ACCIDENT

Aircraft Type and Registration:	Colibri MB2, G-BUDW
No & Type of Engines:	1 Volkswagen 1834cc piston engine
Year of Manufacture:	1992 (Serial no: PFA 043-10644)
Date & Time (UTC):	15 December 2019 between 1228 and 1328 hrs
Location:	Northfield Farm, Spilsby, Lincolnshire
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:	Private Pilot's Licence
Commander's Age:	55 years
Commander's Flying Experience:	1,300 hours (of which 221 were on type) Last 90 days - 11 hours Last 28 days - 1 hour
Information Source:	AAIB Field Investigation

Synopsis

The pilot, who owned G-BUDW, was planning a short flight to test a modification to the aircraft's fuel system. As the aircraft took off a witness heard the engine running roughly before it disappeared from view. The accident site was found approximately one hour later to the north of the runway. It is likely the pilot had attempted to fly a circuit to land back at the airfield.

The investigation found the engine was in poor condition with several defects including a crack in the cylinder head, a split in the inlet manifold joint and deposits on the valve seats. Any of these on their own or a combination of these, could explain the rough running.

The report highlights the guidance issued by the LAA regarding pilot maintenance, on-condition engine monitoring, development of a maintenance schedule and the requirements relating to approval of modifications.

History of the flight

The owner of G-BUDW kept his aircraft at a small farm airstrip near Mavis Enderby in Lincolnshire. In the months leading up to the accident it was reported that G-BUDW had been experiencing a rough running engine and loss of engine power in flight. In April 2019, he had an engine failure and landed in a field. He was able to fix the problem and took off again 40 minutes later. It was reported that he had aborted several flights in recent months and returned to the airfield due to engine problems. The owner had tried several solutions to resolve the engine problems including fitting an additional electric fuel pump. On the day before the accident the owner had modified the fuel system to change the arrangement of the electrical and mechanical fuel pumps.

On the day of the accident, it was reported that the owner intended to undertake a short flight to test the modified fuel system. An old grain shed, at one end of the runway, was used to store G-BUDW and three other aircraft. When the owner of G-BUDW arrived at the airfield, another pilot was working on their aircraft. The other pilot was busy with his own aircraft so, other than exchanging some pleasantries, they did not speak. However, the other pilot was aware of G-BUDW's owner preparing his aircraft.

The other pilot later heard the aircraft start and reported that "the engine sounded fine", a few minutes later he saw the aircraft taxi away. When he heard G-BUDW start its takeoff, he walked out of the hangar to watch and recalled it was 1232 hrs. He reported that when he saw the aircraft come over the crest of the runway it was at about 5 – 10 ft and the engine sounded "good". He then heard the engine go much quieter "as if it had been altered to tick over" and was aware the aircraft was no longer climbing normally. He heard the engine "get loud again then hesitate and get quiet again" and described the engine as "fizzing and popping". The aircraft passed directly over his head, clearing the shed roof by 20 – 30 ft. As the aircraft went out of sight, he could no longer hear the engine and assumed the pilot would be attempting a forced landing in a field. He ran around the shed but could not see the aircraft.

He returned to his car and started a search of the surrounding area but was unable to locate the aircraft. At 1252 hrs, he called the pilot of one of the other aircraft in the hangar and asked if he could come to the airfield and use his aircraft to search the area. At 1315 hrs, the other pilot arrived, prepared his aircraft for flight and started to taxi to the far end of the airfield for takeoff. As he taxied over the crest of the runway, he saw the wreckage of G-BUDW in the field to the north of the runway. They alerted the emergency services and attempted to revive the owner but there were no signs of life. The call to the emergency services was made at 1328 hrs.

The police, paramedics and air ambulance attended but the owner was declared deceased at the scene.

Two other people witnessed parts of the aircraft's flight. One witness, who was to the south of the airfield (Figure 1 - Witness A), saw the aircraft track east to west then saw it turn to the north. He reported the engine sounding rough, describing it as "stuttering a bit" and making a "putt, putt, putt" sound. A second witness, to the north-east (Figure 1 - Witness B) of the airfield reported hearing the aircraft starting its takeoff. He reported that the aircraft sounded "lovely, smooth and sweet".

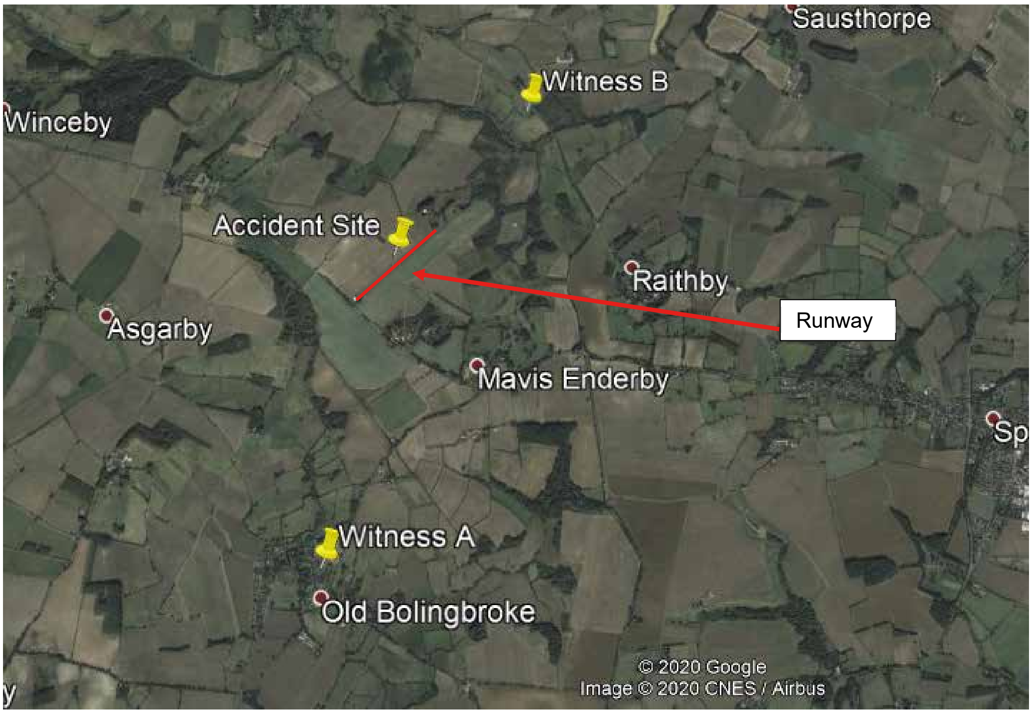

Figure 1
Location of witnesses

Several other people in the surrounding area reported hearing aircraft with engine problems, but the times and distance from the airfield suggest these were unlikely to be the accident aircraft.

Accident site

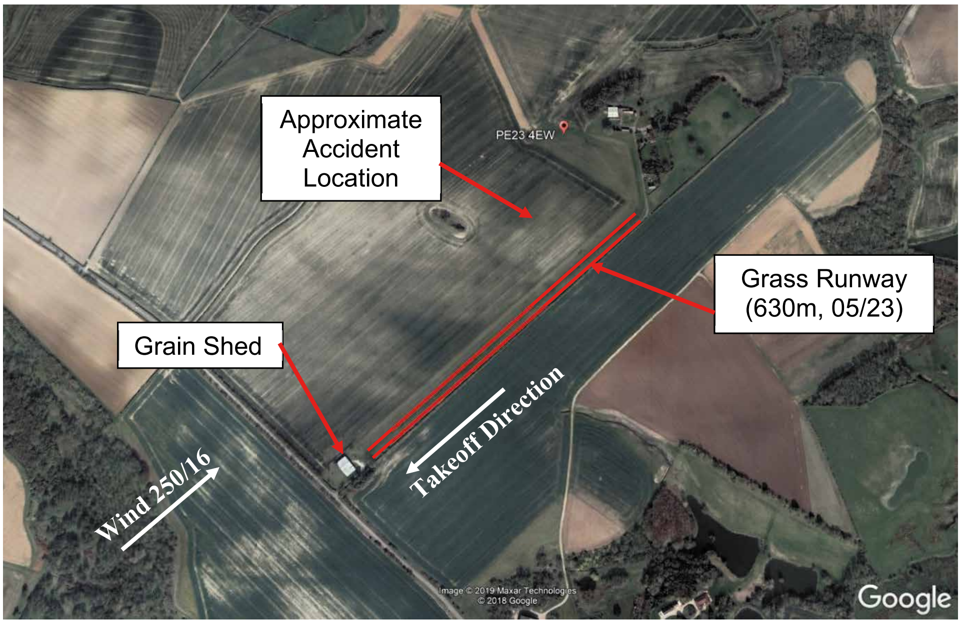

Figure 2
Farm strip showing the accident site location

The aircraft wreckage was discovered approximately 50 m to the north of the grass runway and from the ground marks it was apparent that the aircraft was heading in a south south-westerly direction. The accident site was hidden from the grain shed due to the ground rising and falling around the midpoint of the runway.

The right wing and landing gear had detached from the aircraft during the impact sequence. Ground markings showed that the right wingtip and wheel were the first points to contact the soft, sticky, clay soil (Figure 3). Both blades of the wooden propeller had detached and were found, embedded in the ground where the engine had first struck the ground. The engine was detached from the fuselage. The fuselage was relatively intact and had come to rest 2-3 m from the right wing, adjacent to the left wing, which had also detached. The cockpit area had been severely disrupted. The fuel tank had been moved away from the aircraft by the first responders to minimise the risk of fire as they stated there was still fuel in the tank. No fuel remained in the tank when it was recovered by the AAIB. The wreckage was removed and taken to the AAIB facilities for further examination.

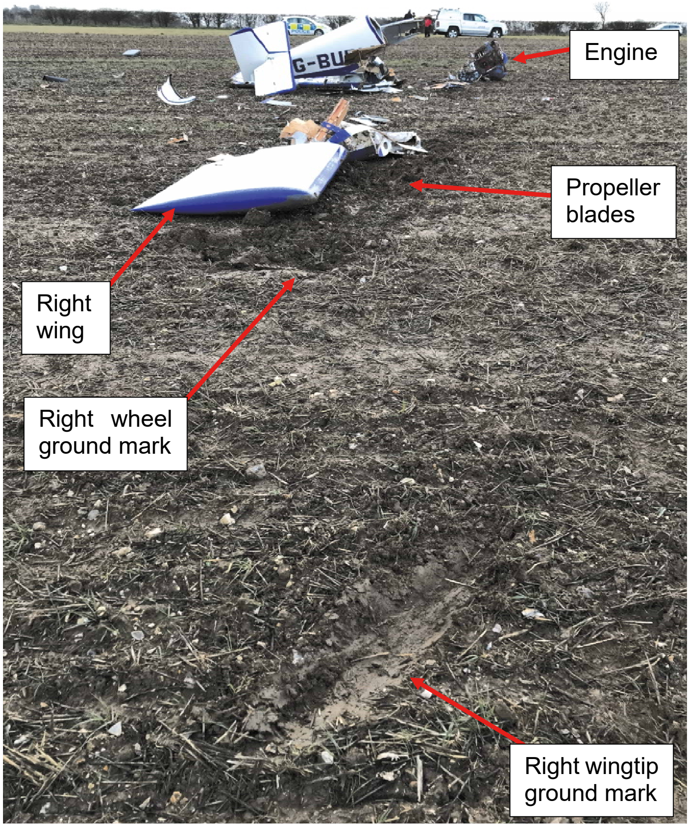

Figure 3

Accident site with ground marks

Recorded information

Radar

No radar recordings existed for the accident flight suggesting that the aircraft was flying at a height of no more than 400 ft agl to be below radar coverage for that area.

GPS devices

An Airbox Aware 5 GPS device was recovered from the accident site which had been active during the flight; however, the file that was downloaded from the device was corrupt and no data for the flight was recovered.

A handheld Yaseu radio with an integrated GPS receiver and recording capability was also recovered from the accident site. However, on examination, no recording was found for the flight because the recording function was in the default OFF position.

Radio transmissions

The aircraft's handheld radio was found tuned to a frequency of 135.465 MHz. The local airfield frequency was 135.480 MHz. The radio's frequency could be changed easily with a little touch on the rotary control knob. It is, therefore, likely that the radio was tuned to the local airfield frequency prior to the accident and that the frequency was knocked slightly during the accident sequence. Transmissions on this frequency are not recorded.

No record was found of any radio transmissions from the aircraft on any other frequency used in the surrounding area.

Aircraft information

The Colibri MB2 aircraft is a homebuilt single seat light aircraft with fixed landing gear, constructed predominantly from spruce and plywood and is operated under a Permit to Fly issued by the LAA. A set of construction drawings for the aircraft was obtained by the AAIB, however these only give construction details for the airframe structure and some other key components such as the flying controls. There were no drawings for the electrical or fuel systems.

G-BUDW was built in 1992 and the original owner and builder flew the aircraft until 2000 when the aircraft was damaged during a forced landing on Taunton Racecourse[1]. Following the accident, the airframe was repaired, and the engine was rebuilt with its capacity increased from 1600 cc to 1834 cc. Once airworthy it was sold, and the new owner converted the ignition system from magnetos to a Leburg electronic ignition system.

The current owner purchased the aircraft in 2007 and flew it regularly. He undertook the maintenance of the aircraft himself, but no evidence of a maintenance programme was found. The aircraft's annual inspection was carried out by a local LAA inspector, as required to maintain the Permit to Fly. Since the engine had been rebuilt, 605 hours of running time had been logged.

Fuel system

The fuel tank was positioned behind the engine bulkhead and was the only fuel system component included in the construction drawings. The outlet from the tank was connected

Footnote

[1] https://www.gov.uk/aaib-reports/colibri-mb2-g-budw-12-august-2000 (accessed 4 June 2020).

to a filter / drain assembly attached to the bulkhead and fuel was fed to a Minnow Fish carburettor, positioned on top of the engine, by the fuel pumps. Non-return valves were fitted between the pumps and the carburettor inlet. The air intake to the carburettor was unfiltered and was fitted with a manually operated, carburettor heating system on the exhaust silencer. The intake manifold split the fuel air mixture to both cylinder heads and had flexible joints to allow for alignment and vibration (Figure 4).

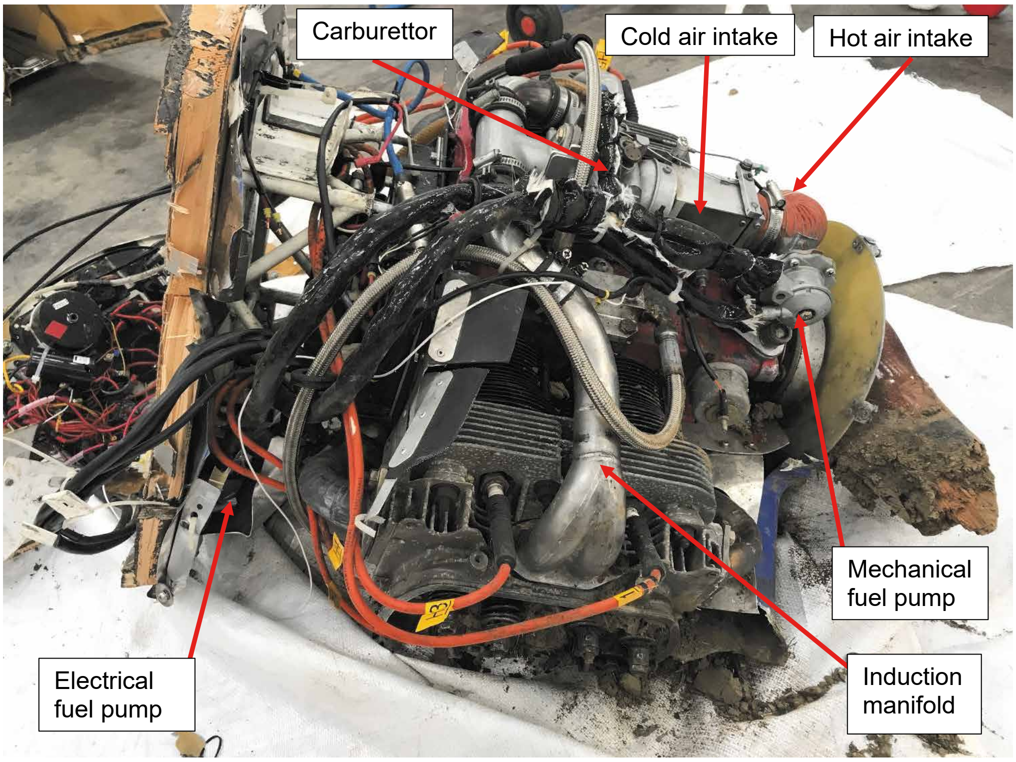

Figure 4
Engine at AAIB facilities

Aircraft examination

The aircraft wreckage was laid out at the AAIB facilities and it was confirmed that there was no evidence of a pre-accident defect or restriction of the flying controls. All the damage found was consistent with the accident. The ignition and fuel systems were removed from the engine, along with the propeller and exhaust system to facilitate a detailed inspection. No anomalies were found during their removal.

Ignition system

The ignition system was sent to a specialist company for testing. It was noted that the coil packs were not the normal type used with the system, but the system functioned correctly. It is probable that these non-standard coil packs were used as this was the prototype installation of the Leburg system and there are no entries in the maintenance logbooks related to their replacement.

Fuel system

The fuel system was removed from the engine and each component individually examined. The copper pipe from the fuel tank to the filter bowl had sheared by twisting, which most likely happened during impact. The rest of the fuel pipes were new fabric-reinforced rubber pipes retained by band clamps and lagged with a fire resistant fibre glass and silicon blanket. This material was wrapped and then held in place by cable ties. The unions (T-pieces, component connectors, etc.) were of a variety of diameters with some push fit, others threaded. Some joints used PTFE tape to aid sealing however this is not recommended because of the risk of slivers of the tape cut by the threads, causing blockages in the fuel system.

The fuel filter bowl contained a small quantity of fine particles and some residual fuel. The filter element was in good condition. The outlet of the filter bowl was connected to a T-piece from which one pipe was connected to the engine driven mechanical fuel pump and the other to an additional electrical fuel pump. The electrical fuel pump was fitted to the bulkhead and could be switched on from a switch on the instrument panel.

A non-return valve was fitted into the outlet pipe from each pump to ensure fuel flow to the carburettor. The electrical fuel pump[2] was a Facet Cube 40106 solid state 12v fuel pump (Figure 5). The manufacturer's datasheet states it is compatible with '*gasoline, diesel, biodiesel, blended alcohol fuels and fuel additives*' and is capable of 32 US Gallons per hour and between 4-7 psi. The manufacturer's data sheet also states that it is not intended for aircraft use however this is probably due to certification requirements rather than its functionality.

Figure 5

Additional electrical fuel pump

There are a wide variety of pump capacities available and there was no evidence that any calculations had been made to size the pump. If the owner had applied to the LAA for a modification he would have been required to present a rationale for the choice of pump. The pump was tested and operated normally.

Footnote

2 https://www.facet-purolator.com/cube/ (accessed 5 June 2020).

The mechanical fuel pump was driven by an auxiliary engine shaft and quill drive. It was a diaphragm pump and records show that the diaphragm and springs were replaced in August 2018. The pump and the fuel priming system functioned correctly and there was a small quantity of fuel remaining in the pump. An internal filter mesh had a small tear (Figure 6 left), it is thought probable that this happened during removal of the mesh when the pump was overhauled. The drive components were examined and found to be worn (Figure 6 lower) to the extent that part of the pump had clashed with the housing (Figure 6 right). This would have limited the volume of fuel pumped on each stroke.

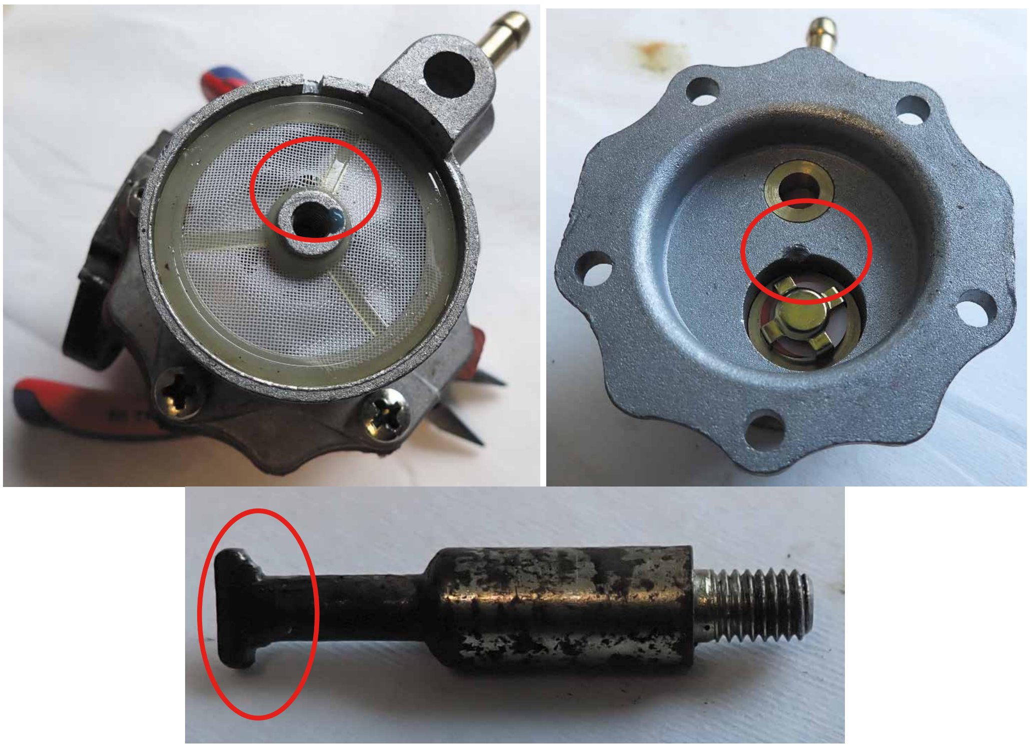

Figure 6

Mechanical fuel pump –
Filter damage, housing damage and drive component wear

Fuel samples

Three metal cannisters of fuel were recovered from the hangar where the aircraft was kept and tested by a fuel laboratory. The laboratory confirmed that the fuel was consistent with Mogas and met the relevant specification[3]. There are many entries in the aircraft logbooks referring to the use of Avgas and so it is likely that the engine was run on both fuel types and mixtures of Avgas and Mogas of varying proportions.

Induction system

The carb heat flap valve and carburettor were examined with no faults found however, there was evidence of small dirt particles in the valve, carburettor venturi and butterfly valve. The

Footnote

[3] BS EN 228:2012+A1:2017 Automotive fuels. Unleaded petrol. Requirements and test methods.

level and size of the particles was consistent with normal operation without an air filter. It was noted that the external surface of a flexible joint in the inlet manifold to the left cylinder head was cracked. Upon closer examination it was found that the crack went all the way through and was approximately 10 mm in length (Figure 7). This crack would have resulted in air entering the system 'leaning' the fuel air mixture. When the interfaces between the inlet manifolds and the engine cylinder heads were disassembled it was found that, in addition to the metal gasket, there was large amounts of silicone instant gasket material. It was not possible to determine whether the metal gasket alone would have provided a suitable seal. No leak paths could be identified.

Figure 7
Inlet manifold flexible joint

Engine

An external inspection of the engine (Figure 8) revealed that the right side had struck the ground, the right rocker cover was missing and the two push rod guide tubes for cylinder 1 were crushed. The rocker cover was found on the accident site and, although covered with soil, was not visibly damaged. The left rocker cover and rocker assembly were removed, and it was noted that the thread on one of the rocker attachment studs differed from the other three suggesting it had been replaced. Furthermore, the nut had been cross threaded onto the stud damaging the thread profile, but it is not considered that this impaired the function of the rocker assembly. All the rocker valve clearance adjusters showed signs of wear. The engine logbooks showed that the valve clearances were checked and adjusted by the owner approximately every 50 hours. The spark plugs were examined, and they all showed signs of use with some build-up of black and light brown coloured deposits.

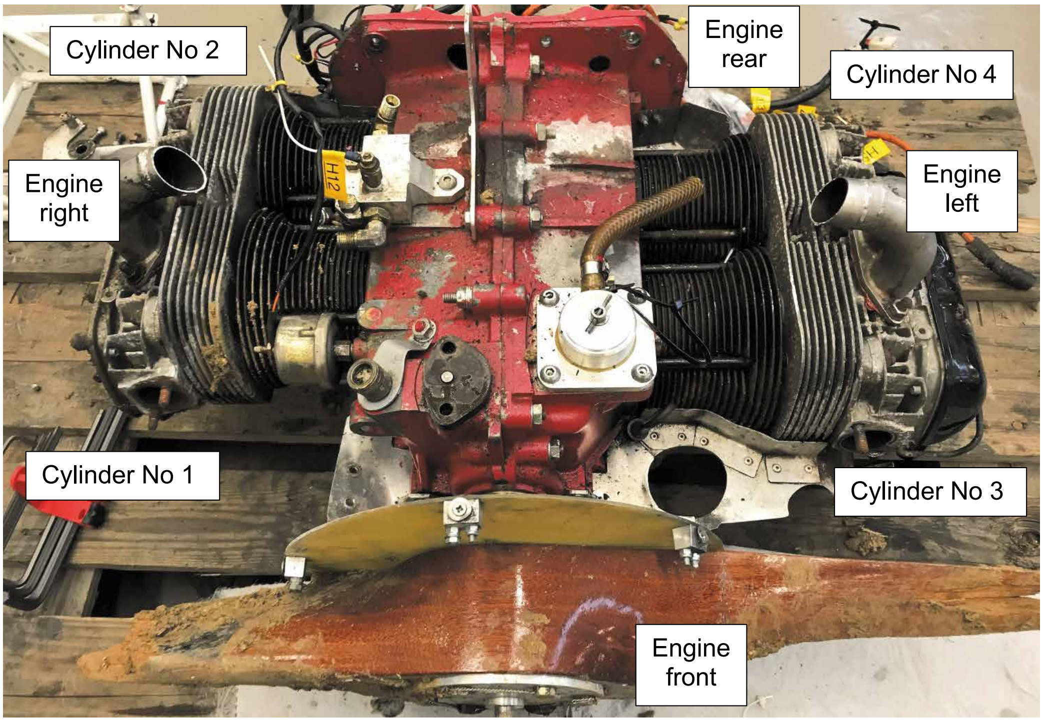

Figure 8

Engine labelling convention

With the rocker assemblies removed, the cylinders were pressure tested to verify cylinder head, piston ring and valve sealing. High pressure air at 50 psi was applied to each cylinder with the piston at bottom dead centre. Air could be heard and felt escaping through the exhaust ports during the test of cylinders 1 and 2. The results are shown in Table 1.

Cylinder	Residual pressure
Cylinder 1	10 psi
Cylinder 2	10 psi
Cylinder 3	37 psi
Cylinder 4	48 psi

Table 1

Cylinder differential pressure test

Both cylinder heads were removed and examined along with the crowns of the pistons (Figures 9 & 10). All the cylinders had evidence of the build-up of combustion deposits. The largest build-up was seen in cylinder 1 with black and white deposits on both the piston crown and the head. Cylinders 2 & 4 showed some build-up of a hard, light brown deposits, whereas cylinder 3 was predominantly a soft black deposit.

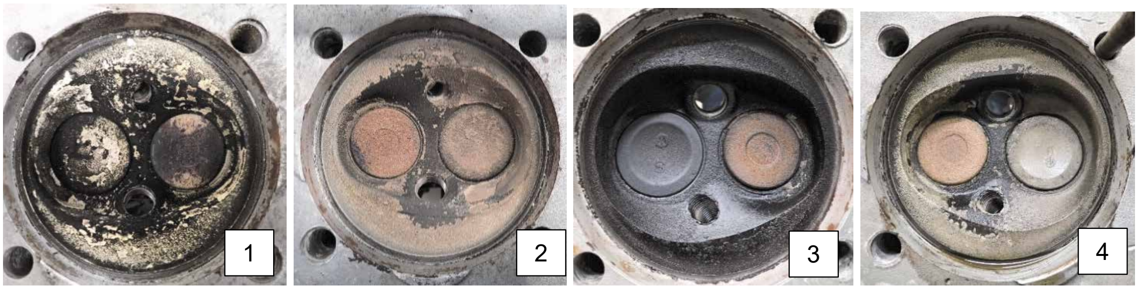

Figure 9

Cyclinder heads

Figure 10

Piston crowns

The valves were removed to facilitate an examination of the valves and their seats. The exhaust valves from cylinders 1, 2 and 3 all showed signs of localised overheating and evidence of uneven seating in the valve seat (Figure 11). All the inlet valves showed signs of carbon build-up on the back face which is thought to be typical for an engine of this age.

Figure 11

Exhaust valve from cylinder 1

The valve seats were examined, and it was noted in cylinder 2 there were crushed light brown deposits on the valve seat sealing face and in the exhaust port. A crack was identified between the inlet port and the larger spark plug hole (Figure 12) with carbon deposit on the exterior surface. All spark plug holes had a helical threaded insert fitted.

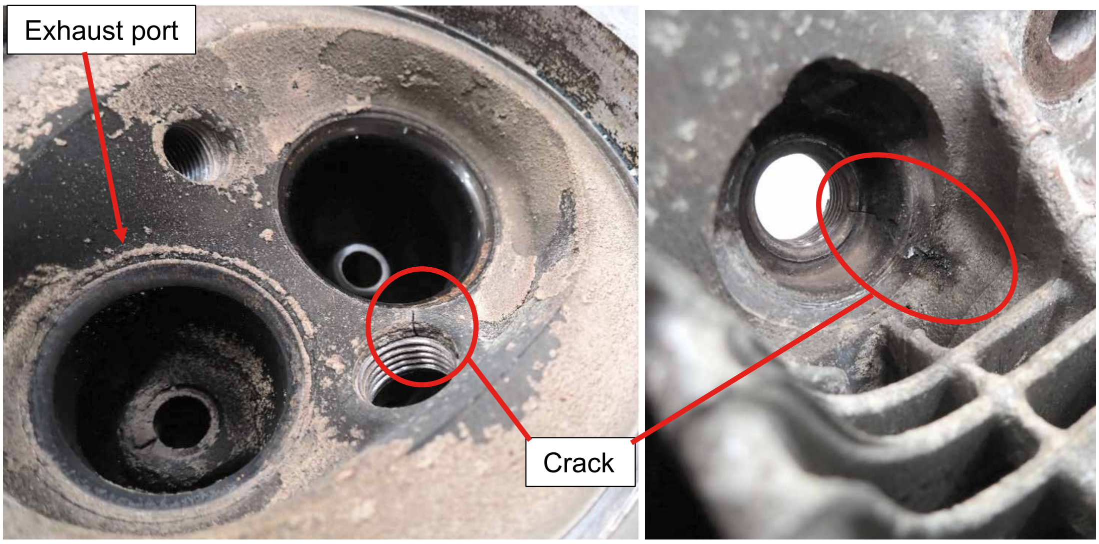

Figure 12
Deposits and crack in cylinder 2

Meteorology

RAF Coningsby is 9 nm south-west of the accident site. At 1150 hrs they reported the surface wind was from 250° at 16 kt, visibility was greater than 10 km, clouds were few at 2,500 ft, temperature was 7°C, dew point 2°C and sea level pressure was 992 hPa. The wind report at 1050 hrs was similar but with gusts to 24 kt. The weather did not change significantly during the time the aircraft was possibly airborne.

Pilot information

The owner of G-BUDW held a valid UK Private Pilot's Licence with a valid Single Engine Piston (Land) rating. He had previously held an Instrument Metrological Conditions (IMC) rating but this was no longer valid.

The pilot's logbook recorded that he had a total of 1,300 flying hours. Since April 2016, when his current logbook started, he had completed 221 hours in G-BUDW. He had completed a pilot medical declaration on the 15 December 2017 which was valid until he reached the age of 70.

Post-mortem

The post-mortem concluded that the pilot died from multiple injuries. There was no evidence that the accident was caused by any medical condition. Toxicology found no evidence of any substance which may have contributed to the accident.

Other information

Partial engine power loss after takeoff

A partial engine power loss is a situation when the engine is producing less than full power but more than idle power. In 2013, the Australian Transport Safety Board (ATSB) published a safety study highlighting the challenges of partial engine power loss after takeoff[4]. The study suggests that pilots are usually trained to deal with a total loss of engine power but often receive little training on partial failures. It highlights that partial failure can be much more difficult to manage because of the choices confronting the pilot and the decisions which need to be made immediately. There can be a strong desire to try to return to the runway to avoid aircraft damage associated with a forced landing on an unprepared surface. However, it can be challenging to judge how far the aircraft will glide and how much height will be lost in the turns. The pilot must also allow for the possibility of further power loss. The study highlights the importance of including partial power loss scenarios in pre-flight planning and pre-takeoff briefings and, if a failure occurs, maintaining aircraft control. CAA Safety Sense Leaflet 1e Good Airmanship[5] explains that attempts to turn back with insufficient energy can result in significant height loss and has resulted in many fatalities.

Carburettor icing

Carburettor (carb) icing is caused by a combination of the sudden temperature drop due to fuel vaporisation and pressure reduction as the mixture passes through the carburettor venturi and past the throttle valve. If the temperature drop brings the air below its dew point, condensation results, and if the drop brings the mixture temperature below freezing, the condensed water will form ice on the surfaces of the carburettor. This ice gradually blocks the venturi, which upsets the fuel/air ratio causing a progressive, smooth loss of power and slowly ‘strangles’ the engine.

Figure 13 is extracted from the CAA Safety Sense Leaflet 14 about carb icing[6], it shows that for the air temperature and dew point on the day of the accident serious carb icing was likely at any power setting. The grass runway was wet with dew which would have increased the likelihood for carb ice forming during the taxi along the runway. Selecting carburettor heat ON before takeoff, including as part of a power check, may reveal the presence of carburettor ice that might then be removed by more prolonged application. It is not known if the pilot did this prior to takeoff or if the engine temperature would have been high enough for the carb heat system to melt any ice that may have accumulated.

Footnote

4 ATSB – ‘Managing partial power loss after takeoff in single-engine aircraft’ – available at https://www.atsb.gov.au/media/4115270/ar-2010-055_no3.pdf (accessed 11 May 2020).
5 http://publicapps.caa.co.uk/docs/33/20130121SSL01.pdf (accessed on 1 Jul 2020).
6 http://publicapps.caa.co.uk/docs/33/20130121SSL14.pdf CAA Safety Sense Leaflet 14 - PISTON ENGINE ICING (accessed 9 July 2020).

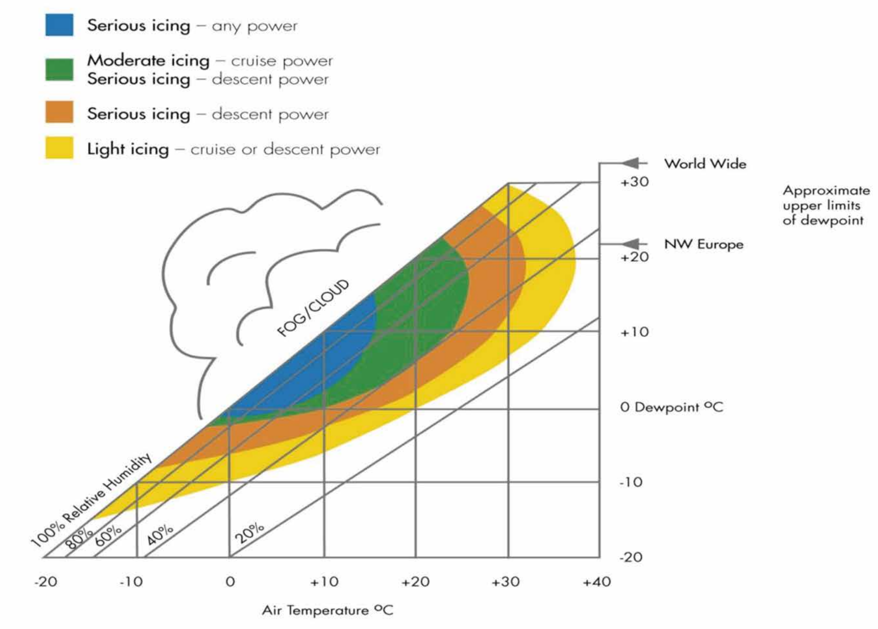

Figure 13

Carburettor icing conditions

Permit to fly aircraft - design changes

In the months preceding the accident it was reported that the engine had been suffering from 'rough running' and a lack of power. To remedy this issue, the owner had fitted the additional electric fuel pump as he believed there to be a fuel starvation issue. It was reported that the electrical pump was originally fitted in series with the engine driven pump, but that the day before the accident flight the fuel system was changed to a parallel configuration. There was no evidence that the pilot had contacted LAA Engineering or an LAA inspector to approve these design changes.

Any modification to an LAA aircraft's design requires approval of the LAA Engineering department. The drawings for the Colibri MB2 do not detail the fuel system so the details of each installation, and each subsequent change, are individually checked by LAA Engineering. So, it would be expected that any pilot/owner would consult with the LAA prior to making any significant design changes, such as fuel system modifications, to their aircraft. The LAA produce a guidance document titled '*When modification approval is not required*'[7] which specifies when approval is not necessary. The guidance concludes by stating '*if there is any doubt over whether LAA Engineering approval is required then clarification should be sought from LAA Engineering'.*

Footnote

[7] LAA TL 3.10 'When modification approval is not required' available at http://www.lightaircraftassociation.co.uk/ engineering/TechnicalLeaflets/Mods%20and%20Repairs/TL%203.10%20When%20Modification%20Approval%20Is%20Not%20Required.pdf (accessed 11 May 2020).

Permit to Fly aircraft – maintenance

CAA Permits to Fly include a condition that all work carried out on the aircraft must be certified by a person authorised by the CAA. For LAA aircraft this person is normally an LAA inspector. There is an exception to this requirement which allows pilots to conduct some maintenance without the need to be certified. The LAA published a guidance document title '*Pilot Maintenance*'[8] which specifies what maintenance a pilot can undertake without the need for further inspection. However, the work undertaken on G-BUDW was beyond that specified in this document so should have been inspected and certified by an LAA inspector prior to flight.

Permit to fly aircraft - maintenance plan

The Air Navigation Order requires that Permit to Fly aircraft are maintained in an airworthy condition. This is achieved by carrying out regular checks on the aircraft's physical condition and undertaking whatever servicing tasks are needed to preserve its condition. Simple servicing tasks are required at regular intervals, typically 50 hours, and more in-depth checks required less frequently. The programme of work needed to maintain an aircraft is called a maintenance schedule. For aircraft with a Certificate of Airworthiness the maintenance schedule is usually specified by the manufacture but for many Permit to Fly aircraft it is left to the owner to develop a suitable schedule. The LAA provide guidance on how to develop a maintenance schedule in their Technical Leaflet TL 2.19 titled 'The LAA Generic Maintenance Schedule'[9] and their website provides a generic schedule for a 50-hour, annual and 3-yearly check[10].

For G-BUDW, the aircraft logbooks recorded that the pilot had changed the engine oil and spark plugs and checked the valve clearances every 50 hours. However, no evidence was found of longer-term maintenance tasks such as engine top-end or complete overhaul.

Permit to Fly aircraft - engine health monitoring

The engine fitted to G-BUDW had accumulated 605 hours since it was last rebuilt. The LAA provide guidance to owners on how to monitor the health of their engine to ensure it continues to be airworthy. LAA Technical Leaflet titled '*Engine overhaul life and operating on-condition*'[11] describes the parameters which should be regularly recorded to detect trends and determine if the engine performance is deteriating. These include, for example, maximum static rpm, rate of climb at best climb speed, oil pressure at a particular cruise rpm, oil consumption and compression in each cylinder.

Footnote

[8] LAA TL 2.05 '*Pilot Maintenance*' – available at http://www.lightaircraftassociation.co.uk/engineering/TechnicalLeaflets/Operating%20An%20Aircraft/ TL%202.05%20Pilot%20Maintenance.pdf (accessed 11 May 2020).

[9] LAA TL 2.19 '*The LAA Generic Maintenance Schedule*' available at http://www.lightaircraftassociation.co.uk/engineering/TechnicalLeaflets/Operating%20An%20Aircraft/TL%202.19%20The%20LAA%20Generic%20Maintenance%20Schedule.pdf (accessed 11 May 2020).

[10] http://www.lightaircraftassociation.co.uk/engineering/Maintenance/Aircraft_Maintenance.html (accessed 11 May 2020).

[11] LAA TL 2.23 '*Engine overhaul life and operating on condition*' – available at http://www.lightaircraftassociation.co.uk/engineering/TechnicalLeaflets/Operating%20An%20Aircraft/TL%202%2023%20Engine%20overhaul%20life%20and%20operating%20on-condition.pdf (accessed 5 May 2020).

No evidence was found of regular engine parameter monitoring of G-BUDW's engine. If this type of monitoring had been conducted it is likely that the low compression on cylinders 1 and 2 would have been detected. The LAA Inspector who completed the previous annual inspection reported that he did an engine compression test by rotating the propeller by hand and did not detect any abnormality.

Analysis

Accident flight

The aircraft was seen taking off and turning to the north. Two witnesses reported hearing the engine running rough. The accident site was discovered approximately one hour later. It is not known for certain when the accident occurred or where the aircraft flew after the initial sightings but the fact that the aircraft was not recorded on radar suggests it did not gain significant altitude. There was no record of the pilot contacting any of the air traffic control frequencies in the surrounding area which suggests he did not travel far from the airfield. Additionally, from the witnesses' descriptions of the rough running engine, it is likely that the pilot would have been looking to land as soon as possible. Therefore, the most likely scenario is that after the turn to the north the pilot tried to fly a circuit to the north of the airfield in an attempt to land back on the runway. The impact marks suggest the aircraft was turning to align with the runway when it struck the ground.

Loss of engine power

The investigation identified that the engine was in poor condition with multiple defects which could have caused the loss of engine power and rough running. The most significant of these were the crack in the cylinder head, the split in inlet manifold joint and deposits on the valve seats. The crack in the head of cylinder 2 would have resulted in a reduction in compression and engine power. The split in the manifold would allow air into the manifold, weakening the mixture and causing the engine to run hot.

The deposits on the valves were most likely a mixture of carbon and oil and not untypical for an engine of this age. In cylinders 1 and 2 it was noted that some of the deposit had flaked off the head and there was evidence that these flakes had been caught and crushed in the valve seats. This would have prevented the valves from sealing, resulting in low compression and loss of engine power. From the sealing checks, only cylinder 4 sealed effectively.

The original power output of the engine was not known but with the defects identified during the examination its power would have been severely reduced. The weather conditions on the day were also conducive to carburettor icing and following the long taxi over wet grass, this may have further reduced engine power.

The long-term engine problems are likely to have been caused by the crack in the head of cylinder 2 and the split in the inlet manifold joint. However, it is believed that on the accident flight, a detached carbon flake caught under the exhaust valve of cylinder 1 further reducing the engine's performance to a point where flight could not be sustained.

Approved maintenance planning

Although the checks for the permit to fly had been signed off by the LAA inspector, no evidence of long-term maintenance planning was identified. The engine logbooks recorded the completion of regular annual tasks which were predominantly oil changes and tappet adjustment.

The LAA Technical Leaflet TL 2.23 regarding on-condition monitoring of aero engines, covers the use of automotive engines in light aircraft applications. The manufacturer's recommendations for service and overhaul intervals do not apply to the duty cycle of a light aircraft. The LAA therefore recommends monitoring of various engine parameters and taking appropriate action when deviation from the 'norm' is noted. During the investigation no evidence was found that engine parameters were being regularly recorded.

This investigation demonstrated that a compression check by feel rather than using compression test equipment is not a reliable indication of the condition of the cylinders. The LAA advise in TL 2.23

> *'Other enthusiasts manage without an air supply, simply by turning the engine by hand and feeling the amount of 'bounce' in the propeller, but its much harder to work out where leaks are occurring with this method.'*

Had the checks and servicing been carried out using the LAA guidance in TL 2.19 and TL 2.23 it is likely the crack in Cylinder 2 and the inlet manifold leak would have been identified.

While there was no defined overhaul period for G-BUDW's engine its poor condition indicated that it required a top-end overhaul.

Approval of design changes

The pilot had made several changes to the aircraft fuel system whilst attempting to resolve an engine problem. There was no evidence that these changes had been inspected by a LAA inspector or that they had been discussed with, or approved by, LAA Engineering. Whilst there is no evidence that these contributed to the accident, it is important that owners/pilots should follow the correct inspection and approval process when making changes to the aircraft configuration. The LAA provide guidance on this process and LAA Engineering should be contacted if there is any doubt on whether approval is required.

Partial engine failure

An engine problem in a single engine aircraft need not necessarily result in a fatal accident. If an engine loses power in flight it may be possible to land in a suitable field. However, during this flight it is likely that the pilot experienced a partial engine power loss. This can be particularly difficult to manage. The ATSB report describes the challenge of judging how far the aircraft can fly with partial power.

In this accident it is likely that the pilot felt he had enough height and power to return to the runway. It is possible that whilst trying to fly back to the runway the engine lost further power reducing the glide distance causing the aircraft to impact the ground before reaching the runway. Many fatal accidents have occurred whilst pilots attempt to turn back to the runway following an engine failure on take off. CAA Safety Sense Leaflet 1e *'Good Airmanship'* advises:

> *'In the event of engine failure after take-off, achieve and maintain the appropriate approach speed for your height. If the runway remaining is long enough, re-land; and if not, make a glide landing on the least unsuitable area ahead of you.'*

Conclusion

The aircraft suffered a partial engine failure shortly after taking off. The evidence suggests that the pilot flew a circuit to the north of the airfield attempting to return to the runway but struck the ground just to the north of the runway.

The investigation found the engine was in poor condition with several defects which could explain the loss of engine power. This included a crack in the head of cylinder 2 and a leak in the manifold.

The pilot had made several modifications to the fuel system, but no evidence was found that these had been approved in accordance with LAA requirements. No evidence was found of on-condition engine health monitoring or an established maintenance schedule for the aircraft.

Published: 1 October 2020.

Bulletin correction

After publication it was noted that the captions for figures 9 and 10 were transposed.

The captions in this report have now been corrected.

The online version of this report was corrected on 19 November 2020.