ACCIDENT

Aircraft Type and Registration:	Avions Pierre Robin DR400-180, F-GDYD
No & Type of Engines:	1 Lycoming O-360-A3A piston engine
Year of Manufacture:	1984
Date & Time (UTC):	19 July 2008 at 1337 hrs
Location:	Llanfihangel Glyn Myfyr, near Corwen, North Wales
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - 2 (Serious) Passengers - N/A
Nature of Damage:	Substantial
Commander's Licence:	Private Pilot's Licence
Commander's Age:	67 years
Commander's Flying Experience:	871 hours (of which 440 were on type) Last 90 days - 41 hours Last 28 days - 16 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft was on the second leg of a seven-day journey from France to the United States of America (USA). As it transited over North Wales, avoiding cloud and the high ground, the engine ran down. The pilot had selected the fuel to feed from the left wing tank. The time that had elapsed since that selection indicated that the engine could have suffered from fuel starvation. However, the conditions were also conducive to carburettor icing. The engine could not be restarted and the pilot carried out a forced landing into a field. During the landing the aircraft ran into a bank in the far corner of the field and was substantially damaged. Both crew members were seriously injured. Although there was a significant spillage of fuel, there was no fire.

History of the flight

The aircraft had departed from Chavenay in France on a seven-day journey to Oshkosh, in the USA, to attend the Experimental Aircraft Association's Fly-In Convention. The first leg from Chavenay to Cherbourg was completed without incident. After landing at Cherbourg, the aircraft was refuelled to full tanks, which equated to 350 litres, and the pilot amended the flight plan to show Inverness as the intended destination, because Stornoway, the planned stopping point at the end of the first day, was due to close before their estimated time of arrival.

The aircraft departed from Cherbourg at 1110 hrs and transited north over the English Channel at 3,000 feet amsl, on a direct track to Bournemouth. Fuel was being fed from the main tank. Five minutes after passing Bournemouth, the aircraft climbed to Flight Level (FL) 65, on track towards Welshpool, near the England/Wales border. When level, the pilot selected the fuel to feed from the left wing tank. Forty litres of fuel from the main tank had been consumed, leaving 70 litres in that tank. The wing tanks each contained 40 litres and the crew's intention was to run the left tank dry to confirm the engine's fuel consumption at the aircraft's current weight, cruise speed, and at that level. Two weeks before, in preparation for the long transit flights over open water on the journey to North America, the pilot had carried out a series of flights, at different altitudes, to determine accurate fuel consumption figures. This was intended to be a further refinement on those calculations.

After 20 minutes at FL65, to avoid cloud, the crew requested clearance to climb to FL85. Due to air traffic conflictions this was not possible, so the pilot descended F-GDYD below the cloud base, to an altitude of between 2,500 ft and 3,000 ft amsl. The planned route took the aircraft east abeam Bristol, overhead Welshpool and on towards Rhyl on the north coast of Wales. Throughout the flight the crew applied carburettor heat every five minutes, checking that the engine rpm dropped and then recovered when the control was returned to the COLD position. On one occasion, after the descent from FL65, the co-pilot noted that the needle on the carburettor temperature gauge was in the amber band, indicating that there was a risk of carburettor icing, and he selected the control to HOT. The temperature indication moved above the amber band, the engine speed reduced by 100 rpm and then recovered as the carburettor heat control was returned to the COLD position. The co-pilot's other duties included operating the radio and assisting with the navigation, using his hand held GPS unit and charts.

North of Welshpool the terrain began to rise and the pilot altered course to the left to avoid high ground and remain clear of cloud. Because the aircraft's fuel consumption was no longer representative of a steady state condition, he considered changing the fuel selector to another tank but did not do so. Both crew members recalled seeing the left wing tank low level warning light illuminate and the pilot noted that there was approximately 15 minutes remaining before that tank would run dry and the engine would stop.

While manoeuvring to avoid the high ground, the engine suddenly ran down to 1,500 rpm. The pilot switched the electric fuel pump ON and moved the fuel selector a quarter turn anti-clockwise to the main tank position, expecting the engine to restart in one or two seconds. The co-pilot's recollection was that the pilot moved the fuel selector before switching the electric fuel pump ON. He also recalled that the fuel pressure gauge gave the same indication before and after the fuel pump selection. The engine did not accelerate, so the crew selected the carburettor heat to the HOT position, it having last been selected two minutes beforehand. Still the engine did not restart, although the propeller continued to windmill. The pilot lowered the nose of the aircraft to achieve an indicated airspeed of 230 kph (127 kt) and moved the fuel selector a further quarter turn anti-clockwise to the right wing tank position. He exercised the throttle control backwards and forwards and confirmed that the mixture was set to RICH. Later, after the accident, the pilot was unsure as to whether he moved the fuel selector back to the main tank or left it feeding from the right wing tank. He had no indication that the electric fuel pump was operating but did not recall seeing the fuel low pressure light illuminate.

Meanwhile, the aircraft descended from a height of between 700 and 800 ft agl and the pilot selected the only field that was within range, and clear of obstacles, for a forced landing. Continuing to exercise the throttle, he carried out an approach to this field but does not recall whether he selected any flap. Just before the aircraft landed, the co-pilot switched off the magnetos. After a gentle touchdown, the aircraft yawed to the left and the pilot attempted to counter this with full right rudder. The aircraft descended into a depression in the far corner of the field, struck a bank nose first, yawed further to the left and came to rest. It was still upright but was substantially damaged. Both crew remained in their seats having suffered serious injuries, particularly to their legs.

A householder in a nearby farmstead, approximately 200 metres away, was alerted by the noise of the aircraft's forced landing. He contacted the emergency services and remained with the crew until assistance arrived. Other members of the public also went to the accident site to assist. There was a significant fuel leak but no fire ensued. Following the arrival of all three emergency services, both crew were airlifted to hospital and subsequently recovered from their injuries.

The Emergency Locator Transmitter had been triggered by the accident and was switched off by a crew member from the air ambulance. He also located the battery for the fire crew, who removed it from the aircraft. The fire service also laid two layers of foam to make the area safe.

Recorded information

The aircraft was fitted with four independent GPS receivers which were recovered and downloaded at the AAIB's facilities in Farnborough. Of the four GPS units, one was mounted in the aircraft instrument panel and powered by the aircraft. The other three were hand-held devices; two were discovered in the aircraft wreckage and the third some distance away from the aircraft's final resting position. Each of the GPS units featured a built-in logging system which recorded the aircraft's GPS position over time. Some also recorded altitude, groundspeed and heading.

Recorded data from the Clee Hill and St Annes radar heads was also analysed. This data included the aircraft's position and its associated pressure altitude, as transmitted by the transponder. These pressure altitudes were corrected for the QNH pressure setting, 1,009 mb, to give the aircraft's altitude above mean sea level (amsl). The altitudes were only approximate, due to the 100 ft resolution of the radar altitude data.

At 13:27:23 hrs, the aircraft was 15 track nm from the accident site at an altitude of 3,300 ft amsl. Over the next eight minutes, the aircraft gradually descended to an altitude of 2,500 ft, passing over an area of rising ground in North Wales. At one stage, over the undulating terrain, the aircraft was 415 ±50 ft agl.

At 13:35:07 hrs, the GPS derived groundspeed showed the aircraft speed starting to decay from 98 kt. This is the point at which it was suspected that loss of engine power occurred. Nine seconds later, recorded radar data confirmed that the aircraft began to descend from 2,500 ft amsl.

Airspeed and altitude continued to decrease for about 35 seconds following the suspected loss of engine power. The groundspeed then appeared to stabilise at approximately 74 kt, while the recorded radar and GPS altitudes suggested a rate of descent of about 900 ft/min. F-GDYD passed overhead Llanfihangel Glyn Myfyr at 13:36:28 hrs at a GPS altitude of between 1,375 ft and 1,530 ft amsl.

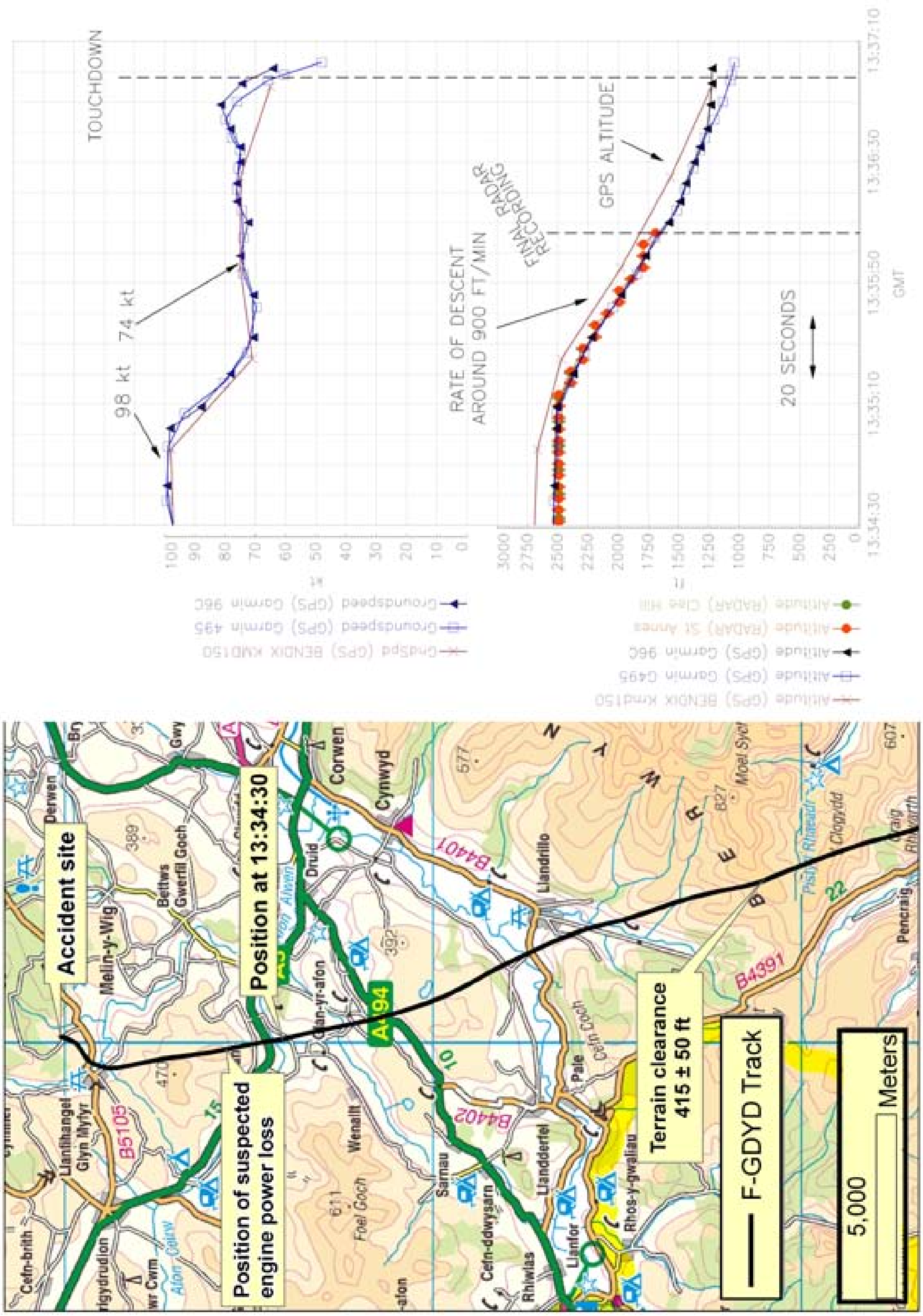

Figure 1

F-GDYD GPS and radar data[1]

Footnote

[1] Terrain elevations in this map are relative to the UK Ordnance Survey datum. Vertical clearances were calculated using radar altitudes by adjusting the terrain elevations to the WGS84 datum.

Using three of the GPS units, which were accurate relative to each other over the final part of the flight, and the locations of the ground marks, touchdown was thought to have occurred at 13:36:58 hrs. Touchdown groundspeed derived from GPS positions was about 63 kt, with a terrain elevation of 1,230 ft amsl. In the 111 seconds between the position where the suspected loss of power occurred and touchdown, the average rate of descent was calculated as 680 ft/min over a track distance of 2.5 nm.

Meteorology

An aftercast provided by the Met Office indicated that, with high pressure over the eastern Atlantic and low pressure over the North Sea, Wales was experiencing a fresh to strong Polar Maritime airflow. Visibility was approximately 25 km, reducing to about 6 km in showers and less than 200 metres in cloud and hill fog. Cloud was estimated to be few or scattered stratus at 1,500 ft amsl, few or scattered cumulus at 2,300 ft amsl and broken at 2,700 ft amsl. The cloud tops were calculated to be between 5,000 ft and 8,200 ft amsl.

In the area of the accident site, the wind at 2,000 ft agl was estimated to be from 330° (T) at 40 kt, reducing to 35 kt at 500 ft agl from the same direction. The crew assessed the wind speed to be less, at about 20-25 kt. The temperature and relative humidity at each height, outside cloud, were estimated to be 5.4°C and 85%, and 9.5°C and 80% respectively. The strong wind gradient gave moderate turbulence over the mountains, with isolated areas of severe turbulence.

Advice promulgated by the Civil Aviation Authority indicates that these combinations of temperature and relative humidity are conducive to serious carburettor icing at any power setting.

The pilot's recollection was that the outside air temperature (OAT) just before the accident was 17°C, with no rain and blue sky ahead. At that temperature, the risk would probably have been of moderate icing at cruise power and serious icing at descent power.

Aircraft information

The Robin DR400-180 is a monoplane constructed predominantly from wood with a fabric covering, and is identifiable by its 'cranked wing' design and one piece sliding perspex canopy. It has a tricycle landing gear and can seat four people in its normal configuration. The accident aircraft had a 110 litre main fuselage tank fitted under what would normally be the rear seat, a 50 litre supplimentary tank in the rear fuselage and 40 litre tanks in each wing root. It had been modified with an additional fuel tank which replaced the rear seat to provide extended range. This modification used a duplicate of the main fuselage tank giving a total capacity of 350 litres of fuel. The single engine fuel supply line could be isolated from all the fuel tanks, fed from an individual wing tank or fed collectively from the tanks in the fuselage by selecting the appropriate position on the rotary selector switch in the cockpit. The instrument panel was equipped with an optional carburettor temperature gauge with an amber band to indicate risk of icing, along with the standard horizontal strip of warning lights at the top of the panel. These included a red fuel low level light and a red fuel low pressure light. The aircraft was fitted with lap restraints only.

The aircraft appeared to have been well maintained prior to the accident. A 200 hour maintenance check on the aircraft had been accomplished two days earlier and the aircraft had flown 176 hours since a comprehensive 2,000 hour overhaul in April 2008.

Accident site and ground marks.

The landing took place in a field 1.4 km north-west of the village of Llanfihangel Glyn Myfyr. The field measured 275 m from boundary to boundary in the landing direction of the aircraft, with a 3.5° downward slope for the majority of its length. It contained a standing crop of grass about 18 in tall. Three distinct tracks of flattened grass were visible, initially on a heading of 086° and starting 90 m from the fence marking the furthest edge of the field. The tracks stopped as they reached a depression 25 m from the fence. At this point the ground dropped away steeply leading to an area of large boulders along the near bank of a small stream. The far bank of the stream was formed by a ridge of earth and large stones. Evidence of blue paint and fragments of the left wing was found on the boulders along the near bank of the stream. There was a clear impact mark in the far bank, where displaced rocks also had traces of blue paint. The grass around this area had become discoloured, consistent with exposure to fuel, as had sections of the adjacent field. The aircraft was located in the corner against a wire fence and steel gate, having turned through 180° from its landing direction.

Impact sequence

The ground marks indicate that the aircraft touched down towards the end of the field and rolled most of the remaining distance with weight on all three wheels. At the point where the ground dropped away it appears the aircraft then became airborne again, until the left wing dropped (a known characteristic for this aircraft at stall) and contacted the large boulders next to the stream. The aircraft then yawed rapidly to the left and impacted heavily on the far side of the stream, nose first into the earth bank. It continued to yaw anti-clockwise until being restrained on the fence and gate.

Initial wreckage examination

There was extensive damage to the fuselage and left wing of the aircraft. The left wing fuel tank remained intact, but had detached from its mount and was hanging by the flexible fuel pipe. The right wing was relatively undamaged but the right wing fuel tank was located some 15 metres away in the adjoining field. The three fuselage fuel tanks were intact and still contained a large amount of fuel. It is estimated that about 170 litres were lost following the impact. The nose and fuselage section forward of the wing spar were heavily disrupted, with the engine and instrument panel hanging down from the rest of the aircraft. Some of this disruption occurred when the crew were lifted out of the aircraft by the emergency services. The propeller blades had minor impact marks consistent with little or no rotation. The flaps appeared to be in the retracted position but heavy disruption of the airframe and the cockpit controls prevented positive confirmation of the selected flap position prior to impact.

Detailed wreckage examination

A significant quantity of fuel was drained from the aircraft at the accident site and, again, upon its arrival at the AAIB facilities at Farnborough. Approximately 107 litres of fuel were drained from the fuselage mounted tanks, but only 0.35 litres from the left wing tank. No fuel was found in the system forward of the fuel selector valve, apart from a very small amount (less than 0.01 litres) in the bottom of the gascolator. There were, however, several breaks in the pipework up to the engine driven fuel pump, caused by the disruption of the airframe during the impact. The fuel selector valve was selected to the right wing tank position. No blockages were identified in the fuel system, the fuel system components were all found to be fully functional and wiring continuity checks revealed no defects. It was not possible to test the fuel tank quantity and low level warning indications due to the amount of disruption to the airframe.

The carburettor was removed from the engine and the bowl was found to be dry. The float was of metal construction with no evidence of leakage and it moved the needle valve correctly when tested. The air intake on the bottom of the carburettor had taken the full force of the impact with the earth bank and was severely crushed. However, there was no evidence of a pre-impact blockage. The carburettor heat valve showed no evidence of any fault but it was not possible to confirm its position at impact. The crew stated that the cockpit indication during the flight was consistent with a functional carburettor heat system. The engine accessory systems were found to be fully serviceable. The engine itself was inspected internally and externally with no evidence found of pre-impact seizure or mechanical damage.

The carburettor temperature gauge and thermistor were tested off the aircraft and found to be sufficiently accurate for indication purposes, though a small time lag was noted before a change of temperature at the thermistor was reflected with any accuracy on the gauge.

Fuel system tests

The aircraft fuel system, from the tank selector valve to the carburettor, was removed from the wreckage and reassembled. Testing was carried out to simulate a fuel tank running dry, then an alternative full tank being selected. A large number of test runs were completed with varying results. In the majority of the tests it was found that the system would re-prime and the carburettor bowl would fill in less than 20 seconds. However, it was observed that the presence of air in the pipe would, on occasion, generate a lock and stop the flow of fuel to the carburettor completely. The exact combination of factors which resulted in an airlock could not be definitively determined, but it demonstrated that fuel could be prevented from reaching the engine.

Individual testing of the fuel low pressure warning system components, including aircraft wiring continuity and pressure switch and transducer function, identified no defects.

Pre-journey planning and tests

The crew had carefully planned their seven-day journey from France to North America, and the return route which would take six days. In addition, the pilot had conducted a number of flights in the accident aircraft to establish accurate fuel consumption figures at different altitudes. To do this, he fed fuel from one of the wing tanks until it ran dry, knowing the quantity of fuel it contained. As the fuel quantity in that tank decreased, first the fuel low level light would illuminate, followed by the fuel pressure light. When the engine note changed, the pilot would switch on the electric fuel pump, select the fuel to feed from another tank and the engine would accelerate back to its previous speed.

The Aircraft Flight Manual gave fuel consumption figures of 40 litres per hour when cruising at 1,000 ft pressure altitude and 33 litres per hour when at 10,000 ft pressure altitude.

Following the accident, the pilot carried out further flights in an aircraft of the same type with a less powerful engine, but which provided some useful data. The fuel low level light illuminated 18 minutes before the low pressure warning light came on; 14 seconds later the engine started to suffer from fuel starvation and the indicated fuel pressure dropped from 350 mb (approximately full scale) to 150 mb. The unusable fuel quantity in that aircraft's wing tanks was found to be approximately 0.2 litres.

Discussion

The atmospheric conditions at the time of the accident were, at best, conducive to moderate carburettor icing at cruise power and there may have been a risk of serious carburettor icing at any engine power. However, the crew stated that they had regularly exercised the carburettor heat during the flight, the last time being two minutes before the engine ran down, and that they had checked the carburettor temperature gauge. If the engine had cut out due to severe carburettor icing, once the engine stopped the remaining heat in the exhaust may not have been adequate to increase the temperature of the incoming air sufficiently when carburettor heat was selected ON. Therefore, ice may have remained or continued to accumulate, preventing the engine from restarting.

The aircraft had been airborne for 2 hours 25 minutes when the engine ran down. This is consistent with the evidence that 80 litres of fuel was used and that all the usable contents of the left wing fuel tank, which was supplying the engine, were consumed. The crew were taken by surprise when the engine stopped but the pilot followed his usual procedure for re-establishing the flow of fuel to the engine. The lack of fuel found in the system downstream of the tank selector valve suggests that the engine stopped as a result of fuel starvation. However, neither pilot remembered seeing the fuel low pressure warning light illuminate and the co-pilot's recollection was that the fuel pressure gauge reading remained normal before and after the electric fuel pump was selected ON. It is possible that the engine was starved of fuel and that the indication system did not respond correctly to the drop in fuel pressure. However, the pilots report that the system was operating correctly prior to the flight and the absence of any defects during examination following the accident suggests that that was unlikely.

It is also feasible that the needle valve in the carburettor could have stuck in the closed position, only being freed by the final impact. This would maintain fuel pressure in the pipe, from where the indicated pressure is sensed, but allow the fuel level in the carburettor bowl to continue to drop until the engine stopped and prevent it from being restarted. This failure mode fits the pilots' recollection of events, but the fail-safe design of the valve, lack of any supporting evidence post-accident and the normal engine performance for the previous two hours of the flight, suggest it is unlikely to have been the cause in this case.

If the engine did cut out due to the selected left wing fuel tank running dry, fuel system testing demonstrated that air locks can be generated, preventing the flow of fuel to the carburettor. If the supply of fuel to the carburettor did eventually resume, given that the engine had been operating in cruise for two hours prior to it cutting out, the cylinder heads would have been sufficiently heat-soaked to remain at a reasonably high temperature. The throttle is linked to an accelerator pump in the carburettor housing, forcing an additional volume of fuel directly into the airflow when the throttle is opened quickly. By continuously pumping the throttle it is possible for the mixture to become too rich to support combustion in a hot engine at 2,500 ft amsl. The continuous selection of carburettor heat during this period may also have exacerbated the problem.

Conclusion

It was not possible to determine, with certainty, the reasons for the engine failure or its inability to restart. When the failure occurred the crew had few locations to choose from for a forced landing, due to the hilly terrain over which they were flying. The flaps may not have been extended before touchdown. If that was the case, the selection of full flap at the appropriate stage would have reduced the landing distance required, though the downward slope of the field and the weight of the aircraft meant it was unlikely to have stopped safely in the landing distance available.