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AAIB
Air Accidents Investigation Branch

# AAIB Bulletin S3/2017 *SPECIAL*

**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | HPH Glasflugel 304 eS, G-GSGS |
| **No & Type of Engines:** | 1 LZ Design D.O.O FES-HPH-M100 brushless electric motor |
| **Year of Manufacture:** | 2016 (Serial no: 059-MS) |
| **Location:** | Parham Airfield, West Sussex |
| **Date & Time (UTC):** | 10 August 2017 at 1121 hrs |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - None |
| **Injuries:** | Crew - None Passengers - N/A |
| **Nature of Damage:** | Fire damage to FES batteries and FES battery compartment |
| **Commander's Licence:** | British Gliding Association Gliding Certificate |
| **Commander's Age:** | 55 years |
| **Commander's Flying Experience:** | 314 hours (of which 25 were on type)<br>Last 90 days - 9 hours<br>Last 28 days - 7 hours |
| **Information Source:** | AAIB Field Investigation |

## Notification

At 1530 hrs on 10 August 2017, the Air Accidents Investigation Branch (AAIB) was notified of a battery fire occurrence involving an HPH Glasflugel 304 eS electric self-sustainer sailplane during landing at Parham Airfield, West Sussex. The occurrence was initially referred to the British Gliding Association (BGA) for investigation in accordance with an existing Memorandum of Understanding between the AAIB and the BGA for non-fatal gliding accidents. Having conducted an initial investigation, the BGA requested further assistance from the AAIB, resulting in the AAIB launching a Field Investigation on 21 August 2017.

**History of the flight**

The pilot had fully charged both Front Electric Sustainer (FES) batteries on 4 August 2017, after which they were disconnected from the chargers for storage. He installed them in the glider on the morning of 10 August, with the intention of flying the glider that afternoon. He initiated the FES battery self-checking procedure before conducting a daily inspection of the glider, after which the self-checking procedure had completed with no faults indicated on the FES Control Unit (FCU). He then fitted the FES battery compartment cover and applied tape around the edges of the cover.

The pilot conducted a ground run of the FES propeller, which operated normally. He then switched the Power Switch OFF, and also turned the FCU OFF, which was contrary to his normal practice of leaving the FCU switched ON.

The pilot launched from Parham Airfield by aerotow at 1021 hrs and flew in ridge lift for a period of 38 minutes before encountering a rain shower. He decided to use the FES propulsion system and turned the Power Switch ON. He then noticed that the FCU was switched OFF, so he switched the FCU ON without moving the Power Switch position[1].

After waiting a few seconds for the FCU green LEDs to show that the FES propulsion system was available, he operated the FES motor which responded normally and operated for 4 minutes. The pilot did not recall observing any fault messages on the FCU during the motor operation.

After stopping the FES motor the pilot noticed that the propeller did not realign itself correctly against the nose of the glider. The pilot had experienced this problem previously and did not consider it to be a significant issue, so he did not attempt to realign the propeller. He switched the Power Switch OFF, leaving the FCU switched ON and continued in soaring flight for a further 1 hour 15 minutes before positioning the glider to land on grass Runway 04 at Parham Airfield. The circuit was flown normally to a smooth touchdown, however at the moment of touchdown the pilot heard an unexpected noise.

As the glider slowed during the ground run, the pilot smelled burning and the cockpit filled with smoke that was moving forwards from behind the pilot's head. The pilot did not report observing any warning messages or illuminated LEDs on the FCU, although his attention was drawn outside the cockpit during landing. He vacated the cockpit normally, without injury, and observed that the FES battery compartment cover was missing and that smoke, followed shortly by flames, was coming from the battery compartment. The airfield fire truck arrived promptly and an initial attempt was made to extinguish the fire using a $CO_2$ gaseous extinguisher, but this proved unsuccessful. Aqueous film-forming foam (AFFF) was then sprayed into the FES battery compartment and the fire was extinguished.

**Footnote**

[1] The FCU User Manual and HPH304 eS Flight Manual both state that the FCU should be switched to ON at all times that the sailplane is in flight, with the Power Switch only switched ON when the pilot wishes to operate the FES propulsion system. The FES system manufacturer stated that despite this departure from approved procedures, the sequence that the FCU and Power Switch were turned ON in this event would not affect the operation of the FES propulsion system.


**Figure 1**

Fire in the FES battery compartment following the landing roll

The FES battery compartment cover was found close to the glider's touchdown point. The cover's rear carbon fibre catch was fractured, consistent with a vertical load acting on the inside of the cover. The cover did not exhibit any overheating damage.

**Aircraft description**

The HPH Glasflugel 304 S is a single-seat flapped sailplane of 18 m wingspan, constructed from composite materials with a retractable mainwheel. The 304 eS variant of the type is a powered variant, capable of self-sustaining flight using a Front Electric Sustainer (FES) propulsion system. The FES system, Figure 2, consists of the following components:

- One 23kW brushless electric motor installed in the nose of the sailplane, with a foldable two-bladed propeller
- One motor controller
- Two 'GEN2' 58V battery packs, connected in series, each with an internal Battery Management System (BMS)
- One FES control unit (FCU) instrument, mounted in the instrument panel, displaying FES system monitoring information and a motor throttle knob
- One LXUI box with a shunt, for current and voltage measurements

- One FES connecting circuit (FCC) box
- One Power Switch, to provide a 12V power supply to the battery contactor, which connects the FES battery packs to the motor controller. It also provides a 12V power supply to the motor controller
- One DC-DC converter to convert FES battery pack voltage to 12V, to power the avionics and components of the FES system requiring a 12V supply (battery contactor, cooling fans, LXUI box and FCC box)

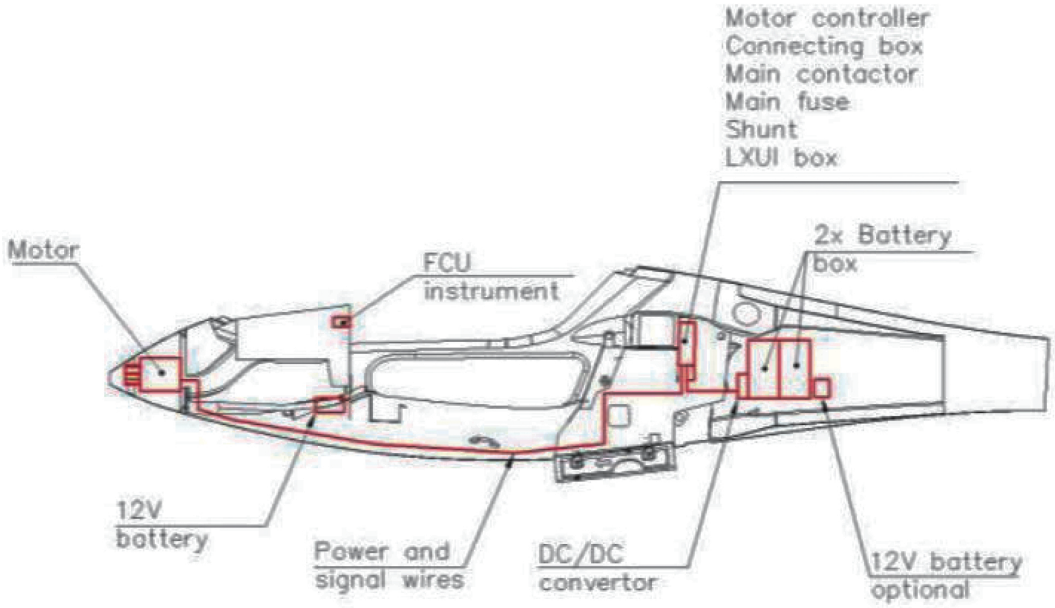


**Figure 2**

FES system installation in the HPH Glasflugel 304 eS powered sailplane (courtesy HPH Spol. S.r.o.)

The FES battery packs are removable for charging remotely from the sailplane. Each FES battery pack is built up from 14 Superior Lithium Polymer Battery (SLPB) cells, connected in series and contained within a carbon fibre battery box with a machined aluminium alloy cover plate/heatsink. The maximum total voltage for each battery pack is 58.3V, giving a maximum voltage of 116.6V for the assembly of both battery packs connected in series. The capacity of each SLPB cell is 41 Ampere-hours (Ah), providing a total capacity for each FES battery pack of 2.1 kWh, or 4.2 kWh for both battery packs connected together. Each FES battery pack has a mass of 15.7 kg.

The HPH Glasflugel 304 eS powered sailplane has a European Aviation Safety Agency (EASA) Restricted Type Certificate (RTC), number EASA.A.030. The sailplane does not have an unrestricted Type Certificate as the FES engine and propeller are not EASA Type Certified in their own right, and are therefore considered part of the sailplane for certification[2] purposes. There are no operational restrictions related to the RTC.

**Footnote**

[2] EASA Part 21.A.23 (c)(2).

The FES propulsion system is also installed in two other powered sailplanes that hold EASA RTCs – the Schempp-Hirth Flugzeugbau Discus-2c FES (EASA.A.050) and the Sportline Aviacija LAK-17B FES (EASA.A.083). In addition, there are a number of other powered sailplanes equipped with the FES propulsion system currently operating on EASA Permits to Fly, that are part-way through the EASA Type Certification process.

The FES propulsion system is also installed in two commercially-available 'EASA Annex II' microlights – the Alisport Silent 2 Electro, and the Albastar AS13.5m FES. These 'EASA Annex II' aircraft are not subject to EASA airworthiness regulations and may operate in the UK under the Single-Seat Deregulation (SSDR) airworthiness exemption from the Air Navigation Order (ANO).

The AAIB is also aware of a number of other FES-equipped EASA Annex II microlights, produced as modifications to existing sailplane designs that are currently in operation. These include two Pipistrel Apis 15M M FES sailplanes operating in the UK under SSDR regulations and one Diana 2 Versvs FES sailplane operating in Italy on an ENAC Permit to Fly. In addition one FES-ASW-27 operates in the USA under FAA Experimental Category regulations.

**FCU description**

The FCU is an instrument installed in the instrument panel that informs the pilot of the status of the FES propulsion system via a display screen, Figure 3. A rotary throttle knob is provided at the bottom of the FCU that controls the power delivered to the propeller during powered flight. The rotary knob may also be pushed to confirm warning messages displayed on the FCU screen.

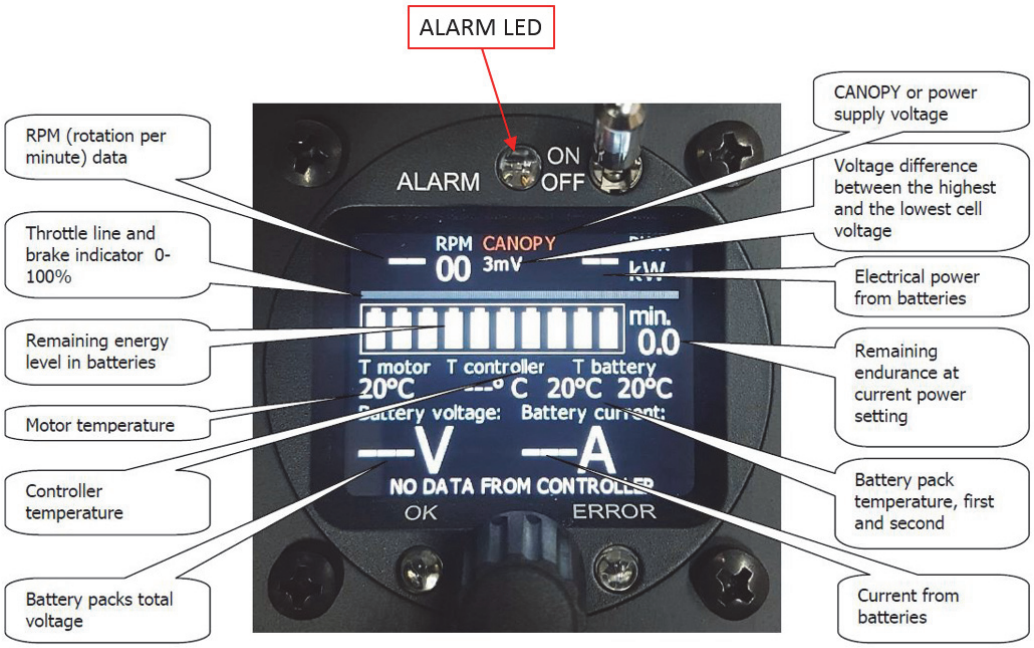


**Figure 3**

FCU main screen (courtesy LZ design d.o.o.)

Coloured LEDs on the FCU instrument bezel are used to confirm the FES system status and alert the pilot of system warning messages. Two levels of warnings are provided:

- YELLOW warning: This is first level of warning, which means that the pilot needs to be aware of the parameter indicated in the warning message and to manage the suggested solution to solve the problem. YELLOW warnings indicate that there is no immediate danger. The top 'ALARM' LED appears as continuous red light. The LED and warning message on screen are confirmed by pressing the throttle knob.
- RED warning: This is second level of alarm which means that the pilot has to manage the solution of the indicated problem immediately. The top 'ALARM' LED appears as a flashing red light. The warning message on the screen is confirmed by pressing the throttle knob, but the flashing top LED persists whilst the fault condition is present. Red warning messages may be recalled by pressing the throttle knob.

In a fault scenario where multiple warning messages are generated, the pilot is not aware of how many messages are present until all have been confirmed by pressing the throttle knob. Warning messages are displayed in the order they were generated and red messages, including the change in the ALARM LED indication from a steady red to a flashing red illumination, are not prioritised over yellow warning messages.

The FCU does not currently record any data or fault messages and therefore it is not known which messages were displayed to the pilot of G-GSGS during the battery fire event. The FES system designer confirmed however that, for the configuration G-GSGS was in when the event occurred (Power Switch OFF, propeller not rotating), the following warning messages may have been generated (Table 1).

| Warning level | FCU screen warning message | ALARM LED | Required pilot action |
|---|---|---|---|
| YELLOW | Battery diff. >3°C, Reduce power! | Steady red, cancellable | Reduce power |
| RED | Battery diff. >6°C, Stop FES motor! | Flashes red, persistent | Stop FES motor |
| RED | Batt. Critical >75°C, Land immediately! | Flashes red, persistent | Stop FES motor and land ASAP |

**Table 1**

Possible FCU warning messages during the G-GSGS FES battery fire event

The first two warnings are generated when the FCU senses a temperature difference between the two FES battery packs. The third warning occurs when the temperature of either FES battery pack exceeds 75°C. Each message is reliant on data sent from a functioning BMS of a FES battery pack. Apart from alerting the pilot to a battery pack temperature exceeding 75°C, the FCU does not provide any indication of a fire occurring in the FES battery compartment. As the FES battery compartment is behind the pilot within the fuselage, a pilot cannot see such a fire if it occurs. The warning messages may also be confusing to the pilot as the required pilot action refers to reducing or stopping the FES motor, when the motor is not in operation.

**Aircraft damage**

The origin of the fire was the forward FES battery; its battery box was ruptured along the rear left corner and the battery assembly was heavily fire damaged, Figure 4. The rear FES battery box suffered from external fire damage although the internal components were only slightly damaged and the cells remained charged.


**Figure 4**

Fire damage to the forward FES battery

The FES battery compartment was heavily fire damaged with burning of the composite material's resin on the internal faces of the battery compartment and around the external cut-out in the upper fuselage skin. The top edge of the removable access panel that forms the front panel of the battery compartment (Figure 5) was also burned on its forward face and the FES electrical components in the equipment bay between the cockpit and the FES battery compartment were covered in soot deposits, demonstrating that the battery compartment had not contained all of the smoke and fumes released by the FES battery fire.


**Figure 5**

Fire damage to the FES battery compartment
front access panel (left image, looking forwards),
and to the forward face of the front access panel (right image, looking aft)

The electrical cable glands in the left side of the front bulkhead of the battery compartment remained intact. The main 325A power fuse was intact, as were fuses on the instrument panel. The DC-DC converter, installed in the battery compartment forward of the FES batteries, was externally fire damaged but when inspected it was apparent that the damage had been caused by external heating of the DC-DC converter during the fire. No evidence of overheating or fire damage internally within the DC-DC converter case was observed.

**Other information**

The pilot reported that in January 2017 one of the FES battery packs from G-GSGS fell from his car onto a paved surface through a vertical distance of around 0.2 m. There was no sign of damage to the battery pack following this event. The pilot did not record the serial number of this battery pack and therefore it is not possible to determine whether this pack was the battery that caught fire during the landing at Parham Airfield.

*Second FES battery fire event*

The AAIB is aware of a second FES battery fire event that occurred at Benesov Airport in the Czech Republic on 27 May 2017. The FES-equipped powered sailplane was de-rigged for storage in its trailer, with both FES battery packs installed and connected together in the sailplane. This was contrary to an instruction in the sailplane's Flight Manual,

which required the connecting cables between the FES battery packs to be removed after landing. The FES battery packs remained charged to approximately 80% capacity after the flight that day. The FES Power Switch was OFF, as were the avionics master switch and FCU switch. The fire occurred in the forward FES battery pack, causing significant damage to the battery compartment. The pilot of this sailplane had reported running over a "hard bump" during the latter stages of the landing roll, but apart from this the flight was unremarkable and no signs of heat emission were present when the sailplane was de-rigged and placed in the trailer after the flight.

*EASA Emergency Airworthiness Directive EAD 2017-0167-E*

As a result of the two FES battery pack fire events, on 6 September 2017 EASA issued Emergency Airworthiness Directive (EAD) 2017-0167-E, applicable to three powered sailplanes types holding EASA RTCs (HPH 304 eS, Discus-2c FES and LAK-17B FES). The EAD requires that:

> *'Modification:*
>
> *(1) Before next flight after the effective date of this AD, modify the FES battery pack or its installation, as applicable, in accordance with instructions approved by EASA, or by the applicable design approval holder.*
>
> *(2) Removal of the FES battery pack from a powered sailplane is an acceptable alternative method to comply with the requirements of paragraph (1) of this AD, provided flights without an installed FES battery pack are allowed for that powered sailplane.'*

At the publication date of this AAIB Special Bulletin, no modification as mentioned in part (1) of EAD 2017-0167-E is currently available.

*FES battery compartment warning systems*

As a result of the AAIB investigation to date, the AAIB remains concerned that existing FES battery installations do not provide sufficient warning to a pilot of a fire or other hazardous condition (such as high pressure) occurring within the FES battery compartment. As the G-GSGS fire event has demonstrated, a severe battery fire may occur rapidly and as the FES battery compartment is behind the pilot, within the fuselage, such a fire may not be seen by the pilot. The FES batteries provide an energetic fuel source for a fire and once started, the pilot has no means by which to suppress or remove the fuel source from the fire. The timely and unequivocal warning of a FES battery fire or other hazardous condition is required, to allow the pilot to decide which mitigating actions to take, such as landing the aircraft immediately or abandoning the aircraft by parachute.

The following Safety Recommendation is therefore made:

**Safety Recommendation 2017-018**

It is recommended that the European Aviation Safety Agency (EASA) requires that all powered sailplanes, operating under either an EASA Restricted Type Certificate, or an EASA Permit to Fly, and fitted with a Front Electric Sustainer (FES) system, are equipped with a warning system to alert the pilot to the presence of a fire or other hazardous condition in the FES battery compartment.

Further, to cover the two commercially-available FES-equipped aircraft types outside EASA airworthiness regulation, the following Safety Recommendations are made:

**Safety Recommendation 2017-019**

It is recommended that Alisport Srl modifies the Silent 2 Electro microlight to incorporate a warning system to alert the pilot to the presence of a fire or other hazardous condition in the Front Electric Sustainer (FES) battery compartment.

**Safety Recommendation 2017-020**

It is recommended that Albastar d.o.o. modifies the AS13.5m Front Electric Sustainer (FES) microlight to incorporate a warning system to alert the pilot to the presence of a fire or other hazardous condition in the FES battery compartment.

**Investigation plan**

The AAIB investigation continues, including detailed examination of the fire-damaged forward FES battery pack from G-GSGS intended to identify, if possible, the origin of the failure within the battery pack. It is also planned to examine additional FES battery packs using CT X-ray inspection techniques to determine whether any internal anomalies are present in those battery packs. The scope of the AAIB investigation also includes a review of the certification processes followed by EASA in the approval of those powered sailplanes in receipt of EASA RTCs.

*Published 25 September 2017*