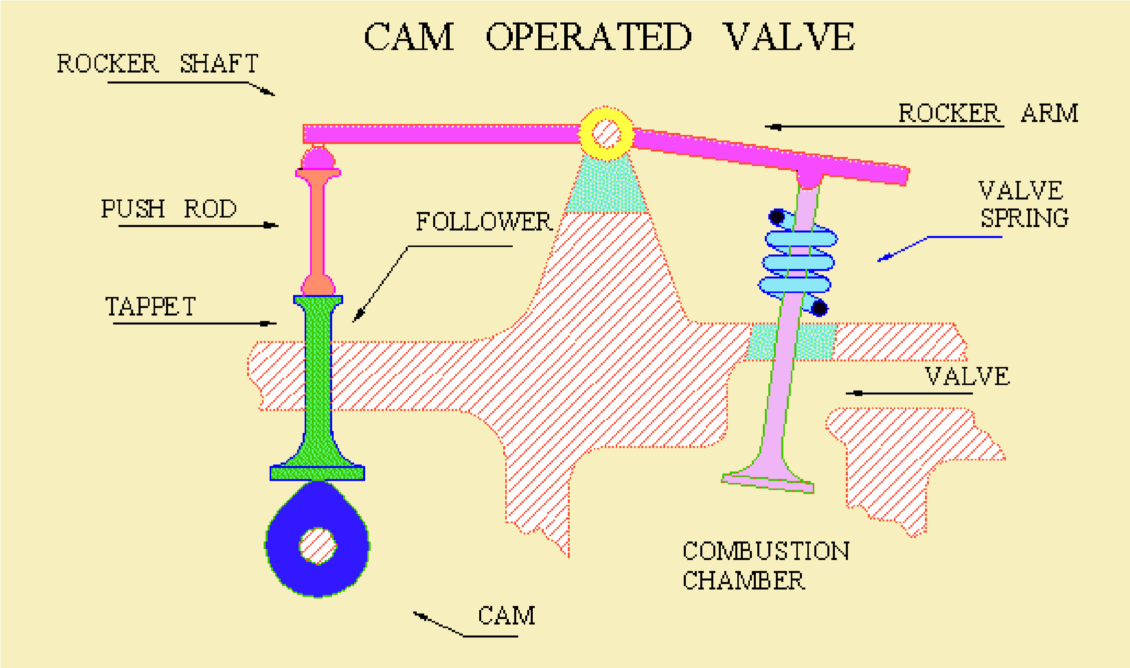
On removing the camshaft it was noted that the surface of one of the cam lobes exhibited evidence of severe spalling[1], with the valve-lifting portion of the profile having been worn down to a significant extent. In addition the surfaces of the cylinder Nos 1 and 2 cam followers had suffered considerable pitting where they had been in contact with the damaged cam lobe.

Photographs of the camshaft, the damaged lobe and the associated cam followers are shown at Figures 1 and 2. Also shown is a sketch indicating the principle of cam/valve operation, although in the subject engine, the cam followers contain hydraulic tappets, which become charged with oil when the engine is running, causing them to expand so that they take up clearances between the various components in the valve operating system. It should be noted that although there is a total of eight valves in the engine, the camshaft has only six lobes because the second and fifth lobes (counting from the front of the engine) each operate the inlet valves of opposing cylinders, Nos 1/2 and 3/4 respectively. Each exhaust valve is operated by a dedicated cam lobe. The effect of the wear was to remove approximately 0.138 in from the cylinder Nos 1/2 inlet valves cam 'peak', which would have resulted in a corresponding loss of inlet valve lift for both cylinders.

The material removed from the cam lobe would have been in the form of finely divided metallic debris, much of which would have fallen into the sump and

Footnote

[1] Process by which flakes of a material are broken off a larger solid body; this can be produced by a variety of mechanisms.

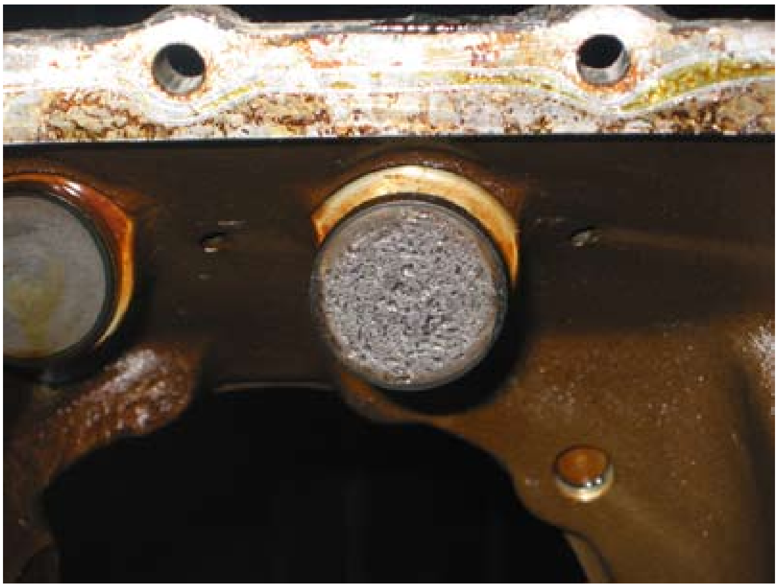


Sketch showing principle of valve operation

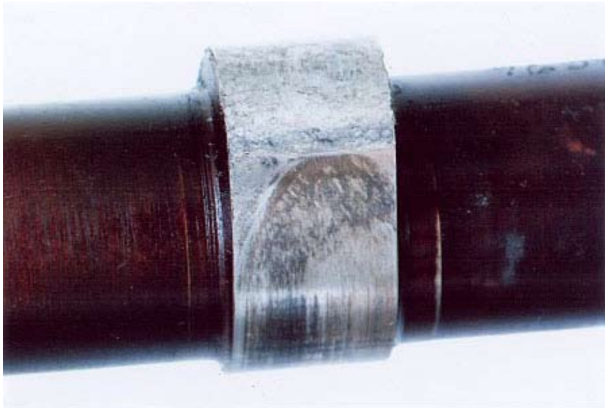
Worn cam lobe, as found during engine strip

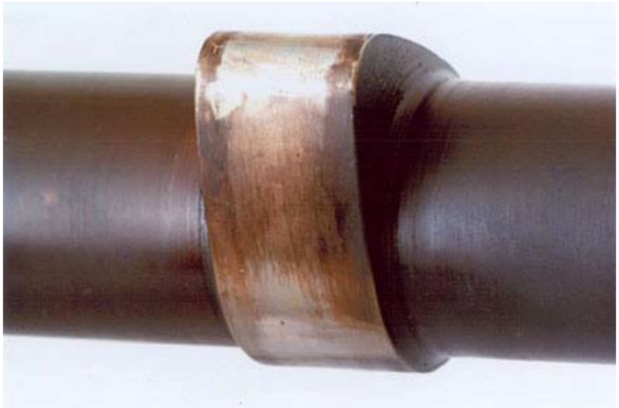
Figure 1

Valve operation and camshaft details



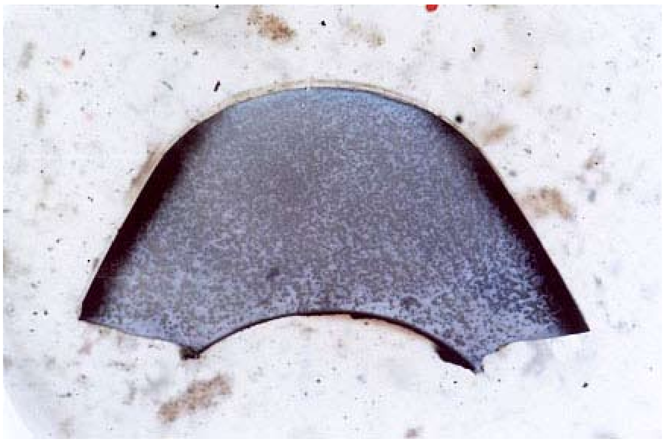
View of spalling on one of the cam followers

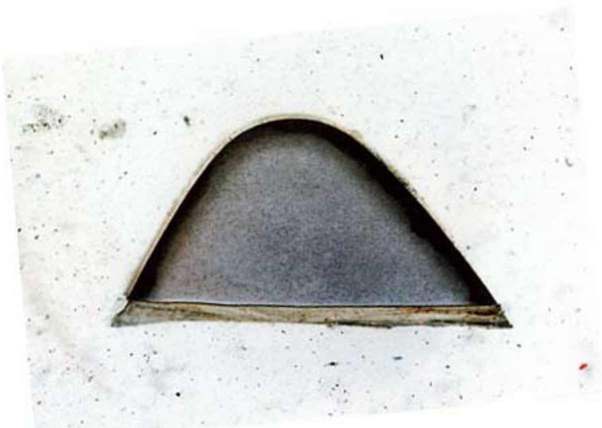




Photos: HT Consultants

Comparison of worn and normal cam lobes





Photos: HT Consultants

Section through worn and normal cam lobes. Note hardened layer showing as dark areas

Figure 2

Details of worn cam

subsequently been caught in the filter. The filter element was recovered but had been partly carbonised within its container, due to the effects of the fire. However, after the remains of the element had been crushed, a quantity of magnetic material, which is likely to have originated from the cam lobe, was apparent within the debris mass. The amount of magnetic material appeared small in relation to the missing portion of the cam, which raised the question of its whereabouts. The scavenge filter was clear, although this had a relatively coarse mesh. The sump was not fitted with a magnetic plug. Some metal particles were observed clinging to the surface of the No 1 piston skirt, although the quantity was small. Whilst it is possible that some debris could have been held in suspension in the oil, it was considered that much of the wear could have occurred prior to the Annual Check on 10 July 2007. The oil change carried out at this time ought to have included the process of examining the old filter to look for any metallic debris, thus allowing an opportunity for investigation, should any have been found.

A metallurgical examination of the camshaft included micro hardness tests on the cam lobe wearing surfaces. During manufacture, the camshafts are subjected to a carburising process, in which carbon is diffused into the surface of the material, resulting in a hardened layer. According to the engine manufacturer, the hardness depth should be around 0.030 to 0.045 in. In fact the micro hardness tests revealed that there was no significant reduction in hardness values until approximately 0.050 in below the surface. The amount of wear on the affected cam lobe was considerably more than this: the wear rate would have increased rapidly once the hardened layer had been removed.

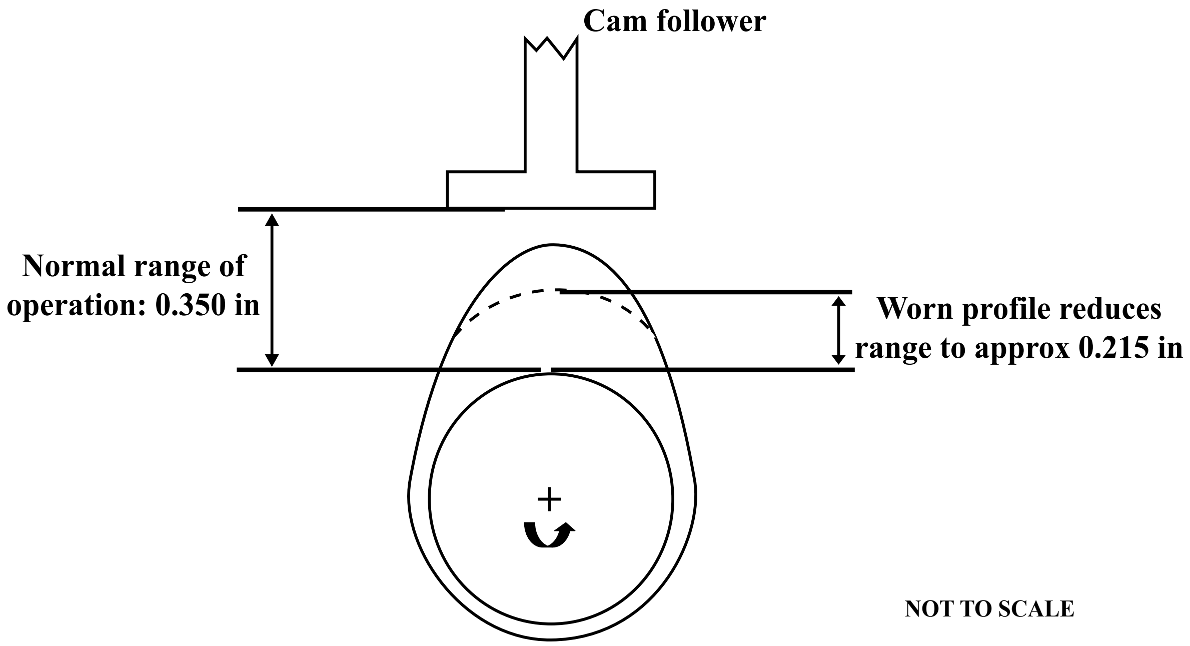
The remainder of the cam lobes appeared in good condition, with little wear having occurred.

Cam wear and its effects

Cam wear is not a new problem and can occur for a number of reasons, such as infrequent engine use and condensation-induced corrosion arising as a result of the aircraft being parked outside in humid conditions. As the camshaft is located at the top of the engine, oil quickly drains away following shutdown. Although an oil film is left behind, condensation can sometimes result in a corrosion pit, which initiates a spalling process between bearing surfaces. When the engine is started from cold, the first few revolutions tend to remove the oil film, thus allowing metal-to-metal contact, until fresh oil is supplied from the pump. The front cam lobes are the most vulnerable as they are located furthest from the oil pump.

A Textron Lycoming Service Instruction, No L180B, issued in November 2001, contains advice on engine preservation for active and stored aircraft. In particular, it recommends a procedure to be followed if it is known that the engine is to remain inactive for 30 or more days. It additionally cautions against pulling the engine through by hand prior to start, as this simply wipes the oil film from cylinder walls, cams and followers, thus extending the period of exposure to which these components are subjected before oil is circulated from the pump.

It is difficult to establish a typical timescale, in terms of engine operating hours, for cam lobes to wear through the case hardened layer, and at which point the wear rate would increase by an unpredictable amount. In addition, the engine manufacturer was unable to provide a figure of how much wear can occur before engine maximum power output is affected. The diagram overleaf illustrates how the cam wear affects valve operation.



The effect of the cam wear in this case was to reduce the cam follower range of movement by approximately 40%. This in turn would reduce the amount by which the inlet valves opened during the induction stroke, thus possibly resulting in a lower volume of fuel/air mixture and ultimately, reduced engine power output.

There is no routine maintenance carried out on the engine that attempts to measure any cam wear, other than an examination of the removed oil filters. Apart from the reduction in maximum power, there would be no other symptoms, such as rough running. Nor would there be any increase in noise, as most, if not all, of the cam wear would be taken up by the expansion of the tappets.

Additional tests

In order to provide additional data concerning cam lobe wear, a UK engine overhaul company conducted a series of engine runs under the supervision of the AAIB. For this they procured a time-expired (ie 2000+ hours) engine of the same model as that fitted to G-AVRP and separately identified a camshaft on which the front lobe was worn almost to the same extent, ie 0.136 in compared with 0.138 in for the accident aircraft. The engine was rebuilt with the worn camshaft installed and run on a test stand, on which the engine was driving a fixed pitch 'club' propeller, specially designed for test purposes. The manifold pressure and rpm were monitored throughout the operating range and several 'slam accelerations' were carried out. The engine operated smoothly throughout, apart from a reluctance to accelerate from a low rpm. Significantly however, the maximum rpm obtained was 2,575, as opposed to 2,700 for an engine in good condition. This equated to a peak power of 134 bhp, compared with the rated value of 150 bhp, ie a loss of around 10%.

The engine was then disassembled and rebuilt once again, this time using a new camshaft. The opportunity was also taken to renew the main and big-end bearings. (Note: this was a decision taken by the engine overhaul company in preparation for eventually releasing the engine as an overhauled unit. As a result, the 'tightness' of the bearings may have absorbed a small amount of power during the subsequent test.) During the next run, it was noted that a higher rpm was achieved for an equivalent manifold pressure throughout the operating range. This translated into a corrected peak power value of 144 bhp. Whilst this figure is still less than the rated value, it should be noted that, camshaft apart, the engine was largely still in its time-expired condition; thus the shortfall would be due to the combined effects of degradation of the cylinder bores, piston rings, cylinder heads and valves. Since the engine from G-AVRP was only half-way through its overhaul life, the equivalent losses from these sources might be expected to be less.

In conclusion, the tests indicated that at least 10 bhp was lost solely as a result of the cam wear, representing 6.7% of the rated maximum power of the engine. It is thus probable that a similar loss may thus have occurred in the engine from G-AVRP, in which the cam wear was marginally more.

Personnel

The pilot had been issued with a UK Private Pilot's Licence (Aeroplanes) (PPL(A)) in November 1998, with a rating that qualified him to fly as pilot in command of microlight aeroplanes (landplanes). In February 2005 he qualified for a Joint Aviation Requirements (JAR) PPL(A) with a class rating for Single Engine Piston (Land) (SEP(Land)) aeroplanes. This rating was revalidated in February 2007.

The pilot's most recent JAA class 2 medical certificate was issued on 7 November 2006, expiring on 7 November 2008.

He had flown into Sandown Airport a number of times before. Prior to the accident, his most recent flight from the airfield was on 17 June 2007 in a Vans RV-7A.

Meteorology

During the investigation an aftercast was obtained from the Met Office. At the time of the accident, the synoptic situation showed a slow moving low pressure area over the Irish Sea; much of southern England was cloud-free due to the advection of dry, continental air from the French coast in a light to moderate southerly flow. There was no significant weather in the vicinity of the accident site, where visibility was between 13 km and 26 km. The estimated surface wind was from 160° at 3 to 7 kt, possibly varying in direction between 110° and 220°; the wind at 500 ft agl was estimated to be from 200° at 12 kt. The temperatures at the surface and at 500 ft were assessed to be 22°C and 20.5°C respectively. The mean sea level pressure was 1009 millibar.

With the presence of the built-up area to the south-east of Sandown Airport, it was considered that the combination of roughness of the airflow over the buildings and higher surface temperatures may have induced variability in the surface wind at the accident site. The aerodrome operator recalled that the surface temperature at the airport was 27°C, which was included in a meteorological observation taken at the time of the accident, and the surface wind was described as light and variable. Subsequently, a record of that observation could not be located. A further, detailed assessment of the temperature at Sandown Airport was carried out and it was estimated that the surface temperature at the aerodrome at 1100 hrs was between 23°C and 25°C. The temperature at 500 ft agl was also revised to between 21°C and 24°C.

Photographs of smoke rising from the crashed aircraft, taken three minutes after the accident had occurred, and another 12 minutes later, appeared to show that the surface wind at the accident site varied during that time between a south-easterly and north-easterly direction.

The impression was of a light wind. The pilot of another Piper PA- 28-140, which took off from Runway 23 at 1030 hrs, reported that the indications from the wind sleeve on the airfield, at that time, were of a surface wind from between 110° and 120° ie a tailwind. The wind sleeve, which is located abeam the threshold of Runway 05 and visible from the Runway 23 threshold, is fully elevated when the wind speed reaches 25 kt. In this instance it was elevated approximately two-thirds.

The CAA conducted a three-yearly assessment of the extent of the meteorological services at Sandown Airport on 15 August 2007; this had been arranged before the accident on 5 August. It was confirmed that the anemometer at the airport, which provided the air/ground radio operator with a digital readout of the wind speed and direction on a Davis Weather Monitor 2 weather station, showed good correlation with other anemometry and the airport's wind sleeve. The temperature sensor on the weather station was also assessed and found to be accurate, within the tolerance limits given in Civil Air Publication (CAP) 746, *Meteorological Observations at Aerodromes*.

CAP 746 also includes the requirement for a meteorological observation in the event of an aircraft accident. It states:

> *'The observer shall provide a full non-routine observation at the time of an aircraft accident on or in the vicinity of the aerodrome. This is to ensure that complete details of the weather at the time of the incident will be available to an official inquiry.'*

The CAA noted that the aerodrome staff were aware of this requirement. It was considered that the aerodrome offered *a comprehensive, quality meteorological service to its users*, providing briefing facilities in the control tower and the restaurant on the airport.

CAP 168, *Licensing of Aerodromes*, provides guidance on the positioning of wind sleeves. It states that they:

> *'should be so positioned on the aerodrome as to be visible from the approaches to all runways and be free from the effects of any disturbances caused by nearby objects. They should be sited so that at least one sleeve is visible from each take-off position .... Preferably between 300 m and 600 m from the runway threshold measured along the runway...'*

Airfield information

Sandown Airport is a licensed aerodrome at an elevation of 55 ft amsl. The Takeoff Distance Available (TODA) on grass Runway 23, as published in the UK Aeronautical Information Publication (UK AIP), is 884 metres. When measured, shortly after the accident, the length of the grass on the runway was less than or equal to the maximum recommended length of 4 inches. The runway has a 1% upslope.

Runway 23 is designated as a code 1 runway for the purpose of determining the freedom from obstacles when landing and taking off. As such, its takeoff obstacle limitation climb surface has a slope of 5%, originating 30 metres beyond the end of the takeoff run and extending out to a distance of 1,600 metres, orientated on the extended centreline. The inner edge of this surface is 60 metres in width and the outer edge is 380 metres wide, with a linear increase in width of the surface between the two edges. See Figure 3.

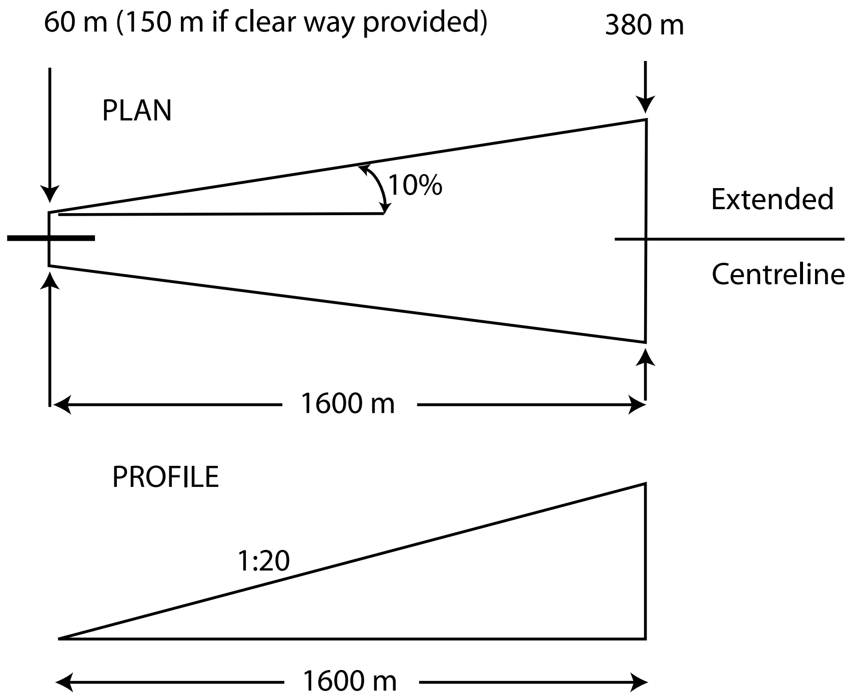


Figure 3

Takeoff climb surface associated with a runway where the code number is 1

Civil Aviation Publication (CAP) 168, entitled *Licensing of Aerodromes*, states:

> *'In ideal circumstances all the surfaces will be free from obstacles but when a surface is infringed, any safety measures required by the CAA will have regard to:*
>
> *a) the nature of the obstacle and its location relative to the surface origin, to the extended centreline of the runway or normal approach and departure paths and to existing obstructions;*
>
> *b) the amount by which the surface is infringed;*
>
> *c) the gradient presented by the obstacle to the surface origin;*
>
> *d) the type of air traffic at the aerodrome;...*

> *... Safety measures could be as follows:*
>
> *a) promulgation in the UK AIP of appropriate information;*
>
> *b) marking and/or lighting of the obstacle;*
>
> *c) variation of the runway distances declared as available;*
>
> *d) limitation of the use of the runway to visual approaches only;*
>
> *e) restrictions on the type of traffic.'*

It also states that:

> *'Existing objects above an approach surface, transitional surface, take-off climb surface, inner horizontal surface or conical surface should as far as practicable be removed...'*

An aerodrome survey in May 2006 identified nine trees in the copse, over which the aircraft was seen to climb, that penetrated the takeoff climb surface associated with Runway 23 by between 3.26 metres (10.7 ft) and 7.28 metres (23.9 ft). It is likely that these trees, which were not felled or pruned, grew in the intervening 14 months up to the time of the accident and that they then represented a higher obstacle. At the time of the survey, the trees identified were up to 144 ft above the elevation of the airfield, within 820 metres of the upwind end of Runway 23. The highest of these trees was included in the AIP entry for Sandown, under *Aerodrome Obstacles*.

Since the accident, a permanent Notice to Airmen (NOTAM) has been published for Sandown Airport cautioning pilots against *'rising ground and trees to SW and NE of AD'*. The airport operator has appointed a contractor to control and manage the trees within the various obstacle limitation and safety surfaces at the Airport to maintain a balanced runway and an obstacle (tree) free environment.

Figure 4 shows a photograph taken from half way down the runway, looking south-west.

Aerodrome communications

The airport provides an air/ground communications service (AGCS), as described in CAP 452, *Aeronautical Radio Station Operator's Guide*. The phraseology specific to an AGCS is provided in CAP 413, *Radiotelephony Manual* (Chapter 4). It states:

Figure 4

Photographs of Runway 23 looking south-west

> *'Information provided by an AGCS radio station operator may be used to assist a pilot in making decisions, however, the safe conduct of the flight remains the pilot's responsibility.'*

CAP 413 also includes examples of phraseology for use by an AGCS, see Table 1.

It was normal practice for the airport's air/ground radio operator to provide pilots, in radio equipped aircraft which were preparing to take off or land, with advice on the surface wind, as determined from the wind sleeve. This was given in the form of a general wind direction ie from the left or right, or from the south-east, north-west etc with the speed being judged from the angle of the wind sleeve. Pilots were also advised if there was a tail wind. The digital wind readout was regarded as a secondary source of wind information.

Recorded information

Primary and secondary surveillance radar information from the radar heads located at Clee Hill and Pease Pottage was available for the aircraft's flight prior to the accident flight. Figure 5 shows this track, starting at 0748:23 hrs as G-AVRP climbed away from Tatenhill airfield, to the west, ending at 0939:40 hrs with the aircraft approaching Sandown Airport. No more radar data of G-AVRP was available.

Performance

The pilot's flight plan specified a route to Pontivy which took G-AVRP via the NDB at Cherbourg and overhead Avranches, a total distance of 186 nm. It also indicated that the aircraft would cruise at 105 kt and had an endurance of 2 hours. The majority of the fuel on board was burned off during the fire following the crash, but it was estimated that the aircraft's takeoff weight at Sandown was 2,120 lb. This was based on the minimum fuel that was understood to have been on board, and is below the maximum allowable takeoff weight of 2,150 lb.

For the conditions estimated to have existed at the time, the Takeoff Distance Required (TODR) by G-AVRP was between 771 metres and 789 metres. The associated Takeoff Run Required (TORR) was between 424 metres and 434 metres and the Net Gradient of Climb on the takeoff flight path, between heights of 50 ft and 1,000 ft aal, was between 7.1% and 7.3%. These figures, derived from the Aeroplane Flight Manual (AFM), are net data and include margins for loss of performance due to factors such as small and unavoidable variations from the correct airspeed, and variations from the average airframe drag and engine power. G-AVRP's AFM was not on the aircraft and was recovered from the initial point of departure.

Event	Response
A/C requests taxi information	(Aircraft callsign) runway (designation) left/right hand circuit wind number (degrees) number (knots) QFE/QNH (pressure) millibars.
A/C reports ready to take off	(Aircraft callsign) no reported traffic (or traffic is...) surface wind (number) degrees (number) knots.

Table 1

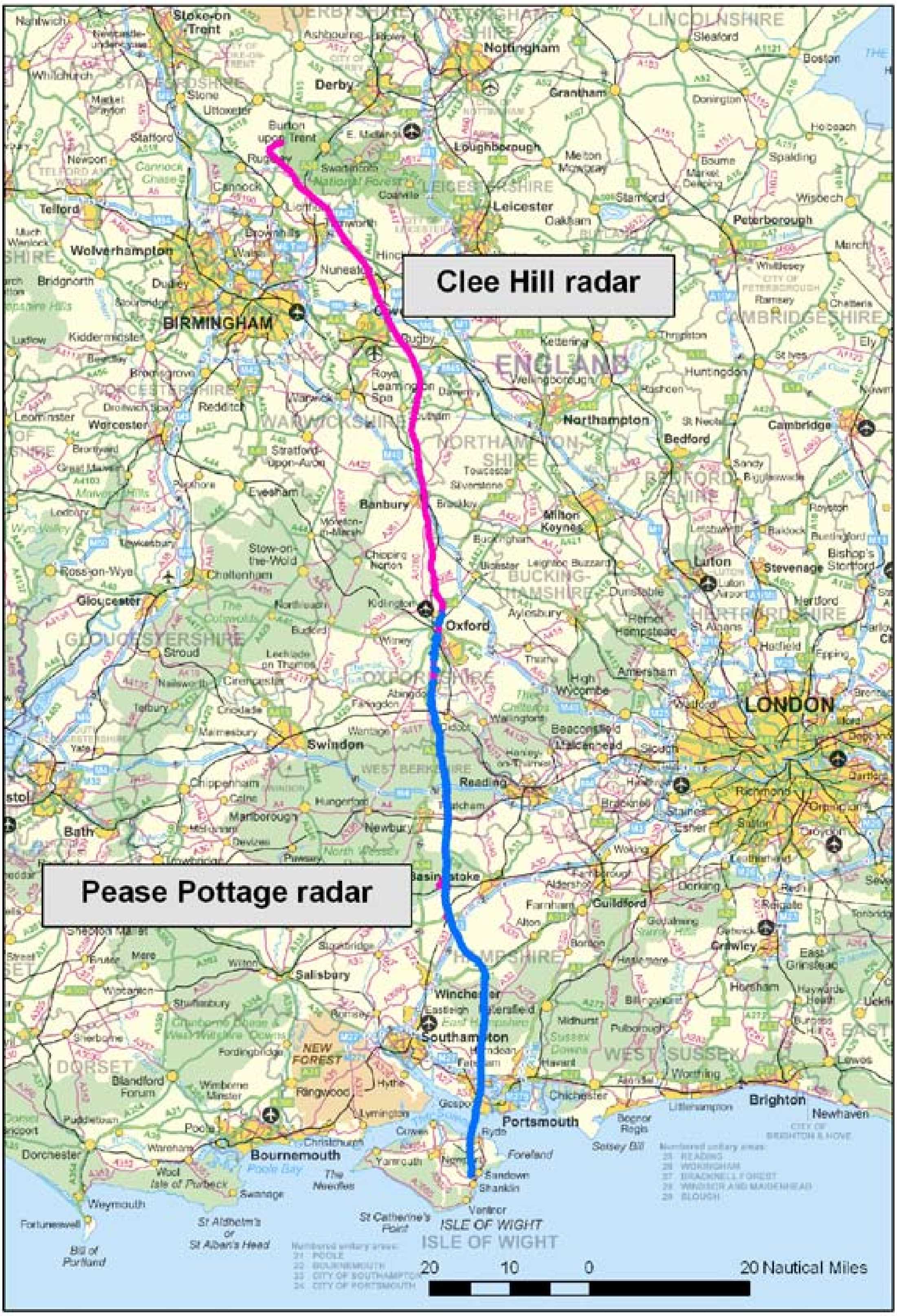


Figure 5

G-AVRP's flight track from Tatenhill to Sandown Airport

If the surface temperature was 27°C, as advised verbally, the TODR and TORR would have been 820 metres and 451 metres respectively, and the Net Gradient of Climb on the takeoff flight path would have been marginally shallower, at 7.0%.

Some specific UK registered PA-28-140's AFMs include CAA Change Sheet No. 3 issue 1 to the FAA approved UK Flight Manual. This specifies corrections which are applicable to certain performance calculations and reflect that aircraft's less capable performance, as noted during an airworthiness flight test. This CAA Change Sheet had not been issued for G-AVRP's AFM.

As an example, for the estimated conditions at the time, and incorporating the CAA Change Sheet corrections, increases the TODR to between 848 and 868 metres and the TORR to between 466 metres and 477 metres. The Net Gradient of Climb on the takeoff flight path reduces to between 4.6% and 4.7%. Similarly, if the surface temperature was 27°C, the TODR and TORR would become 902 metres and 496 metres respectively, and the Net Gradient of Climb on the takeoff flight path would be 4.4%.

The TODR, from rest to a height of 50 ft aal, is based on the following takeoff technique, as advised in the AFM:

'Engine: Full throttle

Wing flaps: Retracted

Lift-off initiated at the take-off safety speed of 74 mph (64 kt).'

The net gradient of climb between 50 ft aal and 1,000 ft aal is predicated on that speed, configuration and throttle setting being maintained. There is no data in the AFM for takeoff performance with flaps selected.

On the evidence available, the aircraft's centre of gravity was calculated to be at 90.6 inches aft of the datum; within the permitted range, towards the forward limit of 89.55 inches aft of the datum.

The aircraft's power-off stalling speed at a weight of 2,120 lb, with the flaps retracted, was 61 mph (54 kt). With 10° of flap set, the power-off stalling speed, at the same weight, was 52 mph (46 kt). A stall warning light was installed on the instrument panel to provide warning at a uniform 5 to 10 mph speed increment above the stall, in all configurations. During the aircraft's last airworthiness flight test, in July 2003, the aircraft stalled within 1 mph of its scheduled stall speed. During the stall the nose dropped but the wings remained level.

CAA Safety Sense Leaflet 7c, entitled *Aeroplane Performance*, states under the heading *TAKE OFF – POINTS TO NOTE*;

*'**Decision point**: you should work out the runway point at which you can stop the aeroplane in the event of engine or other malfunctions e.g. low engine rpm, loss of ASI, lack of acceleration or dragging brakes. Do NOT mentally programme yourself in a GO-mode to the exclusion of all else.'*

The aircraft's earlier departure from Tatenhill Airfield, at a cooler time of day, was not observed. Its asphalt Runway 08/26 is 1,190 metres in length, which is also the TORA. The airfield is situated on higher ground than the surrounding countryside and there are no significant obstacles for aircraft taking off.

Air tests

The most recent air tests carried out on the aircraft were in May 2000 and July 2003; these were conducted by the same pilot on both occasions from the same airfield (Tatenhill) and comprised part of the renewal of the Certificate of Airworthiness (C of A). The performance section of the Airworthiness Flight Test Schedule included a timed climb; a comparison of the results is shown below, see Table 2.

Note that for the maximum power check on the ground, the Schedule requires the aircraft to face crosswind unless the wind strength makes this hazardous, in which case the aircraft should be parked into wind. Scheduled rate of climb is determined from the Performance Section of the Flight Manual.

The Flight Test Schedule notes that:

> *'Unless it is impractical to do so, the aircraft should be loaded to maximum take off weight. It is permissible to test at a lower weight if climb data and stall speeds are scheduled with weight.'*

It can be seen from the table that the aircraft was loaded reasonably close to its maximum authorised weight of 2,150 lbs.

After completing the flight test an Engineer's Declaration on the front page of the Schedule is signed, which certifies that the air test results are within the allowable tolerances. If there is a shortfall in the climb rate, the reasons for acceptance must be stated, although a shortfall in excess of a specified maximum value should not be submitted unless discussed with the CAA Flight Department. The maxima in the 2000 and 2003 tests were respectively 80 and 70 ft/min; the difference was due to the 2003 test being completed using a later revision of the Test Schedule. The reason for accepting the shortfall in the 2000 air test was stated as *"Weather conditions"*, with the explanation in the later test being "*A/C in need of paint strip and re-spray"*.

Parameter	**May 2000**	**July 2003**
Max power engine rpm on ground	2350	2290
Mean weight, lb	1974	1966
Mean altitude, ft	2460	2480
Mean OAT, °C	+16	+14
Scheduled rate of climb, ft/min	620	610
Observed rate of climb, ft/min	580	540
Difference from scheduled, ft/min	-40	-70

Table 2

In October 2005 the CAA issued Letter to Owners/ Operators No 2839, which gave advice on changes to the CAA's policy for flight testing resulting from the implementation of European Commission Regulations. Additional information was contained in Airworthiness Notice (AN) No 48, issue 4 of which is dated 29 September 2006. Both publications refer to the European Aviation Safety Agency (EASA) Regulations Part M, which deals with continuing airworthiness, the responsibility for which has passed from the CAA to EASA. Part M, Section B requires a 'Competent Authority' (ie the CAA in the UK) to develop a survey programme to monitor the airworthiness status of aircraft on its register. The procedure is laid down in M.B.303, with details of acceptable means of compliance contained in AMC M.B. 303 (b); 'Aircraft Continuing Airworthiness Monitoring'. This paragraph lists a number of items that sample product surveys of aircraft would include, such as 'In-flight surveys, as deemed necessary by the competent authority'.

Prior to these Regulations the flight testing regime for all aircraft was published in the British Civil Airworthiness Requirements (BCARs), with Section A3-5 dealing with flight testing for renewal of the Certificate of Airworthiness or Permit to Fly.

The EASA Regulations will not be fully in force until 28 September 2008 but the AN anticipates the measures that need to be in place by that date and identifies when a flight test is necessary. A fundamental change arising from these Regulations is that EASA aircraft are no longer subject to the systematic programme of continuing airworthiness flight test (CAFT), previously carried out at the time of C of A renewal, or to an agreed flight test sampling programme, required under the BCARs. No distinction is made between privately operated aircraft and those engaged in Civil Air Transport (CAT). Therefore, no flight test was conducted on G-AVRP at the last C of A renewal in August 2006.

Other accidents and incidents

AAIB Bulletin 1/1997 reported on an accident at Sandown Airport involving a PA-28-140, registration G-OHOG, which descended into the trees 800 metres beyond the end of Runway 23 while taking off. These were the trees over which G-AVRP managed to climb, before descending into the ground. The pilot of G-OHOG had commented that his aircraft had climbed at a shallow angle to clear the trees, but that it encountered disturbed air when it was 30 ft to 40 ft above them. The aircraft then began to sink towards the trees and, realising that a collision would occur, the pilot closed the throttle and raised the nose of the aircraft to reduce the severity of impact.

It was calculated that G-OHOG, with four people on board, had weighed 2,150 lbs, and an aftercast report, from the Met Office, assessed the surface wind as being from 120º at 3 to 7 kt, with the surface temperature at 20°C and the mean sea level pressure 1021 millibar.

Evidence indicated that some flap was selected for the takeoff and that the stall warning light was illuminated on the instrument panel as the aircraft flew past the light aircraft parking area adjacent to the threshold of Runway 05. It also appeared to be illuminated prior to impact with the trees.

Discussion

Performance

The weight of G-AVRP at the time of the accident was estimated to be close to the maximum authorised, which suggests that it must have taken off from Tatenhill earlier that morning overweight. There were no witnesses to this takeoff so no comment can be made as to the length of takeoff run or the subsequent climb performance. However, the 1,190 metres of available asphalt runway and the relatively cool temperature may have served to mask any performance shortfall caused by the excessive weight or lack of engine power.

The aircraft's predicted performance at Sandown Airport, calculated on the basis of the estimated takeoff weight and the conditions that were assessed to have existed at the time, indicated that G-AVRP should have taken off successfully, avoiding all obstacles. The fact that this was not the case could have been because of a number of factors.

The shortfall in the aircraft's climb performance during its last Airworthiness Flight Test, in July 2003, was at the maximum limit and, subsequently, the investigation revealed wear in the engine. The performance capabilities of certain UK registered PA-28-140s have been downgraded, following flight test. When considered necessary, this is applied in the form of a CAA Change Sheet to a particular aircraft's AFM. Such an amendment had not been issued for G-AVRP and, consequently, the performance calculations may have been optimistic.

It is possible that the wind shifted during the takeoff, presenting the aircraft with a tailwind, or that there was an initial tailwind of which the pilot was not aware. The aircraft's estimated takeoff weight, which was based on the minimum fuel that was understood to have been on board, may have been greater, increasing the TODR and reducing the climb performance. Also, it is conceivable that the takeoff technique, in particular the aircraft's speed, differed from that recommended in the AFM, again with an adverse effect. Finally, there is no record of the surface temperature at the airport upon which to base an accurate assessment of the aircraft's performance capability; an increase in temperature reduces the performance of the aircraft.

The length of the aircraft's takeoff ground roll appears to have exceeded the calculated TORR by 163 metres. It also exceeded, by some 85 metres, a TORR that was calculated on the basis of the warmest surface temperature that was recollected and also included the CAA Change Sheet performance corrections which are added to some other PA-28-140s. This indicates that G-AVRP was underperforming even before it lifted off the runway and that there were early signs that the takeoff was unlikely to be successful. Consequently, it would have been appropriate to abort the takeoff at that stage. CAA Safety Sense Leaflet 7c, entitled *Aeroplane Performance*, advises selecting a decision point on the runway at which the aeroplane can be stopped in the event of lack of acceleration during takeoff.

Some trees, notified in the AIP, penetrate Runway 23's takeoff obstacle limitation climb surface, which has a 5% slope. Since the accident, a contractor has been appointed to control and manage the trees to maintain a balanced runway and an obstacle-free environment.

Once airborne, it is likely that the pilot was attempting to use all the energy available in the aircraft to clear the obstructions ahead. Accordingly, the aircraft's nose-up attitude was seen to increase as it cleared the trees approximately 700 metres beyond the end of the runway. In doing so, its speed would have reduced and, realising the aircraft's predicament, the pilot may have decided to land it in the field where it crashed, contacting trees in the process, which caused lose of control. Alternatively, G-AVRP could have lost sufficient speed for it to stall. The aircraft's stall behaviour during its last Flight Test resulted in the nose dropping while the wings stayed level. This reflects the observations of witnesses at the airport when the aircraft disappeared from view.

The pilot requested Runway 05 for his departure, but was advised that Runway 23 was in use because of landing traffic. His decision making would have been assisted by a suitably located wind sleeve within 300 metres to 600 metres of the threshold of Runway 23, as advised in CAP 168, *Licensing of Aerodromes*, in addition to the airport's one wind sleeve, which is located abeam the threshold of Runway 05.

Engine

The engine had sustained considerable damage in the impact and subsequent fire. Consequently it was not possible to test the magnetos or the integrity of the ignition harness. Nor was it established, in the absence of the refuelling history, what type of fuel was being used at the time of the accident, although the presence of a lead nodule on a spark plug, together with evidence of lead in the carburettor residues, indicated the recent use of leaded fuel. The use of motor gasoline can make an engine more susceptible to stopping as a result of vapour lock. However, the engine kept running in this case, which, together with the apparent lack of problems on the two flights to Sandown, suggests that the fuel type was not a factor in the accident.

No major mechanical failure had occurred in the engine, although the cam lobe that operated the inlet valves of cylinders 1 and 2, had suffered a considerable amount of wear. This had resulted in a reduction of approximately 40% of the cam follower range of movement, which in turn would have caused a similar reduction in valve opening. A consequence of this could be that a reduced amount of fuel/air mixture would be drawn into the affected cylinders during the induction stroke, with a corresponding reduction in maximum power output. Indeed, additional tests indicated that, in an engine with a cam lobe worn to a similar degree, at least 10 bhp was lost solely as a result of the cam wear, representing 6.7% of the rated maximum power of the engine. It is thus probable that a similar loss may have occurred in the engine from G-AVRP.

Worn cams are not a new problem, yet there is little or no available data on wear rates or effect on power. A number of AAIB investigations have revealed worn camshafts in accidents where performance issues have not been a concern. Similarly, whilst engine overhaul agents can find worn cams in engines that have been reported by their owners to be down on power, cam wear can be found in engines where there have been no such reports. This suggests that a degree of wear can occur without impacting on engine performance and/or many pilots are simply unaware of performance deterioration because, for example, they seldom operate their aircraft at maximum weights out of limiting airfields.

On aircraft with fixed pitch propellers, such as G-AVRP, confirmation of maximum power is indicated by full throttle static engine rpm on the ground, which would be around 2,450 rpm in this case, although it would vary according to wind speed and direction. However, such a test is not conducted as part of the normal pre-takeoff power checks, with maximum power only being applied at the start of the takeoff roll. By this stage the pilot is involved with the conduct of the takeoff and it would be easy for him to dismiss any observed low rpm as wind effects. Thus, in the absence of a dedicated air test, conducted at high weights, it is probable that the only indication to the pilot of a gradual loss of performance is a perceived reduction in obstacle clearance, during take off from an airfield with which the pilot is familiar.

Air tests

The most recent air tests were carried out in 2000 and 2003, respectively around 600 and 200 operating hours prior to the accident. A comparison of the data indicates a deterioration in the climb performance over the period. The validity of such a comparison might be questionable, but it should be noted that, in this case, both tests were conducted at near-identical weights and temperatures, by the same pilot at the same airfield.

Whilst it is tempting to conclude that the reduction in climb rate could be an indication of the onset of cam wear, it is important to bear in mind that other factors, such as poor panel fit, paint finish, propeller condition, loose exhaust baffles and ignition system performance, could all make a contribution. Also, despite the absence of reliable data on cam wear rates, there is a perception that the wear process progresses comparatively rapidly, especially in the softer substrate material beneath the hardened layer. This being the case, the 2003 air test might be considered as being too long ago for cam wear to be a factor; thus the subsequent performance loss arising from this would be additional to whatever was responsible for the somewhat marginal results.

In fact the 70 ft/min shortfall in the climb rate put the aircraft on the cusp of failing the air test and, as a consequence, its C of A renewal. A failure would have resulted in an investigation into the cause(s) of the shortfall, an opportunity that is no longer available since the CAA ceased the requirement for C of A renewal air tests. It is probable that, for many privately operated aircraft, such tests represented the only occasions on which a professional assessment of performance was made.

The end of C of A renewal air tests coincided with changes in the Regulations in which EASA assumed overall responsibility for continuing airworthiness. News of this was promulgated in the UK by means of a letter to Operators and an Airworthiness Notice. However, in the absence of any logical arguments presented in these documents, the reason for the removal of the air test requirement seems to stem simply from the fact that the administration of continuing airworthiness had changed, as opposed to the results of any safety assessment. An additional feature of the new Regulations is that no distinction is made between privately operated aircraft and those engaged in commercial air transport, despite the different operating regimes of these categories.

The guidance material associated with the Continuing Airworthiness Regulations allows flight tests, or 'in flight surveys' to be conducted 'as deemed necessary by the competent authority'. On the face of it, this seems to allow each EASA member state the freedom to require flight tests, either on an ad hoc or regular basis. However, it is probable that the intent is not to permit the imposition of regular tests, since this would counter the EASA ethos of a common standard across the European region.

Safety Recommendations

This is the second accident of this nature at Sandown Airport, involving the same type of aircraft departing from Runway 23 in light south-easterly winds. The direction of the surface wind is an important factor during takeoffs, particularly when an aircraft's performance may be marginal. In addition to the wind direction and speed being notified over the radio by the air/ground radio operator, good visual indications enhance the information available to departing pilots, especially if their aircraft are not fitted with a radio. Hence, the following Safety Recommendation is made:

Safety Recommendation 2008-050

It is recommended that the Isle of Wight/Sandown Airport aerodrome licence holder installs an additional, suitably located wind sleeve within the appropriate distance from the threshold of Runway 23, in accordance with the advice contained in CAP 168.

Safety action

In May 2008, the Isle of Wight/Sandown Airport aerodrome licence holder installed an additional windsleeve located about 70 metres from the threshold of Runway 23. The windsleeve is clearly visible to the pilot of an aircraft on the threshold of Runway 23.

The lack of a requirement for a periodic flight test, which includes a measure of the aircraft's climb performance at or near its maximum weight, removes a degree of quality assurance upon which aircraft performance calculations can safely be made. For many pilots of privately owned light aircraft, a reduction in the maximum available power might remain undetected so long as operations are confined to relatively light weights at non-limiting airfields. However, the availability of maximum performance becomes increasingly vital at higher weights and shorter runways, as demonstrated by this accident. The issue of a Certificate of Airworthiness is a declaration of confidence in the condition of the aircraft: until 2005 the same certificate conferred a similar degree of confidence that the aircraft would meet its performance criteria. If performance issues are considered in the context of continuing airworthiness, it follows that a periodic confirmation that an aircraft can deliver its scheduled performance should form an integral part of this process. The following Safety Recommendation is therefore directed to EASA:

Safety Recommendation 2008-051

It is recommended that the European Aviation Safety Agency amend that part of the Regulations dealing with Continuing Airworthiness so that aircraft under their jurisdiction will require a periodic performance assessment.