Investigation report

L2012-05

Forced Landing of an Ultralight Aircraft at Hyvinkää on 26 August 2011

Translation of the original Finnish report

OH-U478

Ikarus C 42 B

Onnettomuustutkintakeskus
Olycksutredningscentralen
Safety Investigation Authority, Finland

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SUMMARY

An Ikarus C 42 B ultralight aircraft, registration OH-U478, made a forced landing in a field at Hyvinkää on 26 August 2011 at 16:06. The engine stopped on a training flight at approximately 160 m AGL when the aircraft was in a landing pattern. The aircraft sustained no damage during the landing. The flight instructor and the student pilot escaped without injury.

The flight commenced from Helsinki-Malmi airport at 15:30, heading for Hyvinkää aerodrome where it arrived at approximately 16:00. The plan was for the student pilot to make 6-7 practice landings at Hyvinkää. This was his third cross-country training flight with an instructor. Whereas the first approach and landing were uneventful, during the second approach the engine RPM suddenly decreased to idle at approximately 160 m AGL when the aircraft was on the downwind leg. The power lever, however, was still at cruise power. The flight instructor took over the flight controls. Within a few seconds the engine stopped. The flight instructor realised that they would not make it to the aerodrome and so he steered the aircraft north towards fields and made a successful emergency landing.

The engine was visually inspected, but no abnormalities were found. The engine started normally and numerous test runs were carried out. The fuel system was inspected and pump pressures were measured. The mechanical fuel pump pressure was correct (0.3 bar) and the electric fuel pump pressure was the minimum permissible (0.15 bar). At first nothing out of the ordinary was found when the ignition systems were being tested. However, after several test runs during an ignition test it was discovered that ignition circuit B was inoperative. This fault appeared sporadically and on several test runs did not materialise at all. Nevertheless, because circuit A was operative, the engine ran almost normally. The electronic module of circuit B was replaced with another unit known to operate normally.

During one test run an ignition malfunction was also detected in circuit A. The malfunction in this circuit appeared less often than the one in circuit B. The electronic module of circuit A was also replaced. Following a test flight the aircraft was approved for flight operations.

After that the engine operated faultlessly for 60 flight hours until one training flight when intermittent malfunctioning occurred in one of the ignition circuits. Following this, the entire ignition system was removed, placed on an ignition test bench and tested for approximately six hours at varying RPM. The ignition system worked flawlessly during the test run, after which it was reinstalled on the aircraft. Test runs at varying engine RPM continued for approximately 1.5 hours. Most of the test was, however, run at cruise power RPM. The ignition system worked normally. Since the fault was not found, the entire ignition system was replaced with another system known to operate normally and the aircraft was approved for flight operations.

The engine worked perfectly for approximately 100 flight hours until one time during taxiing when it stopped four times and would not restart. The flight instructor and the student pilot pushed the aircraft back to the hangar.

The entire fuel system was inspected and partly replaced. The mechanical fuel pump was opened at which time it was discovered that the suction valve cover was slightly off of its correct position

over the intake port. Hence, the pump was not generating pressure. Sideways scoring was visible on the valve cover which indicated that the pump had periodically functioned normally and periodically operated either partially or not at all.

The electronic modules that were assembled in the engine at the time of the forced landing were sent to the German and Austrian air accident investigation authorities for testing under their supervision. The modules were functionally tested at the engine manufacturer's laboratory. Prior to testing both electronic modules were X-rayed and the images were analysed. The electric contacts of some of the components in the electronic module of circuit A were found to have too little soft solder in them. Quick Electrical Tests were performed on both electronic modules. The electronic module of circuit B failed its first test, but it functioned normally during the two following tests. No faults were discovered during the thermo cycle test. The electronic module of circuit A passed both tests flawlessly.

The engine stoppage was caused by a damaged suction valve in the mechanical fuel pump and the subsequent fuel feed failure. Low fuel pressure in the electric fuel pump was a contributing factor.

It is likely that neither of the ignition systems' intermittent malfunctions caused the engine to stop.

During the investigation engine manufacturer published an information letter where it orders temperature sensitive label to be installed on electronic module. Based on this letter Finnish Transport Safety Agency issued an airworthiness directive, where installation of temperature sensitive label is mandatory to all electronic modules of Rotax 912 –engines, which are not certified. During the investigation BRP-Powertrain (Rotax) published a line maintenance manual (ver. 3 /1.9.2012), where replacement of the fuel pump is mandatory in every 5 years.

The Safety Investigation Authority issues one safety recommendation. It is recommended that Deutscher Aero Club e.V. (ultralight aircraft type certificate approval organization in Germany) advises the aircraft manufacturer to comply with the engine manufacturer's instructions and recommendations as regards the construction of fuel systems.

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SYNOPSIS

An ultralight aircraft, registration OH-U478, made a forced landing at Hyvinkää on 26 August 2011 at 16:06 (all times are in Finnish time). The aircraft was privately owned and it was operated by Kevytilmailu - Light Aviation. The engine stopped on a training flight at the approximate height of 160 m when the aircraft was in a landing pattern. The flight instructor made a successful forced landing in a field.

On 2 September 2011 Safety Investigation Authority, Finland (SIA) authorised Investigator Esko Lähteenmäki to carry out a preliminary investigation into the causes of the engine stoppage. On 28 May 2012, on the basis of the preliminary investigation, SIA expanded the preliminary investigation into investigation L2012-05. Investigator Esko Lähteenmäki was appointed as team leader for the investigation group, accompanied by Chief Air Safety Investigator Ismo Aaltonen as member of the group. The investigation group was assisted by the German and Austrian air safety investigation authorities by nominating accredited representatives.

The aircraft was transported by road to Helsinki-Malmi airport where the causes for the engine failure were investigated. The ignition system was tested at the repair shop of Aerotecno Oy in Hämeenkoski and the electronic modules were tested in Austria at the laboratory of BRP-Powertrain GmbH & Co. KG under the supervision of the Austrian Air Accident Investigation Bureau.

The engine manufacturer and the fuel pump manufacturer were informed of the mechanical fuel pump fault while the investigation was ongoing.

Comments pursuant to European Union Regulation No 996/2010 were requested from the interested parties, the Finnish Transport Safety Agency, the Finnish Aeronautical Association and the manufacturers of the aircraft and the engine. The comments were included as appropriate to the final report.

The investigation was completed on 12.6.2013.

The material used in the investigation is archived at the Safety Investigation Authority, Finland.

1 FACTUAL INFORMATION

1.1 History of the flight

The aircraft took off from Helsinki-Malmi airport at 15:30 for Hyvinkää aerodrome where it arrived at approximately 16:00. The plan was for the student pilot to make 6-7 practice landings at Hyvinkää. This was his third cross-country training flight with an instructor. The first approach and landing were uneventful, but then the engine RPM abruptly decreased to idle when the aircraft was on the downwind leg for the second time. The power lever, however, was still at cruise power. The flight instructor took over the flight controls and realised that they would not make it all the way to the aerodrome. He steered the aircraft north towards some fields at which time the propeller stopped. It had continued to rotate for about 10 seconds after the loss of power. According to the flight instructor the electric fuel pump was on during the entire flight.

The flight instructor kept looking for a suitable stretch of field where he could make a headwind or a crosswind landing. The first strip was to the left of their route. The instructor turned towards it but soon realised that it was too short for landing. He levelled out and continued to fly in tailwind towards a field straight ahead of them. Taking into consideration the relatively short (360 m) strip and the tailwind the flight instructor applied heavy sideslip. He managed to bring the aircraft to a halt 15 m before a ditch at the end of the strip. The surface of the strip where they landed on the field was semi-dry and closely cropped. The aircraft was not damaged during the landing.

1.2 Injuries to persons

There were no injuries to persons.

1.3 Damage to aircraft

There was no damage to aircraft.

1.4 Other damage

There was no other damage.

1.5 Personnel information

Flight instructor:	Age 73. Private Pilot Licence (A), Glider Pilot Licence and flight instructor rating. Ultralight Pilot Licence and instructor rating. Total flight experience approximately 10 000 hours. Approximately 1500 hours on the type.

Student pilot: Age 56.
Student Pilot Licence.
Total flight experience approximately 40 hours.

1.6 Aircraft information

Ultralight aircraft: Ikarus C 42 B, s/n 0504-6679, year of manufacture 2005. Ultralight aircrafts are not type-certificated.

Total flight hours: 1508 h.

Engine: Rotax 912 ULS, s/n 5644771, year of manufacture 2005.

Running time: 1508 h.

The time between overhauls (TBO) for the engine is 1500 h, but this was extended by 100 hours according to the AIR M8-4.

1.7 Meteorological information

Wind 180 degrees, 7-8 knots. Visibility over 10 km, clouds 4/8 1200 m, temperature 18°C.

1.8 Aids to navigation

The aids to navigation had no bearing on the occurrence.

1.9 Communications

The flight instructor called Helsinki-Malmi air traffic control at approximately 17:00 and reported the forced landing.

1.10 Aerodrome information

The forced landing site is approximately 1 km north of Hyvinkää aerodrome. It was a fairly soft and closely cropped field, approximately 350 m in length. The first touchdown mark was approximately 200 m from the beginning of the strip. The aircraft came to a halt approximately 15 m before a ditch at the end of the strip.

1.11 Flight recorders

There were no flight recorders on the aircraft.

1.12 Wreckage and impact information

Apart from measuring the length of the field and the markings on it no other investigation was carried out at the site.

1.13 Medical and pathological information

No medical or toxicological tests were conducted.

1.14 Fire

There was no fire.

1.15 Survival aspects

No rescue action was needed.

1.16 Tests and research

1.16.1 Inspection of the engine malfunction

The engine was visually inspected. No aberrations were found. The fuel load of 98E5 automotive gasoline was approximately 50 litres. Engine oil and coolant were at the correct levels. The propeller turned normally when turned by hand. The fuel sample taken from the drain valve was free of water. There was a normal amount of fuel in the carburettor float chambers and the bowls were clean.

The engine fired up normally and several test runs were made. The engine operated flawlessly from idle to maximum power. At first, no irregularities appeared in the ignition systems.

1.16.2 Fuel system inspection immediately after the forced landing

The fuel system was meticulously inspected all the way from the tank to the carburettors. Fuel pump pressures were measured.

When the mechanical fuel pump alone was being used, fuel pressure in the fuel line leading to the carburettors was 0.25 bar (at 4000 r/min). When the mechanical and electric fuel pumps were on concurrently, fuel pressure was 0.27 bar. With the mechanical fuel pump disconnected the electric fuel pump generated 0.15 bar (at 4000 r/min). When the electric fuel pump's bypass line was blocked with hose clamp pliers, fuel pressure rose to 0.3 bar. The minimum permissible fuel pressure is 0.15 bar and the maximum permissible pressure is 0.4 bar (Rotax 912 IM 14.2, rev May 01/2007).

As the fuel system was being inspected it was noticed that there were significant discrepancies between the fuel system itself and the system diagram published by the engine manufacturer. A coarse filter was missing from the end of the line inside the fuel tank. Furthermore, there was no return line to the tank from the fuel manifold for the purpose of eliminating vapour lock, and there was no check valve in the electric fuel pump's bypass line.

The valve had been replaced by a restrictor jet which was 2.3 mm in diameter.

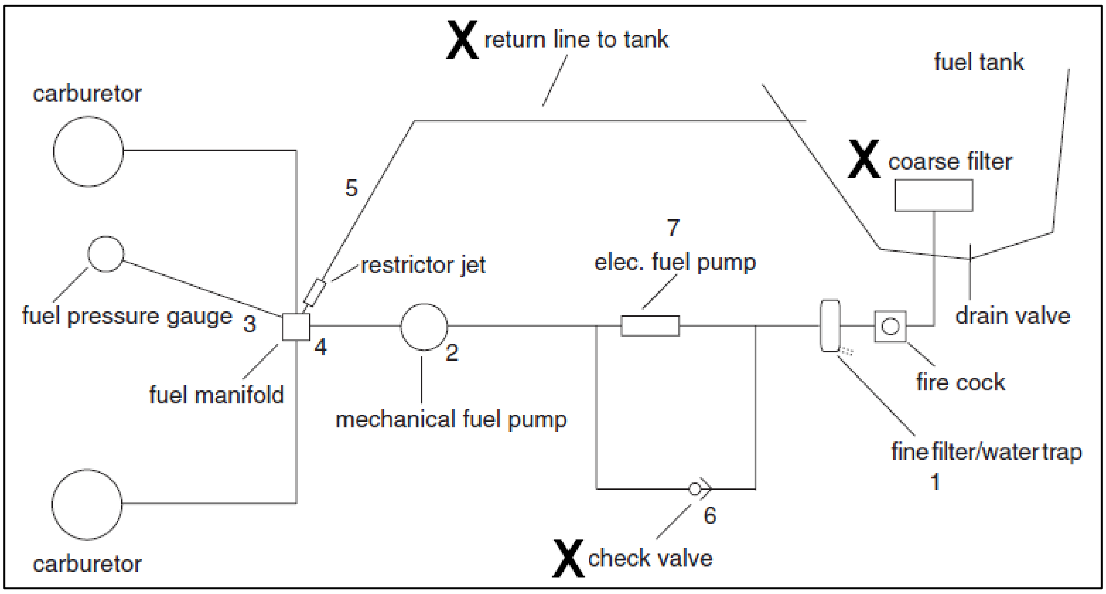

Figure 1. The engine manufacturer's fuel system diagram. The letter X indicates the parts that were missing from OH-U478. All of them are important for the reliable functioning of the fuel system. Source: BRP-Rotax Installation Manual, figure 54.

1.16.3 Inspection of the ignition system

Rotax 912 series engines are fitted with a dual ignition system in which the traditional magnetos are replaced by electronic modules. There are two electronic modules, A and B, which are supplied by the engine's AC generator. Both circuits are totally independent and they share no components. The electronic module is a plastic box, roughly the size of a cigarette box, in which the electronic components are cast in plastic. Each cylinder has two spark plugs: circuit A controls one plug and circuit B the other. Even if one circuit fails, the engine will keep running.

After several engine test runs when the ignition system was being tested, it was discovered that circuit B was inoperative. The malfunction was sporadic and did not appear at all during many test runs. At times it appeared as soon as the engine was being fired up, but then, during the next engine start, the system would function quite normally. After a few engine starts the malfunction recurred and intermittently appeared during the running of the engine. Nevertheless, due to the second ignition system, the engine ran almost normally.

The following parts and components of ignition circuit B were inspected and electronically tested: the magneto stator coil, trigger coils, wires and electrical contacts to the electronic module, charging coils and spark plugs, ignition cables and spark plug connectors. The magneto's trigger coil air gaps were gauged. All measured values met the manufacturer's requirements. Both ignition switches were electronically tested, disassembled and visually inspected. No faults were discovered in the switches, both of which were then replaced. The electronic module was the only part that could not be tested due to the lack of suitable equipment. The wires to the electronic modules were visually inspected and determined to be intact.

When electronic modules A and B were switched with each other, the malfunction in ignition followed module B. It was replaced with a previously used module known to operate normally, following which the engine ran flawlessly.

For the engine to stop the malfunction in modules A and B must occur simultaneously. Test runs were continued so as to expose the fault.

Prior to the planned test flight an ignition system indicator was installed in the aircraft. It was fabricated from a car's electronic tachometer. 'Pulse encoders' were fitted on both ignition circuits by wrapping a few turns of electric wire around one spark plug cable controlled by each circuit. When both ignition systems were operating the indicator would display engine RPM at approximately twice the actual speed. When one electronic module was switched off the indicator displayed the true engine RPM. In this engine type each spark plug is actuated once per every turn of the crankshaft.

During one test run the indicator displayed that one electronic module had switched off. By using the ignition switch, circuit A was found to be the one malfunctioning. While the fault in circuit A would later reappear, it occurred less frequently than that of circuit B.

Both electronic modules were replaced with previously used modules which were known to operate normally. Following a test flight the aircraft was approved for flight operations. The extra tachometer was left in place in the aircraft.

The engine then ran normally for 60 flight hours until one training flight when the extra tachometer indicated occasional ignition faults in one of the systems. The sound of the engine was noted to have changed as well. Following these malfunctions the entire ignition system was removed, placed on a test bench and tested for approximately six hours at varying engine RPM. During the test the electronic modules were heated to 70^{o}C (the maximum permissible temperature is 80^{o}C). All connections and couplings were being bent and stretched. The operation of the ignition system was being monitored by an oscilloscope. The ignition system worked flawlessly during testing.

The ignition system was reinstalled on the engine and test runs at varying engine RPM continued for 1 h 40 min. Most of the test was, however, run at cruise power RPM. The ignition system worked faultlessly.

Since no fault was found, the entire ignition system was replaced with another system known to operate normally and the aircraft was approved for flight operations.

From then on the engine worked faultlessly for approximately 100 flight hours until 25 July 2012, when it stopped four times during taxiing before a flight and would not restart. The flight instructor and the student pilot pushed the aircraft back to the hangar.

The maximum permissible temperature of electronic modules is 80°C (Rotax MMH 74-00-00 2.1, rev May 01/2007). Since the modules are installed on top of the engine, they can reach very high temperatures. On a warm day following a flight the temperature peaks after the engine has been turned off and no cooling air is passing through the engine compartment. Engine coolant and oil temperatures in such conditions still hover at approximately 100°C.

In the summer of 2012, during the investigation, the electronic modules of OH-U478 and OH-U520 (a reference aircraft) were fitted with Telatemp thermometer strips. The strips monitor temperatures from 60-110°C. While the electronic modules of OH-U478 did not reach 60°C, those of OH-U520 did reach 60°C in some situations. In the engine compartment of OH-U478 cooling air flows more efficiently than in that of OH-U520.

The electronic modules installed in the aircraft at the time of the forced landing were the following:

Circuit A: p/n 966726, s/n 05.0089, DUCATI Energia, made in Italy.

Circuit B: p/n 966726, s/n 05.0095, DUCATI Energia, made in Italy.

The running time of both electronic modules was 1508 h, which match with the flight hours of the airframe and the running time of the engine.

1.16.4 Inspection of the engine failure that occurred on 25 July 2012

The engine operated normally during test runs except for the fact that as the ignition system was being tested at engine idle, approximately 1800 r/min, the ignition point of circuit A remained at the engine start ignition timing, which is 4° B.T.D.C, when it should have been at 26° B.T.D.C. In accordance with the manual ignition testing is to be done at 3000 r/min. When this was carried out the ignition operated normally. The discovered fault has no effect on engine operation at power settings used in flight.

The entire fuel system, tank included, was removed. The sediment on the bottom of the tank was flushed and the filter, which looked clean, was replaced with a new one. All fuel lines up to the fire cock were replaced with new ones, and the restrictor jet on the fuel pump's bypass line was removed and replaced with a check valve.

The mechanical fuel pump was opened by force, since it is not designed to be disassembled. Once this was done it was discovered that the suction valve cover was slightly off of its correct position over the intake port. As a result, the pump did not generate pressure. Sideways scoring was visible on the valve cover, which indicated that the pump had periodically functioned normally and periodically operated either partially or not at all. Because the fastening of the valve cover was loose the valve could turn in a sideways direction. The running time of the pump was the same as that of the engine.

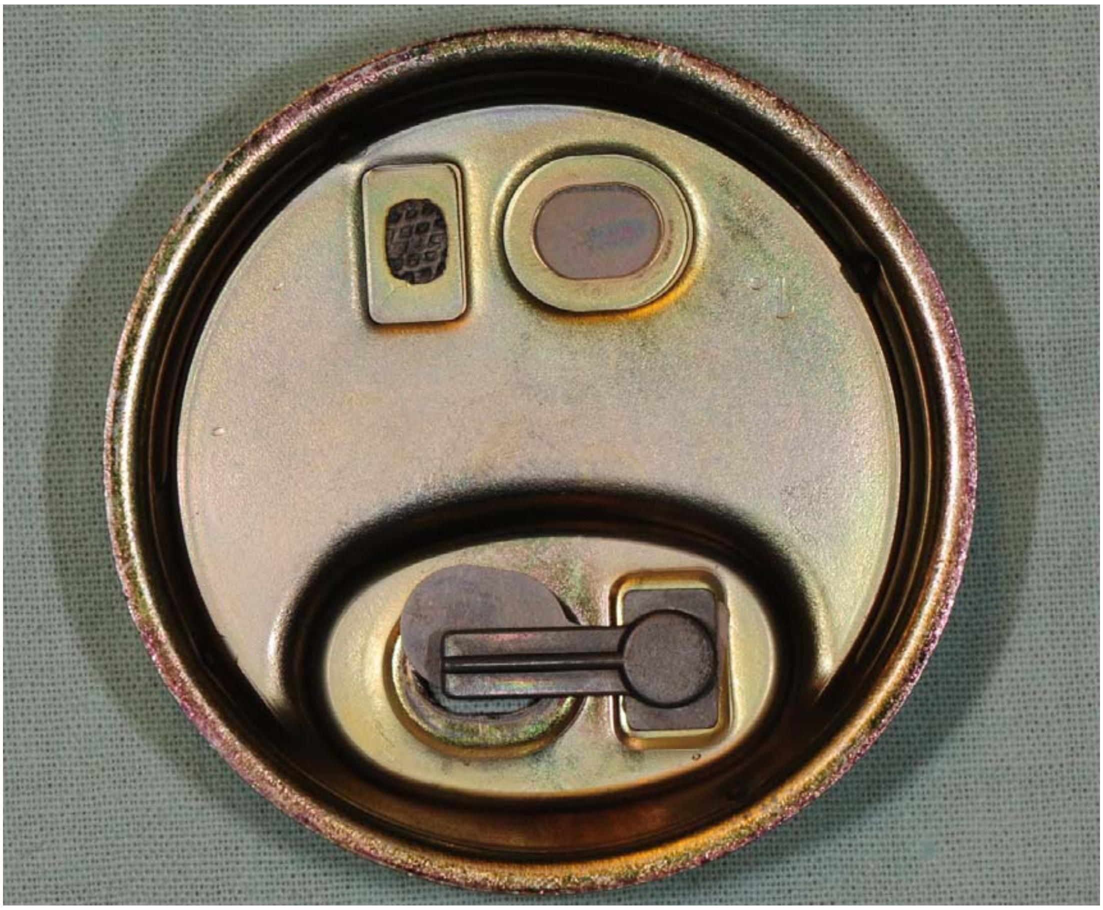

Figure 2. Suction valve cover turned slightly off of its correct position.

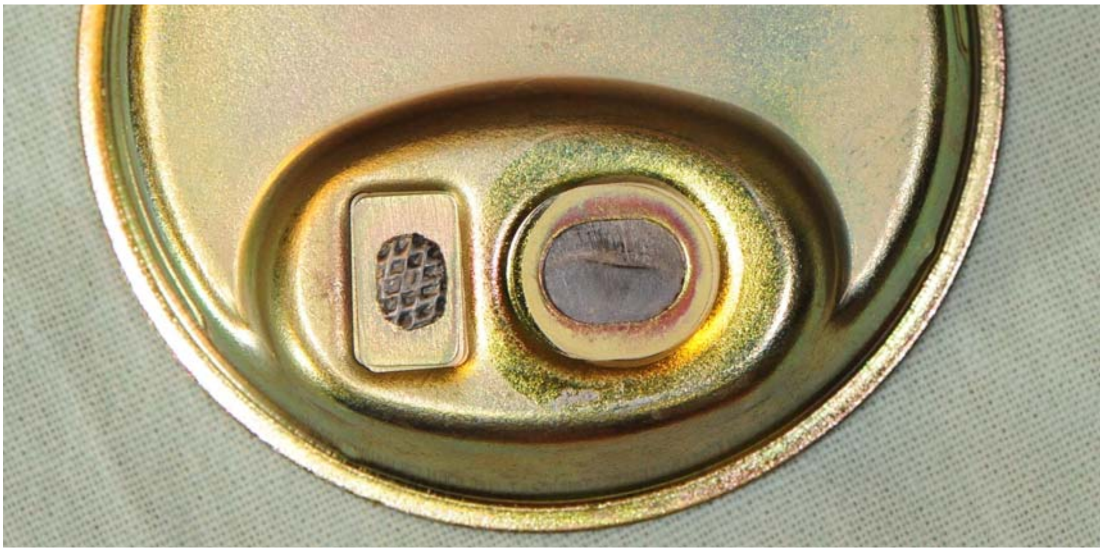

Figure 3. Sideways wear grooves are clearly discernible on the valve cover. Judging by the scoring the cover had constantly been moving between the fully closed and a half open position.

1.16.5 Inspection of the electronic modules abroad

The electronic modules on the aircraft at the time of the forced landing were sent to the Austrian Air Accident Investigation Bureau, under whose supervision they were functionally tested at the engine manufacturer's BRP-Powertrain GmbH & Co. KG laboratory. Prior to the tests both electronic modules were X-rayed and the images were analysed. The electric contacts of some of the components in the electronic module of circuit A were found to have too little soft solder in them. Poor-quality soldering enables the emergence of micro-fractures in a coupling.

Three Quick Electrical Tests were performed on both electronic modules. The electronic module of circuit B failed its first test, but it functioned normally during the two following tests. The electronic module of circuit A functioned normally.

At the request of the investigation group BRP-Powertrain GmbH & Co. KG put both electronic modules through a 26 hour thermo cycle test. During this test the electronic modules were in a thermal testing chamber where they were heated and cooled. The entire test includes four identical thermal cycles. One test cycle encompasses keeping the electronic modules at 80^{o}C for 4 h 10 min. Following this, the temperature was reduced to -20^{o}C where the modules were kept for 2 h 10 min. Crankshaft speed was mostly maintained at 5300 r/min during the test. It was possible to visually monitor the spark plugs during the test. In addition, the electric pulse of one spark plug was digitally measured. Both electronic modules performed normally during the test.

The aforementioned test is the engine manufacturer's standard thermo cycle test carried out for quality control purposes.

1.17 Organizational and management information

The aircraft was privately owned and it was operated by Kevytilmailu-Light Aviation flying club. The club provides training with ultralight aircraft and also rents aircraft. The club had a training certificate. Ultralight aircraft do not require a maintenance organisation.

1.18 Additional information

1.18.1 Earlier engine malfunctions

A fortnight before the forced landing the engine had malfunctioned during taxiing. The first time the engine stopped it was at idle while student pilots were being changed between two training flights. At that time the engine started normally and flight operations were continued.

Approximately one week from the abovementioned occurrence the engine stopped 30 seconds or so after engine start. It then started normally again. Once engine RPM rose to approximately 2500 r/min it stopped for a second time but again started normally. The pilot decided to abandon the planned flight and taxied the aircraft back to the hangar which was approximately 100 m away. When the pilot arrived at the hangar the engine stopped again (this occurrence resembles the one of 25 July 2012).

There is no mention of the first malfunction, following which the flight was not abandoned, in the aircraft's journey logbook. After the second occurrence, following which the pilot cancelled the flight, the pilot said that the second occurrence was either recorded into the journey logbook or onto the defect list which was kept in the airport office. During the investigation, however, no such record was found.

1.19 Useful or effective investigation techniques

X-raying was used to inspect the physical condition of components and soldered joints of the electronic modules cast in plastic.

2 ANALYSIS

2.1 Engine malfunctions

The engine malfunctions were caused by faults in the ignition and fuel systems. These systems are independent of each other. Malfunctions appeared in both ignition circuits, A and B, during the investigation. If they occur simultaneously the engine will fail. Still, the probability of two independent ignition circuits simultaneously failing in an engine is extremely remote. Since the tests could not categorically trace the intermittent ignition malfunctions, the entire ignition system was replaced with another system which was known to operate normally.

There are two fuel pumps in the fuel system: an electric fuel pump and a mechanical, engine-driven fuel pump. The purpose of the electric pump is to guarantee fuel supply in case the mechanical pump fails, and to expedite the evacuation of fuel vapours from the fuel manifold. This entails that the electric fuel pump is switched on and that its pressure is nearly identical to that of the engine-driven fuel pump. As per the checklist the electric fuel pump must be switched on for takeoff and landing. It is also used prior to engine start.

The suction valve of the mechanical pump was damaged to such an extent that its bypass had greatly varied. The more the valve was in the open position the more fuel would return to the suction side, thereby supplying less fuel to the carburettors. If the electric fuel pump is switched on it should be able to transfer fuel to the carburettors through the mechanical fuel pump. This, however, requires sufficient electric fuel pump pressure. In this particular fault the mechanical pump moved fuel towards the electric fuel pump because the pressure of the electric fuel pump was only one half or so of the pressure generated by the mechanical pump. The lack of power was caused by a missing check valve on the electric fuel pump’s bypass line. The check valve had been replaced by a 2.3 mm restrictor jet. When the electric fuel pump’s bypass line was blocked using hose clamp pliers, pressure in the electric fuel pump’s bypass line rose to the level of the mechanical pump.

There were significant discrepancies between the fuel system and the system diagram published by the engine manufacturer. The diagram resembles that of many other type certified aircraft. The three identified differences fundamentally degrade the engine’s reliability. The missing coarse filter from the end of the fuel line inside the fuel tank allows large contaminants (leaves, insects, etc.) to enter the fuel line. A restrictor jet which was 2.3 mm in diameter was in the electric fuel pump’s bypass line, replacing the diagram-specific check valve. Fuel passed from the supply side to the suction side through the restrictor jet. The pressure was at the minimum permissible level. The third irregularity involved no return line from the fuel manifold for the purpose of eliminating vapour lock. The missing return line possibly contributed to the earlier engine malfunctions during taxiing. The residual heat from the previous flight had vaporised the fuel in the fuel manifold and the mechanical fuel pump. Because of this the fuel level in the carburettors had fallen too low, resulting in engine stoppage. The low power of the fuel pumps, for their part, had slowed the evacuation of fuel line vapours through the carburettors. Automotive gasoline, used in this aircraft, vaporises much easier than aviation gasoline.

The mechanical fuel pump's suction valve fault and the inefficiency of the electric fuel pump can be regarded as causal factors to the engine stoppage that resulted in the forced landing, as well as the engine stoppages during taxiing. Since the pump fault was sporadic and varied to a degree, it was hard to trace. The investigation was also significantly hampered by the intermittent ignition malfunctions.

2.2 Electronic module failure

There are approximately 500 electronic modules being used in Finland, some of which are in type certified aircraft. Whereas the electronic ignition system used in Rotax 912 series engines in Finland has proved quite reliable, some electronic module failures have occurred. In earlier types of electronic modules wires would break close to the surface of the boxes. In the newer modules the wire type has been changed and wires are better braced.

The investigation aimed to establish the extent of electronic module failures in Finland. This proved to be impossible because there are no comprehensive statistics as regards ignition malfunctions that resulted in forced landings. Discussions with some operators revealed a few instances in which faulty electronic modules had been replaced with new ones. The importer of the engine said that approximately five electronic modules were purchased from them in the past nine years or so. Since it is known that electronic modules have been purchased from other suppliers as well, it was not possible to establish the total number.

It is difficult to detect a fault in one ignition system in engines fitted with dual ignition systems. Typically a malfunction is detected during the ignition system check before takeoff. If the malfunction is sporadic and does not appear precisely at the time of the pre-takeoff check, it may go unnoticed. In the air the malfunction only materialises as a minor decrease in engine RPM.

2.3 Occurrence reporting

Already before the forced landing the engine had a history of failing on the ground. The first time this occurred flight operations were immediately continued after engine restart. The flight instructor considered the stoppage as a problem associated with engine idling and, this being the case, he did not report a defect. The second time, after the engine stopped three times on the ground, the flight was abandoned. The pilot said that the second occurrence was either recorded into the journey logbook or onto the defect list which was kept in the airport office. No such entry was found during the investigation. The pilot should also have filed a defect report pursuant to Finnish Aviation Regulation GEN M1-4. The investigation could not clearly establish how, or by whom, the aircraft was deemed airworthy. It is possible that a test run was made specifically for this purpose, or at least before the next flight. In all likelihood the engine functioned normally at that juncture.

Finnish Aviation Regulation GEN M1-4 provides for defect reporting in Section 4.1 'Mandatory report' as follows: *The Finnish Transport Safety Agency shall be notified of any incidents, interruptions, defects, errors or other exceptional circumstances (occurrences) related to aircraft operations, maintenance, repair or manufacture, or to airport operations or air navigation services, which endanger, or without intervention would endanger the safety of the aircraft, its occupants or any other persons*.

Occurrence reporting is particularly important to the safety of aviation. When an occurrence concerns a technical fault, defect reporting comprises two distinct reports. First and foremost, a report of an identified defect must be made to the owner of the aircraft, to the maintainer and the next pilot. The most important thing is to prevent the operation of the aircraft before the defect is corrected. A defect so serious that it forces a pilot to abort the flight must be recorded into the journey logbook's right hand page in the place which is specifically reserved for such entries. Corrective action must also be logged on the very same page. If several pilots use the same aircraft, such as in flying clubs, the detected defect must absolutely be reported to the other users with, for example, a note left inside the cockpit.

The 'Malfunction or Defect Report' as per Aviation Regulation GEN M1-4 is an important flight safety instrument for the Finnish Transport Safety Agency and the Safety Investigation Authority, Finland. All reports are included in the statistics which indicate, among other things, the number of defects in different aircraft types, engines and systems – and thereby permit the introduction of needed measures.

3 CONCLUSIONS

3.1 Findings

1. The flight instructor had valid documents required for the flight.
2. The student pilot had valid documents required for the flight.
3. The aircraft's Certificate of Registration and the Permit to Fly were valid.
4. The flight was a cross-country training flight from Helsinki-Malmi airport to Hyvinkää aerodrome where the student pilot was to make practice landings.
5. The engine RPM suddenly decreased to idle, despite the fact that the power lever was still set to cruise power, at approximately 160 m AGL when the aircraft was on the second downwind leg. The engine stopped after approximately 10 seconds.
6. The flight instructor made a successful emergency landing in a field.
7. Following the forced landing the engine started normally.
8. The mechanical fuel pump's suction valve was damaged, causing an intermittent fuel feed failure to the carburettors.
9. The aircraft's fuel system significantly differed from the engine manufacturer's system diagram.
10. The electric fuel pump pressure was at the minimum permissible level.
11. There was no check valve in the electric fuel pump's bypass line. It had been replaced with a small-diameter restrictor jet. This construction contributed to the low fuel pressure.
12. Sporadic malfunctions appeared in both electronic modules during test runs.
13. Should one electronic module fail the engine will not stop. It is not easy to notice an ignition malfunction during flight. If the fault occurs simultaneously in both electronic modules the engine will stop.
14. The electronic module of circuit B failed one of the three Quick Electrical Tests conducted by the engine manufacturer. No faults were discovered in the electronic modules during the 26 hour thermo cycle test.
15. No defect reports pursuant to Finnish Aviation Regulation GEN M1-4 were made as regards the engine malfunctions that occurred prior to the forced landing.
16. The time between overhauls (TBO) for the engine is 1500 h, but this was extended by 100 hours according to the AIR M8-4.

3.2 Probable causes and contributing factors

The engine stoppage was caused by the mechanical fuel pump's damaged suction valve and the subsequent fuel feed failure. Low fuel pressure in the electric fuel pump was a contributing factor.

It is not likely that the intermittent malfunctions of both ignition systems caused the engine stoppage.

4 SAFETY RECOMMENDATIONS

4.1 Safety actions already implemented

During the investigation BRP-Powertrain (Rotax) published an information letter where it orders temperature sensitive label to be installed on electronic module. Based on this letter Finnish Transport Safety Agency issued an airworthiness directive M3151/13 25.2.2013, where installation of temperature sensitive label is mandatory to all electronic modules of Rotax 912 –engines, which are not certified.

During the investigation BRP-Powertrain (Rotax) published a line maintenance manual (ver. 3 /1.9.2012), where replacement of the fuel pump is mandatory in every 5 years.

4.2 Safety recommendations

1. The fuel systems of many ultralight aircraft conflict with the engine manufacturer's instructions. Among other things, in this investigation a coarse filter was missing from the end of the line inside the fuel tank, there was no return line for the purpose of eliminating vapour lock, and there was no check valve in the electric fuel pump's bypass line.

   The Safety Investigation Authority, Finland recommends that Deutscher Aero Club e.V. (ultralight aircraft type certificate approval organization in Germany) advises the aircraft manufacturer to comply with the engine manufacturer's instructions and recommendations as regards the construction of fuel systems.

4.3 Other observations and proposals

The propeller of an engine fitted with a reduction gearbox will not windmill following an engine stoppage during flight. Therefore, it is important to try to restart the engine in the air with the same starting procedure as on ground by using the starter motor. If the motor is warm, no choke should be used. Nevertheless, the main focus must still be on the safest possible execution of a forced landing.

Helsinki 12.6.2013

Esko Lähteenmäki Ismo Aaltonen

A SUMMARY OF COMMENTS RECEIVED FROM FINAL DRAFT REPORT:

Finnish Transport Safety Agency

Finnish Transport Safety Agency had no comments to the report.

Finnish Aeronautical Association

Finnish Transport Safety Agency notes this kind of technical investigation has significant effect in improving flight safety.

The engine manufacturer, BRP-Powertrain (Rotax)

There was a safety recommendation issued to engine manufacturer in **draft** report. It was recommended to include an ignition fault indicator, such as a warning light, that alerts of even short-lived transient malfunctions in the engine's ignition system.

According to the engine manufacturer installing this kind of warning system may weaken the reliability of the electric system. In addition the engine manufacturer doesn't see a warning system necessary, because the engine has a double ignition system and simultaneous fault in both systems is highly improbable. The ignition system must be checked before every flight.

Safety recommendation was deleted in final report.

Aircraft manufacturer, Comco Ikarus GmbH

Comco Ikarus GmbH did not comment draft report.