Air Accident Investigation Unit Ireland

SYNOPTIC REPORT

ACCIDENT
Comco Ikarus C42B, EI-ERM
Bartragh Island, Co. Mayo

3 January 2021

An Roinn Iompair
Department of Transport

Foreword

This safety investigation is exclusively of a technical nature and the Final Report reflects the determination of the AAIU regarding the circumstances of this occurrence and its probable and contributory causes.

In accordance with the provisions of Annex 13[1] to the Convention on International Civil Aviation, Regulation (EU) No 996/2010[2] and Statutory Instrument No. 460 of 2009[3], safety investigations are in no case concerned with apportioning blame or liability. They are independent of, separate from and without prejudice to any judicial or administrative proceedings to apportion blame or liability. The sole objective of this safety investigation and Final Report is the prevention of accidents and incidents.

Accordingly, it is inappropriate that AAIU Reports should be used to assign fault or blame or determine liability, since neither the safety investigation nor the reporting process has been undertaken for that purpose.

Extracts from this Report may be published providing that the source is acknowledged, the material is accurately reproduced and that it is not used in a derogatory or misleading context.

[1] **Annex 13**: International Civil Aviation Organization (ICAO), Annex 13, Aircraft Accident and Incident Investigation.
[2] **Regulation (EU) No 996/2010** of the European Parliament and of the Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation.
[3] **Statutory Instrument (SI) No. 460 of 2009**: Air Navigation (Notification and Investigation of Accidents, Serious Incidents and Incidents) Regulations 2009.

AAIU Report No: 2022-003
State File No: IRL00921001
Report Format: Synoptic Report
Published: 10 March 2022

In accordance with Annex 13 to the Convention on International Civil Aviation, Regulation (EU) No 996/2010 and the provisions of SI No. 460 of 2009, the Chief Inspector of Air Accidents, on 3 January 2021, appointed John Owens as the Investigator-in-Charge to carry out an Investigation into this Accident and prepare a Report.

Aircraft Type and Registration:	Comco Ikarus C42B, EI-ERM	
No. and Type of Engines:	1 x Rotax 912-ULS	
Aircraft Serial Number:	0802-6491	
Year of Manufacture:	2010	
Date and Time (UTC)[4]:	3 January 2021 @ 14.00 hrs	
Location:	Bartragh Island, Co. Mayo, Ireland	
Type of Operation:	Private	
Persons on Board:	Crew – 1	Passengers – 1
Injuries:	Crew – Nil	Passengers – Nil
Nature of Damage:	Substantial	
Commander's Licence:	National Private Pilot Licence (NPPL) Aeroplane (A) issued by the Civil Aviation Authority (CAA) of the United Kingdom (UK)	
Commander's Age:	63 years	
Commander's Flying Experience:	650 hours	
Notification Source:	Sligo Air Traffic Control (ATC)	
Information Source:	AAIU Report Form submitted by the Pilot AAIU Field Investigation	

[4] **UTC**: Co-ordinated Universal Time. All times in this report are quoted in UTC; local time was the same as UTC on the date of the accident.

SYNOPSIS

The Comco Ikarus C42B aircraft, with the Pilot and one passenger on board, was en route from Sligo Airport (EISG) to Belmullet Aerodrome, Co. Mayo (EIBT). When the aircraft was overhead Bartragh Island, Co. Mayo, at an altitude estimated by the Pilot to be six to seven hundred feet, the engine cut out. The Pilot made one attempt to restart the engine without success, before carrying out a forced landing on a sandy beach on the south-western side of the island. The nose landing gear and right main landing gear collapsed during the landing and detached before the aircraft came to rest. The Pilot and passenger were uninjured and exited the aircraft unaided. There was no fire.

NOTIFICATION

The Pilot informed Sligo ATC immediately after the accident occurred. Sligo ATC notified the AAIU on-call duty Inspector. The AAIU on-call duty Inspector spoke with the Pilot, who advised that neither he nor the passenger was injured. The Pilot provided the duty Inspector with photographs of the aircraft and of the accident site, and upon reviewing these, and due to the incoming tide, the duty Inspector gave permission for the Pilot to recover the aircraft from the site. The AAIU subsequently examined the aircraft at the location to which it had been recovered.

1. FACTUAL INFORMATION

3

1.1 History of the Flight

At 13.21 hrs, before the flight commenced, the Pilot informed ATC at EISG that he had the aircraft's engine started '*for the last ten minutes, heating up*' and that he was ready to '*move out to the runway*'. He also advised that there were two people on board, '*four hours' fuel*', and that he was routing to Belmullet '*probably for an hour*'. The Pilot told ATC that he would be routing back to EISG at '*around the four o'clock mark*' and that his maximum altitude en route would be 1,500 to 2,000 feet (ft).

The aircraft took-off from Runway (RWY) 11 at EISG at 13.27 hrs, before turning to take up a westerly heading. ATC at EISG requested the Pilot to report when the aircraft was at the ATC zone boundary to the west. As requested, at 13.35 hrs, the Pilot reported that the aircraft was at the zone boundary at Dromore West (Co. Sligo). ATC at EISG then requested the Pilot to contact Shannon ATC. The Pilot contacted Shannon at 13.38 hrs and advised of his intentions. The aircraft then left controlled airspace and no further transmissions from the aircraft were received (nor were they required).

From Dromore West, the aircraft routed to Easky and then Enniscrone (both in Co. Sligo), before heading towards Bartragh Island, Co. Mayo, which is approximately 20 nautical miles (NM) south-west of EISG. The Pilot informed the Investigation that when he was south of Bartragh Island and heading west at an altitude of six to seven hundred feet, he attempted to increase the engine power to climb, but that the engine '*chugged twice*' and cut out.

The Pilot said that the carburettor heat had been ON approximately five minutes earlier, before being selected OFF and he thought that he may have re-applied the carburettor heat just before he attempted to increase the engine power, but wasn't sure. He said he made one attempt to restart the engine, but that the engine did not start. He then selected a site at which to land. He said he performed a '*very tight right-hand turn to turn-back because otherwise I was going over water and cliffs*' and that he also had to side-slip[5] the aircraft and '*forced it to get it down as soon as possible*'.

The aircraft landed on a sandy beach on the south-western side of Bartragh Island. The nose landing gear and right main landing gear collapsed during the landing and detached before the aircraft came to rest in wet sand (**Photo No. 1**). The Pilot and passenger were uninjured and exited the aircraft unaided. There was no fire.

Photo No. 1: Final resting position of aircraft (*photograph provided by the Pilot*)

1.2 Interview with Pilot

The Pilot said that he purchased 22 litres of fuel (MOGAS[6]) from a petrol station before the flight and that there were 18 to 20 litres of fuel in each of the aircraft's two fuel tanks before refuelling. He said it was six to eight weeks since the aircraft had last been flown. The Pilot informed the Investigation that he started the engine and that it was running for 15 to 20 minutes before the aircraft was refuelled. He said he shut down the engine and poured the newly purchased fuel into his refuelling assembly which comprised a tank, a filter, and a hand pump, and that the aircraft was refuelled from this assembly. He said he took a fuel sample from the aircraft before refuelling and explained that it was visually examined for water and that none was observed.

[5] **Side-slip:** Intentional side-slip is a manoeuvre in which an aileron input is made in one direction, with a simultaneous rudder input in the opposite direction. This manoeuvre is used to increase the rate of descent without increasing airspeed.
[6] **MOGAS:** When automotive gasoline (leaded or unleaded) is used in an aircraft, it is known as MOGAS.

The Pilot said that the aircraft was operating normally up to the time that the engine cut out and that the engine had been operating at 4,300 RPM[7] (the Pilot stated that the engine speed at take-off would be 5,200 to 5,300 RPM). When asked by the Investigation, he indicated that the aircraft's electric fuel pump was not on at the time that the engine cut out.

1.3 Injuries to Persons

The Pilot and passenger reported that they were uninjured.

1.4 Damage to Aircraft

The right main landing gear and the nose landing gear detached from the aircraft during the landing. One of the propeller's three blades was broken, and another was damaged. A tubular member within the fuselage that actuated the right-hand trailing edge flap was broken. The lower fuselage, inboard of the right main landing gear, sustained minor impact damage. There was evidence of rippling in the covering of the right wing, at its outboard upper surface. There was a hole in the lower surface of the right aileron. In addition, significant salt/sand contamination of the airframe and the exterior surface of the engine was evident.

1.5 Other Damage

No other damage was reported.

1.6 Personnel Information

1.6.1 Flying Experience

The Pilot reported his flying experience to the Investigation as per **Table No. 1**.

Total all types:	650 hours
Last 90 days:	61 hours (all on type)
Last 28 days:	1.5 hours (all on type)

Table No. 1: Pilot's flying experience

1.6.2 Licence and Medical Certification

The Pilot held an NPPL(A) which was issued by the UK CAA on 25 June 2012. Section IX of the licence ('*Validity*') states that the licence '*shall remain in force for the holder's lifetime* […]' and that '*The licence holder is entitled to exercise licence privileges on aircraft registered in the United Kingdom*'. The CAA website states that '*the NPPL can only be used on UK-registered aircraft inside UK airspace, unless you have an agreement with the aviation authorities in another country which will allow you to fly in that country's airspace*'.

The Pilot's Class 2 Medical Certificate was issued by a CAA Aero-Medical Examiner (AME) on 10 July 2019. The Class 2 Medical expired on 10 July 2020. The LAPL Medical (required for an NPPL), as recorded in the Medical Certificate, had an expiry date of 10 July 2021.

[7] **RPM:** Engine rotational speed in revolutions per minute.

1.7 Pilot Licensing Requirements within Ireland

S.I. No. 333 of 2000 '*Irish Aviation Authority* [IAA] *(Personnel Licensing) Order, 2000*', Article 5 (1) ('*Flight Crew Members to be Licensed'*) states:

> '*Subject to the provisions of this Order, a person shall not act as a flight crew member of an aircraft registered in the State unless that person is the holder of an appropriate licence issued or validated by the Authority* […]'.

The IAA's Aeronautical Notice, P.21, titled '*ACCEPTANCE OF FLIGHT CREW LICENCES*' (Issue 3, 7 April 2017), which was extant on the date of the accident, stated in Section 3:

> '*The holder of an appropriate pilot licence or aviation qualification*[8] *issued by another ICAO signatory state or its national aviation authority or qualified entity, which permits or is accepted as being appropriate to enable the holder to act as pilot-in-command within that state of an aircraft described in Annex II*[9] *of EU Regulation No 216/2008 (as amended), shall be exempt within the territorial limits of the State from the requirements of Article 5 of the Order* [S.I. 333 of 2000] *while acting as a member of the flight crew of an aircraft being operated as a private aircraft*'.

Section 4 stated, *inter-alia*:

> '*This Direction shall apply only provided that the appropriate pilot licence or aviation qualification holder has:-*
>
> *a) given prior notification to the Authority by submitting the appropriate details in the manner published by the Authority on its website;* […].

The IAA advised the Investigation that a notification relating to the Pilot's licence had not been received.

1.8 Aircraft Information

1.8.1 General

The Ikarus C42B, is a high-wing aircraft, manufactured in Germany by Comco Ikarus. The fuselage, wings and flight control surfaces are of tubular aluminium construction. Non-load bearing composite panels are fitted to the fuselage. The wings and flight control surfaces are covered in a laminated fabric.

---

[8] **Aviation Qualification:** According to Aeronautical Notice P. 21, this means a qualification, other than a pilot licence, which certifies or attests that a person has completed a course of flight and theoretical knowledge training according to a syllabus approved or accepted directly or indirectly by another ICAO signatory state according to national rules, and which purports that the holder thereof is deemed to be adequately trained to act as pilot of the relevant subject aircraft.

[9] Annex II of Regulation (EC) 216/2008 has been superseded by Annex I of Regulation (EU) 2018/1139.

The subject aircraft was fitted with two inter-connected fuel tanks, with a total capacity of 65 litres (L). The tanks are located within the fuselage section and are filled through a single refuelling point located on the right side of the fuselage. A Rotax 912-ULS horizontally opposed, four-cylinder, twin-carburettor engine was installed, which powered a three-bladed, ground-adjustable propeller. Fuel from the tanks is supplied to the engine through an in-line fuel filter, an electric pump, a shut-off valve, and an engine-driven pump. According to the Pilot Operating Handbook (POH) for the aircraft, the electric fuel pump is to be used during engine starting, aircraft take-off, climb, descent and landing, and in the event of engine power loss in flight. The aircraft's two side-by-side seats were fitted with four-point restraint harnesses.

A ballistic recovery system was installed, comprising a parachute that is deployed by a ballistic device when activated by the Pilot. The device was not deployed during the occurrence.

A carburettor heating system is fitted to the C42B model (**Figure No. 1**). This is manually controlled by a cockpit-mounted selector knob which operates a flap installed within the engine air intake system via a push-pull cable. Pulling the selector knob selects the carb heat to ON by closing the flap within its housing and permitting air that has been heated by the engine exhaust silencer to be directed to the engine air intake system. When selected to OFF by pushing in the selector knob, the flap opens and permits the engine air intake system to use ambient air supplied through a duct in the engine cowling. Air filters are located at each carburettor; therefore, intake air is filtered regardless of the position of the carburettor heating flap.

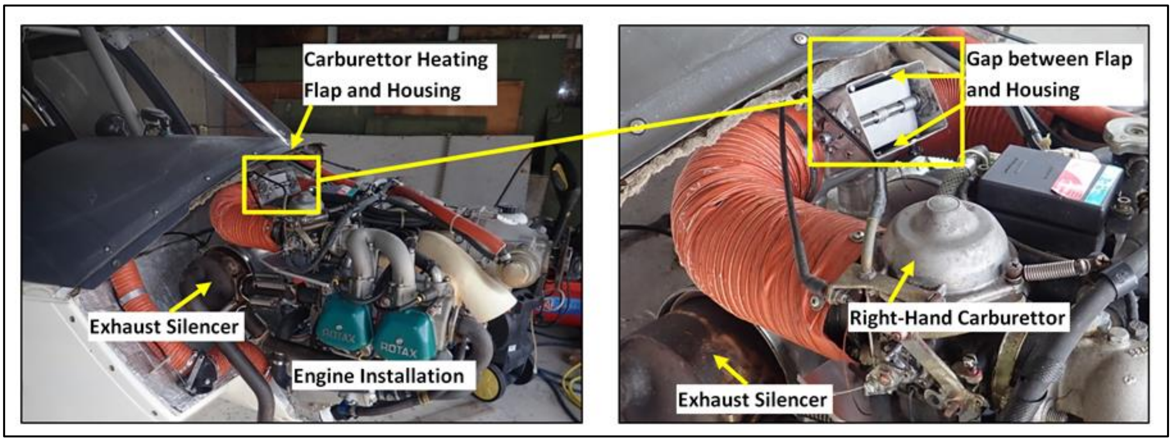

Figure No. 1: Location of carburettor heat flap (pictured in the closed (ON) position)

The Maintenance Manual for the aircraft type highlights that the flap '*does not close completely*'. This can be seen in the right-hand image in **Figure No. 1**, which shows that when the flap is in the closed position, there is a gap present between the edges of the flap and its housing.

Section 1.11 of the POH (Issue 4, Rev 5, dated 23 August 2019) relates to '*Engine limitations according to the Rotax operating manual*'. Regarding [permitted] fuel, it states:

> '*Fuel:* *Euro-Super ROZ 95 unleaded (DIN EN 228 with max. 5% ethanol)*
> *Super Plus ROZ 98 unleaded (DIN EN 228 with max. 5% ethanol)*
> *AVGAS 100 LL*
> *AVGAS UL91'*.

The Periodic Inspection checklist, as contained in the Aircraft's Maintenance Manual, includes the following regarding the carburettor heating flap: '*Check carburettor heating air flap (C42 B/E only) for freedom of movement*'. The check is to be carried out on every 50 hour and every 100 hour inspection.

1.8.2 Operating/Maintenance History and Airworthiness Certification

The aircraft is categorised as an Annex I[10] aircraft and is therefore subject to national legislative requirements rather than the legislative requirements of the European Union. The aircraft's most-recent Flight Permit and its associated Validity Certificate were issued by the IAA on 4 September 2020. The Validity Certificate had an expiry date of 3 September 2021. The aircraft's maximum operating weight, as stated on its Flight Permit, is 472.5 kg, and therefore the aircraft (fitted with two seats and a ballistic recovery system) is classified as a microlight.

The aircraft's logbook records that a '*full service*' was carried out on 2 August 2020 at a total flight time of 861 hours and 5 minutes, and that an '*ANNUAL INSPECTION FOR RENEWAL OF PERMIT TO FLY*', which includes a check to ensure that all necessary Service Bulletins have been completed, was carried out on 6 August 2020 by an Inspector designated by an IAA-approved Irish national maintenance organisation. The logbook records that the aircraft flew on six days since the Annual Inspection was performed, up until the date of the accident, by which date, a total flight time of 875 hours and 45 minutes was recorded. The last flight recorded prior to the accident was on 4 December 2020.

The last entry made in the engine logbook was on 11 November 2020, which records that the engine operated for a total of 887 hours and 45 minutes up until that date. The Annual Inspection was also recorded in the engine logbook (6 August 2020).

1.9 Aircraft Examination

On 11 January 2021, the Investigation examined the aircraft at the location to which it had been recovered. During the examination, it was noted that the carburettor heat flap housing was worn in the area of the flap spindle (**Photo No. 2**). The flap was found to move freely to the open and closed positions when the cockpit-mounted selector was operated and the wear did not appear to adversely affect the operation of the flap.

Photo No. 2: Carburettor heat flap housing worn in area of flap spindle

[10] Annex I of Regulation (EU) 2018/1139 lists the categories of aircraft for which the Regulation is not applicable.

The aircraft's in-line fuel filter casing was of clear plastic construction, which facilitated a visual inspection of the membrane within the filter; the membrane appeared to be free from debris/contamination. The Investigation took a fuel sample from the aircraft's fuel tank drain. To facilitate the taking of a sample from the carburettors' fuel supply line, the Pilot disconnected the fuel line and switched on the aircraft's electric fuel pump. The fuel flowed freely from this line into the sample containers.

A follow-up examination of the aircraft was conducted on 1 April 2021. At this stage, repairs to the aircraft had commenced. The Pilot advised the Investigation that the engine had been started subsequent to the recovery of the aircraft. The Pilot started the engine again in the presence of the Investigation. Further fuel samples were taken on this date.

1.10 Carburettor Icing

1.10.1 Types of Icing

Information regarding carburettor icing is contained in numerous publications, including a Safety Sense Leaflet (No. 14) on '*Piston Engine Icing*', published by the UK Civil Aviation Authority (CAA) and a Safety Promotion Leaflet (GA 5) on the same subject, which was published by the European General Aviation Safety Team (EGAST).

The CAA's Safety Sense Leaflet notes that there are three main types of induction system icing: Carburettor (*carb*) Icing, Fuel Icing, and Impact Icing, and that the terms '*Carburettor Icing*' and '*Carb Icing*' are used to cover all forms of induction system icing.

The Safety Sense leaflet states the following:

'*a) Carburettor Icing*
The most common, earliest to show, and the most serious, is carburettor (carb) icing caused by a combination of the sudden temperature drop due to fuel vaporisation and pressure reduction as the mixture passes through the carburettor venturi and past the throttle valve.

If the temperature drop brings the air below its dew point, condensation results, and if the drop brings the mixture temperature below freezing, the condensed water will form ice on the surfaces of the carburettor. This ice gradually blocks the venturi, which upsets the fuel/air ratio causing a progressive, smooth loss of power […].

b) Fuel Icing
Less common is fuel icing which is the result of water, held in suspension in the fuel, precipitating and freezing in the induction piping, especially in the elbows formed by bends.

c) Impact Ice
Ice which builds up on air intakes, filters, alternate air valves etc. is called impact ice. It forms on the aircraft in snow, sleet, sub-zero cloud and rain (if either the rain or the aircraft is below 0°C) […]'.

The Safety Sense Leaflet outlines that a partially closed throttle associated with a reduced power setting results in a larger temperature drop, with the result that carburettor icing is more likely at low power settings. In addition, a partially closed throttle can be restricted more easily by any ice build-up.

1.10.2 Guidance on the use of Carburettor Heat

The aircraft's POH gives the following guidance on the use of carburettor heat in Section 4.3, '*Cruising Flight*':

> *'At the first indication of carburettor icing (rpm drop, stuttering engine running, increase in fuel consumption as indicated by the flow meter, if installed) apply carburettor heat and, if possible, fly the aircraft into non-icing conditions'.*

The CAA's Safety Sense Leaflet also gives guidance on when carburettor heat should be used. It states the following:

> '[…]. *Hot air should be selected:*
>
> - *as a matter of routine, at regular intervals to prevent ice build-up;*
> - *whenever a drop in rpm or manifold pressure, or rough engine running, is experienced;*
> - *when carb icing conditions are suspected; and*
> - *when flying in conditions within the high probability ranges indicated in the chart* [**Figure No. 2**].
>
> […] *During the cruise, carburettor heat should be applied at regular intervals, to prevent carburettor ice forming*'.

1.10.3 Carburettor Icing Charts

Numerous charts have been published to indicate the likelihood of carburettor icing forming, depending on the ambient temperature and humidity. The chart shown in **Figure No. 2** is contained in the UK CAA's Safety Sense Leaflet (No. 14).

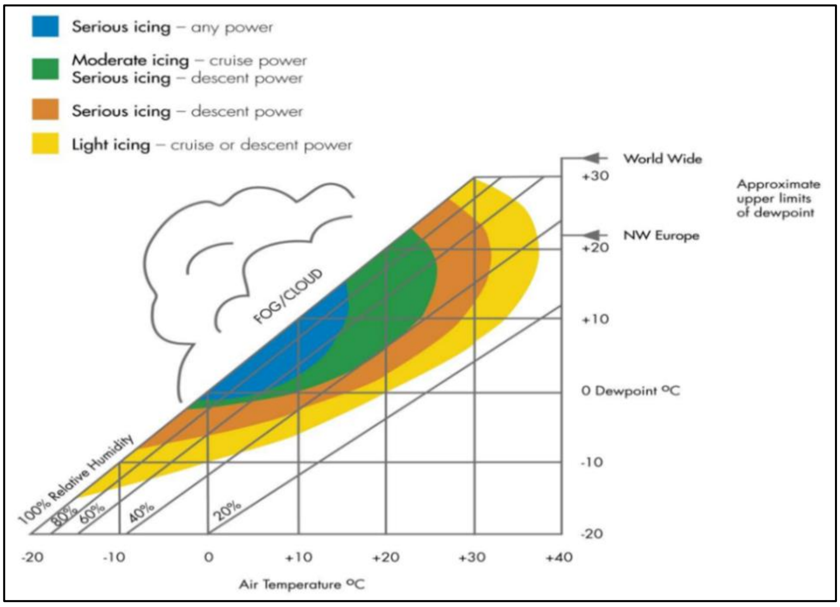

Figure No. 2: Carburettor icing chart, as published by the UK CAA

A chart including the same information as that published by the CAA is contained in Transport Canada's (Canadian Airworthiness Authority) Aeronautical Information Manual (TP 14371E, 2020-1). The following warning is included:

> '[The] *chart is not valid when operating on MOGAS. Due to its higher volatility, MOGAS is more susceptible to the formation of carburetor icing. In severe cases, ice may form at OATs up to 20° C higher than with AVGAS*'.

The following chart was produced by the Australian Civil Aviation Safety Authority (CASA) (**Figure No. 3**). Instead of the dew point, it includes a parameter known as the '*dew point depression*', which is the ambient temperature minus the dew point. A lower dew point depression (i.e. a smaller difference between the dew point and the ambient temperature) can result in an increased likelihood of carburettor icing.

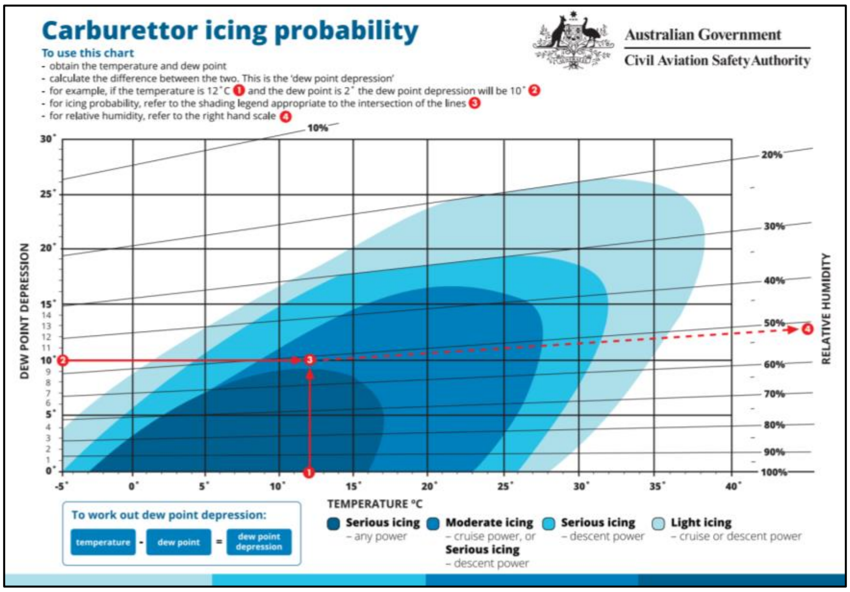

Figure No. 3: Carburettor Icing probability chart, as published by CASA

1.10.4 Air Accident Investigation Unit Reports relating to Carburettor Icing

The AAIU has published numerous reports relating to accidents and serious incidents that identified carburettor icing as a probable cause, including Report No. 2003-019, Report No. 2008-008, Report No. 2009-016, Report No. 2010-003, Report No. 2010-006, Report No. 2014-012, and Report No 2020-017.

1.11 Vapour Lock

1.11.1 Background

According to a Technical Leaflet (TL2.26, Issue 2 Dec 2017) published by the UK Light Aircraft Association (LAA) regarding '*Procedures for Use of E5 Unleaded Mogas to EN228*', due to its volatility the Initial Boiling Point of MOGAS is '*only slightly above ambient temperature, so it takes only a slight raise in temperature or drop in pressure to make it start to vapourise*'.

The leaflet notes that:

> '*If the vapour collects and forms a large bubble which becomes entrapped at a high point or constriction in the fuel pipe, this can form a "vapour lock", effectively preventing the passage of fuel to the engine and causing a "dead cut" similar to what would happen if you were to turn off the fuel cock*'.

The leaflet also states the following:

> '*Vapour problems are most likely to occur in aircraft fitted with engine-driven mechanical fuel pumps, and are rarely experienced with a purely gravity-fed system or those with an electric fuel pump situated at the tank outlet* […]. *Unfortunately, in the typical aircraft system the fuel pump is located above the fuel tank, so the fuel pressure on the upstream side of the fuel pump is reduced below atmospheric by the action of the pump sucking up the fuel, making it very vulnerable to fuel vapour formation on the inlet side of the pump, with symptoms as described above.*
>
> *If the engine is fitted with a mechanical pump, bolted to the engine crankcase, then heat conducted into the pump from the engine crankcase will raise the temperature of the pump body significantly and only the flow of cool fuel through the pump keeps the pump temperature moderate*'.

According to the '*Aviation Maintenance Technician Handbook – Powerplant, Volume 1*' (FAA-H-8083-32A, 2018), as published by the Federal Aviation Administration (FAA) of the United States (US), the three general causes of vapour lock are: lowering of the pressure on the fuel (which reduces its boiling point), high fuel temperatures, and excessive fuel turbulence (caused by movement of the fuel in the tanks, the mechanical action of the engine-driven pump, and sharp bends or rises in fuel lines). The Handbook also states that the incorporation of booster [electric] pumps in a fuel system reduces its tendency to vapour lock by keeping the fuel in the lines to the engine-driven pump under pressure.

1.11.2 Aircraft Manufacturer's Service Bulletins

The Aircraft Manufacturer issued several Service Bulletins relating to the aircraft's fuel system.

Comco Ikarus Service Bulletin '*SB-42-017A-2014 Fuel system*', dated April 2014, relates to the installation of fuel tanks with a combined total capacity of 65L and a fuel return line. The Service Bulletin states '*the retro-fitting of a fuel return line is mandatory in order to reduce the theoretical possibility of vapour formation*'. Fuel tanks with a combined total capacity of 65L were installed on the subject aircraft.

Comco Ikarus Service Bulletin '*SB-42-019-2015 Electrical Fuel Pump C42-Series*', dated May 2015, states:

> '*Experiences with the use of the UL* [ultralight] *aircraft, IKARUS C42 series have shown that, after installation of the fuel return line, in conjunction with the currently installed mechanical fuel pump (Rotax P/N 893115) on the ROTAX engine 912/912S, pressure drop may occur after switching off the auxiliary electrical pump. Until the problem has been solved, the UL IKARUS C42 series aircraft must only be operated with the auxiliary electric pump switched on*'.

Comco Ikarus Service Bulletin Supplement '*SB-42-019-2015 Fuel Pump C42-Series*', dated April 2017, states: '*The previous determination that the electric fuel pump should be switched on even after the start can be cancelled if the modification described below is carried out on the fuel system*'. The modification entails the installation of an additional gasket under the mechanical fuel pump and the replacement of the fuel return tee/cross piece installed as part of SB-42-017A-2014, with a modified version containing a larger orifice.

No records were provided to the Investigation regarding the completion of the Service Bulletins on EI-ERM. However, the Flight Permit renewal application form to be completed by the aircraft owner contains the following statement: '*All maintenance recommendations from the manufacturer have been reviewed by me and implemented as appropriate. Any decision not to comply with a recommendation has been recorded in the aircraft logbook*'.

1.12 Information Regarding Fuel

1.12.1 General

When unleaded automotive gasoline is used in an aircraft, it is known as MOGAS. Unleaded automotive gasoline sold in Ireland normally conforms to the EN228 specification and contains approximately 5% ethanol volume per volume (v/v). The presence of ethanol increases the fuel's volatility causing it to evaporate more easily at a given temperature and absorb more heat during the mixing of the fuel and air in the carburettor. Therefore, carburettor throat temperatures are lowered more than would occur with a fuel that does not contain ethanol (such as Avgas).

Another factor that affects the volatility of unleaded automotive gasoline is its seasonal variability: two main types – winter grade and summer grade – are sold depending on the time of year. Summer grade automotive gasoline has a lower volatility than winter grade to limit evaporative emissions due to expected higher ambient temperatures. Therefore, due to its higher volatility, winter grade unleaded automotive gasoline will evaporate more easily at a given temperature than summer grade. According to the LAA's Technical Leaflet TL2.26 regarding '*Procedures for Use of E5 Unleaded Mogas to EN228*', tests by the British Gliding Association (BGA) showed that:

> '[…] *with the same ambient conditions, the carb throat temperatures of a Lycoming 0-360* [aircraft engine] *were typically 7° C lower with winter grade Mogas than Avgas*. *The result is that when using Mogas, carburettor icing will occur over a wider range of temperature and humidity conditions than would be the case for an aircraft using Avgas*'.

The IAA's IGA 9 R2 Safety Leaflet regarding '*Using Unleaded Petrol (Mogas) in Aircraft*' notes that '*Ethanol absorbs water which increases the likelihood of carburettor icing*'. Water in the fuel can take the form of dissolved water or free water. The EN228 specification includes a '*clear and bright*' appearance requirement that is checked by visual inspection. The specification does not include an actual limit for water content and once it remains dissolved, water will not be detectable by visual inspection.

The Safety Promotion Leaflet, GA 5 on '*Piston Engine Icing*' as published by the European General Aviation Safety Team (EGAST), states that '*Carburettor icing is more likely when MOGAS is used, because of its volatility and water content*'.

The UK CAA's Safety Sense Leaflet No. 14 states that '*Testing has shown that because of its greater and seasonally variable volatility and higher water content, carb icing is more likely when MOGAS is used*'.

A report published by the United States Federal Aviation Administration (FAA), titled '*Engine Performance Comparison Associated with Carburetor Icing During Aviation Grade Fuel and Automotive Grade Fuel Operation*' (DOT/FAA/CT-82/110, dated May 1983), states that '*Surprisingly, little moisture needs to be present in ambient air to initiate carburetor ice/frost formation. This is especially true with autogas* [MOGAS]'. The report also stated that one of the ways in which ice may form in the induction system is when water that is entrained or dissolved in the fuel is cooled below 32^{o} Fahrenheit (0^{o} Celsius).

Regarding vapour lock, the IAA's IGA 9 R2 Safety Leaflet states '*Alcohol (ethanol) in Mogas* […] *affects the fuel's vapour pressure, leading to an increase*[d] *probability of vapour lock*'.

1.12.2 Testing of Fuel Samples

1.12.2.1 Samples Taken on 11 January 2021

The fuel samples taken from the aircraft's fuel tank drain and from the carburettors' fuel feed line on 11 January 2021 were analysed in a laboratory specialising in fuel analysis. The results of the analysis found that the sample taken from the fuel tank drain and from the carburettors' fuel feed line were consistent with '*Winter grade EN228 motor spirit* [automotive gasoline]' and that '*no apparent contamination is obvious as the fuel fits the profile of an unleaded petrol*'.

The fuel was found to be clear and bright, indicating no free water was present. However, visible '*particulate*' matter, that was white in colour, was detected in both samples. It was noted to be '*light and easily dispersed in the fuel*'. The water content of the sample taken from the fuel tank drain was found to be '*>1,000 ppm* [parts per million]'. The water content of the sample taken from the carburettors' fuel feed line was found to be '*694 ppm*'. The laboratory considered the water content to be '*quite high*'.

The particulate matter was subsequently analysed at another laboratory. The laboratory stated that '*the tank sample had the best representation of the white solids*' and that, inter-alia, '*the solids appeared to be mainly inorganic*[11] *materials with Oxygen, Sodium, Phosphorous, Calcium, Iron, and Zinc, the primary elements*'.

---

[11] **Inorganic:** In chemistry, the primary difference between organic and inorganic compounds is that organic compounds always contain carbon, while most inorganic compounds do not.

1.12.2.2 Samples Taken on 1 April 2021

Due to the particulate matter and the water content noted by the laboratory in the samples taken on 11 January 2021, the Investigation took a further sample from the aircraft's fuel tank drain during its re-examination of the aircraft on 1 April 2021. A sample was also taken from the Pilot's refuelling assembly, which the Pilot said still contained the remains of the fuel used to refuel the aircraft prior to the accident flight. These samples were also analysed in a laboratory. The results of the analysis found that the sample taken from the fuel tank drain had a water content of '*1,308 ppm*'. The water content of the sample taken from the Pilot's refuelling assembly was found to be '*786 ppm*'. No issues were identified with other parameters analysed and no particulate matter was found.

1.12.2.3 Sample Obtained from Petrol Station

For comparison purposes, the Investigation obtained a sample of unleaded petrol (MOGAS) from a petrol station. This sample was analysed in a laboratory on the same morning it was obtained (19 April 2021). The laboratory found that the sample had a water content of '*202 ppm*'.

1.13 Meteorological Information

Met Éireann, the Irish Meteorological service, provided the Investigation with a meteorological aftercast for Bartragh Island at the time of the accident (**Table No. 2**).

Meteorological Situation:	High pressure to the west of Ireland gives a slack northerly airflow across the country.
Surface Wind: **Wind at 2,000 ft:** **Between Surface and 300 ft:**	North to north-east, 6-10 kts with isolated gusts 15-20 kts. North-east 15 kts. North to north-east 5-10 kts.
Visibility:	>30 km.
Weather:	Dry with cloudy patches and bright or sunny spells.
Cloud:	Few (1-2/8th oktas[12]) cumulus cloud with bases around 2,000-3,000 ft and broken (5-7/8th oktas) stratocumulus clouds with bases 3,500-4,500 ft.
Surface Temperature/Dew Point:	5/1 degrees Celsius [^{o}C].
Mean Sea Level (MSL) Pressure:	1026 hPa [hectoPascals].
Freezing Level:	1,000-1,500 ft.
Other Comments:	Nil.

Table No. 2: Aftercast of meteorological conditions at Bartragh Island at time of accident

[12] **okta:** An estimate of cloud coverage in the sky on a scale from 0 to 8; completely clear sky is described as 0 oktas, while completely overcast sky is described as 8 oktas.

The Investigation also requested an estimate of the temperature and dew point at 600-700 ft over Bartragh Island. *Met Éireann* estimated that the temperature was 2 to 3°C and the dew point was -1°C.

Aviation-specific weather information comprising Terminal Area Forecasts (TAFs), which contain weather forecast information for airfields, and Meteorological Aerodrome Reports (METARs), which include data for temperature and dew point, are provided by *Met Éireann* several times each day. The information is readily accessible by pilots and can assist in assessing weather conditions prior to flight. The METAR issued for EISG at 12.00 hrs indicated that the temperature at EISG was 4°C and that the dew point was 0°C. The METARs issued for EISG at 12.30 hrs and at 13.00 hrs indicated that the temperature at EISG was 4°C and that the dew point was 1°C.

2. ANALYSIS

2.1 Introduction

Subsequent to the accident, the aircraft's engine was successfully started by the Pilot. The Investigation considered several possible factors that may have resulted in the engine cutting out during the accident flight, including carburettor icing, the carburettor heating system, and vapour lock.

2.2 Carburettor Icing

2.2.1 Fuel Used

At the time of the accident, the aircraft was operating on unleaded petrol (MOGAS), which was obtained from a local petrol station, and was one of the fuels listed in the aircraft's POH.

2.2.2 Meteorological Conditions

The meteorological aftercast provided to the Investigation by *Met Éireann* for Bartragh Island at the time of the accident estimated that the temperature at 600-700 ft was between 2°C and 3°C, and the dew point was -1°C. According to the carburettor icing charts produced by the UK CAA and Transport Canada, these conditions were conducive to '*Serious Icing*' at any power setting. A warning contained on the chart produced by Transport Canada states that it is '*not valid when operating on Mogas*', which is '*more susceptible to the formation of carburettor icing*'. Therefore, when MOGAS is used, carburettor icing could occur at conditions other than that indicated by the charts.

The carburettor icing probability chart produced by the CASA includes a '*dew point depression*' parameter. In the case of this accident, the dew point depression was between 3°C and 4°C at 600-700 ft in the Bartragh Island area. When this information is applied to this chart, it also indicates that the meteorological conditions were conducive to '*Serious Icing*' at any power setting.

The Investigation notes that the information contained in the METAR issued for EISG at 12.00 hrs on the day of the accident indicated that the temperature at EISG was 4^{o} C and that the dew point was 0^{o} C. The METARs issued at 12.30 hrs and 13.00 hrs indicated that the temperature at EISG was 4^{o} C and that the dew point was 1^{o}C. When this information is applied to each carburettor icing chart, the charts indicate that the conditions at EISG at the time of departure were conducive to '*Serious Icing*' at any power setting.

2.2.3 Fuel Analysis

2.2.3.1 Water Content

Laboratory analysis of the fuel samples taken by the Investigation on 11 January 2021 identified a water content of *'>1,000 ppm*' in the sample taken from the aircraft's fuel tank drain, and a water content of 694 ppm in the sample taken from the carburettors' fuel feed line. The laboratory considered the water content to be '*quite high*'.

The water content of the sample taken from the fuel tank drain on 1 April 2021 had a water content of 1,308 ppm. The Pilot advised the Investigation that he visually inspected a sample of fuel from the aircraft before the accident flight and that no water was observed. The specification for MOGAS (EN228) does not include an actual limit for water content, other than that it should be '*clear and bright*'. However, once water remains dissolved in the fuel, it will not be detectable by visual inspection. For comparison purposes, the Investigation obtained a sample of unleaded petrol (MOGAS) from a petrol station and immediately sent it for laboratory analysis; this identified a water content of 202 ppm.

The Pilot said that there were 18 to 20 litres of fuel in each of the aircraft's two fuel tanks before it was refuelled for the accident flight and that the aircraft had not flown for six to eight weeks beforehand. The ethanol present in MOGAS is known to absorb water, and it is possible that in the weeks before the accident, the water content of the fuel in the aircraft's two fuel tanks increased due to moisture-laden air entering the fuel tank vents and/or condensation. Published information from the IAA, EGAST, and the UK CAA highlights that carburettor icing is more likely when using MOGAS due to its water content. Increased water content would further increase this likelihood. However, the possibility of some moisture ingress during the forced landing and/or subsequent recovery of the aircraft cannot be excluded.

Laboratory analysis of the fuel sample taken from the Pilot's refuelling assembly determined that the water content was 786 ppm. This was taken on 1 April 2021, which was several weeks after the accident, and moisture may have been absorbed during the period since the accident. Consequently, the Investigation does not consider it to be necessarily representative of the water content of the fuel used to refuel the aircraft before the accident.

2.2.3.2 Seasonal Grade

Laboratory analysis of the fuel samples from the aircraft determined that the fuel used was consistent with '*winter grade EN228 motor spirit*'. Winter grade would be typical for the time of year. Due to its higher volatility, winter grade unleaded automotive gasoline will evaporate more easily at a given temperature than summer grade, and absorb more heat during the mixing of the fuel and air in the carburettor, lowering the throat temperatures and further increase the likelihood of carburettor icing.

2.2.4 Carburettor Icing – Summary

The Pilot said that the carburettor heat had been ON approximately five minutes prior to the engine cutting out, before being selected OFF, and he thought that he may have reapplied the carburettor heat just before he attempted to increase the engine power. The Investigation considers it possible that due to the prevailing meteorological conditions, the carburettor heat being off in the preceding minutes, the volatility of the winter grade fuel, and a probable higher than normal water content, the engine cut out as a result of carburettor icing. It is possible that carburettor ice began to form after the carburettor heat was selected to OFF, and only manifested itself when the carburettor heat was reapplied or when the air/fuel flow through the carburettors changed when the throttle was moved in an attempt to increase engine power.

2.2.5 Carburettor Heating System

During examination of the aircraft, the Investigation noted that the carburettor heat flap housing was worn in the area of the flap spindle. However, the flap was found to move freely to the open and closed positions when the cockpit-mounted selector was operated. The design of the system is such that when carburettor heat is selected to ON, the flap does not close completely, resulting in a gap between the edges of the flap and its housing. Furthermore, as outlined above, the Pilot reported that the carburettor heating had been selected to OFF approximately five minutes before the engine-cut. Therefore, the wear in the area of the spindle, while not desirable, was not considered to have been a factor in the accident.

2.3 Vapour Lock

A progressive, smooth loss of power, which would be a typical symptom of carburettor icing, was not reported, whereas it was reported that the engine chugged twice and cut out. Subsequent to the accident, the engine was successfully started. Therefore, the Investigation also considered the possibility that the engine cut out due to vapour lock, which could, according to the LAA's Technical Leaflet TL 2.26, prevent *'the passage of fuel to the engine and caus*[e] *a "dead cut" similar to what would happen if you were to turn off the fuel cock*'.

According to the FAA's '*Aviation Maintenance Technician Handbook – Powerplant, Volume 1*', high fuel temperature is one general cause of vapour lock. Although the event occurred during winter, on a day when the air temperature at 600-700 ft was estimated by Met Éireann to be approximately 2-3^{o} C, the temperature within the engine bay would be much higher due to radiated heat from the engine.

Two other general causes of vapour lock, as noted by the FAA publication, are low fuel pressure and fuel turbulence. The area at the inlet to a mechanical fuel pump is vulnerable to the formation of fuel vapour due to the pressure reduction caused during pumping. Heat transfer through the pump from the engine could also occur. The use of an electric booster pump reduces the likelihood of vapour lock by keeping the fuel in the lines to the engine-driven pump under pressure. When asked by the Investigation, the Pilot indicated that the electric fuel pump was not on at the time; therefore, it is possible that vapour may have formed at the inlet of the mechanical fuel pump, resulting in the engine cutting out in the manner described by the Pilot.

An Annual Inspection for the renewal of the Flight Permit was carried out on 6 August 2020 by an Inspector designated by an IAA-approved Irish national maintenance organisation; this includes a check to ensure that all necessary Service Bulletins have been completed. However, no records were provided to the Investigation regarding the status of the fuel system Service Bulletins on the aircraft, some of which may have had an effect on the likelihood of vapour lock occurring.

2.4 Particulate Matter

Visible '*particulate*' matter, that was white in colour, and was '*light and easily dispersed in the fuel*', was detected in the samples taken by the Investigation on 11 January 2021 from the aircraft's fuel tank drain and the carburettors' fuel feed line. On 1 April 2021, the Investigation took a further sample from the fuel tank drain and from the Pilot's refuelling assembly. No particulate matter was found in either of these samples. In addition, no visible debris/contamination was evident in the membrane within the aircraft's in-line fuel filter when it was inspected by the Investigation on 11 January 2021. Furthermore, the fuel flowed freely from the carburettors' fuel feed line when the sample was being taken from this source. These factors suggest that the particulate matter may have been due to some form of contamination arising during the initial sampling process; therefore, the Investigation considers it not to have been a factor in the accident.

2.5 Operating Altitude

The engine cut out at a reported altitude of 600 to 700 ft. In the case of this accident, the Pilot was able to carry out a forced landing on a nearby sandy beach. However, operating at such an altitude would give limited time during which to diagnose the problem, attempt an engine restart while identifying a suitable landing site, and prepare for a landing.

2.6 Pilot Licence

The Pilot's NPPL(A) was issued by the UK CAA. Aeronautical Notice P.21, as published by the IAA, requires that prior notification be provided to the IAA before such a licence can be accepted for use on an Irish-registered aircraft within Ireland. The IAA advised that prior notification was not received.

3. CONCLUSIONS

3.1 Findings

1. The aircraft's flight permit was valid.

2. Aeronautical Notice P.21 (Issue 3, 7 April 2017) required prior notification to the IAA before a UK CAA-issued NPPL(A) could be used on an Irish-registered aircraft within Ireland . The IAA advised the Investigation that prior notification was not received.

3. The aircraft was operating on MOGAS, which was one of the fuels listed in the aircraft's Pilot Operating Handbook.

4. The aircraft was operating in meteorological conditions conducive to serious carburettor icing at any power setting.

5. Carburettor icing is more likely to occur when MOGAS is used, because of its volatility and water content.

6. Analysis of the fuel used found that it was consistent with winter grade automotive gasoline (MOGAS), which further increases the likelihood of carburettor icing.

7. Analysis of the fuel used identified a water content that was considered to be higher than normal. A high water content would increase the likelihood of carburettor icing.

8. The Pilot reported that the carburettor heat had been ON approximately five minutes prior to the engine cutting out, before being selected OFF.

9. The Pilot stated that he may have re-applied the carburettor heat just before he attempted to increase the engine power, but wasn't sure.

10. The carburettor heat flap housing was worn in the area of the flap spindle. This wear, while not desirable, was considered not to have been a factor in the accident.

11. Vapour lock is more likely when using MOGAS.

12. The altitude at which the aircraft was operating would give limited time during which to diagnose the problem, attempt an engine restart while identifying a suitable landing site, and prepare for a landing.

3.2 Probable Cause

The aircraft's engine cut out, at a low altitude, resulting in a forced landing during which the aircraft sustained substantial damage.

3.3 Contributory Cause(s)

1. Operating in meteorological conditions that were conducive to serious carburettor icing.

2. The carburettor heat was OFF in the minutes preceding the event.

3. The higher volatility of automotive gasoline (MOGAS), in particular winter grade automotive gasoline, and a probable higher than normal water content, increased the likelihood of carburettor icing.

4. Vapour lock in the aircraft's fuel system, which is more likely when MOGAS is used, may have been a factor.

4. SAFETY RECOMMENDATIONS

This Report does not sustain any Safety Recommendations.

- END -

Produced by the Air Accident Investigation Unit

AAIU Reports are available on the Unit website at www.aaiu.ie

An Roinn Iompair
Department of Transport

Air Accident Investigation Unit,
Department of Transport,
2nd Floor, Leeson Lane,
Dublin 2, D02TR60, Ireland.
Telephone: +353 1 804 1538 (24x7)
Email: info@aaiu.ie
Web: www.aaiu.ie
Twitter: @AAIU_ireland