ACCIDENT

Aircraft Type and Registration:	CZAW SportCruiser, G-EWZZ
No & Type of Engines:	1 Rotax 912 ULS piston engine
Year of Manufacture:	2010 (Serial no: LAA 338-14815)
Date & Time (UTC):	9 August 2014 at 1440 hrs
Location:	Kingarth, Isle of Bute, Scotland
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Serious) Passengers - 1 (Fatal)
Nature of Damage:	Aircraft destroyed
Commander's Licence:	National Private Pilot Licence
Commander's Age:	53 years
Commander's Flying Experience:	555 hours (of which 100 were on type) Last 90 days - 29 hours Last 28 days - 1 hour
Information Source:	AAIB Field Investigation

Synopsis

Shortly after takeoff from Runway 27 at Bute Airstrip, the pilot reported that the engine appeared to lose power and the aircraft was no longer able to climb. With the area around the airfield unsuitable for a landing he attempted to return to the runway, but in doing so flew into the ground. The aircraft came to rest upside down in a ditch and caught fire. The pilot and passenger sustained serious burns from which the passenger later died.

The aircraft was fitted with a ballistic parachute recovery system which had not been activated during the flight. However, the investigation highlighted a number of issues, concerning such systems, which present a risk to the aircraft occupants and first responders following an accident.

Seven Safety Recommendations were made to address the risk to individuals following an accident involving an aircraft equipped with a ballistic parachute recovery system.

Introduction

The accident involving G-EWZZ highlighted a number of issues concerning the risk of injury to third parties following an accident involving an aircraft fitted with a ballistic parachute recovery system. In order to address these issues, this accident report has been written in two sections. The first will address the accident and the second the ballistic parachute recovery system.

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Section One – Aircraft accident

History of the flight

The pilot of G-EWZZ arranged with a group of pilots to fly to Bute Airstrip, near Kingarth on the Isle of Bute, for lunch. He and his passenger travelled separately to Strathaven Airfield, in South Lanarkshire, where the aircraft was based. The pilot could recall little of the day's events and could not remember the time he arrived at Strathaven Airfield, but did recollect that he had conducted a pre-flight inspection and refuelled the aircraft from one or more fuel cans. However, he could not remember how much fuel was in the aircraft before he departed for Bute.

The pilot reported that the flight from Strathaven to Bute was flown without incident. The aircraft was parked with the other aircraft while the pilot and passenger went for lunch in a nearby hotel with the rest of the group. On returning to the aircraft, the pilot conducted a pre-flight inspection during which he noticed nothing abnormal. The outbound journey had been flown using the fuel from one tank[1]. Prior to carrying out the power checks for the return flight the pilot selected the other tank. The pilot reported that the power checks were "fine". The propeller pitch controller was set to the TAKE-OFF position and not adjusted or reselected during the accident flight.

The aircraft was the last of the group to depart Bute, using Runway 27, so none of the other pilots were able to provide further information on the accident. However, the takeoff and part of the flight was recorded by two separate witnesses on their mobile phone cameras.

The pilot thought that he would have selected one stage of flap and recalled that the aircraft "got off the ground, no problem". However, the engine then seemed to lose power. He could not remember the height at which this occurred, nor could he recall any specific features of the loss of power beyond a change in the engine noise and the aircraft not performing as he expected. The pilot checked that he had selected full throttle, the choke was OFF and the tank containing the most fuel had been selected. He did not apply the carburettor heat and could not remember checking the airspeed.

The pilot stated that he initially thought that he might have to ditch in the sea, which was directly beyond the end of the runway so he unlatched the canopy and instructed the passenger to hold it closed. However, the aircraft maintained height and the pilot decided to land back on Runway 27. He then made a series of right turns onto an approximate downwind heading with the intention of flying a low-level circuit. The pilot's last recollection was of the aircraft being nose high, giving him little or no forward visibility before the aircraft struck the ground.

During the accident sequence the aircraft inverted with the cockpit section suspended over a roadside ditch with both the pilot and passenger restrained in the aircraft by their harnesses. The pilot told the passenger to undo his seatbelt but received no response

Footnote

[1] The pilot could not recall which tank had been selected on each flight.

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before a fire developed. The pilot evacuated the aircraft by dropping into the ditch and crawling underneath the passenger. He then assisted the passenger to escape from the burning aircraft. Both the pilot and passenger sustained serious burns.

Witnesses reported that the fire seemed to start immediately after the aircraft stopped and both the pilot and passenger evacuated the aircraft very quickly. The witnesses called the emergency services and after treatment at the accident site, both the pilot and passenger were flown separately to Glasgow by an Air Ambulance and a Royal Navy Search and Rescue helicopter. The passenger later died of his injuries in hospital.

Airfield description

Bute airstrip is an unlicensed grass airfield located 850 m south-west of the village of Kingarth on the Isle of Bute, Figure 1. It has a single runway orientated 27/09 with a declared length of 480 m. The approach to Runway 27 is through a gap cut in a large area of trees which border the eastern end of the airfield. The sea is 600 m west of the end of Runway 27. Between the runway and the sea is an area of small rectangular fields orientated north-south and the edge of a links golf course.

The terrain surrounding the airfield has a pronounced slope up to the north from the runway. The surface of the fields on the lower slopes was very soft though the ridge just north of the A844 road was relatively firm. There are various power and communication wires crossing the fields parallel to the runway.

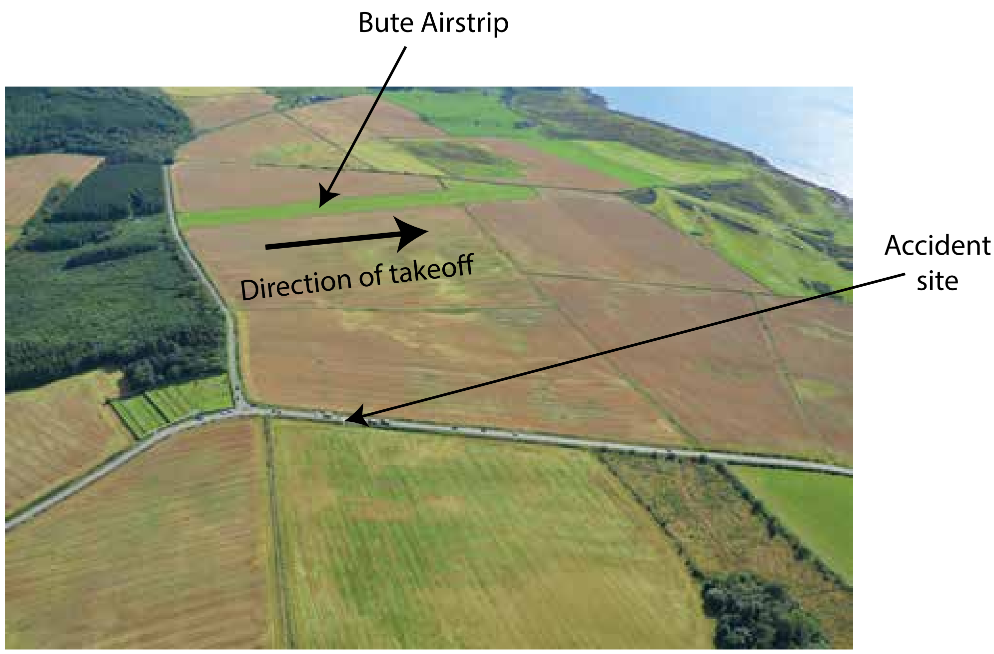

Figure 1

Bute airstrip (Photo courtesy of Police Scotland)

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Meteorology

Weather information was acquired by analysing witness mobile phone video recordings and interviews with other pilots who operated from Bute on the day of the accident.

The video shows excellent visibility with no low cloud. The other pilots reported the surface wind as from approximately 260º at 13 to 17 kt. The temperature recorded at 1420 hrs at Prestwick Airport, 20 nm to the south-east, was 16ºC, the dew point was 10ºC and the QNH 1022 HPa.

Aircraft description

General

The SportCruiser is a single-engine, all-metal aircraft fitted with a tricycle landing gear and wheel fairings. It has two side-by-side seats, each fitted with a four-point harness. Access to the cockpit is through a one piece canopy that is connected to the fuselage by two swivel hinges located on the forward sides of the canopy frame. The canopy cannot be jettisoned and entry and exit from the cockpit is only possible by raising the canopy about the forward hinges.

G-EWZZ was a home-built aircraft, designed under the EASA Light Sport Aircraft specification, and operated under a Permit to Fly issued by the Civil Aviation Authority (CAA) on the recommendation of the Light Aircraft Association (LAA).

Flying controls

Two interconnected control columns operate the aileron and elevators via a series of control rods and bell cranks. The rudder is controlled by steel cables connected to the rudder pedals. The flaps are electrically actuated. The aircraft is also equipped with an aileron and elevator trim system utilising trim tabs fitted to the elevator and right aileron. The trim motors are controlled by buttons on the control column and the position of the trim is shown on two indicators located on the left side of the instrument panel.

Although there is no record in the aircraft documentation, at the time of the accident G-EWZZ was fitted with an autopilot that could control the aircraft in roll and pitch. The pilot stated that since he purchased the aircraft in September 2013, he had not fitted or removed any parts which might relate to an autopilot.

Fuel system

Fuel is stored in two 57 ltr fuel tanks located in the leading edge of each wing. The fuel flows from the tanks through strainers to a selector valve mounted on the centre console. It then passes through a gascolator and electrical fuel pump mounted on the engine side of the firewall. The fuel then flows through an engine drive pump to the two carburettors. A sensor between the mechanical fuel pump and carburettor provides information on the fuel pressure.

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Engine

G-EWZZ was fitted with a Rotax 912 ULS piston engine equipped with a double contactless ignition system. Each ignition system had its own control unit, ignition coils and spark plug. The electrical supply for the ignition system was independent of the aircraft battery.

Carburettor heating was obtained by moving a flap in the engine bay to direct warm air from around the engine into the engine air intake. The carburettor heat control was mounted on the instrument panel.

Propeller

The following propellers had been approved for used on the Rotax 912 ULS engine fitted to the SportCruiser:

- The Woodcomp Klassic, ground adjustable, three-bladed propeller which has a weight of 2.5 kg.
- The Woodcomp SR 3000/2, two-bladed, electronically operated variable pitch propeller, which has a weight of 11 kg.
- The Woodcomp SR 3000/3 electronically operated variable pitch propeller, which has a weight of 12.48 kg.

The aircraft documentation recorded that a Woodcomp Klassic propeller was fitted to G-EWZZ. However, at the time of the accident it was found fitted with a Woodcomp SR 3000/3 variable pitch propeller, serial number 0988.

Propeller pitch controller

Photographs of the cockpit, taken prior to the accident, show that G-EWZZ was also equipped with a CSC-1 propeller pitch controller. The engine rpm and manifold pressure is sent directly from the engine to the controller where the values are shown on the display. The controller can be operated in manual mode, where the pilot can manually adjust the rpm, or in automatic mode, where the rpm is maintained at a preset value. The controller always defaults to manual mode during engine start. By operating a push mode select button the pilot can sequence through the climb and cruise settings; the default cruise setting is 5,000 rpm. However the system does need to be set up correctly, the installation should be inspected by an LAA inspector and the operation of the system should be checked during the annual check flight. No records were found that any of these actions took place.

Instruments

G-EWZZ was fitted with a Dynon D100 Electronic Flight Instrument System (EFIS), Dynon D120 Engine Management system (EMS), ASI and altimeter. The EFIS integrates and displays the flight information including airspeed, altitude, magnetic compass, turn-rate, slip/skid ball, bank angle and vertical speed. The EMS displays the engine information including rpm, oil pressure, oil temperature, cylinder head temperature and exhaust gas temperature. The pilot stated that when he purchased the aircraft there had been an intermittent fault

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in the EMS, which did not affect the EFIS, which he fixed by replacing a pin in the plug which provided electrical power to the unit. The aircraft was not equipped with the optional vane-type stall warner that can be fitted to the leading edge of the left wing. However, the pilot stated that the EFIS would provide an audio warning when the aircraft approached the stall, but due to spurious warnings he had disabled this function.

Accident site

The accident site was approximately 590 m north of Bute Airstrip along the line of a fence and ditch that ran parallel to the A844. With the exception of the field to the north of the road, which contained a crop of corn approximately 0.4 m high, there were no other suitable areas in the immediate vicinity in which to land. See Figure 2.

Figure 2

Accident site

Ground marks and paint flakes from the right wingtip show that the aircraft touched down on the right mainwheel and nosewheel at a relatively shallow angle, banked to the right on a heading of approximately 115º(T). The nosewheel broke off and the aircraft continued to slide forward with the inner section of the left wing striking and knocking over several fence posts. After approximately 10 m the front section of the aircraft dropped into a ditch and the aircraft turned over onto its back with the fin coming to rest in a hedge. Propeller cut marks in the ground indicated that the engine was still producing power when it struck the ground.

Foliage in the ditch, the fence posts and foliage on the north side of the ditch were all badly burnt, whereas the grass on the south side of the road was not. This burn pattern was consistent with the direction of the wind.

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Damage to the aircraft

General

The aircraft had been extensively damaged by fire and the cockpit area and instrument panel had been destroyed. Most of the aluminium control rods in the centre section of the aircraft had melted, though the steel fittings remained intact. This indicated that the temperature in the area of the cockpit had reached between 650ºC and 1,200ºC. The left wing had sustained more damage than the right with the inner section of the fuel tank having been destroyed by fire. A large dent on the leading edge of the inner section of the left wing was consistent with it having hit the fence posts. The right wing was mostly intact and the right fuel tank contained a small quantity of fluid that was not recovered. The base of the fin and the left stabiliser were both damaged by the heat.

Controls

All the control surfaces moved freely and there was continuity between the rudder pedals and the rudder. Examination of the elevator electrical trim motor revealed that the operating screw was at 30% of its range of travel.

Due to the damage and disruption to the aluminium control rods it was not possible to establish continuity for the elevator and ailerons. However, all the steel connecting rods and fittings were still connected and therefore it is unlikely that there had been a disruption in the flying control system. The flap electrical drive motors had also been destroyed and the control rods extensively damaged; consequently it was not possible to establish the position of the flaps from the wreckage. It was also not possible from the video to determine the position of the flaps prior to the accident.

Engine

The engine and carburettors had been extensively damaged and the insulation on the electrical wiring had melted. Consequently, it was not possible to determine the serviceability of the carburettors and ignition system. Two of the propeller blades had failed close to the blade root in a direction consistent with the engine producing power at the time of impact. The third blade had failed approximately 16 cm from the blade root and the direction of failure indicated that the blade was not rotating when it failed. The engine could not be turned by hand.

The engine was taken to a Rotax approved service centre where it was dismantled and the parts examined. The fuel pump diaphragm and non-return valves were intact and there was no debris on the magnetic plug. All the major components were intact and the inspection revealed no obvious reason why the engine might have lost power. There was also no evidence of any parts of the engine having overheated while the engine was operating. The bearing shells that supported the crankshaft showed evidence of having started to melt after the engine stopped rotating. The No 1 and 2 cylinder connecting rods moved freely, but the No 3 and 4 were very stiff to move. The No 3 and 4 cylinders were closest to the source of heat and it is believed that the stiffness was caused by the bearing shells on the connecting rods having started to melt.

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Examination of the propeller

The propeller was examined, under the supervision of the AAIB, by the UK agent. The propeller was identified as a Woodcomp SR 3000/3/1700/R/T/CS/C, serial number 0988. While the AAIB did not have access to the propeller log book, it was established that the propeller had been manufactured in October 2008 and fitted to another SportCruiser, registration G-CFPA. The propeller was damaged in an accident that occurred in October 2010 and was returned to the factory for overhaul in March 2011.

The propeller back plate and hub was intact, but displayed evidence of heat damage. All three pitch limit microswitches and the electrical wires to the electrical motor had been damaged by heat. The two fine pitch microswitches were established as being at, or close to the electrical fine pitch stop and the course pitch microswitch was assessed as being in transit between the course and fine pitch limit. From the angle of the root of one of the blades it was established that the blade pitch was at 16.6º. The blades are normally set to give a fine pitch limit of 18º and a course pitch limit of 28º. However the agent advised that on the Rotax 912 ULS, 18º of blade pitch gives a static rpm of around 5,450 rpm and some owners set the fine pitch stop at 16.5º in order to get a static takeoff rpm of 5,650 rpm.

The electrical motor was tested and found to operate in both directions. The propeller hub was dismantled and all the components were examined. The mechanical pitch stops were all close to, but not touching, the mechanical fine stop set at 12.5º. The blades turned freely in the hub and with the exception of the blade centring cone and the blade bearings all the components were in relatively good condition. The blade centering cone had two rows of dimples formed by contact with the bottom of the three blades. It is possible that this damage was caused by inadequate preload which allowed the centering cone to rotate. The grease on the bearings had dried out, possibly as a result of the post-crash fire. The outer races on the bearings were all heavily indented. None of these factors would have prevented the propeller from operating normally.

The assessment was that the propeller was probably operating satisfactory at the time of the accident with the blade pitch at the electrical fine pitch stop position of 16.6º. On the Rotax 912 ULS engine this pitch angle would give a maximum static rpm at takeoff of between 5,600 to 5,650 rpm.

Testing of fuel

The AAIB was provided with two 1 litre samples of fuel that had been taken from two fuel cans believed to have been used to refuel G-EWZZ prior to the flight to the Isle of Bute. Testing established that both samples were consistent with unleaded gasoline with no evidence of contaminants in either sample.

It was not possible to recover or test any of the fuel that remained in the right fuel tank.

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Pilot Information

The pilot held a National Private Pilot's Licence (NPPL) issued in April 2010 with a Simple Single Engine Aeroplane (SSEA) rating issued in October 2011. His logbook showed that he had met the ongoing validity requirements for the SSEA rating, the last instructor signature was dated 12 February 2013. However, this rating requires additional differences training to operate aircraft with variable pitch propellers. Such training is recorded by an entry and signature in the pilot's logbook by a suitably qualified instructor; there was no record that this additional training had been completed.

Medical

Pilot

The pilot had a Declaration of Medical Fitness to Fly, issued in April 2010, which was valid for five years. The burns that the pilot sustained in the accident totalled about 40% of his body surface area, which required extensive medical treatment during an extended stay in hospital.

Passenger

The passenger's burns totalled approximately 80% of his body surface area of which 60% were full thickness. This was beyond the limits of survival and he subsequently died in hospital. A post-mortem examination was conducted by a pathologist on behalf of the Procurator Fiscal. A specialist aviation pathologist interpreted the report on behalf of the AAIB.

The aviation pathologist commented that there was no evidence of significant impact injuries and the pathologist who carried out the post-mortem, commented that the distribution of the burns suggested that they occurred while the passenger was in his seat.

The aviation pathologist also commented that this was a survivable accident and that while commercially available fire-resistant flying clothing might not have altered the fatal outcome, their protective benefits should be highlighted to light-aircraft pilots. The CAA Safety Sense leaflet No 1 '*Good Airmanship Guide'* suggests that pilots and passengers:

> *'Wear clothes that cover the limbs and will give some protection in the event of fire. Avoid synthetic material which melts into the skin.'*

Last flight test report

The last flight test was carried out as part of the Permit to Fly renewal (revalidation) and was dated '*21.1.14*'. The report recorded the following:

'Max static rpm	*5,420 rpm*
Actual loaded weight at take-off	*595 kg*
Actual C of G position at take-off	*540 mm aft of datum*
Time to climb, 1000ft to 2,000ft	*78 secs*
Climb at	*73 mph*
Minimum airspeed achieved	*Flaps up 41 kts'*

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Weight and Balance

Aircraft empty weight and balance

The last documented weight and balance of the aircraft was dated 18 January 2010. While the documentation did not record which propeller was fitted, the initial flight test report, dated 30 June 2010, stated that it was a Woodcomp Klassic. LAA inspectors who undertook the inspection for the issue and renewal of the Permit to Fly between 2011 and 2014 all recorded that the Klassic propeller was fitted. However, there is photographic evidence that shows that G-EWZZ was fitted with the Woodcomp SR/3000/3 variable pitch propeller on a number of occasions between 2011 and the date of the accident. The pilot also stated that when he purchased the aircraft in September 2013 it was fitted with the Woodcomp variable pitch propeller and that he had at no time removed or replaced this propeller. The fitment of the heavier variable pitch propeller would have an effect on the weight and balance of the aircraft.

The Maximum Takeoff Weight of the SportCruiser is 600 kg and the operating Centre of Gravity (CG) range is 405 to 507 mm aft of the aircraft datum. The aircraft weight and balance report, dated 18 January 2010, made no reference to an autopilot having been fitted to the aircraft and recorded the empty weight and position as:

'Empty weight	*373.70 kg*
Empty CG	*441.64 mm aft of datum'*

Following the accident the empty weight and balance was calculated by the LAA, with the Woodcomp SR 3000/3 variable pitch propeller and autopilot fitted, as:

'Empty weight	*393.7 kg*
Empty CG	*368.3 mm aft of datum'*

Aircraft weight and balance at the start of the accident flight

As a result of the fire damage, and injuries sustained by the occupants, it was not possible to make an accurate calculation of the weight and balance of the aircraft at the start of the accident flight. Both the pilot and passenger's weights would have increased as a result of their medical treatment and therefore the weights were estimated by reducing their post-accident weights to give a predicted pre-flight weight of 100 kg and 110 kg.

The amount of fuel on the aircraft was unknown, but to allow for the planned flight, with a small reserve, it was unlikely to be less than 20 ltr of fuel weighing 14.8 kg.

The minimum aircraft weight, and position of the CG, was estimated at the start of the accident flight to have been:

'Aircraft equipped with Woodcomp Klassic propeller

Take-off weight	*598.5 kg (limit 600 kg)*
Take-off CG	*539 mm aft of datum (limit 405 to 570 mm)*

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Aircraft equipped with Woodcomp SR 3000/3 propeller and autopilot	
Take-off weight	*618.5 kg (limit 600 kg)*
Take-off CG	*536 mm aft of datum (limit 405 to 570 mm)'*

Video analysis

Two witnesses, one standing close to the threshold of the airstrip and the second standing approximately 500 m from the start of the takeoff run and close to the accident site, videoed the accident flight. While both videos recorded the audio it was difficult to detect the noise from the engine above the noise generated by the wind.

The video clip taken close to the threshold lasted for 21 seconds and started during the aircraft takeoff run. There appeared to be nothing unusual about the rotation or initial climb; the aircraft then levelled off and descended before levelling off again.

The video clip taken close to the accident site lasted for 1 minute 34 seconds. It was not possible to establish an engine speed from the audio recording but analysis of the flight path established the following:

- The runway is approximately 480 m long and the takeoff run was estimated to be between 135 and 141 m.
- After takeoff, the maximum pitch attitude of the aircraft during the climb was estimated to be 20º.
- After reaching a height of approximately 50 ft above the ground, and 90 ft above sea level, the aircraft made a small descent before levelling off.
- At times during the remainder of the flight the aircraft appeared to porpoise during which it gained and lost some height.
- As it crossed the electrical pylons close to the accident site, the wings were level and the height was estimated to be 40 ft above the ground and 120 ft above sea level.
- Towards the end of the video the aircraft had a high nose attitude and the wings were initially level. It then banked to the right and started to descend maintaining the nose-high pitch attitude.
- The accident site was 90 ft above sea level.

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ATSB report on partial power loss

In 2013 the Australian Transport Safety Board published a safety report on managing partial power loss after takeoff in single-engine aircraft[2]. The key messages in their report were that in order to prevent or minimise the risk of harm following a partial power loss pilots should emphasise:

> *'Pre-flight decision making and planning for emergencies and abnormal situations for the particular aerodrome.*
>
> *Conducting a thorough pre-flight and engine ground run to reduce the risk of a partial power loss occurring.*
>
> *Taking positive action and maintaining control either when turning back to the aerodrome or conducting a forced landing until on the ground, while being aware of flare energy and aircraft stall speeds.'*

Analysis – aircraft accident

General

G-EWZZ was a home-built aircraft that had been fitted with unrecorded modifications, which meant that it was not in compliance with its Permit to Fly. Calculations show that with these modifications the aircraft was likely to have been over its approved MTOW of 600 kg when it departed Bute.

The pilot reported that the aircraft flew satisfactorily on the outbound flight to Bute and that it was during the climb from the airstrip on the return flight to Strathaven that he experienced the symptoms that caused him to believe that he had a partial loss of engine power. The lack of performance could have been due to a combination of factors including a technical fault, handling and aircraft weight.

Aircraft weight

Aircraft weight will affect an aircraft's climb performance and handling qualities. G-EWZZ departed Strathaven without incident and given the greater fuel load would have been approximately 10 kg heavier than when it departed Bute. Therefore, although the aircraft was probably overweight, it is unlikely that this, alone, affected its performance to an extent that it could not have sustained a positive rate of climb.

Technical fault

The pilot could not recall any of the engine parameters or the airspeed of the aircraft during the accident flight. The video evidence showed that the engine was still running at the end of the flight, and the ground marks and damage to two of the propeller blades were evidence that it was still producing power. However, the damage to the engine and aircraft fuel system meant that it was not possible to establish if the engine had sustained a partial loss of power.

Footnote

2 http://www.atsb.gov.au/publications/2010/avoidable-3-ar-2010-055.aspx

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The aircraft was fitted with an autopilot and variable pitch propeller; there were no records of either installation on G-EWZZ. The autopilot had been destroyed in the fire, although its presence is unlikely to have caused the accident. Photographic evidence indicates that the variable pitch propeller had been fitted to the aircraft since 2011 without any reported problems. LAA inspectors who carried out the annual permit renewals all stated that the fixed pitch propeller was fitted when they inspected the aircraft.

The last flight test of G-EWZZ was carried out with a fixed pitch propeller, which was different from the type fitted at the time of the accident. The test report recorded a rate of climb, at a takeoff weight close to MTOW, of 770 ft/min. It is not known what the rate of climb would have been with a Woodcomp SR 3000/3 variable pitch propeller fitted.

From the video evidence, the ground run and takeoff appeared to be satisfactory and the initial climb angle reached an estimated 20º before the nose was lowered. This indicated that the engine was producing sufficient power at this time and also suggests that carburettor icing was unlikely.

It could not be determined if the unrecorded modifications or the recent replacement of the pin in the plug that supplied the electrical power to the EMS had affected the operation of the engine, propeller, or the engine and airspeed indications.

Handling

After the initial climb, the video evidence showed the aircraft pitch attitude reducing and the aircraft continued to fly in a near level attitude. In normal circumstances, the aircraft would be expected to accelerate and then continue its climb, which was not the case during this stage of the accident flight.

The pilot identified that the aircraft was not performing as expected and decided to try and return to Runway 27 at Bute. His decision appeared to have been influenced by the area of water ahead of the aircraft and also the fact that neither he, nor his passenger, were wearing or carrying lifejackets. Additionally, the options to conduct a landing were limited owing to the obstacles.

After the pilot perceived the power loss, he unlatched the cockpit canopy and instructed the passenger to hold it shut. It is possible that the passenger was able to hold the canopy in the closed position, which may have had little overall effect on the flight. Equally the effect of a canopy slightly open could have caused additional drag, which might have exacerbated the effect of the loss of engine power and resulted in the pilot being unable to maintain height. However, the effect of the canopy being unlatched could not be determined.

The turn onto the downwind leg resulted in the aircraft flying towards rising ground and there would have been a strong tail wind component, which would have increased the ground speed. Towards the end of the flight the aircraft was seen to be descending in a slightly nose-high attitude and at this point may have been in a stalled condition. The pilot reported that at this stage his forward visibility was poor and he was unaware that the aircraft was descending towards the rising ground.

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Section two - Ballistic Parachute Recovery System (BPRS)

Terminology

During this investigation it became apparent that a number of different terms are used to describe a system of deploying an emergency parachute by the use of a rocket. One of the most common terms was Ballistic Recovery System (BRS), which is also the name of the manufacturer of one such system. To avoid confusion, this report will use the descriptor Ballistic Parachute Recovery System (BPRS) as a generic term to describe such systems and the term Ballistic Recovery System (BRS) to refer to the manufacturer of the equipment fitted to the accident aircraft (G-EWZZ).

Aircraft installation

G-EWZZ was equipped with a BRS-6 1350 softpack LSA 'whole aircraft' BPRS. The components in the system are shown in Figure 3 and consist of:

- a parachute pack mounted forward of the instrument panel, aft of the firewall (item 1);
- a number of harnesses and cables to attach the parachute, and the parachute to the aircraft (item 2 and 4).
- a rocket contained in a launch tube mounted above the rudder pedals and between the engine firewall and instrument panel (item 3), which is connected by a cable to the parachute (not shown in Figure 3);
- an activation handle mounted on the instrument panel (item 5).

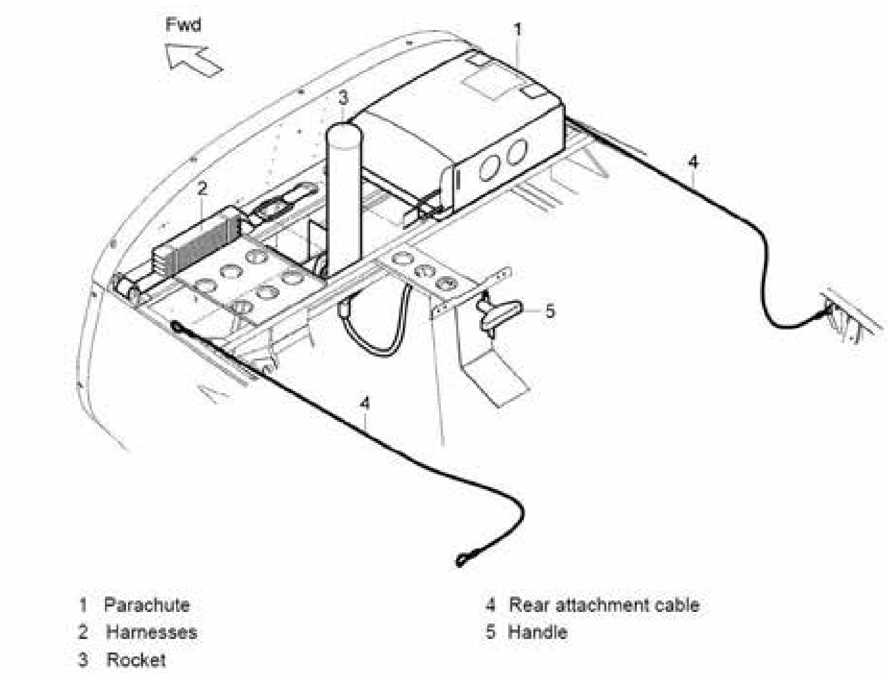

Figure 3
BPRS installation on the SportCruiser

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Deployment of the system is achieved by removing the safety pin from the handle (item 5) and pulling the handle rearwards. This action fires the rocket, which on leaving its launcher (item 3) passes through a frangible panel located forward of the canopy. The rocket pulls the parachute from its pack (item 1), to leave the aircraft suspended by the harnesses and cables (item 2 and 4) under the inflated parachute.

Rocket launcher

The construction of the rocket launcher and motor is shown at Figure 4.

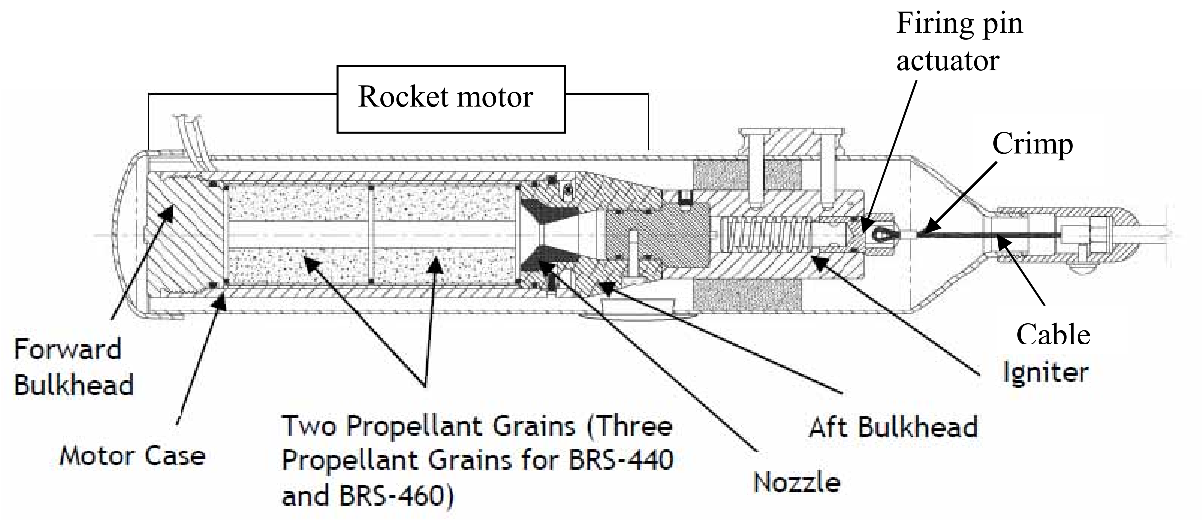

Figure 4
Rocket and launcher

Warning placards

The manufacturer of the system, BRS, required the SportCruiser to have three warning placards attached to the airframe. An orange and black 'Ballistic Warning' placard attached aft of the canopy on each side of the fuselage and a red and grey 'Stay Clear' placard attached on the right side of the parachute egress panel, Figure 5.

G-EWZZ also had a BRS logo attached near the base of the left side of the fin, Figure 6. There were no other placards or logos on the outside of the aircraft to indicate that the aircraft was fitted with a BPRS.

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Figure 5

Warning labels required by BRS for the SportCruiser installation

Figure 6

BRS logo on left side of fin

Condition of the BPRS following the accident

The markings on the fin and side of the fuselage warning that a ballistic system was fitted to the aircraft had all burnt off in the post-crash fire. Due to the fire damage to the aircraft it was difficult to identify many of the components in the BPRS system.

The empty rocket motor casing was found lying within the inverted wreckage, approximately 1 m from the firewall where the launcher was fitted, Figure 7.

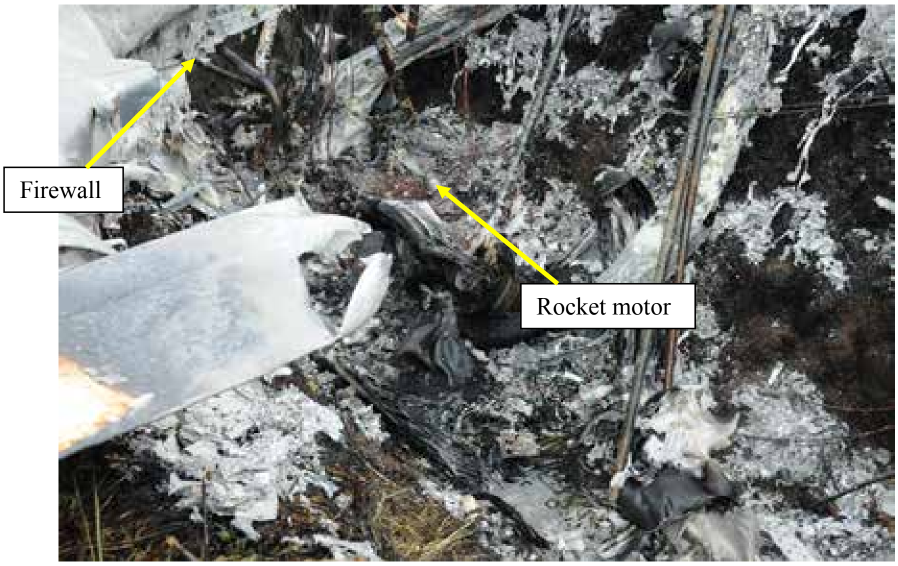

Figure 7

Location of burnt out rocket motor

The rocket casing had been badly damaged by heat and on one side the metal had melted leaving numerous holes. The forward bulkhead on the rocket motor was missing and there was no evidence of propellant remaining in either the rocket motor or nozzle. There was also no evidence of the rocket casing having exploded, Figure 8.

Figure 8

Rocket motor casing

Approximately two thirds of the rocket launcher had been destroyed in the fire and the remaining part had detached from the firewall and combined with other components and molten metal, Figure 9. The cable from the firing handle was not attached to the firing pin actuator which was still fitted in the base of the launch tube. An x-ray examination revealed that both primer cartridges had operated. The police advised that tests carried out on similar primers showed that they generally 'cooked off' at a temperature of approximately 180ºC. The firing handle had been badly distorted, the red paint had burnt off and the outer conduit had burnt away. It is believed that the actuating cable became detached from the firing unit as a result of the crimp, which forms the loop at the end of the cable, having softened and possibly melted in the post-crash fire.

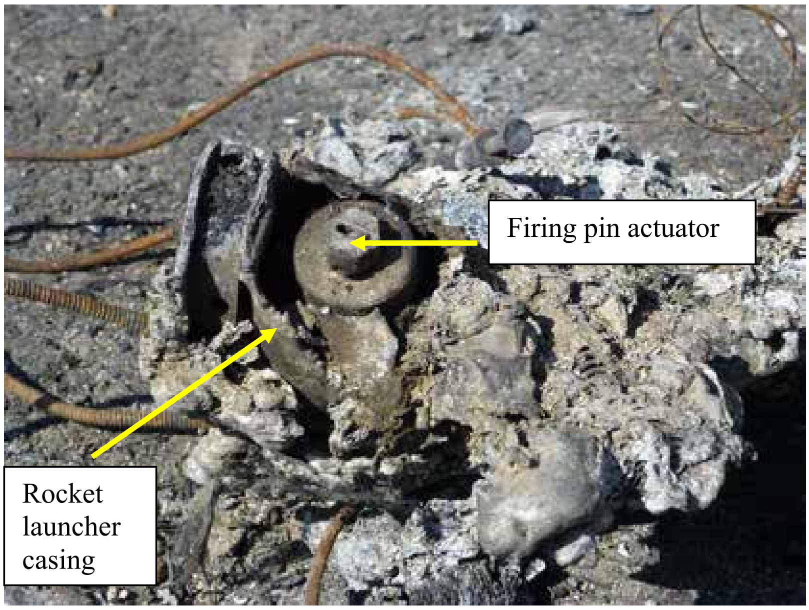

Figure 9

Base of rocket motor launch tube

Advice to emergency workers

The manufacturer, BRS, issued[3] the following warning and advice to emergency workers on the hazards that they might face following an accident to aircraft fitted with a ballistic parachute recovery system.

> *'One potential hazard rescue workers may encounter is an unfired, rocket-deployed emergency parachute system. While these devices are intended to save lives, they have the potential to cause injuries or even death to rescue workers.'*

Footnote

3 BRS part No 020002-01, Revision A. Owner's manual and general installation guide for BRS-6th Emergency Parachute Recovery Systems.

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The guidance contains the following steps that should be taken to disarm the rocket motor.

> *'1. Locate the BRS parachute system by finding the RED activation handle and tracing it to the parachute pack. Note presence or absence of safety pin. Pin if necessary. NOTE: Keep in mind that a badly damaged airplane may have already put the activating housing into a stretched state that could be close to firing.*
>
> *2. Identify the rocket motor launch tube (photos below). Note where the activating housing attaches to the base of the launch tube.*
>
> *3. Cut the activating housing at the base of the launch tube using a bicycle cable cutter (identified below) or equivalent.*
>
> *4. Remove the still-live rocket motor to a secure place and contact BRS for further directions about permanently disabling it.'*

BRS offer the following advice if a rocket motor has separated from its launcher during the accident sequence.

> *'A rocket motor that has separated from the igniter poses no significant hazard, unless it is exposed to fire. Experience has shown that a rocket motor subjected to high temperatures (fire) will not ignite in a normal manner and launch. Rather, they have been observed to burst in a relatively non-threatening display.'*

Report by the Swiss Accident Investigation Board on the dangers from a BPRS

A number of Safety Investigation Authorities[4] have highlighted the dangers from BPRS, following an accident, and have made safety recommendations to address the safety concerns. The Swiss Accident Investigation Board (SAIB) produced a report on the potential risk of BPRS in aircraft to rescue workers and investigators. The report considered the effect of the rocket motor 'cooking off' in a fire which the report stated would generally occur at a temperature of 180º to 220º C. Tests also considered the effect of a 'slow cook off', which simulated the rocket having been in close proximity to a fire.

The SAIB made a number of recommendations on the placarding of aircraft equipped with a BPRS and the actions to be taken following an accident. For the thermal behaviour of rocket motors the SAIB stated:

> *'The results show that these rocket motors can react violently in particularly in a slow cook off scenario with rapid ejection of individual heavy fragments. It is also possible that open energetic substances can remain at the place. First responder teams should know these hazards and should be trained to apply the corresponding counteractive measures'.*

Footnote

[4] An example of concerns raised by SIAs are contained in the following documents:
- Australian Transport Safety Board safety recommendation R20040095.
- National Transportation Safety Board safety recommendations A-04-36 to 41.
- Swiss Accident Investigation Board report number 2148.

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Previous Safety Recommendations made by the AAIB

In 2008 a Dyn'Aero MCR-01, 21-YV (call sign F-JQHZ) was involved in an accident which was reported in the June 2009 AAIB Bulletin. On approach to a small private landing field, the aircraft rolled left and crashed in the garden of a private house. The aircraft was fitted with a BPRS, which had not deployed, but was 'live'. It was identified during the investigation that there was a risk to emergency personnel such that any further slight disturbance of the associated aircraft structure, or of the cable itself, by the first responders attending the scene, whilst attempting to gain access to the aircraft's occupants, could have fired the rocket, potentially causing serious injury or even the death to anyone nearby. As a result the AAIB issued the following Safety Recommendations:

Safety Recommendation 2009-007

It is recommended that the International Civil Aviation Organisation publish a Standard which defines internationally agreed warning placards for application to all aircraft fitted with ballistic parachute recovery systems that give as clear an indication as possible at the greatest distance reasonable of the dangers posed to first responders to an accident aircraft fitted with a ballistic parachute recovery system.

Response from International Civil Aviation Organisation (ICAO):

'The safety recommendation states that ICAO publish a Standard which defines internationally agreed warning placards for application to all aircraft fitted with ballistic parachute recovery systems (BPRS), that give as clear an indication as possible at the greatest distance reasonable of the dangers posed to first responders to an accident aircraft fitted with a ballistic parachute recovery system.

ICAO received a similar safety recommendation in 2005 and tasked its Airworthiness Panel (AIRP) to consider the matter. During its deliberations, the Panel concluded, among others, that requiring warning placards in aircraft fitted with BPRS would not increase the safety of response personnel at accident sites, and therefore did not support the recommendation.

Safety Recommendation 2009-007, however, took into account the fact that a member of the public may be a first responder to an accident involving an aircraft fitted with BPRS, and thus merits a further consideration.

Notwithstanding, ICAO believes it would be inappropriate to develop a specific Standard in Annex 8, Airworthiness of Aircraft, before the Federal Aviation Administration, the Civil Aviation Authority and the European Aviation Safety Agency take action with respect to Safety Recommendation 2009-008. After which, ICAO would request the AIRP to reconsider the issue and in developing Standards and Recommended Practices (SARPs) for warning placards, if and where necessary, to indicate the dangers posed to first responders

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by an aircraft system. Such SARPs may be associated with Notes included in the text, where appropriate, that would give references to harmonized requirements developed by other authorities, particularly in response to Safety Recommendation 2009-008.'

Safety Recommendation 2009-008

It is recommended that the Federal Aviation Administration, the Civil Aviation Authority and European Aviation Safety Agency, cooperate to require the application of warning placards of a common agreed standard, to be applied to all aircraft fitted with ballistic parachute recovery systems for which they have airworthiness responsibility, to maximise the possibility of first responders being made aware of the danger posed by a live system following an accident. These placards should be applied in such a manner that at least one such placard should remain visible regardless of the stationary attitude of the aircraft.

Response from Civil Aviation Authority:

'The CAA accepts this recommendation. BCAR Section S, the CAA's design requirements for Small Light Aeroplanes, already contains a requirement for an easily distinguishable external warning placard to be fitted to aircraft where the ballistic recovery system is installed, in order to minimise the potential hazard to personnel on the ground. The CAA is currently working with UK General Aviation representative bodies to extend this requirement, for the aircraft for which it has airworthiness responsibility, to require warning placards which would maximise the possibility of first responders being made aware of the danger posed by a live system following an accident such that at least one should remain visible regardless of the stationary attitude of the aircraft. In parallel, the CAA will co-operate with the Federal Aviation Administration and the European Aviation Safety Agency in order to achieve a common standard for the design of these placards.'

Response from the European Aviation Safety Agency (EASA):

'The recommendation has been addressed by ICAO. ICAO published the State Letter AN 6/26-05/46 dated 12 August 2005, warning states of the danger of rocket-assisted parachute systems and amendments to the Manual of Aircraft Accident and Incident Investigation (Doc 9756 part III - Advance edition). The ICAO Airworthiness Panel concluded that requiring a warning placard would increase safety, however in some conditions associated with aircraft accidents such a warning placard would not be visible until personnel are within the danger zone, hence the mandatory carriage of such a placard would be of limited benefit.

As a result of the above ICAO State Letter and Airworthiness Panel review, the Agency considers that no further action is warranted.'

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Regulations concerning the use of a ballistic parachute recovery system

ICAO

ICAO has identified the danger from a BPRS and has included the following advice in the ICAO manual of aircraft accident and incident investigation[5]:

> *'An armed and undeployed rocket-deployed emergency parachute system presents a potentially serious safety risk to personnel attending the site of an accident. There is also inconsistent identification and marking of the hazards posed by the rocket and the associated equipment on the external surfaces of the aircraft. Any failure to correctly identify the hazard posed by the rocket at an accident site could result in serious injury or death.'*

EASA

The standard specification for a Light Sport Aircraft is specified in ASTM F2245-11, which refers to ASTM F2316-12 for the airframe emergency parachutes.

ASTM F2316-12 provides information on the design of the system and the labels and warning placards to be affixed to the components and aircraft. G-EWZZ appeared to comply with these requirements. The specification also makes the following statement about fire hazards:

> *'The installation design and location of the extraction device must consider fire hazards associated with the activation of the parachute system and reduce this fire hazard potential as much as possible without compromising function of the evacuation device.'*

With regard to the safety of rescue workers the specification states:

> *'All producers of ballistically deployed rescue systems shall provide on their website or by printed goods made available as requested, explanations or instructions about safetying their systems or disabling their systems as required for the safety of rescue personnel arriving at the scene of an incident or accident.'*

The information on the BRS web site for the equipment fitted to G-EWZZ was restricted to the components that constitute the BPRS and did not provide any information as to where the components were fitted in the SportCruiser, or the routing of the activation cable.

Footnote

5 ICAO Manual of aircraft accident and incident investigation, Part III, paragraph 13.16.4.

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British Civil Airworthiness requirements (BCAR)

BCAR Section S is the basis for the issue of Permits to Fly for small light aeroplanes referred to in Regulation (EC) 216/2008 Annex II. Section K refers to microlight parachute recovery systems and states:

> *'S 2003 General*
>
> *It must be shown by analysis or test that:*
>
> *a) the airworthiness of the aeroplane, the safety of its occupant(s) and personnel on the ground will not be degraded by the installed parachute recovery system;'*
>
> *S 2041 Markings and placards.*
>
> *d) A warning placard must be placed on the exterior of the aeroplane close to the stored energy device, which is easily distinguishable by ground personnel, warning of the potential hazard.'*

Light Aircraft Association

With regard to the BPRS fitted to the SportCruiser, the LAA Airworthiness Approval Notice[6] states:

> *'For the BRS system, it (Approval notice) only addresses the impact of the installation on the airworthiness of the aircraft and the safety of the system in respect of third parties: it does not address the effectiveness or otherwise of the recovery system itself.'*

Analysis - Ballistic recovery system

General

The emergency response personnel and accident investigators were initially unaware that G-EWZZ was fitted with a BPRS and the initial medical treatment of the occupants was carried out next to the burning wreckage. The possibility that such a system was fitted to the aircraft was only confirmed when the accident investigator, during the initial examination of the wreckage, identified what he believed was a burnt out rocket motor. It was very difficult to identify any of the other components of the BPRS in the aircraft wreckage.

It is normal practice for accident investigators in the UK to review the information in the CAA's civil aircraft registration database, commonly referred to as 'G-INFO', prior to attending the accident site. The installation of a BPRS is not recorded on this database.

Footnote

6 Reference LAA 338-738, Supplement 5.

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Condition of the BPRS on G-EWZZ

As the actuating cable was not connected to the rocket launcher, it was initially assumed that the BPRS had been manually activated and may have started the fire. However, the firing pin actuator was subsequently found to be fitted in the rocket launcher indicating that the rocket motor and igniter had 'cooked off' in the post-crash fire; this means that the BPRS had not been activated during the flight. There was no evidence of the rocket motor having exploded, which would have produced shrapnel. Instead it would appear that the forward bulkhead in the rocket had been blown-off and the rocket had been propelled towards the centre of the cockpit area. The parachute remained in its pack, the steel components survived, but the composite fibre harnesses were destroyed.

Warning placards

The risks to first responders and accident investigators is well documented. For the warning placards fitted to aircraft equipped with a ballistic recovery system, EASA and the CAA have adopted the standards in ASTM F2316-12. While the SportsCruiser is fitted with the required warning placards, they were not considered adequate to alert individuals to the presence of the hazard from the BPRS for a number of reasons.

- The advice to first responders and investigators is that, due to the potential risk from a rocket motor 'cooking off', they should stay clear of an aircraft that has been on fire until the rocket motor has cooled down. However, the aircraft warning placards are relatively small and difficult to read from a safe distance. The ATSM states that the warning placard should be triangular of a minimum size of 1 inch.

- The placards are only fitted around the cockpit area, which on G-EWZZ were destroyed by fire; the wings and the tail section were relatively undamaged.

- There are no warning placards on the lower surfaces of the aircraft and wings, and the existing placards are difficult to see once the aircraft has inverted, particularly if the accident occurs in a crop or thick vegetation. Light aircraft commonly end up inverted during an emergency landing in a field.

- The accident to G-EWZZ occurred at the weekend, when there is no readily available support for sports aircraft in the UK. It was not known what system had been fitted to the aircraft. The SportCruiser website stated that the aircraft could be fitted with an optional ballistic recovery system, but provided no information as to where the components were located on the aircraft. A photograph on this website showed a BPRS warning label affixed to the fuselage just aft of the canopy. From this photograph it was incorrectly assumed that the BPRS would be fitted, as in other aircraft, aft of the pilot's seats. It was only after speaking to another owner and contacting the manufacturer in the USA that it was realised the system was fitted between the engine firewall and the instrument panel.

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- The warning label indicating where the rocket and parachute will leave the aircraft was only required to be fitted on the right side of the aircraft. A low resolution photograph of G-EWZZ on the CAA's G-INFO database only showed the left side of the aircraft and therefore the investigators were initially unaware of the location where the rocket would exit the airframe.

- During rescue operations, it is normal practice for the emergency service to remove the top of the cockpit and any other parts of the structure necessary to free the occupants. However, there are no markings on the aircraft as to the routing of the BPRS actuating cable and it is possible, particularly when it is routed through the cockpit roof, that the emergency services could inadvertently disturb the cable and launch the rocket.

Location of BPRS components

In the SportsCruiser some BPRS components are located in positions that present potential risks:

- The rocket motor and rocket launcher is fitted close to the fuel selector and fuel pipes. It is considered that in this location there is a higher risk of a post-crash fire should the BPRS be inadvertently operated during the rescue operation.

- The BPRS firing unit on the SportsCruiser is fitted between the instrument panel and firewall, and above the rudder pedals. The BPRS manufacturers advise first responders to make the system safe by cutting the actuator cable close to the firing unit. With this design it would be challenging to make the BPRS safe with occupants on board, or when the aircraft has been damaged.

Ballistic Parachute Recovery System – Safety Recommendations

It is widely recognised that following an aircraft accident, a BPRS presents a hazard to first responders, casualties and investigators. These systems are becoming more prevalent and are continuing to be developed and fitted to much larger aircraft.

In order for the emergency services to manage the risk from a BPRS, it is considered that:

- Aircraft should be fitted with warning placards that can be identified and read from a safe distance even with the aircraft is in an inverted attitude.

- The placard should provide information on the location of the rocket launcher and the routing of the actuator cable.

- The rocket launcher should be fitted on the aircraft such that following an accident it can be easily disarmed before the casualties are removed from the aircraft.

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- There should be a centralised information system that is easily accessible by the emergency services and investigators that contains the following essential information:
  - o The registration of aircraft equipped with a BPRS.
  - o The type of system fitted.
  - o The location of the major components and routing of the actuator cable.
  - o The actions required to make the system safe.

The existing placarding and installation of BPRS appears to focus on the airworthiness of the aircraft and the safety of individuals during normal operation, handling and maintenance of the aircraft. However, these measures do not fully address the risk posed to the aircraft occupants and third parties following an accident. The AAIB previously made Safety Recommendation 2009-007 to ICAO to publish an international standard on warning placards. ICAO responded that it would be inappropriate to develop such a standard until the FAA, CAA and EASA had addressed Safety Recommendation 2009-008. While the CAA acted on Safety Recommendation 2009-008, the EASA felt that the publication of an ICAO State Letter[7] on the risks to third parties from BPRS was sufficient and, therefore, no further action was taken.

As a result of the identified safety issues, and taking into consideration the responses to the previous AAIB Safety Recommendations, the following Safety Recommendations are made for aircraft operating under European Aviation Safety Agency regulations:

Safety Recommendation 2015-006

It is recommended that the European Aviation Safety Agency review the requirement for the placarding of aircraft fitted with a Ballistic Parachute Recovery System so that the warning placards contain information on the location of the rocket launcher and the actuating device, and can be read from a safe distance regardless of the stationary attitude of the aircraft.

Safety Recommendation 2015-007

It is recommended that the European Aviation Safety Agency introduce the requirement that the rocket-launcher in an aircraft Ballistic Parachute Recovery System is fitted in a position where it can be readily disarmed following an accident.

Safety Recommendation 2015-008

It is recommended that the European Aviation Safety Agency disseminate information for first responders and accident investigators to allow them to identify if an aircraft is equipped with a Ballistic Parachute Recovery System. This information system should include details on the actions required to make the system safe.

Footnote

[7] Hazards associated with rocket-deployed emergency parachute systems. Ref AN 6/26-05/46 dated 12 August 2005.

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Safety Recommendations 2015-006 and 2015-007 relate to aircraft that are regulated by EASA. Safety Recommendation 2015-008 relates to information dissemination for aircraft that operate in Europe. However, the BPRS is also fitted to aircraft that are not regulated by EASA and are referred to in Regulation (EC) 216/2008 Annex II[8]; these aircraft are regulated by the appropriate National Aviation Authority. Therefore, for the identified safety issues also to be addressed for aircraft referred to in Regulation (EC) 216/2008 Annex II and in addition to address the dissemination of information for BPRS fitted to aircraft operating in the UK, the following Safety Recommendations are made to the Civil Aviation Authority:

Safety Recommendation 2015-009

It is recommended that the Civil Aviation Authority review the requirement for the placarding of aircraft referred to in Regulation (EC) 216/2008 Annex II, fitted with a Ballistic Parachute Recovery System, so that the warning placards contain information on the location of the rocket launcher and the actuating device, and can be read from a safe distance regardless of the stationary attitude of the aircraft.

Safety Recommendation 2015-010

It is recommended that the Civil Aviation Authority introduce the requirement that, for aircraft referred to in Regulation (EC) 216/2008 Annex II, the rocket-launcher in an aircraft Ballistic Parachute Recovery System is fitted in a position where it can be readily disarmed following an accident.

Safety Recommendation 2015-011

It is recommended that the Civil Aviation Authority introduce an information system, for aircraft operating in the UK that allows first responders and accident investigators to identify if an aircraft is equipped with a Ballistic Parachute Recovery System. This information system should include details of the type of system fitted, the location of the major components, routing of the actuator cable and the actions required to make the system safe.

Safety Recommendation 2015-012

It is recommended that the Civil Aviation Authority takes action to ensure that information on the risks from Ballistic Parachute Recovery Systems is disseminated to the emergency services operating in the United Kingdom.

BULLETIN CORRECTION

The date of the accident was incorrectly stated as 9 September 2014; the accident occurred on **9 August 2014**. The online version of the Bulletin was corrected prior to publication.

Footnote

[8] Annex II of Regulation (EC) no 216/2008 of the European Parliament and of the Council of 20 February 2008 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency, and repealing Council Directive 91/670/EEC, Regulation (EC) No 1592/2002 and Directive 2004/36/EC

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