SERIOUS INCIDENT

Aircraft Type and Registration:	Pioneer 300, G-CGTL
No & Type of Engines:	1 Rotax 912ULS engine
Year of Manufacture:	2012 (Serial no: LAA 330-15038)
Date & Time (UTC):	25 May 2020 at 1400 hrs
Location:	Near Abergavenny Airfield, Gwent
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to propeller and lower fuselage
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	53 years
Commander's Flying Experience:	1,306 hours (of which 4 were on type) Last 90 days - 10 hours Last 28 days - 0 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and additional enquiries by the AAIB

Synopsis

The aircraft was on its first flight after maintenance when an electrical current audio warning was announced during the climb, followed shortly thereafter by a loss of engine power. The electrically-operated landing gear did not extend when selected and there was insufficient time for the pilot to extend the landing gear manually. He performed a successful wheels-up forced landing in a field.

The aircraft was not examined by the AAIB. Given the weather conditions on the day and the use of Mogas fuel, the investigation considered vapour lock in the fuel system as a potential cause of the loss of engine power.

The electrical current problem may have been exacerbated by the loss of engine power. This, in isolation or in combination with landing gear system adjustment issues, could account for the failure of the landing gear to extend when selected.

History of the flight

Background

The aircraft had recently undergone modification, reassembly and maintenance, much of which was done under the supervision of a Light Aircraft Association (LAA) inspector at his premises at Abergavenny Airfield. The maintenance had included an annual inspection for renewal of the aircraft's Permit to Fly, which had expired during the period when the work was being undertaken.

Following completion of the maintenance, the pilot, who was a friend of the aircraft owner, was to undertake a post-maintenance check flight. Subject to that being satisfactory, the plan was to then carry out a test flight for renewal of the Permit to Fly after which he would fly the aircraft back to its home base.

The flight

The pilot arrived at the airfield at around 1130 hrs to find G-CGTL parked on the apron, fuelled and ready to fly. He met with the LAA inspector who briefed him on the work that had been performed on the aircraft. Although the aircraft had not flown since being reassembled, the engine had been run for approximately 15 minutes with no issues apparent.

The pilot carried out the pre-flight checks and checked the weather and NOTAMS for Cardiff Airport. He reported that at around 1330 hrs he ran the engine on the apron for approximately 12 minutes and was happy with the engine temperature and pressure readings. The exact duration of the ground run was not determined. After completing control checks, he taxied to the threshold of Runway 15 where he carried out a final full power check, a magneto drop check and a carburettor heat check, all of which were normal. He took off and climbed to the south. He reported that when the aircraft was at 600 ft agl an Electrical Flight Instrument System (EFIS) *'electrical power'* warning was announced through his headset. As he commenced a right turn through 180° to return to the airfield, the engine started to vibrate violently and run erratically before losing thrust and stopping. He checked that the electric fuel boost pump was ON, changed the selected fuel tank and attempted to restart the engine. The engine fired and operated for several seconds before once again losing thrust, although it continued to operate with the propeller windmilling.

Realising he would not make it back to the airfield, the pilot turned the aircraft into wind, lowered the landing gear selector switch and chose a field in which to land. However, the three landing gear indication lights did not illuminate and he noted that the landing gear circuit breaker had tripped. He reset the circuit breaker and reselected the landing gear DOWN but the circuit breaker tripped again. The aircraft was at approximately 300 ft agl and there was insufficient time to lower the landing gear manually. At 75 ft agl he switched the engine off and conducted a successful wheels-up landing in a field approximately 1.6 miles south of the airfield (Figure 1). The pilot was uninjured and exited the aircraft without assistance.

Following the forced landing the LAA inspector recovered the aircraft. After lifting the aircraft, he reported that the landing gear extended normally and the engine started and appeared to run normally, including at full power. The aircraft was then taxied to the edge of a track, where the wings were de-rigged for recovery.

The pilot later commented that he had previously experienced the '*electrical power*' warning on G-CGTL, but only on the ground with the engine at idle or taxi power and all electrical loads running. The owner subsequently advised the pilot that he had also previously experienced this warning twice on climb out and extending and raising the landing gear had appeared to resolve it.

Figure 1
G-CGTL after landing

Meteorology

Cardiff Airport, approximately 31 miles south-west of Abergavenny Airfield, was reporting good weather conditions at the time of the flight with no cloud, visibility in excess of 10 km and a wind of between 6 and 8 kt from the south-west. The temperature was 21°C with a dewpoint of 8°C. When plotted on the Civil Aviation Authority (CAA) carburettor icing chart (Figure 2) they indicate that there was a likelihood of moderate icing at cruise power and serious icing at descent power.

The pilot reported that the actual wind at Abergavenny prior to takeoff was predominantly southerly at 7 kt and the temperature was 19°C with a dewpoint of 8°C.

Aircraft information

The Pioneer 300 is a home-built, two-seat light aircraft of conventional layout and predominantly wooden construction which is sold in kit form. The landing gear retraction/extension system uses a single electric motor which drives three screw jacks, one for each landing gear. The right main landing gear is the master leg and movement of the left and nose landing gear legs are slaved to it. DOWN stop and UP stop microswitches on the right main landing gear provide stop limits for the electric motor. The current drawn by the motor is directly proportional to the torque being produced. A circuit breaker rated at 7.5 Amps, is incorporated in the system. In addition to protecting the wiring, the circuit breaker ensures the motor cannot exert undue loads on the wooden airframe and mechanical aspects of the landing gear system, if the motor stop limits are exceeded.

When the landing gear legs are fully extended, the screw jacks operate overcentre mechanisms to lock them in position. Indication of the landing gear position is provided by microswitches on each landing gear and three landing gear indication lights, illuminate green when the landing gear are down and locked. If the electric motor fails, or the landing gear does not lock down for any reason, a hand crank can be used to drive the mechanism manually; approximately 40 turns are required to fully extend the landing gear.

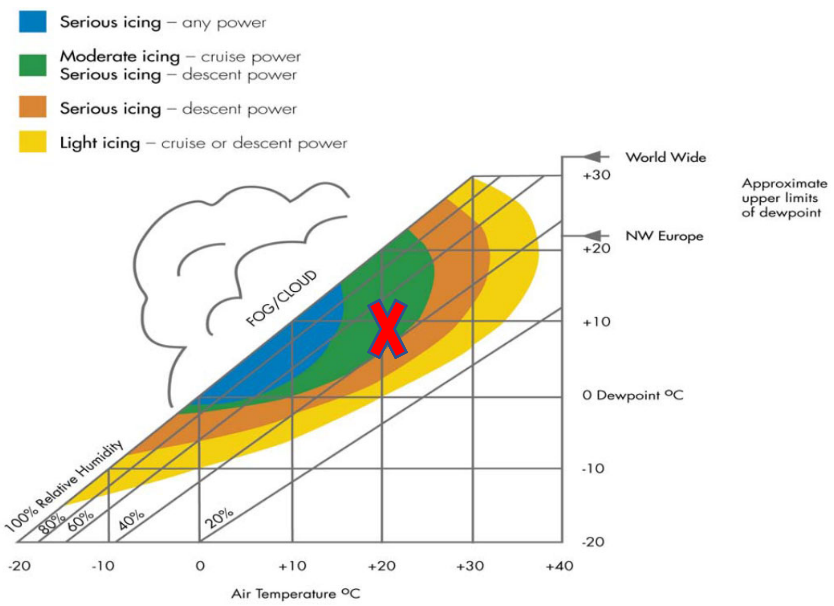

Figure 2

Carburettor icing chart

In the March 2017 edition of its monthly magazine, the LAA wrote an article about landing gear issues on Pioneer 300 and 400 aircraft, including the importance of correct adjustment of the landing gear extension/retraction system and its microswitches. It points out that the Pioneer landing gear system requires regular inspections including retraction checks, to ensure that it remains correctly adjusted.

G-CGTL was fitted with a Rotax 912ULS four-cylinder, horizontally opposed, four-stroke, piston engine and a two-blade variable-pitch propeller. The engine has two carburettors, one at the rear of each pair of cylinders. G-CGTL was also equipped with a dual screen Dynon Avionics Skyview EFIS system which incorporates an engine monitoring function. Selected engine parameters are monitored and relevant warnings appear in a dedicated message window on the Skyview display and associated audio alerts are announced via the audio panel or intercom. Warnings relevant to the electrical system include ‘ELECTRICAL CURRENT’ and ‘VOLTAGE’ warnings.

Fuel

G-CGTL was approved by the LAA to use Mogas (unleaded motor gasoline) with an ethanol content not exceeding 5% volume, designated as E5 Mogas. LAA Technical Leaflet (TL) 2.26 *‘Procedures for use of E5 unleaded Mogas to EN228’* dated December 2017, contains guidance relating to the use of Mogas in LAA aircraft and the associated operational limitations.

Mogas has a wider boiling point range and contains more volatile components than Avgas, which means it can form a vapour more easily. Therefore, an increase in temperature or a drop in pressure can cause it to vapourise. The reduction in pressure with altitude, as an aircraft climbs causes vapours to form more easily, even at moderate temperatures. Furthermore, Mogas can become heat-soaked in hot weather.

When fuel turns to vapour in a fuel system, it can form a bubble creating a 'vapour lock' which can restrict or prevent the fuel flow to the engine. This can cause lean running of the engine or loss of engine power. This situation can be further exacerbated if the fuel system design is such that a fuel delivery line passes close to a hot part of the engine, further increasing the likelihood of vapourisation. Due to its greater tendency to vapour lock, the LAA restricts Mogas to operation with a fuel tank temperature not exceeding 20°C and an altitude not exceeding 6,000 ft.

As Mogas contains a larger proportion of low boiling point hydrocarbons than Avgas, it evaporates earlier when it enters the carburettor. This, in addition to ethanol's tendency to absorb water, means carburettor icing is more likely to occur when using Mogas.

Mogas has a shorter shelf life compared with the more chemically stable Avgas and TL 2.26 cautions against storing it in large quantities or using old fuel. The composition of Mogas varies by season, with winter grade Mogas containing more volatile components and having a higher vapour pressure than summer grade, to assist engine starting in cold weather. This reduces the temperature at which vapourisation occurs. TL 2.26 advises that using winter fuel in spring, summer or autumn can increase the likelihood of vapour problems.

Aircraft maintenance

G-CGTL, in common with other Pioneer aircraft, was required by the LAA to undergo a modification to the flight control hinge bolts. Its fuselage had also suffered damage due to moisture ingress while hangered at its home base. The owner arranged to have the wings and elevators removed by a local maintenance organisation and these were transported to Abergavenny Airfield, where the modification to the flight controls was carried out under the supervision of an LAA inspector. The fuselage was sent to a separate facility for repair and repainting, after which it was transported to Abergavenny where the aircraft was reassembled and independent post-rigging inspections were carried out. This included landing gear retraction checks.

The LAA inspector carried out some additional maintenance at the owner's request. This included replacing the nosewheel and checking and adjusting the landing gear. He subsequently reported that he had encountered some difficulty when adjusting the landing gear system. The maintenance also included tightening the nuts on the choke and throttle quadrant, changing the engine oil, replacing the oil filter, visually inspecting the oil and fuel lines, undertaking an engine compression check and performing the annual inspection for renewal of its Permit to Fly, which had expired on 16 May 2020. The accompanying worksheets indicated that much of this work was done by an assistant and inspected/signed off by the LAA inspector. A Permit Flight Release Certificate was issued by the LAA inspector to enable test flying.

When refuelling the aircraft following completion of the maintenance, a piece of electrical insulation tape, approximately eight inches long, was found floating in the left wing fuel tank. No work had been carried out in the fuel tank during the recent maintenance. The left wing was removed and the tank was removed, drained, inspected and flushed; no other contamination was noted. The LAA inspector advised that the aircraft had been fuelled from his personal supply, which had recently been replenished with fresh fuel from a local garage forecourt. The wings and control connections were re-rigged once again and independent post-rigging inspections carried out.

Prior to the incident flight, the LAA inspector briefed the pilot on some of the work which had been undertaken on the aircraft, including the actions taken as a result of finding the debris in the left fuel tank. The LAA inspector reported that he advised the pilot to remain in the vicinity of the airfield and to be aware that the landing gear had been adjusted, therefore manual operation may be necessary. He was therefore surprised to see the aircraft depart the airfield after takeoff. The pilot did not recall being made aware that the landing gear had been adjusted.

Aircraft examination

The aircraft was examined by a representative from the LAA Engineering department, who noted minor damage to lower fuselage panels, floor support and the tip of one propeller blade. Low and high-power engine runs were conducted and the variable-pitch propeller was operated; all systems appeared to be working normally. Inspection of the fuel system included checking the fuel filters, carburettor float bowls and gascolator; no anomalies were noted. A fuel pipe to the right carburettor was found to be loose, although no leakage was observed when a fuel system pressure test was conducted. The fuel pipe had not been disturbed during the recent maintenance. Fuel samples were collected from the aircraft fuel system and the inspector's fuel supply.

The wings were rigged and the aircraft jacked to carry out landing gear extension and retraction tests. The LAA Engineering representative reported that the landing gear appeared to operate normally mechanically and electrically but noted that although the nose landing gear locked down correctly, when retracted, it did not retract sufficiently into its housing for the wheel to come in to contact with the wheel brake. The examination did not establish the reason for the landing gear circuit breaker tripping.

The aircraft was not examined by the AAIB.

Post-incident repair

During a subsequent repair assessment at a separate maintenance facility, the incident damage was discovered to be more extensive than initially estimated. Additionally, several issues relating to the initial aircraft assembly were identified and are under review by LAA Engineering. One issue which may have potential relevance to this incident is that the left fuel tank vent was positioned in such a way that it could have generated a lower than normal fuel tank pressure; staining was noted on the underside of the wing in the vicinity of the vent which indicated that there had been fuel flow from this vent. In isolation, the LAA did not consider that this finding would have prevented fuel from entering the fuel pump, however the reduced fuel system pressure could have contributed to a fuel vapourisation issue.

The maintenance facility had the carburettors overhauled as a precaution and no anomalies were noted. It also intends to replace all fuel hoses. At the time of publication of this report, the aircraft was still undergoing repair and the maintenance facility had not yet undertaken further examination of the aircraft fuel system.

Information from the aircraft manufacturer

The aircraft manufacturer stated that if the landing gear system is correctly set up, a landing gear buzzer will sound in the air if the flaps are down and the landing gear is in the UP position or not fully extended.

It indicated that incorrect setup of the landing gear microswitches could cause the landing gear circuit breaker to trip. Correct adjustment of the microswitches is required for the landing gear electrical motor to stop in the correct position. The manufacturer stated that the post-incident observation, that the nosewheel was neither fully retracted or braked in its housing, would not have had an adverse effect on the aircraft. Nor should it have prevented successful extension of the landing gear.

Tests and research

The fuel samples taken from the aircraft fuel system and the fuel supply during the LAA aircraft examination were analysed using gas chromatography with a mass spectroscopy detector to investigate the presence of ethanol. A trace level of ethanol was detected in each sample, well within the 5% allowable.

The samples were also tested for vapour pressure and the results obtained fell in the correct range for spring, summer, and autumn volatility grades of Mogas. The results were not consistent with winter grade fuel. However, the laboratory could not be definitive on this matter as it noted that the containers in which the samples were collected and stored were not ideal and may have allowed a loss of vapours, which could have contributed to the low result.

Operational procedure for engine failure

Section 4 ‘Emergency procedures’ of the Pioneer 300 flight manual states:

> *‘The engine installed in the Pioneer 300 is not certified and can fail at any time. Never fly over areas on the which a safe landing cannot be made in the event of an engine failure.’*

It also states:

> *‘Due to the airframe structure and retractable gear emergency forced landings should be performed with gear and flaps up. This configuration has been demonstrated to minimise damage.’*

Analysis

Operational aspects

The pilot indicated that he had intended to remain within gliding distance of the airfield but considers that he was distracted by the electrical warning and continued to climb while trying to establish its cause. Had he remained within the immediate vicinity, he considers that he could have made it back to the airfield following the loss of engine power.

Loss of engine power

The engine operated normally on the ground following the forced landing and during subsequent examination several days later. No obvious cause for the loss of engine power was identified.

Debris of unknown origin was found and removed from the left wing tank prior to the flight. A post-incident examination by the LAA did not identify any debris or contamination in the fuel system or carburettor float bowls, and this was ruled out as a potential cause of the loss of engine power. No anomalies were noted during subsequent overhaul of the carburettors.

The issues associated with the use of Mogas are well documented in LAA TL 2.26. The ambient temperature on the day was between 19 and 21°C. The aircraft was sitting in the sun when the pilot arrived at the airfield and remained so for another two hours, which could have created potential for heat soaking of the fuel tanks. An extended engine ground running period would have caused high engine temperatures. Given the combination of these factors, it is possible that the temperature in the fuel tanks, or elsewhere in the fuel system, exceeded the 20°C operational limit for Mogas. This could have led to fuel vapourisation and vapour lock within the fuel system, interrupting the fuel flow to the carburettors, which in turn could account for the engine vibration and loss of power. The positioning of the left fuel tank vent may also have generated a lower than normal fuel tank pressure and could have contributed to any fuel vapourisation problems.

Laboratory testing of the fuel samples indicated that the ethanol content was well within the 5% allowable and the samples appeared to be consistent with the appropriate grade of Mogas for the time of year.

The weather conditions on the day created a likelihood of moderate carburettor icing at cruise power. The pilot recalled that he maintained the initial climb power setting while attempting to establish the reason for the electrical warning, reducing the likelihood that carburettor icing could have contributed to the loss of engine power.

Landing gear and electrical issues

Post-incident examination identified that the nose landing gear did not retract fully into its housing. It was not established whether this was related to landing gear adjustment issues or misalignment which may have occurred during the forced landing. The subsequent repair facility noted heat damage in the nosewheel housing which it considered was due to wheel friction.

While the aircraft manufacturer indicated that this would not necessarily prevent successful extension of the landing gear, correct adjustment of the landing gear system and its microswitches is crucial to ensure the landing gear electrical motor stops in the correct position. Improper adjustment can cause the motor to require greater than normal torque to actuate the gear and could cause the landing gear circuit breaker to trip to protect the mechanical aspects of the system. There was no indication of a problem with the landing gear system until the pilot attempted to lower the landing gear for the forced landing and he did not report the landing gear buzzer sounding. The importance of correct adjustment of the landing gear system and its microswitches has previously been promulgated by the LAA.

The pilot reported an aural '*electrical power*' warning during the climb. Based on the range of available engine parameter warnings it is likely that more specifically this was an ELECTRICAL CURRENT warning generated by the EFIS engine monitoring function. The extended engine running period on the ground may have depleted the aircraft's battery. There are many electrical loads in the aircraft, including two EFIS displays and all systems were likely to have been operating during the short flight. It is therefore possible that the additional and potentially increased electrical demand caused by raising the landing gear after takeoff, may have come close to, or exceeded the alternator output, leading to the ELECTRICAL CURRENT warning. This situation could have been further exacerbated by the loss of engine power and the alternator output would likely have remained insufficient to support operation of the landing gear motor, despite the pilot's attempts to reset the landing gear circuit breaker.

The aircraft owner reported that previous occurrences of the ELECTRICAL CURRENT warning were cleared by extending and raising the landing gear. While these actions may have temporarily resolved the problem on those occasions, this option was not available to the pilot during the incident flight. The previous warnings may have indicated that something was amiss with the set up of the landing gear system and/or its interaction with the electrical system.

The Pioneer 300 flight manual advises that in the event of an emergency forced landing, the landing gear should be retracted. While in different circumstances the problems with the landing gear could have resulted in an unsafe condition, in this instance it was perhaps fortuitous that the landing gear remained retracted. That the pilot attempted to lower the landing gear prior to the forced landing, may indicate that he was not fully conversant with the emergency procedures for the Pioneer 300.

Conclusion

The aircraft was not examined by the AAIB and the investigation did not conclusively identify the cause of the engine power loss or the landing gear problems. But given the weather conditions on the day and the use of Mogas, vapour lock in the fuel system was considered as a potential cause of the loss of engine power. The electrical current problem, either in isolation or in combination landing system adjustment issues, could account for the failure of the landing gear to extend when selected.

Faced with several warnings and system failures, the pilot prioritised flying the aircraft and completed a successful forced landing because his training and practice enabled him to identify a suitable landing site within the gliding capability of the aircraft.