FINAL REPORT

AAIU Report No: 2010-016
State File No: IRL00909071
Published: 13/10/10

In accordance with the provisions of SI 205 of 1997, the Chief Inspector of Air Accidents, on 11 August 2009, appointed Mr. Leo Murray as the Investigator-in-Charge to carry out a Field Investigation into this Accident and prepare a Report. The sole purpose of this Investigation is the prevention of aviation accidents and incidents. It is not the purpose of the Investigation to apportion blame or liability.

Aircraft Type and Registration:	Avid Mk. IV Speedwing, G-BTMS
No. and Type of Engines:	1 x ROTAX 582 UL
Aircraft Serial Number:	PFA 189-12023
Year of Manufacture:	1999
Date and Time (UTC):	11 August 2009 @ 16.55 hrs
Location:	5 nm southwest of Tuskar at position 52° 09.60 N 006° 19.17 W
Type of Flight:	Private
Persons on Board:	Crew – 1 Passengers – Nil
Injuries:	Crew – Nil Passengers – Nil
Nature of Damage:	Damaged beyond economic repair
Commander's Licence:	JAA Private Pilot Licence (UK)
Commander's Details:	Male, aged 53 years
Commander's Flying Experience:	152 hours, of which 4 were on type
Notification Source:	Marine Rescue Coordination Centre (MRCC)
Information Source:	AAIU Field Investigation

SYNOPSIS

The aircraft departed Haverfordwest Airport in Wales at 16.00 hrs en-route to Taghmon in Co. Wexford. After approximately 55 minutes flying time the engine stopped without warning. The Pilot immediately selected the other fuel tank and attempted to re-start the engine. With the aircraft descending through 900 ft the restart attempt was abandoned and a successful ditching was carried out. The Pilot was not injured. The Investigation found that the engine stopped probably due to fuel starvation relating to a fuel-vapour related problem.

FINAL REPORT

1. FACTUAL INFORMATION

1.1 History of the Flight

The Pilot acquired the aircraft in the United Kingdom (UK) and undertook a familiarisation flight with an instructor on 16 March 2009. During this flight a significant shimmy was noticed on the nose leg. This defect was subsequently rectified by an engineering facility, and the aircraft was then stored pending collection by the Pilot.

On the day of the accident, the aircraft was brought to Haverfordwest Airport by trailer and prepared for flight. The aircraft had been operated on MOGAS[1], and approximately 67 Litres remained in the fuel tanks. An uplift of 23 litres of AVGAS 100LL[2] was made prior to departure, filling both fuel tanks. AVGAS had to be uplifted, as MOGAS was not available at the departure airport. No water checks were made on the fuel system by the Pilot during his pre-flight checks. Following an engine run-up, the Pilot selected the Left fuel tank for departure. The aircraft departed Haverfordwest Airport at 16.00 hrs. Due to the cloud base at approximately 1,800 ft the Pilot elected to cruise at an altitude of 1,600 ft to remain clear of cloud, in accordance with Visual Flight Rules.

At approximately 16.55 hrs, during the sea crossing, the engine stopped without warning. The Pilot made a distress (MAYDAY) call on Shannon 124.700 MHz which was heard by Shannon Air Traffic Control. The Pilot then turned the fuel tank selector to the Right tank and attempted to re-start the engine. The starter was operated briefly, but as the aircraft was descending through 900 ft any further attempt at re-start was abandoned. The Pilot then set the aircraft up for a ditching, which was carried out successfully. Following the ditching, the aircraft stabilised with the wings resting at the water surface, but with water rapidly filling the cabin. The Pilot released his four-point harness and donned his floatation jacket. As the doors opened upwards he had to wait for 2-3 minutes for the water level to rise before he could evacuate the aircraft. A rowing vessel, the '*British Orchid*', was nearby and a crewman witnessed the descent and ditching. The crew of the vessel, who were attempting to set a round the UK rowing record, went towards the aircraft to assist the Pilot. Shortly afterwards an Irish Coast Guard Sikorsky S61N helicopter, which was deployed by the MRCC following the Pilot's distress call, successfully winched the Pilot to safety. He was transferred to an ambulance at Waterford Airport and brought to Waterford Hospital.

1.2 Aircraft Information

1.2.1 General

The Avid Mk. IV is a two-seat, kit-built[3] aircraft powered by a ROTAX 582 (48.5 kW) two-stroke engine. The aircraft can be completed with a choice of wing options. G-BTMS was fitted with a 'Speedwing', which utilises a shorter wing section permitting increased cruising speed to be achieved. The wings on the Avid IV design are designed to fold alongside the fuselage for ease of hangarage and transport. Rigging or de-rigging takes only a few minutes and does not involve flight control or fuel line connections.

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[1] **MOGAS**: Motor Gasoline, now normally supplied as unleaded fuel.
[2] **AVGAS 100LL**: Aviation Gasoline, grade 100 Low Lead.
[3] **Kit-built**: Factory built components assembled by an amateur builder.

G-BTMS was completed as a kit-built aircraft in 1999, and following several changes of ownership, was purchased by the Pilot in February 2009. It had a valid Permit-to-Fly, issued by the Light Aircraft Association (LAA) at the time of the accident. The aircraft was properly maintained. The aircraft had flown a total of 243 hours prior to the accident flight.

1.2.2 Fuel System

The fuel system installed in G-BTMS consisted of two main wing tanks; a standard Right tank with a capacity of 55 litres, and an optional Left tank with a capacity of 35 litres. The two tanks supplied fuel through 1/4 inch fuel lines to a fuel selector valve situated just above shoulder height behind the pilots seats. Fuel was supplied through this valve to the top of a Header tank, consisting of a metal cylinder, situated behind the passenger seat (the right seat). The Header tank supplies fuel to the engine carburettors via a fuel filter, fuel shutoff and a pneumatically driven fuel pump. The Header tank was fitted with a manually operated vent valve to remove any trapped air in the fuel system (**Photo No. 1**).

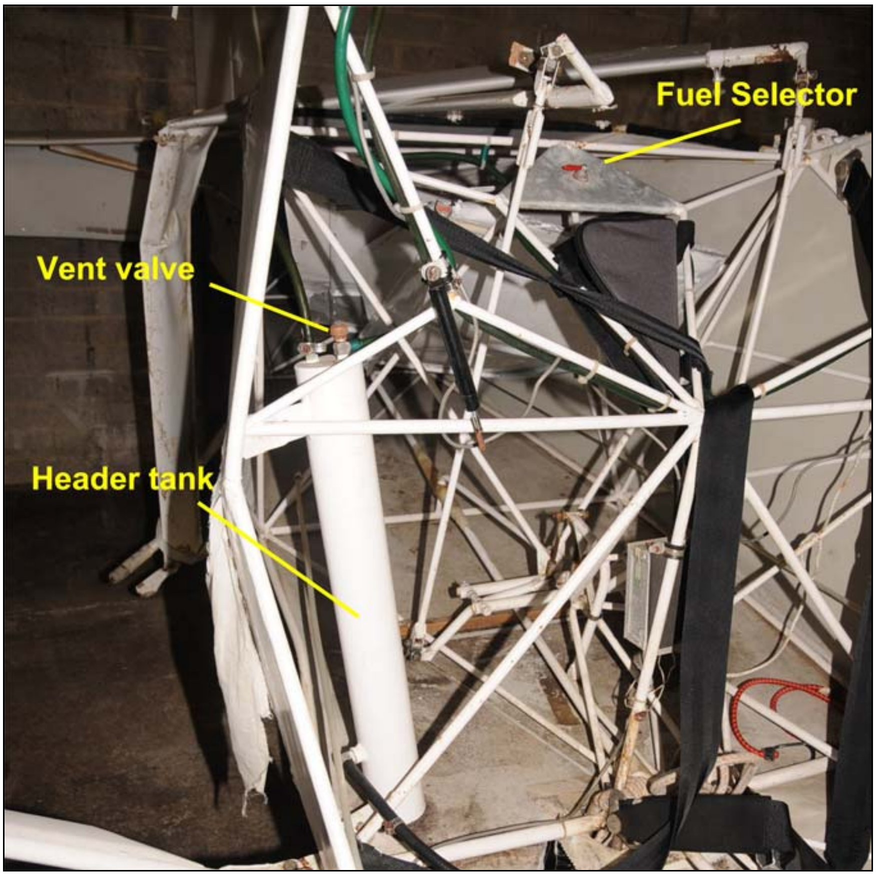

Photo No. 1: View of fuselage looking aft showing positions of the Header tank, Vent valve and Fuel Selector.

The fuel level in flight could only be assessed visually by the Pilot through translucent tank panels in each wing root. No other instrumentation or gauges were installed to measure or assess the fuel quantity during flight. Typed notes recovered from G-BTMS entitled, 'Flying the Avid Flyer' include the following regarding the fuel system: '*Wing tanks hold 90 litres of fuel. Main starboard wing tank holds 55 litres. Port wing holds 35 litres. The aircraft becomes port wing heavy with no fuel in the main tanks. Always use the Left tank first.*'

The fuel system in G-BTMS differs in some respects to the manufacturers construction manual. The addition of the fuel selector valve and the position of the fuel shutoff valve were non-standard. In particular, the vent line was left open-ended at a point between the pilot seats, inside the cabin. The construction notes refer to the vent line being installed between the Header tank to a section of aluminium vent tubing installed in the butt rib (innermost wing rib) venting above the wing surface. After finishing the vent tube should be bent to the rear and downward.

1.3 Field Investigation

1.3.1 General

The AAIU was notified by the MRCC at 16.57 hrs that an aircraft was in distress and attempting to ditch in the vicinity of Tuskar Rock. By 17.15 hrs the aircraft had been located and two Inspectors of Air Accidents deployed to supervise the recovery of the aircraft. An RNLI[4] lifeboat was successful in securing a line on the semi-submerged aircraft and towing it to Carna Beach for subsequent recovery by road. The aircraft was inspected by Investigators at Carna Beach where it was recovered from the sea at 20.20 hrs. The aircraft was substantially intact. The engine cowling and nose undercarriage leg were not recovered. Some additional damage was likely to have occurred during the towing operation in the sea, mainly to the wings and flaps. Samples were taken from the fuel drains and a preliminary survey of the wreckage was carried out. The wreckage was recovered to a secure site that evening and was brought to the AAIU facility at Gormanston the following day for further technical examination.

1.3.2 Inspection of Wreckage

Immersion in the sea for some hours was evident on the engine components. Rotation of the remaining propeller blade was only possible by 8-10 cm due to sea water in the cylinders. After removal of the spark plugs and draining of the ingested seawater, rotation of the engine by means of the propeller was possible. The four spark plugs were inspected. All were in a serviceable condition and revealed no evidence of fouling. No pre-accident defects were apparent with the engine installation.

The flight controls were examined for full and free operation. This inspection revealed no pre-accident defects with the installed flight control systems or linkages. Inspection of the cockpit however, revealed that the right stick was held in a forward position by a red removable bungee cord, the ends of which were attached to the nose-steering mechanism. As the two control sticks are interconnected, it required a constant rearward force to be applied by the Pilot on the left stick to keep the correct pitch attitude in flight. A second red bungee, which probably had been attached to the left seat stick for transport purposes, was found loose under the left seat in the vicinity of the main control linkages. To facilitate the inspection the doors and seat were removed (**Photo No. 2**).

[4] **RNLI**: Royal National Lifeboat Institution.

Photo No. 2: General view of wreckage with doors and seat removed

1.3.3 Fuel System

The contents of both fuel tanks were drained. The Right tank contained approximately 16 litres of fuel (a mixture of AVGAS and MOGAS) and approximately 10 litres of seawater. The fuel and water separated naturally. The Left tank contained approximately 19 litres of seawater and no fuel. The areas of both wings adjacent to the fuel filler caps showed extensive staining representative of fuel outwash following immersion in the sea.

Both fuel tanks were fitted with vent caps. The Right tank vent tube had broken off but the tank could still vent through the opening. The Left tank vent tube had been bent flat, fracturing the tube. The fabric was removed from the left wing and the tank examined. No leaks were found in the tank. The fuel tank outlet fitting was removed and inspected. There were no blockages in the fitting and the fuel filter gauze was clear. The tubing to the selector valve contained air and was found free of blockage.

The fuel selector was found in a position where fuel should flow from the Right tank. The valve is operated by rotating a small lever, coloured red, to select either wing tank to supply fuel. The selector operates as follows: From the left stop, 20 degrees below the horizontal, the valve can be moved anticlockwise by approximately 58 degrees. From this point the fuel flow becomes increasingly restricted for the next 10 degrees of rotation. For the next 84 degrees of rotation, neither tank will supply fuel to the system. Further rotation of the selector results in a similar restricted flow followed by full flow from the right tank until the right stop is reached. The selector valve was examined for correct operation and no mechanical faults were found. The position of the selector valve behind and between the pilot seats would have made it very difficult for the Pilot to reach while properly seated with his safety harness fastened. No placard was installed to indicate the function or the orientation of the fuel selector valve.

The tubing to the top of the header tank contained air and was free of blockages. The header tank was found to contain approximately 970 ml of fuel and 330 ml of seawater. The remainder of the header tank capacity (approximately 250 ml) was air under slight negative pressure, which was observed when the vent valve was opened. The fuel line from the side of the header tank contained seawater. The fuel shutoff valve, situated in the floor of the cockpit, was in the open position and functioned correctly. The fuel filter, which could be inspected visually, contained seawater. The two underwing fuel drains, and the fuel drain at the bottom of the header tank, were all found under spring tension in the normal (closed) position.

1.3.4 Fuel System Samples

Samples from the Right tank fuel drain, both Carburettors (labelled Carb S1 and S2), and the fuel supply line on the engine side of the fuel shutoff, were sent to a laboratory for analysis. The samples were found to be mixtures of fuel and water in varying amounts arising from the aircraft being immersed in the sea for a considerable period.

The fuel layers were analysed by Gas Chromatography with Mass Selective Detector (GS/MSD) and all fluids by Fourier Transform Infra-Red (FTIR) and compared to AVGAS and MOGAS references. The analysis indicated that the sample taken from the Right tank drain was found to consist of an automotive gasoline (MOGAS) with a pale yellow-green colour. A trace amount of tetra ethyl lead was present in the fluid. The Carb S1 sample contained two layers, the top layer was found to consist of automotive gasoline with a trace amount of tetra ethyl lead present. The bottom layer was found to consist of water with a small amount of hydrocarbon present. The Carb S2 sample and the sample from the fuel supply line were both found to consist of water with slight sediment in the Carb S2 sample.

1.3.5 Fuel System Venting

The current manufacturer of the Avid IV provided the following information regarding the fuel system:

'*… the vent line is not normally needed on a dual wing tank setup. Only in a one tank setup is the vent line needed. The vent line may have been added to allow for a single tank to be used at a time. If that is the case and the Pilot had the fuel selector to only one tank and not both tanks, with the vent line closed, that would allow for possible fuel starvation'*.

The Investigation examined the fuel systems in two other Avid Mk. IV aircraft. One had a fuel system with each fuel tank supplying the Header tank directly with no tank selector, unlike that in G-BTMS. The second aircraft had a fuel system similar to G-BTMS but with the Header tank vent line routed to the bottom of the fuselage. The vent valve is opened to vent the system as necessary and is normally closed during operation. The pilot of this aircraft remarked that he has had no problems whatsoever with this system during the past 15 years of operation.

1.3.6 Use of (Unleaded) MOGAS

G-BTMS was powered by a ROTAX 582 UL, liquid cooled, 2-stroke, 2-cylinder in-line engine with rotary valve inlet. It is approved for use with Unleaded MOGAS to BS 228 (RON 90 minimum). AVGAS 100LL may be used, but increased wear and deposits in the combustion chamber will occur when using this fuel.

There are a number of factors to consider when using MOGAS in an aircraft. As G-BTMS was operating on an LAA Permit, the information contained in the LAA document entitled '*Operating information – Unleaded MOGAS'* (Issue 6 - 26 May 2009)' is relevant. It is essential to use fuel to BS EN228 (fuel termed *'Premium Unleaded'* is 95 RON[5]). Some forecourts are supplying fuel with varying amounts of alcohol added to the fuel. Alcohol in the fuel can damage rubber components in the fuel system and can also cause problems through progressively absorbing water, which can suddenly come out of solution later, and stop the engine in flight. A test which is described in the Civil Aviation Authority (CAA) Safety Sense Leaflet 4b, is only sensitive to alcohol levels of 5%. Commercial test kits are available to detect levels down to around 1%. If the aircraft has been standing for 24 hours or more then a standard water check from all fuel drains should be carried out.

MOGAS also has a very short 'shelf-life' (typically a few weeks) as over time the more volatile fraction will evaporate, leaving a residue of low-volatility fuel which will cause poor starting, reduced performance and possibly engine damage through detonation or over-heating. Also MOGAS in storage has a much greater tendency to form gum deposits than AVGAS. These gum deposits can block carburettor jets and cause moving parts to stick. It is best practice to uplift fresh quantities of MOGAS as needed thus ensuring the quality remains high and that the fuel is of the correct blend, as MOGAS is blended differently depending on the time of year. Using summer fuel in winter may cause difficulty in starting, while using winter fuel in summer will increase the likelihood of vapour problems. The CAA have agreed that an acceptable procedure to meet airworthiness requirements is that receipts should be kept for all fuel purchased in any year.

Unleaded MOGAS has a much higher vapour pressure than AVGAS 100LL or AVGAS 80/87. As the initial boiling point of the fuel is only slightly above the ambient temperature, it takes only a slight rise in temperature or drop in pressure to make it start to vaporise. This property makes it much more likely to suffer vapour-related problems than AVGAS especially in hot weather or operating at high altitude.

Accordingly, operation with MOGAS fuel is limited to a fuel tank temperature of 20°C and 6,000 feet operating altitude. When the fuel turns to vapour in the fuel system a number of problems can occur. If the vapour collects to form a bubble, it may become trapped at a point in the fuel supply line causing a vapour-lock, starving the engine of fuel, and causing a dead cut similar to closing the fuel shutoff valve. Also if the fuel vaporises due to a hot spot or low pressure area but does not become entrapped, a stream of vapour bubbles will enter the carburettor along with the fuel causing raised Exhaust Gas Temperature, lean running and reduced power.

[5] **RON**: Research Octane Number.

Another vapour-related problem is pneumatic-lock where fuel vaporises within the fuel pump due to elevated fuel pump temperature. The vapour is forced to expand on the outlet side of the pump. This pressure is enough to push the fuel past the carburettor float valve and the engine suffers a rich cut with raised fuel pressure indications and rough running.

If the aircraft is approved for MOGAS use, then placards must be fitted as specified adjacent to the filler caps and also on the instrument panel highlighting the limitations of Unleaded MOGAS as outlined in the LAA document. No such placards were fitted to G-BTMS.

1.4 Pilot Interview

The Pilot was interviewed the day following the accident. The Pilot was the holder of a JAA PPL (A) issued in the United Kingdom together with a Medical Certificate Class II. All licences and ratings were valid. The Pilot had a total flight experience of 152 hours with 4 hours on the accident type. He recounted the events of the accident flight in detail and made all licensing and paperwork regarding the aircraft available to the Investigation. This paperwork included comprehensive handling notes on the Avid Mk. IV issued under the Popular Flying Association Pilot Coaching Scheme (now the Light Aircraft Association). A receipt was made available for the fuel uplift made at Haverfordwest on the day of the accident.

1.5 Survivability

Following the engine stoppage, the Pilot had no option but to carry out a controlled ditching. This was successfully accomplished. The Pilot's 4-point safety harness was properly fastened and remained intact during impact with the sea. The harness provided adequate restraint during the deceleration. The Pilot had donned a survival suit prior to undertaking the flight and carried a floatation jacket which he put on when the aircraft entered the water.

Article 19(2)(c) of the UK Air Navigation Order (2005) sets out specific equipment to be carried by non-public transport aircraft when flying over water. This equipment, detailed in Schedule 4 of the Order, specifies that an Emergency Locator Transmitter (ELT) of either automatic or survival type, be carried and be capable of transmitting on 121.5 MHz and 406 MHz. At the time of the accident, a general exemption (*No. 744*) was in force regarding this requirement. As such, no ELT was required to be carried in G-BTMS.

1.6 Requirement to submit a Flight Plan

There is a requirement under the UK *Rules of the Air Regulations* (2007) for a pilot to file a flight plan with air traffic services inter alia:

The Commander of an aircraft who intends to fly or who flies across any boundary of airspace notified as either the London or Scottish Flight Information Region (apart from the boundary common to each), shall cause a flight plan, containing such particulars of the intended flight as may be necessary for search and rescue purposes, to be communicated to the appropriate air traffic control unit within the London or Scottish Flight Information Region before flying across the boundary.

No flight plan was filed with Air Traffic Services, however a *General Aviation Report* was filed regarding the flight.

2. ANALYSIS

2.1 General

On 11 August 2009, the day of the accident, the Pilot travelled to Haverfordwest in the UK to collect the aircraft and fly it to ILAS Field at Taghmon in Co Wexford. Although he had undergone a familiarisation flight with an instructor, it was then 6 months since he had last flown the aircraft. Considering this, it may have been prudent for the Pilot to undergo additional familiarisation training or some flying in the local area to re-acquaint himself with the aircraft and its systems prior to undertaking the cross-water flight. The Pilot indicated to the Investigation, and evidence has established with reasonable certainty, that the aircraft had a full fuel load prior to departing Haverfordwest Airport. Prior to the uplift of 23 litres of AVGAS on the day of the accident, the aircraft was operated on MOGAS. Thus the fuel used on the accident flight was a mixture of 67 litres of MOGAS, which had been stored in the aircraft tanks for approximately five months, and the 23 litres of AVGAS uplifted shortly before the flight.

2.2 Pre-flight Checks

The pre-flight checks were not conducted with thoroughness. No water check was made of the fuel on board by the Pilot during the external pre-flight inspection. This check is essential as the aircraft had not flown for several months, in fact it would have been better to replace the fuel being MOGAS with a fresh supply.

A bungee cord, used to limit right control stick (and control surface movement) while the aircraft is secured on the ground, was not noticed or removed before flight. A second check of the flight controls made before take-off to ensure 'full and free' movement also failed to detect the presence of the bungee cord. After take-off the aft force needed on the control stick to establish a climb should have alerted the Pilot to something being amiss with the primary flight controls. Lack of familiarisation with the Avid may explain to some degree the decision to continue the flight in these circumstances.

A second identical bungee cord was found loose under the pilots bench seat; the cord was located adjacent to the elevator control linkages and could have caused additional control problems at any time.

2.3 Engine Stoppage

The Pilot stated that the engine stoppage was sudden, and without rough running or indications of mechanical damage. Examination of the engine confirms that no mechanical failure of the powerplant took place. Although the aircraft was operating below cloud, the nature of the stoppage was not consistent with carburettor icing or rich-running (pneumatic-lock) problems as there did not appear to be any loss of power or rough running evident.

The Pilot stated that the Left tank was selected before take-off and remained in that position until after the engine stoppage when the Right tank was selected. Assuming that the fuel selector lever was in a position to draw fuel (a selection within an arc of 84 degrees will not allow fuel from either tank) then fuel should have been available to the system. The Left tank filler cap vent tube was likely to have been bent post accident as the Pilot was situated on top of the wing prior to his recovery by helicopter.

All fuel lines and filters were found free of obstruction, so fuel should have been available to the engine. It appears probable that the fuel supply to the engine was interrupted after approximately 55 minutes of flying time.

The fuel system in G-BTMS was not strictly in accordance with the manufacturer's specification. With a selector valve installed enabling either tank to supply fuel, the vent line should have been routed above the wing rib to provide positive pressure to the system in accordance with the installation drawings. Adequate venting is essential to proper fuel system operation. The pneumatically driven fuel pump will be unable to continue to draw fuel if there is not adequate venting in the system. Also, operation using MOGAS, or a fuel mixture which is predominantly MOGAS, poses increased risk of vapour-related problems. The storage of fuel in the aircraft tanks for at least 5 months would have reduced the volatility of the fuel, which was then topped off with a quantity of AVGAS. Taken all the above into account it seems probable that the engine in G-BTMS stopped due to a fuel supply problem. The Investigation is of the opinion that a fuel vapour-related problem, in probability a vapour-lock in the fuel supply line, occurred during flight. It is not possible to say if inadequate venting of the Header tank contributed to the loss of fuel flow.

The Pilot attempted to re-start the engine after selecting the opposite (Right tank). The attempt to re-start the engine was unsuccessful. As the vent valve on the Header tank was closed, it is possible that the system was unable to supply fuel at the proper rate due to negative pressure in the Header tank. Opening the Header tank vent valve may have allowed a positive fuel flow to resume through the Header tank permitting a re-start attempt. In the circumstances, the Pilot had little time to achieve this and was faced with an imminent ditching. It is probable that during the immersion in the sea and subsequent towing operation fuel was displaced from the tanks and fuel system allowing ingress of large amounts of seawater.

2.4 Survivability

With no success at re-starting the engine and with little height remaining the Pilot had no option but to ditch the aircraft into the open sea. The Pilot correctly made a distress call and having unsuccessfully attempted to re-start the engine concentrated his attention on the task of ditching. Ditching an aircraft in the open sea incurs a certain amount of risk. The speed and controllability of the aircraft, the wind, the height and direction of the sea swell and impact forces all serve to make this procedure a demanding one in any circumstances.

The actual ditching was successfully carried out by the Pilot, despite the fact that he was not particularly familiar with the aircraft and also had a degree of control restriction to contend with. After the ditching was complete, he evacuated the aircraft without injury. Fortunately, a nearby boat came immediately to his aid, followed by recovery by an Irish Coast Guard helicopter that were alerted by the MRCC following the Pilot's earlier distress call. Although the Pilot used an immersion suit, the lifejacket was not of an approved type for aircraft use. Given the time of useful consciousness when immersed in the sea, an inflatable type life jacket with signalling devices is required.

3. CONCLUSIONS

(a) Findings

1. The Investigation found no mechanical damage to the engine or ancillary components.

2. The stoppage did not exhibit the symptoms of carburettor icing or rich-running (pneumatic-lock).

3. The engine stopped probably due to a fuel-supply related problem, in probability a vapour-lock in the fuel supply system.

4. Supplying the engine from a single tank via the fuel selector valve, with the Header tank vent valve closed, may have contributed to low fuel pressure and the vapour-lock condition.

5. Following a checkout on type, the Pilot had not flown the aircraft for 5 months prior to the accident flight.

6. The pre-flight checks carried out on the aircraft were not sufficiently thorough.

7. No flight plan was filed for the planned flight as required by the UK Rules of the Air Regulations (2007).

8. The Pilot's initiative in transmitting a distress call subsequent to the engine stoppage was the primary factor in Search and Rescue being alerted in a timely manner.

9. The ditching and subsequent evacuation were carried out by the Pilot in difficult and demanding conditions.

10. The aircraft incurred only minor damage in the ditching, however some additional damage occurred during towing. Total immersion in seawater rendered the airframe and engine beyond economic repair due to extensive salt-water corrosion.

(b) Probable Cause

The engine stopped after approximately 55 minutes flying time probably due to a vapour-lock in the fuel supply system.

(c) Contributory Factor

Possible inadequate venting of the fuel system due to the Header tank vent valve being closed.

4. SAFETY RECOMMENDATIONS

This Investigation does not sustain any Safety Recommendations.

- END -