ACCIDENT

Aircraft Type and Registration:	Europa, G-NDOL	
No & Type of Engines:	1 Rotax 912ULS engine	
Year of Manufacture:	1995 (Serial no: PFA 247-12594)	
Date & Time (UTC):	28 May 2017 at 1200 hrs	
Location:	Apperknowle, Derbyshire	
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:	Light Aircraft Pilot's Licence	
Commander's Age:	79 years	
Commander's Flying Experience:	1,146 hours (of which 880 were on type) Last 90 days - 7 hours Last 28 days - 1 hour	
Information Source:	AAIB Field investigation	

Synopsis

The aircraft took off from Coal Aston Airfield but did not achieve a normal rate of climb. At the end of the runway it turned to the left and then stalled, descending into an adjacent field. The pilot was possibly attempting to land back at the airfield. The evidence indicates that the engine suffered a partial loss of power, probably as a result of fuel vapour disrupting the fuel supply to the engine. It was found that the fuel vapour return line had been connected to the inlet of the fuel selector valve, rather than to the fuel tank. Any vapour in the fuel system was therefore routed back to the engine instead of returning to the fuel tank to dissipate. The accident was not survivable.

History of the flight

Background

The pilot purchased the aircraft in 2014 and kept it in a hangar at Coal Aston Airfield. In August 2016 he landed with the landing gear retracted, causing damage to the propeller. The propeller was replaced, but subsequently he again landed with the landing gear retracted. He borrowed a replacement propeller from a friend and fitted it to his aircraft.

On the day of the accident the pilot was engaged in testing a modification he had designed for the aircraft to warn of an impending landing with the landing gear retracted. Persons he spoke to at the airfield said that he was very focussed on this modification.

Previous flights

The pilot carried out two separate flights earlier in the morning before the accident flight. Grass Runway 29 was in use at Coal Aston and at 1100 hrs he took off on the first flight. He flew to the south of the airfield, flying over his house, located 5 nm to the south. He returned and landed at 1120 hrs. He commented afterwards to a friend at the airfield that he had just done an "awful" landing, the "worst ever".

A short while later he began a takeoff from Runway 29. After becoming airborne the aircraft was seen to fly above the runway at a height of about 10 ft to 15 ft before landing ahead and stopping on the runway. The reason for this short flight was not determined; it may have been related to the landing gear warning modification, but he did not discuss it with anyone.

Accident flight

At about 1156 hrs, the pilot started another takeoff from Runway 29. Witnesses alongside the runway, approximately three-quarters along its length, saw the aircraft lift off and start to climb. However, the aircraft did not appear to them to be climbing as well as they expected and it was still quite low, estimated at 100 ft to 150 ft, when it passed in front of them. As the aircraft passed by they heard the engine noise reduce; one person suggested the engine sounded as though it had reduced to about 4,000 rpm, and another that the engine was sputtering.

The witnesses saw the aircraft start a left turn at the end of the runway and continue in a left turn before descending in a steep nose-down attitude out of sight. Moments later they heard a "thud" as it struck the ground.

Other witnesses were in a house to the south of the airfield. Through a ground floor window they saw the aircraft pass across their field of view, flying very low and in a banked attitude. They then heard the sound of a crash, and immediately alerted the emergency services and ran across to the accident site.

They reached the aircraft but were unable to assist the pilot who had not survived the impact. The emergency services were at the scene within approximately 7 minutes.

Pilot information

The pilot first qualified for his licence in 1991 and had been flying for 26 years; the majority of his flight time was on Europa aircraft. He had recorded 34 hours in the 12 months prior to the accident, including a one hour flight with an instructor in September 2016. He had flown 5 hours in 2017; his most recent flight before the day of the accident was 20 April 2017.

Meteorology

The weather conditions at Coal Aston Airfield were clear with a westerly wind of approximately 10 kt, good visibility and scattered clouds. As a result of the scattered clouds, the sun was out for most of the morning. At Doncaster Sheffield Airport, 20 nm to the north-east, the temperature was recorded as 20°C at 1150 hrs.

Airfield information

Coal Aston Airfield is located on a ridge of high ground at an elevation of 720 ft amsl. The ground falls away to the west and south, limiting the options for a forced landing when taking off in a westerly direction. Grass Runway 29/11 is 610 m long and 20 m wide, and the surface is undulating with an overall downslope from east to west. At the west end of Runway 29 is an open grass area, extending for 160 m, and then a hedgerow. A minor road runs behind the hedge beyond which there are several small fields, sloping down away from the airfield.

Description of the aircraft

General

The Europa is a home-built, two-seat, side-by-side light aircraft of conventional layout and composite construction. It is sold in kit form and in the UK its construction is overseen by the Light Aircraft Association (LAA) through a network of approved inspectors. Once the aircraft has been completed to the required standard a Permit to Fly can be issued.

It is available with either tricycle landing gear, or as a mono-wheel with a single mainwheel, tailwheel and outriggers on the wings. G-NDOL was a mono-wheel version with a 'classic' wing which had stall warning strips fitted. During the most recent flight test, the stall speed in the clean configuration was recorded as 52 kt with natural buffet occurring at 55 kt; behaviour at the stall was noted as satisfactory.

Engine

This aircraft was fitted with the recommended Rotax 912ULS engine, although when originally constructed it had another engine type installed. The modification to the current engine was completed in 2002.

The Rotax 912ULS is four-cylinder, horizontally-opposed, four-stroke, piston engine producing 73.5 kW (98.5 BHP) at 5,800 rpm (Figure 1). G-NDOL, which had a fixed-pitch propeller with a recorded maximum static rpm of 5,550 rpm, would have a maximum static power of 62 kW. At 4,000 rpm this reduces to approximately 25 kW.

The cylinder barrels are air cooled and the cylinder heads are water cooled. It is fitted with self-sustaining, dual electronic ignition systems to operate the two spark plugs fitted to each cylinder.

It has two carburettors, one at the rear of each pair of cylinders. Fuel is supplied from the aircraft fuel system by an engine-driven fuel pump installed near the front of the engine. Because of the relative location of these components, the fuel pipes are routed across the top of the engine to connect them.

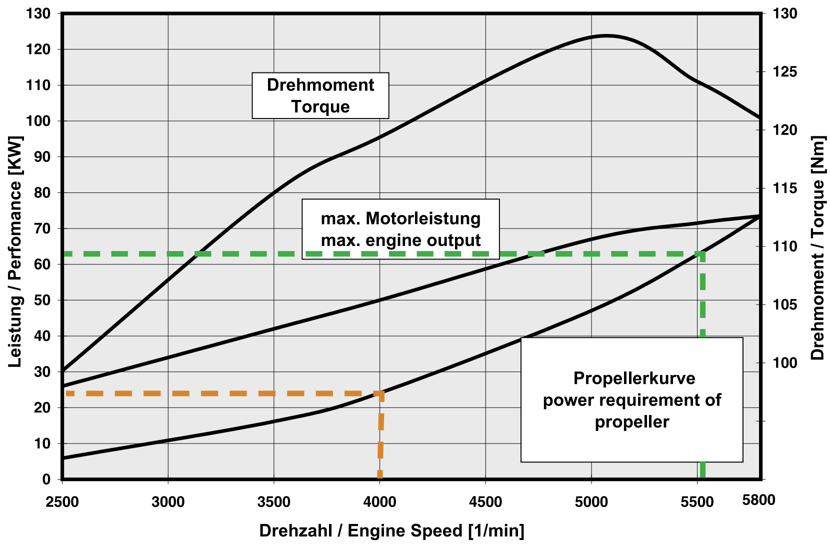

Figure 1

Engine performance graph

This aircraft was fitted with an optional carburettor heat system modification which used the hot water from the cooling system to heat the carburettor bodies and thereby prevent carburettor ice formation.

The ground-adjustable, fixed-pitch propeller on this aircraft was driven via a reduction gearbox.

Fuel system

The fuel tank is installed in the fuselage behind the seats. It is saddle-shaped to fit around the pitch and flap control push rods. This arrangement provides a main tank of approximately 60 litres and a reserve tank of approximately 9 litres. The fuel filler is connected to the right hand side of the tank, and as fuel is added the right hand side fills first and therefore is designated the RESERVE tank. When the reserve side is full, additional fuel then flows over the saddle into the other side and upper part of the tank, which is designated the MAIN tank (Figure 3).

Fuel outlets are provided from both the main and reserve tanks. These are fitted with a coarse mesh filter to prevent larger debris blocking the fuel outlet. A selector valve enables the fuel supply to be selected to MAIN, RESERVE or OFF. From the selector valve the fuel is piped via an electric fuel pump and a fine fuel filter to an engine-driven fuel pump and then to the dual carburettors. A fuel vapour return line is fitted in the fuel line between the carburettors, this is to allow any fuel vapours to return to the tank and dissipate though the tank vent system. This fuel vapour return line is fitted with a restrictor orifice to limit fuel flow.

Accident site

The accident site was located in a field approximately 200 m south of the runway at Coal Aston Airfield (Figure 2). The aircraft was inverted and the evidence indicated it had struck the ground in a steep nose-down attitude. The ground was hard; a thin layer of turf covered a hard stone sublayer. In addition to the main fuselage impact point, a clear mark in the ground was made by the leading edges of the wings.

The main wreckage came to rest approximately 19 m from the initial impact marks. Most of the wreckage was within the area between the main wreckage and the ground marks. A notable exception was a substantial piece of a propeller blade which was found approximately 39 m from the initial impact point and perpendicular to the wreckage trail.

There was no fire.

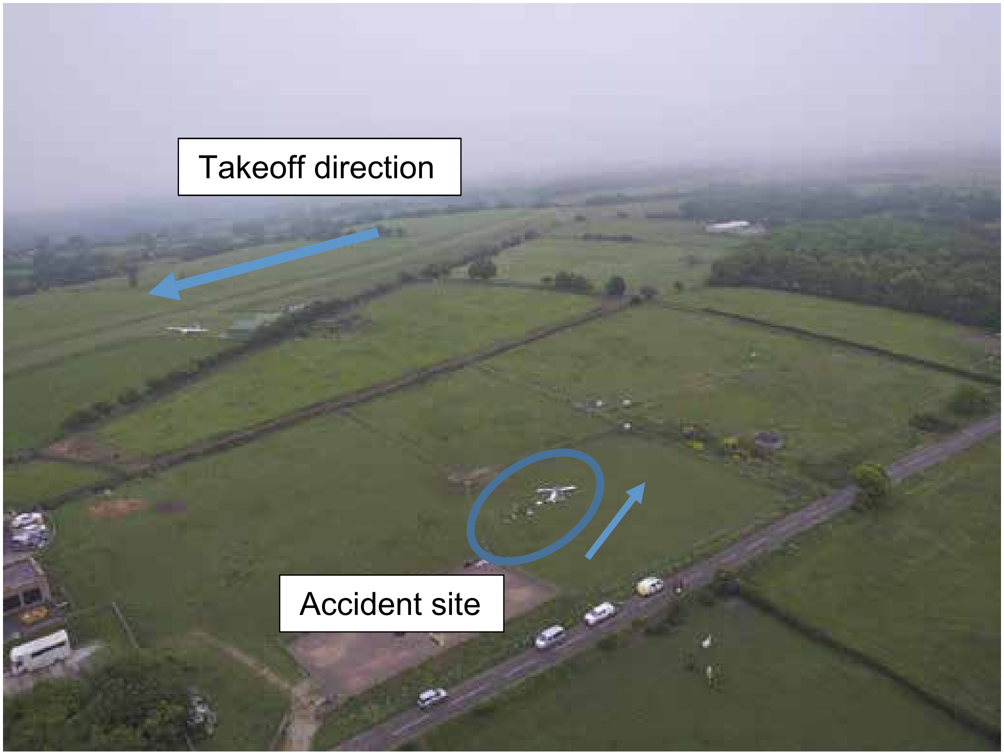

Figure 2
Coal Aston Airfield and the accident site

Initial assessment of the wreckage

Although the aircraft was severely disrupted by the impact, the wings and tail surfaces remained attached to the fuselage. Due to the impact angle the fuselage had crumpled in the area of the cockpit and the engine and the rear fuselage had detached.

It could be confirmed that prior to the accident the flying controls were intact and there was no evidence to suggest that they would not have operated normally. The elevator trim position was found in a normal flight position.

It was not possible to conclusively determine the position of the landing gear and flaps, which operate together from a single lever, but the evidence indicated it was most likely that they were in the retracted position.

The instrument panel was heavily disrupted and fragmented so it was not possible to determine pre-impact switch positions. A number of instruments were found with the indicating needles stuck in a position. The rpm indicator was stuck at 4,100 rpm and the fuel pressure gauge was stuck at 0.14 bar, which is below the minimum fuel pressure specified by the engine manufacturer of 0.15 to 0.40 bar.

The fuel selector valve was found selected to the MAIN tank position as indicated by its placard.

The senior fire officer at the scene stated that when he arrived fuel had been leaking from the fuel tank vent line, it was sealed to prevent further leakage. The fuel quantity on board at the time of the accident was therefore more than the 40 litres recovered from the fuel tank.

Recorded information

The pilot carried a tablet computer with him in the aircraft, but it was damaged in the accident and it was not possible to retrieve any information from it.

Detailed examination of the wreckage

Fuel system

The fuel system on the aircraft was found to be in good condition and its installation was similar to the manufacturer's recommended design configuration but with some notable differences (Figures 3 and 4).

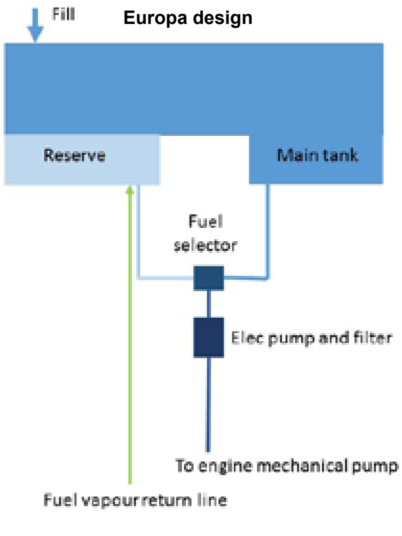

Figure 3

Fuel system schematic based on Europa build manual

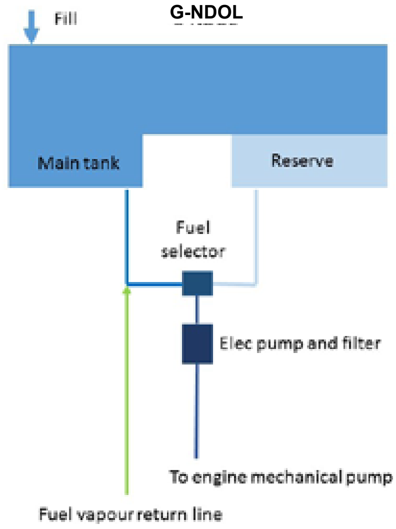

Figure 4

G-NDOL fuel system schematic

The fuel selector was configured such that the left side of the tank was used as RESERVE and the right side and remainder of the tank was designated as MAIN. This configuration was indicated by a placard close to the selector. This was the original design configuration but it was amended, by Europa, to the current configuration early in production.

No coarse fuel filters were found on the tank outlet fittings.

The fuel vapour return line was routed to a 'T' fitting on the fuel selector where it combined with fuel from what had been configured as the main tank (Figure 5).

The fuel lines from the fuel tank to the selector valve and the fuel vapour return line from the engine were all of a similar flexible type with a stainless steel braid cover and threaded metal end fittings. The outlet from the fuel selector to the fuel pumps and to the fuel filter were rigid aluminium lines. A flexible type with a stainless steel braid cover was fitted from the fuel filter to the engine-driven fuel pump. The fuel lines from the engine-driven fuel pump to the carburettors were plain flexible lines with push fit connectors secured with screw type hose clips; these lines appeared to be relatively new.

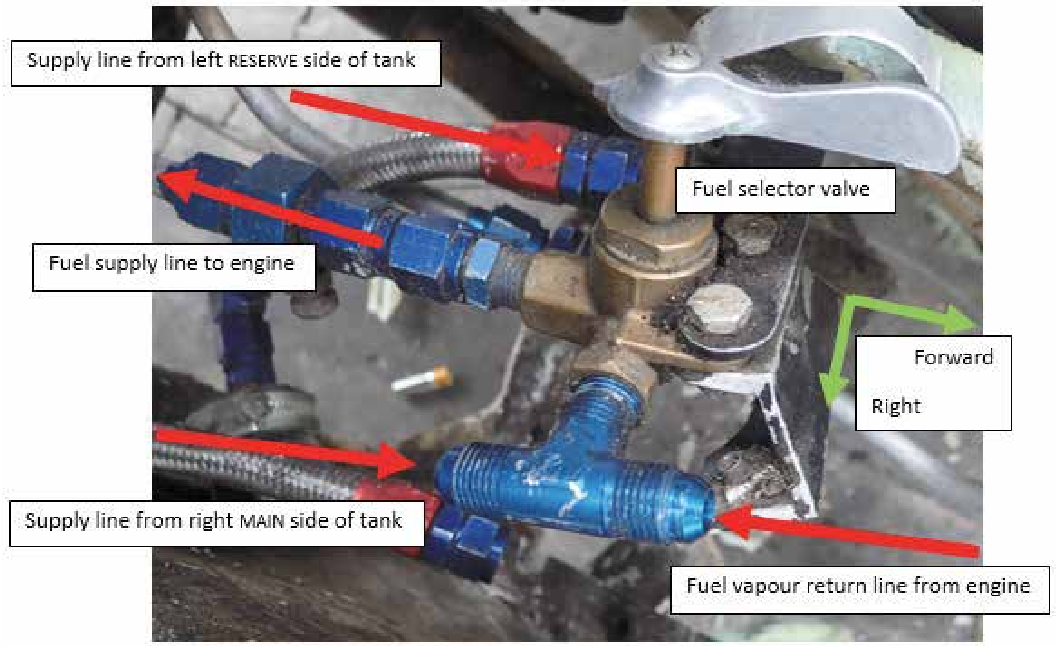

Figure 5

Fuel selector valve showing 'T' fitting on inlet from right side of tank

Testing of fuel filter

The fuel filter assembly was removed and its sintered bronze filter element was inspected. It was found contaminated with general dirt and debris which included insect remains (Figure 6).

Figure 6

Fuel filter element showing contamination found

A flow test was carried out to determine the degree of restriction caused by the debris. The first test was carried out using the filter element fitted at the time of the accident and the test was then repeated with a new element. On both occasions fuel was supplied to the filter by the electric fuel pumps from the aircraft. The results from both the old and the new filters were similar and the fuel flow recorded was well in excess of that required by the engine at full power.

Fuel testing

A sample of the fuel recovered from the fuel tank was tested by a specialist facility. It was found to be consistent with forecourt unleaded fuel to EN228 specification and it contained 4.5% ethanol (E5 Mogas). No records indicating where or when the fuel was sourced were found.

Approved fuels

Historically, suitable LAA aircraft had been able to operate on unleaded Mogas fuel to EN228 standard (forecourt unleaded fuel). In around 2010 fuel companies started to introduce ethanol into this fuel to preserve fossil fuels. Nowadays fuel companies are required by European law to blend bio-fuel into their fuels and the normal choice is ethanol, currently not exceeding 5% by volume and is designated E5 Mogas.

Until late 2014 the UK CAA prohibited the use of Mogas containing ethanol in single engine piston aeroplanes, but at this time it transferred responsibility for choice of fuel and provision for appropriate guidance to the aircraft's type design organisation. For aircraft operating on an LAA Permit to Fly this is the LAA.

The LAA issued guidance in Technical Leaflet TL 2.26; '*Procedures for use of E5 unleaded Mogas to EN228'* which is available from their website. It includes the procedure for clearing eligible aircraft to use E5 Mogas and directs owners to download the relevant inspection checklist to use. This checklist is then verified by an LAA inspector and, if satisfactory, details are entered in the aircraft's engine and airframe log books. The check list for the engine installed on this aircraft includes the following inspection:

> *'A vapour return line must be fitted, to circulate a small amount of surplus fuel and any vapour back to the fuel tank, via a restrictor orifice of around 0.35 mm diameter. Refer to Rotax 912/912S Installation Manual for details.'*

The Rotax 912/912S Installation Manual, which is applicable for the 912ULS, includes the following note:

> *'NOTE: The* [vapour] *return line prevents malfunctions caused by the formation of vapour lock'*

Details of operational limitations are discussed in the leaflet and the following placard summarising these limitations is described. It must be fitted on the instrument panel, or a similar place and in clear view of the pilot.

> ***'USE of E5 Mogas***
>
> - *only legal in aircraft specifically approved for the purpose*
> - *fuel to be fresh, clean, water free and not exceed 5% alcohol content*
> - *verify take-off power prior to committing to take-off*
> - *tank fuel temperature not above 20º C*
> - *fly below 6000 ft*
>
> *WARNING – CARB ICING, WATER CONTAMINATION AND VAPOUR-LOCK MORE LIKELY'*

This aircraft and engine combination can be approved to use E5 Mogas and although G-NDOL was fitted with the required placards, no log book entry or checklist could be found to show the required procedure to use E5 Mogas had been completed or verified by an LAA inspector.

Aircraft maintenance history

The aircraft had been issued with a Permit to Fly and its certificate of validity was in date.

The most recent flight test for the Permit to Fly was conducted on 6 July 2016. The engine static rpm was recorded as 5,550 rpm, and the climb rpm as 5,350 rpm. The propeller was subsequently replaced.

Entries in the aircraft log book record that fuel was drained from the aircraft in October 2016 and then it was refuelled in March 2017.

The last Annual Permit Renewal Inspection was completed satisfactorily on 28 June 2016.

The LAA inspector completing the inspection recalled:

> *'some of the engine compartment fuel hoses, which although still serviceable at the time, would need replacing at some stage in the future.'*

The aircraft log book entry for the Annual Permit Renewal Inspection in April 2014 recorded that some of the fuel lines on the engine were showing signs of wear. They were replaced.

Analysis of the aircraft and engine logbooks show that between June 2006 and June 2011 the were a number of reports of the engine 'rough running'. Significant rectification work was undertaken following these reports which included checking and replacement of parts in the fuel and ignition systems. There were no subsequent reports of 'rough running' in these log books. The pilot's personal flying logbook entry for 18 July 2016 contained an annotation '*Vapour lock – not nice*'.

In March 2007 the aircraft was inspected by an LAA inspector in accordance with checklist PFA/ULM2 to allow Mogas [with no ethanol] to be used. This checklist included the requirement to check a fuel vapour return line was fitted and connected to the tank.

When the Rotax engine was installed in 2002, the LAA inspector who inspected the installation recalled that the fuel vapour return line was routed along the right hand side of the aircraft and into the fuel tank via a fitting on the right hand side of the fuel tank.

There are no log book entries relating to changing the routing of the fuel vapour return line and it could not be determined when the change was made.

Pathology

Post-mortem and toxicological examinations were conducted on the pilot on behalf of the Coroner. There was no evidence of any medical or toxicological factor which could have contributed the accident.

Other information

The aircraft was kept in a steel hangar on the airfield. On a sunny day, temperatures inside such a building are likely to be higher than ambient.

A friend of the pilot, who also flew at the Coal Aston Airfield, had researched the ethanol content of Mogas available at different petrol stations around the local area. He found a local station where the ethanol content was tested as zero and both he and the pilot normally purchased their fuel in jerry cans from there.

In 2015, the friend had researched fields which might be available for a forced landing in the event of an engine failure after takeoff on Runway 29. He considered there were limited options but there was one field ahead he thought suitable if sufficient height was gained by the end of the runway. He had discussed its location with the accident pilot and practised a takeoff technique to gain maximum height while over the airfield.

Partial loss of engine power

A partial loss of engine power after takeoff presents a more complex decision to a pilot than a complete engine power loss. With an engine that is still providing some power, a pilot can be led to consider a turnback towards the runway instead of accepting a forced landing ahead. However, in turning back, they may then find themselves in a worsening situation; manoeuvring and turning downwind at low level and low speed carry a significant risk of loss of control. Additionally, engine power may be unreliable resulting in a total power loss at a potentially critical time.

The CAA published in May 2017 the Skyway Code[1] containing safety information for General Aviation. Guidance is provided concerning partial engine failures:

> *'Particularly at low level, focus on maintaining speed and control. Provided you keep the aircraft at flying speed and under control, engine failures are unlikely to be fatal.*
>
> *Partial engine failures can confuse the decision making process. Assess whether the failure is likely to become worse – for example if rapidly losing oil pressure, the engine may not run for much longer. Take a positive decision to either put down in a field or continue to an aerodrome, depending on your judgement of the problem.'*

A publication by the Safety Promotion Unit of the Civil Aviation Authority of New Zealand in 2013[2], concerning engine partial power loss advised:

> *'Many occurrences result in fatalities or serious injury due to pilots losing control of their aircraft after an engine partial power loss, especially in the takeoff phase of flight.'*

The article emphasised the importance of considering the options in the event of a partial power loss at the pre-flight planning stage and reviewing them again immediately before takeoff.

ATSB Transport Safety Report '*Aviation Research and Analysis - AR-2010-055 Avoidable Accidents No. 3 Managing partial power loss after takeoff in single-engine aircraft*'[3] provides information and guidance on partial engine power loss events and advises:

> *'Partial engine power loss is more complex and more frequent than a complete engine power loss.'*

Footnote

1 http://www.caa.co.uk/General-aviation/Safety-information/The-Skyway-Code/ [Accessed 24 August 2017]
2 https://www.caa.govt.nz/assets/legacy/Publications/Vector/Vector_2013-3.pdf [Accessed 18 August 2017]
3 https://www.recreationalflying.com/tutorials/safety/ATSB_ar2010055.pdf [Accessed 27 August 2017]

Analysis

Operational aspects

On the day of the accident the weather conditions were good; it was warm but not hot. The aircraft was kept in a hangar where the temperature may have been higher than the ambient, thus the temperature of the fuel may have been above 20 °C. The pilot moved the aircraft out of the hangar and then went on a local flight for around 20 to 30 minutes. The aircraft was parked outside for a while before he took off and flew a short 'hop' along the runway. Although the reason for this 'hop' was not determined the pilot did not mention having experienced a problem to anyone at the airfield.

The aircraft was seen to take off on the accident flight but it did not achieve a 'normal' rate of climb. The engine power was reduced although it was still producing power at impact; evidence from the wreckage and witnesses suggests it may have been operating at approximately 4,000 rpm. This would represent about 40% of takeoff power, probably sufficient to maintain level flight or a small climb gradient but any turn would diminish this performance. An aircraft's rate of climb is dependent on the difference between the available engine power and the power required for level flight; hence a modest reduction in engine power can result in a significant reduction in climb performance.

The evidence from the accident site suggests that the landing gear and flaps were retracted at impact. If so, this would indicate that the pilot was not aware of any problem until after he had lifted off from the runway and performed the single action of gear and flap retraction. The aircraft was at an estimated height of 100 ft to 150 ft when the left turn began; starting to turn at such a low height suggests the pilot was aware of a problem. There was approximately 160 m of open ground ahead before the hedgerow but beyond that options for a forced landing were somewhat limited. The partial loss of power could have led the pilot to consider a turnback, believing he could maintain height, but in the takeoff phase as soon as any turn is started the associated reduction in climb performance is likely to require a descent to maintain airspeed. In contrast, a total power loss at low level does not usually offer the option of a turnback with its risk of a loss of control, because an immediate landing ahead is required. The ground cues during the low level turn downwind could have given the pilot an impression of an increasing and higher than actual airspeed, and thereby led to a stall. Any pre-stall indications of buffet would have been very brief; a recovery from such a low height would not have been possible.

Engineering aspects

The evidence from the accident site together with the eye-witness accounts suggest that the aircraft had stalled prior to ground impact.

Inspection of the aircraft did not reveal any anomalies that would have affected its ability to fly or be controlled. The aircraft and pilot log books recorded a previous history of problems with engine power, including on one occasion '*vapour lock*'. The reason for these problems does not seem to have been resolved, as evidenced by the entry for July 2016.

There was one significant anomaly relating to the fuel system that may have been relevant to the accident. The fuel vapour return line was connected to the inlet of the fuel selector valve, rather than to the fuel tank. This would have the effect of routing any fuel vapour that formed in the fuel system back to the engine instead of returning to the fuel tank to dissipate.

The two flights conducted earlier in the day meant the aircraft would have been parked with a hot engine. The warm fuel, heat soak from the hot engine and the fuel system installation in the aircraft made the aircraft more susceptible to the formation of fuel vapour, especially when using E5 Mogas. Limitations that are stipulated with the approval for using this type of fuel make reference to this.

Due to the installation of the fuel system on G-NDOL any fuel vapours that formed would not have been dissipated to atmosphere via the fuel tank vent as designed, but instead they would be recirculated back into the fuel supply to the engine and thereby increasing the risk of a disruption to the fuel supply to the engine.

The aircraft was using E5 Mogas, and although it was eligible to use this fuel, no evidence of the relevant procedures to approve its use could be found. The checklist that is completed as part of this procedure includes an inspection to ensure a fuel vapour return line is installed to route any fuel vapours back to the fuel tank.

A similar inspection to approve the use of Mogas had been satisfactorily completed in 2007, it contained the same requirement to check the installation of a fuel vapour return line.

The available evidence indicates that fuel vapour probably formed in the fuel supply to the engine. Anomalies with the fuel system meant that any vapour that formed might not dissipate effectively. Instead, it would have been returned to the engine where it is likely it would disrupt the fuel supply to the engine reducing the power it was able to produce.

Conclusion

The aircraft suffered a partial loss of power shortly after takeoff, probably as a result of fuel vapour disrupting the fuel supply to the engine. The likelihood of vapour lock was increased by the incorrect routing of the vapour return line into the fuel selector valve rather than the fuel tank. The pilot attempted a left turn downwind at low level, possibly intending to return to land at the airfield. The aircraft stalled in the turn at a height from which a recovery would not have been possible.

Safety action

The AAIB discussed the investigation findings with the LAA and the LAA took the following action.

On 19 July 2017 the LAA issued Airworthiness Information Leaflet LAA/MOD/247/010. This required a mandatory inspection, before next flight, of all Europa aircraft operating under an LAA administered Permit to Fly. The inspection was to check for the correct installation of a fuel vapour return line. Details can be found on the LAA website.