AAIB
Air Accidents Investigation Branch

# AAIB Bulletin 5/2022

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**(ALL TIMES IN THIS BULLETIN ARE UTC)**

# AAIB Field Investigation Reports

A Field Investigation is an independent investigation in which AAIB investigators collect, record and analyse evidence.

The process may include, attending the scene of the accident or serious incident; interviewing witnesses; reviewing documents, procedures and practices; examining aircraft wreckage or components; and analysing recorded data.

The investigation, which can take a number of months to complete, will conclude with a published report.

## ACCIDENT

| | |
|---|---|
| **Aircraft Type and Registration:** | Silent 2 Electro, G-CIRK |
| **No & Type of Engines:** | 1 FES electric motor |
| **Year of Manufacture:** | 2013 (Serial no: 2054) |
| **Date & Time (UTC):** | 23 April 2021 at 1305 hrs |
| **Location:** | Wormingford Airfield, Colchester, Essex |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - None |
| **Injuries:** | Crew - 1 (Serious) Passengers - N/A |
| **Nature of Damage:** | Aircraft destroyed |
| **Commander's Licence:** | Light Aircraft Pilot's Licence (Sailplanes) |
| **Commander's Age:** | 71 years |
| **Commander's Flying Experience:** | 295 hours (of which 55 were on type)<br>Last 90 days - 13 hours<br>Last 28 days - 13 hours |
| **Information Source:** | AAIB Field Investigation |

### Synopsis

During the ground roll for a self-launched takeoff, the motor glider suffered a propeller strike shortly before it got airborne. The eyewitness evidence and recorded data showed that the glider climbed steeply to about 100 ft before stalling and entering an incipient spin to the left. The glider struck the ground nose-first and the pilot suffered serious injuries, in part due to the lack of energy absorbing structure ahead of the pilot's seat. The pilot had no recollection of the accident flight. No mechanical fault or defect was found that would explain the aircraft pitching up excessively after takeoff. The steep climb was most likely the result of an excessive aft stick input that was not corrected.

While the investigation could not positively identify the cause of the aft stick input, it is likely that distraction, pilot workload or stress were factors in the accident. Additional contributory factors were the aircraft's characteristics of low stick forces with low sensory feedback, and poor stall warning indications.

As a result of the investigation findings the BGA has published and sent a *'Safety Briefing'* to Silent 2 Electro owners in the UK which provides guidance on operating the motor gilder. This has also been provided to the European Gliding Union for onward dissemination to other European gliding associations.

## History of the flight

G-CIRK was a self-launching motor glider[1] (SLMG[2]) equipped with a nose-mounted Front Electric Self-launch motor (FES[3]). The accident flight was the pilot's second self-launched flight of the day. Other than experiencing a left wing drop during the ground roll, the pilot's previous launch, two hours earlier, had appeared to go without incident.

On the accident flight, with the assistance of a wing runner, the pilot prepared to take off on Runway 09 (RW09) at Wormingford Airfield (Wormingford). After giving the all-out signal the pilot started G-CIRK's motor and began his takeoff roll. When he could no longer keep up with the aircraft, the wing runner released the right wing, whereupon the glider's left wing dropped to the ground. After the wingtip wheel touched the ground, the aircraft yawed left but the pilot managed to correct this and was then able to level the wings after approximately 10 m of ground contact. Shortly after the glider's wings had been levelled, its tail lifted off the ground and a witness saw a puff of dirt near the nose of the glider, which they assumed had resulted from a propeller strike. Witnesses reported that, after liftoff, G-CIRK initially began a shallow climb before its nose pitched up and it climbed more steeply than during its previous launch.

At a witness-estimated height of between 50 ft and 200 ft agl, the glider rapidly rolled left and appeared to enter a spin. After rotating between 90° and 180° around the vertical, G-CIRK struck the ground nose first before coming to rest upright, in a field bordering the runway.

Several gliding club members were quickly on scene and administered first aid to the pilot until air ambulance medics arrived, approximately 10 to 15 minutes after the accident. Once medically stabilised, the pilot was evacuated by air to hospital with injuries reported to be life-threatening.

## Accident site

The accident site revealed that the aircraft had struck the ground in a steep nose-down attitude, after which the aircraft had yawed to the left and ended up pointing in the opposite direction of its final travel before coming to rest (Figure 1). The aircraft was about 230 m north-east of where it lifted off from the runway. The front of the cockpit was destroyed (Figure 2), the left wing had suffered significant damage and the tail had snapped in half. Both propeller blades had detached at their root and were close to the wreckage.

A series of 11 propeller slash marks were found on the runway surface near the liftoff point (Figure 4) with an initial spacing of about 10 cm.

**Footnote**

1 In this report the terms glider and sailplane are used as interchangeably for the same class of aircraft.
2 An SLMG is an aircraft with the characteristics of a non-power-driven glider, which is fitted with one or more power units and which is designed or intended to take off under its own power.
3 FES stands for Front Electric Self-launch / Self-sustainer. FES motors are used as both self-sustainer propulsion systems on gliders and also for self-launch on some light gliders.

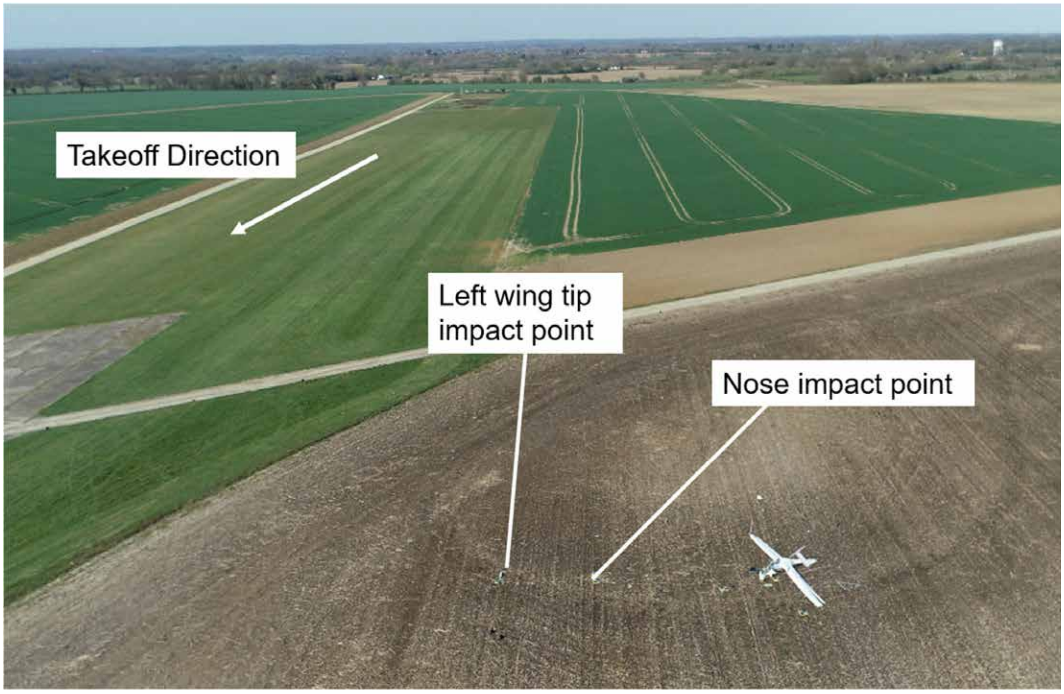


**Figure 1**
Accident site

**Figure 2**
Damage to the aircraft

## Recorded information

*Sources of recorded information*

Recorded information was recovered from three flight loggers[4] fitted to the glider and a ground recording of its FLARM[5] transmission data[6]. This provided a GPS derived track and altitude of the glider during its takeoff run, climb and subsequent descent, with the data ending shortly before the glider struck the ground.

A GPS derived track and altitude recording was also available for the previous self-launch of G-CIRK, with it taking off at 1129 hrs and landing at 1158 hrs. A video recording of this takeoff was also captured by a witness using a mobile phone.

*Recorded data*

Figure 3 provides the GPS derived data for the accident flight and previous self-launch takeoff, with the recordings aligned when the glider had started to climb. The altitude of both recordings has been adjusted to indicate height agl and the derived KTAS is based on a wind from 130° at 11 kt[7]. Figure 4 provides the GPS data points for the accident flight overlaid on a terrain image. Figure 3 and Figure 4 also provide the relative timing and position on the runway respectively for the propeller strike[8].

The recorded data, in conjunction with witness marks on the runway, showed that approximately 12 seconds after the pilot had started the takeoff run, G-CIRK's propeller struck the surface of the runway (Figure 3 and Figure 4 Point A). However, this did not appear to adversely affect its acceleration and two seconds later, the data indicates that it may have then lifted off but remained close to the runway surface for several seconds whilst it continued to accelerate (Figure 3 and Figure 4 Point B).

About six seconds after the propeller strike, G-CIRK was recorded at a height of about 15 ft agl and its estimated airspeed was 42 KTAS (Figure 3 and Figure 4 Point C). It then climbed for the next six seconds at an average rate of 900 ft/min, while also deviating to the left of runway track by about 12° (Figure 4). As the aircraft climbed, its airspeed also gradually reduced. The trajectory of the aircraft, based on the maximum recorded height of 88 ft agl (Figure 3 and Figure 4 Point D), indicates that it climbed to about 100 ft agl, at which point its airspeed was about 30 KTAS (Figure 3 and Figure 4 Point E). The glider then descended. The last data point was recorded when the glider was at about 40 ft agl and its rate of descent was 500 ft/min (Figure 3 Point F). The glider subsequently struck the ground, 36 m laterally from the last data point.

**Footnote**

4 LX Navigation manufactured Eos 57, Zeus 4.3 and FLARM Red Box.
5 FLARM is a flight alarm system that transmits the position and altitude of an aircraft over a low-powered, short-range radio as part of an electronic conspicuity system that can alert pilots to the proximity to other suitably equipped aircraft.
6 Data recorded by the Open Glider Network (OGN) http://wiki.glidernet.org/ [accessed March 2022].
7 Based on information provided by the Met Office.
8 Analysis of the recorded GPS track during the previous takeoff and the accident flight, in combination with the position where the takeoff runs had commenced and the propeller marks occurred, showed that the horizontal position of the aircraft was accurate to within 4 m.

Comparison of the accident takeoff and the previous self-launch takeoff showed that the aircraft's acceleration during the takeoff roll, and its airspeed during the first few seconds of the climb, were similar. However, the climb profiles then diverged. During the previous takeoff, the initial rate of climb was maintained at about 200 ft/min (Figure 3 Point G) until the glider's airspeed had reached 50 KTAS, after which, the climb rate increased to about 430 ft/min.

During the previous flight, it was estimated[9] that the FES motor had been in operation for a total of about nine minutes.

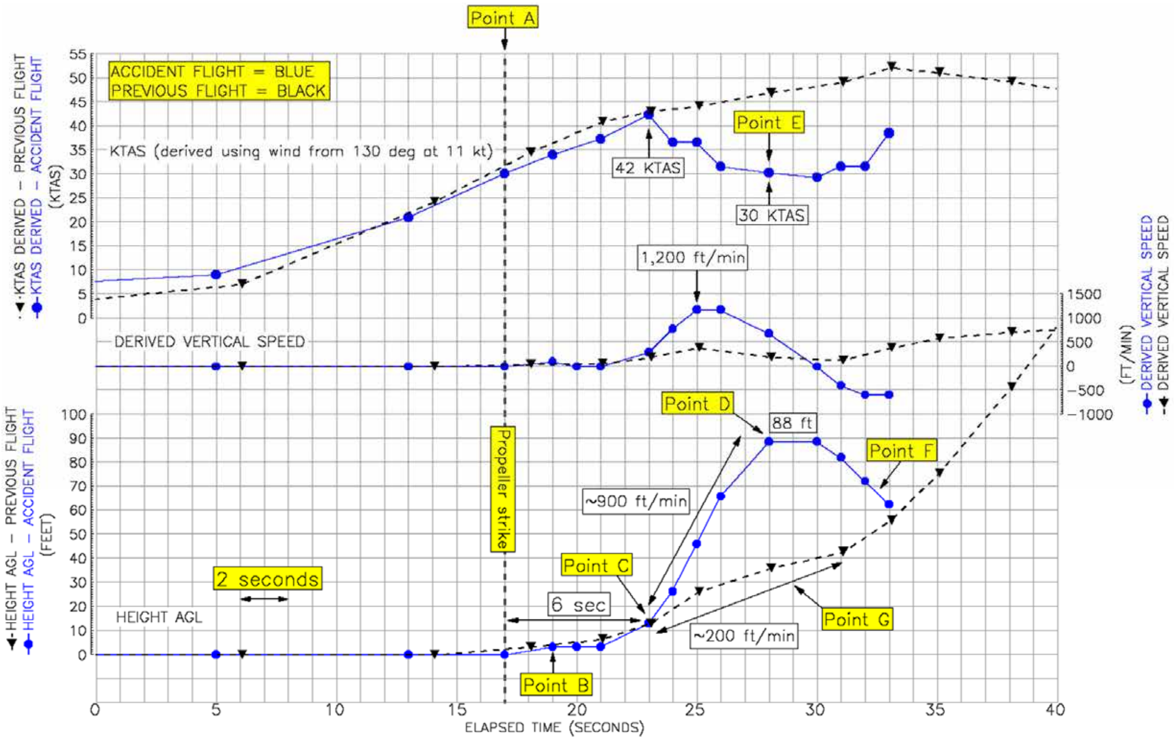


**Figure 3**

GPS derived data for accident and previous self-launch takeoff

**Footnote**

9 Based on the recording from the Eos 57 that included an environmental noise level intended to identify if an engine or FES was in use during flight.

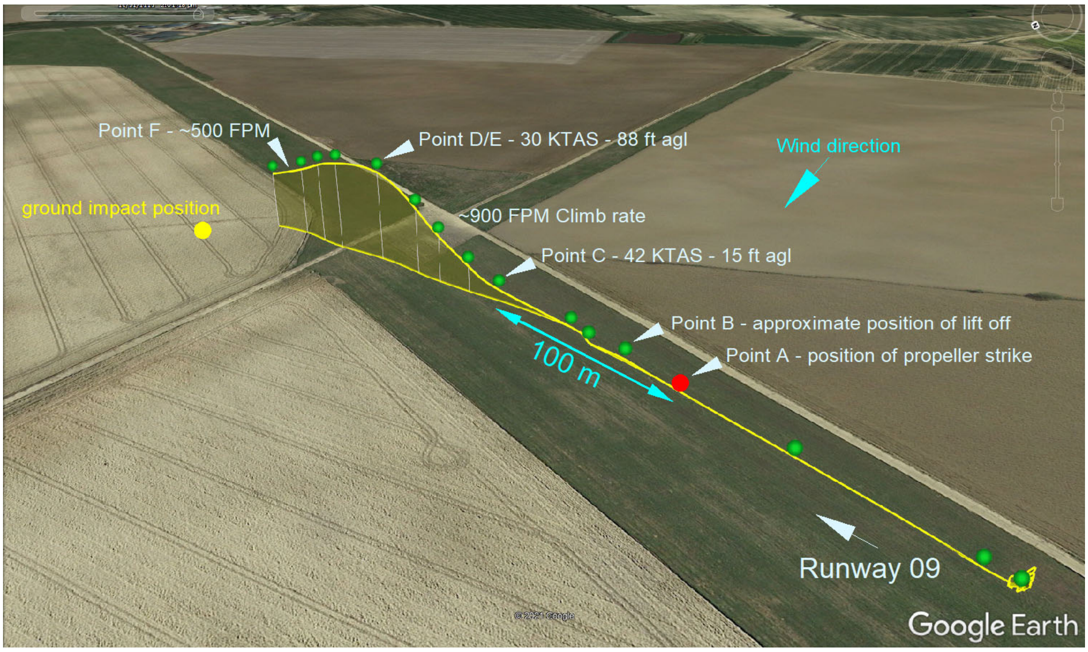


**Figure 4**

GPS derived data for accident takeoff

*Video of the takeoff prior to the accident takeoff*

The video of the pilot's previous takeoff showed that approximately three seconds after the glider started to move, the pilot transferred his left hand from the instrument panel mounted FES control unit onto the flap lever (Figure 5). The flap lever appeared to be in the flap +1 position but the angle from which the footage was taken meant that this could not be positively confirmed. After a further five seconds, the wing tip runner released the right wing and the glider immediately started rolling left over a period of one second, until the left wing touched the ground. G-CIRK's tail wheel lifted off the ground three seconds later, just before the glider rolled right into a wings level attitude. During the following six seconds, some minor oscillations were noted in all axes but the pilot appeared to correct these. The glider then lifted off and climbed in a nose up attitude to a height of about 30 ft agl, before the nose was lowered slightly, to what appeared to be an almost level pitch attitude, and a shallower climb was established. The video ended when the glider was at a height of about 45 ft agl.

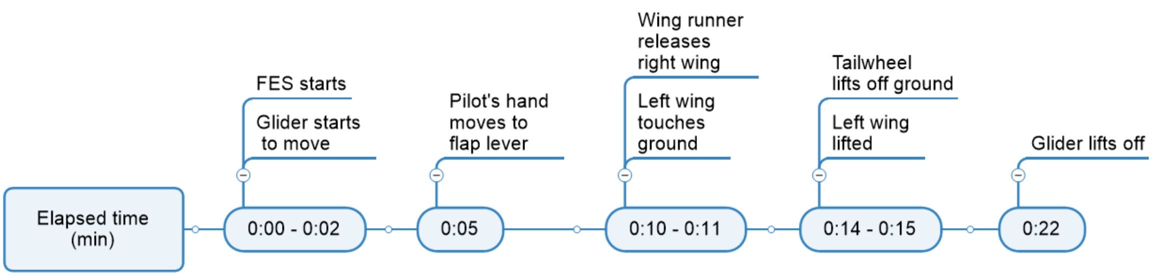


**Figure 5**

Timeline of the pilot's previous self-launch takeoff

**Aircraft information**

*General*

The Silent 2 Electro is a single-seat electric-powered SLMG. It has a maximum takeoff weight of 300 kg, or 315 kg if a Ballistic Parachute Recovery System (BPRS) is fitted, and it can be operated in the UK as a Single-Seat De-regulated Microlight (SSDR). This means that it is not required to have a Certificate of Airworthiness or a Permit to Fly; there is no requirement for its design or construction to be checked and anyone can perform maintenance on it.

The aircraft is factory-built and constructed from carbon and glass fibre re-enforced plastic. It has a 13.5 m wingspan with a small wheel under each wing tip, and a retractable monowheel (Figure 6). The flying controls, which consist of a speed brake, flaperons, rudder, elevator, and a moving tailplane, are operated by a system of pulleys, cables and push rods. The tailplane angle is coupled by a cable to the position of the flap control rod. The flap positions are: S, -1, 0, +1 and L (Land). As the flap is moved down the tailplane moves leading-edge down to compensate for the trim change due to flap deflection. There is no separate pitch trim lever so the pilot cannot trim for a specific speed.


**Figure 6**
Silent 2 Electro (image used with permission)

The accident aircraft, G-CIRK, had a fixed tailwheel and was fitted with the optional Magnum 300 BPRS. The standard aero tow hook had been removed and replaced with a belly hook mounted further aft to assist with winch launches.

Using another Silent 2 Electro aircraft, held in a level attitude with a pilot in the seat, the minimum distance between the propeller tip and the ground was measured to be 13 cm. The propeller tip touched the ground when the aircraft was pitched 5° nose-down.

*Propulsion system*

The aircraft is powered by a nose-mounted FES 22 kw brushless electric motor and a folding propeller with a maximum rpm of 4,500. The motor is powered by two 58 V lithium polymer batteries connected in series, providing a total voltage of 116 V. Power to the motor is controlled by a FES Control Unit (FCU) instrument mounted on the instrument panel (Figure 7). The FCU instrument displays propeller speed and battery charge levels, and it has a rotary throttle knob for controlling the motor speed. The knob does not have any stops and can be rotated continuously in either direction. Clockwise rotation increases rpm and anti-clockwise rotation decreases rpm. The motor is stopped by rotating the knob anti-clockwise with a few twists.

The two batteries are fitted in a compartment behind the cockpit. When fully charged the batteries have a combined capacity of 4.3 kWh and can supply sufficient energy for about 12 minutes at full power or operate at a cruise power setting of 4 KW for about an hour.

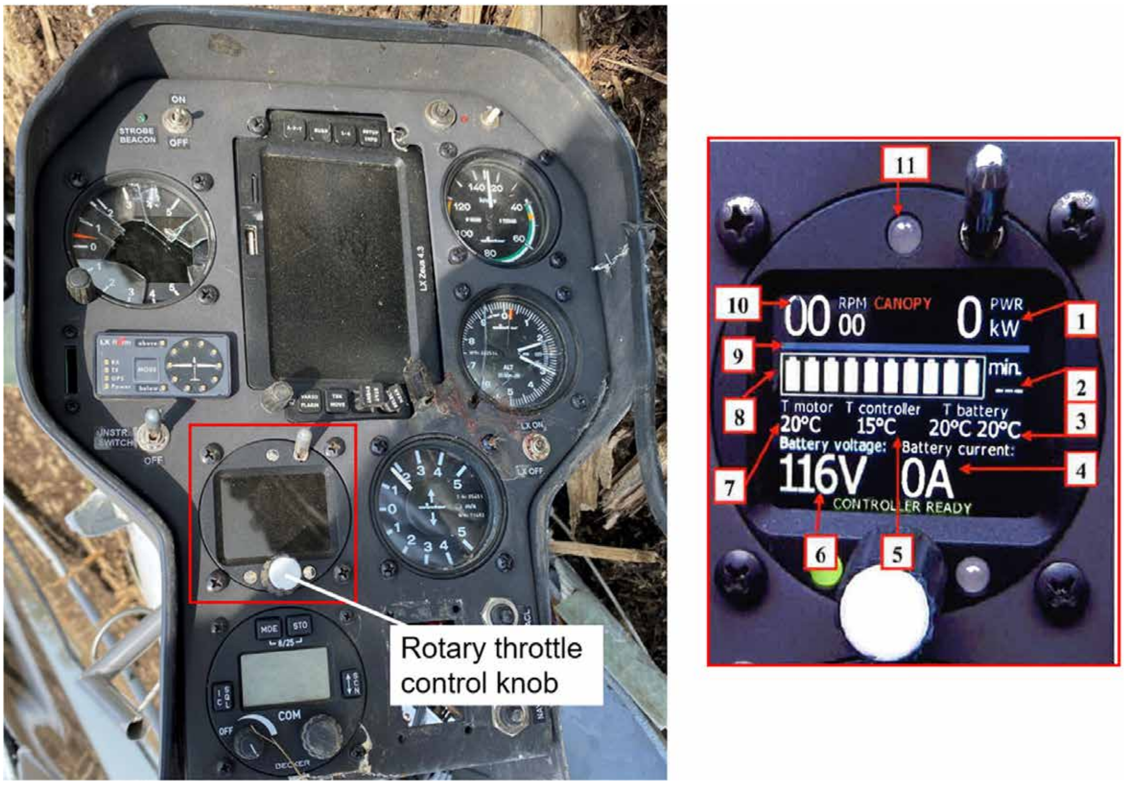


**Figure 7**

FCU instrument in the cockpit instrument panel (left) and enlarged detail (right)

*Pitot tube*

A pitot tube is used for measuring airspeed and G-CIRK was fitted with an angled version attached to the leading edge of the vertical tail (Figure 8, left). This same type of pitot tube was fitted to the Silent 2 Electro that was used for a flight evaluation as discussed later in the report. Later model Silent 2 Electro's have a straight pitot tube (Figure 8, right). It was reportedly changed to reduce aerodynamic drag.


**Figure 8**

Angled pitot tube fitted to G-CIRK and the flight evaluation aircraft (left) and straight pitot tube fitted to later model Silent 2 Electro's (right)

*Flight and Maintenance Manual*

Typically, a flight manual, often referred to as a pilot's operating handbook, is an aircraft-specific reference document supplied by manufacturers of regulated aircraft and targeted at pilots flying that aircraft type. It is normally a comprehensive manual containing important information for pilots about their aircraft and its systems. Flight manuals would typically include details of limitations to be observed, operating performance data, procedures for normal and emergency situations and other pilot-relevant information.

Unlike for regulated aircraft, there is no requirement for SSDR aircraft to have a flight manual, although the manufacturer of G-CIRK did publish one. Rather than issuing a standalone flight manual and a separate routine maintenance manual, the glider's manufacturer published a combined Flight and Maintenance Manual (FMM). In addition to the usual contents of a flight manual, it contained details of routine maintenance tasks to be carried out on the aircraft.

While exceeding the UK regulatory requirement, the FMM was not as comprehensive as might be expected for a regulated aircraft. The investigation made the following observations on the content of the FMM:

- Neither target liftoff nor recommended climb speeds were specified.
- FMM guidance is to maintain a '*tail down attitude* [during the takeoff roll] *to avoid a prop*[eller] *strike*' but does not specify whether the tail wheel should be held on the ground or to what degree it can, or should, be raised as airspeed increases.

- The '*Aborted Take-Off and Engine Failure Drill*' does not include actions in the event of an engine failure or aborted takeoff before liftoff.
- While the Normal Procedures section of the FMM highlights the risk of a propeller strike on takeoff, the emergencies section does not include actions to take if one occurs.
- The flap position table in the Performance Data section appears to contradict the Normal Procedures section. The former states that the '*best usage*' flap settings for takeoff are L and +1 but the latter says to '*set the flaps at position +1*.'
- While the FMM recommends pilots familiarise themselves with the stalling characteristics of the glider it does not specifically direct them to explore how those characteristics differ during powered flight.
- In a section called 'Electric Powerplant Use and Maintenance' the FMM states '*Always self-launch with freshly charged batteries*', but this does not appear in the 'Operating Limitations' section of the FMM.

*Stall speeds*

The FMM provides the following indicated (IAS) and calibrated (CAS) stall speeds[10] for the aircraft with landing flap (Table 1). Stall speeds with other flap configurations are not published.

| Gross Weight | Stall Speed (IAS) | Stall Speed (CAS) |
|---|---|---|
| 245 kg | 32 kt | 29 kt |
| 275 kg | 34 kt | 31 kt |
| 300 kg | 35 kt | 32 kt |
| 315 kg | 35 kt | 32 kt |

**Table 1**

Silent 2 Electro stall speeds (with landing flap)

*Aircraft manufacturer*

The aircraft was originally manufactured by a company called Alisport SRL in Italy which produced a total of 49 Silent 2 Electro's between 2011 and 2018, including G-CIRK. In 2018 this company was bought by Porto Aviation which produced an additional two Silent 2 Electro's before selling the design and assembly jigs to a new company called Alisport

**Footnote**

[10] The indicated airspeed (IAS), expressed in kt is KIAS and is the speed indicated on the airspeed indicator, which has some instrument and position error. The calibrated airspeed (CAS), expressed in kt as KCAS, is the airspeed that would be indicated with no instrument or position error, and reflects aircraft performance. The true airspeed (TAS), expressed in kt as KTAS, is the CAS corrected for air density and is the actual speed of the aircraft relative to the air mass. At sea-level on a standard day TAS and CAS are the same.

Swiss in October 2019[11]. Alisport Swiss completed the final assembly on two Silent 2 Electro's before ceasing production in 2021. It is not yet known if production will resume. In this report the term 'aircraft manufacturer' will be used for Alisport Swiss and the term 'original aircraft manufacturer' will be used for Alisport SRL.

While under construction at the original aircraft manufacturer the type received an approval from the Deutscher Aero Club (DAeC). This meant that the aircraft met the German ultralight requirements LT-ULF, and the type received is what is called a 'Geraetekennblatt' which is a form of approval but is not an internationally recognised type certificate.

**Aircraft examination**

The aircraft wreckage was recovered to the AAIB facility near Farnborough for a detailed examination. All the damage to the flying controls was consistent with impact damage. The tailplane actuation system operated normally but the broken tail boom had resulted in the actuating cable going slack, so it was not possible to determine the tailplane angle at impact. It was also not possible to determine the flap angle at impact due to damage to the flap control system. No mechanical fault was found that would cause an un-commanded pitch-up. There were no blockages in the pitot tube. The landing gear was in the DOWN position and the BPRS had not been operated. 4.5 kg of nose ballast was fitted.

The electric motor was too severely damaged to test, but the separated propeller blades indicated that the motor was rotating at impact. As well as the root damage, the propeller blades had leading edge nicks and one blade had tip damage (Figure 9).

**Figure 9**
Propeller blade damage

Both batteries were removed and connected to test equipment. Their state is detailed in Table 2.

**Footnote**

[11] An additional 91 non-electric versions of the Silent 2 were also built.

| | Battery 1 | Battery 2 |
|---|---|---|
| State of Charge | 64.5% | 64.7% |
| Stage of Health | 99.1% | 99.1% |
| Voltage | 53.0 V | 53.0 V |

**Table 2**

Battery state after the accident

The maximum voltage of each battery is 58 V. The motor manufacturer estimated that an unloaded total voltage of 106 V would result in a maximum rpm of 4,200 instead of the normal maximum of 4,500 rpm.

The 10 cm initial spacing of the propeller slash marks in the runway surface indicated an approximate groundspeed of 27 kt at a propeller rpm of 4,200, and 29 kt at 4,500 rpm.

### Survivability

The pilot suffered serious injuries in the accident and spent more than three months in hospital. He had been secured by a four-point harness, but the aircraft type does not have significant energy absorbing structure ahead of the pilot's seat to protect the occupant in a nose-first impact. As an SSDR the aircraft type was not required to meet the crash load test requirements of CS 22.561[12].

### Weight and balance

Each Silent 2 Electro is provided with a weight and balance report which provides a table of seat load and nose ballast resulting in a recommended CG. The moment arms of the seat and the nose ballast are not provided.

G-CIRK's weight and balance table indicated that, for the pilot's declared boarding weight of 72.5 kg, the recommended amount of nose ballast was 3.0 kg for a CG of 404 mm. The forward and aft CG limits were 357 mm and 448 mm respectively. The takeoff weight was 294 kg. The pilot found that 3.0 kg of ballast left the glider feeling "tail-heavy" so he chose to fly with 4.5 kg of nose ballast. This changed the trim point to make the glider more nose heavy, requiring a reportedly, "more-comfortable," aft stick input to hold desired attitudes. He also reported that using flap S at speed above 70 kt gave a "more balanced" feel to the controls than using flap -1 or 0.

Measurements on another Silent 2 Electro revealed a discrepancy between the measured moment arm of the nose ballast and the moment arm used in its weight and balance table. The moment arm measured between the centre of the nose ballast and the wing leading edge datum was 137 cm, but the figure used in the table was 147.1 cm. The moment arm could not be accurately measured on G-CIRK due to the structural damage, but the moment arm used in its table was 151.0 cm.

**Footnote**

[12] CS 22 refers to Certification Specification 22 which contain the EASA certification requirements for sailplanes.

## Meteorology

At the time of the accident, good weather prevailed. While wind velocity was not recorded at Wormingford Airfield, Stansted Airport and RAF Wattisham, 20 nm west and 13 nm northeast of Wormingford respectively, both recorded south-easterly winds between 9 and 13 kt around the time of the accident. These observations and those of eyewitnesses indicated that when the pilot began his takeoff, the wind at Wormingford was south-easterly at 10 to 15 kt. The crosswind would have been approximately 10 kt from the right. The glider's crosswind limit for takeoff was 19 kt (35 km/h). The recorded data analysis[13] was based on the Stansted Airport wind recorded at 1320 hrs which was 130°/11 kt. The air temperature at Stansted at that time was 14°C.

## Airfield information

Wormingford is a grass airfield with a single runway designated RW09/27, approximately 1,600 m long and orientated 080°/260° M (Figure 10). The runway is bounded by a track to the south and arable land to the north.

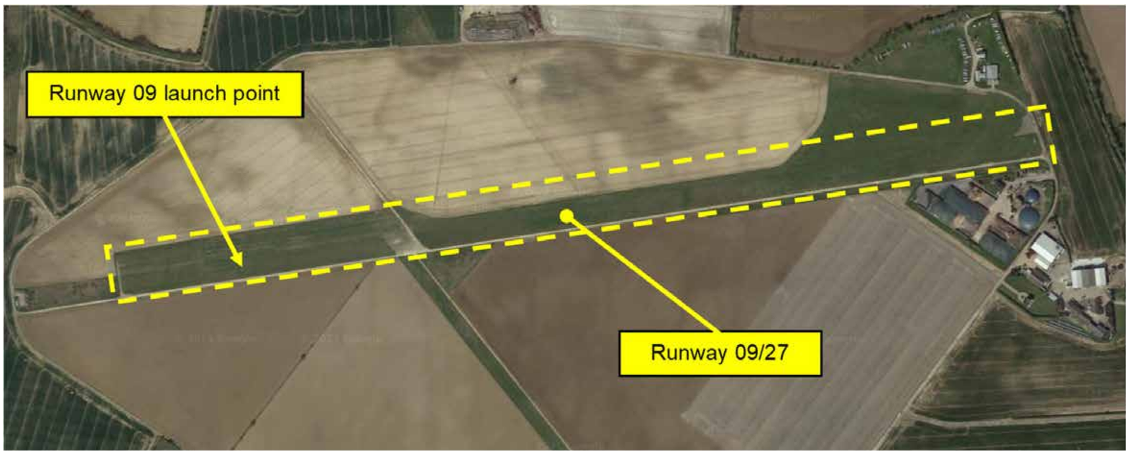


**Figure 10**

Wormingford Airfield
(image ©2021 Bluesky, CNES/Airbus Getmapping plc, Infoterra Ltd & Bluesky, Maxar Technologies, Map data ©2021)

The gliding club stated that the runway was proactively maintained, with any ruts being filled by hand and the surface routinely rolled to ensure it stayed "relatively flat and smooth." The accident pilot described RW09 as being in "good condition."

## Accident pilot and training

The accident pilot started gliding in 2014 and undertook most of his flying with the club at Wormingford. He held a Light Aircraft Pilot's Licence for sailplanes (LAPL(S)) as well as a British Gliding Association (BGA) glider pilot's certificate. The pilot achieved the BGA's Silver gliding endorsement in 2017 and qualified as a BGA Basic Instructor in 2019. His

**Footnote**

[13] See *Summary of recorded data.*

LAPL(S) licence was valid for life and he held a current flying medical certificate at the time of the accident.

The pilot bought G-CIRK second-hand in late-2019. The glider was supplied with a Flight and Maintenance Manual (FMM)[14] and, in addition to this, the pilot obtained a set of flight notes developed by a UK representative of the manufacturer. These flight notes were informally developed to supplement the FMM, providing amplifying guidance beyond that contained within it. The notes were described as '*a summary of the general characteristics of the Silent 2 Electro compiled by a selection of pilots based on their own personal experience of flying the aircraft*' and explicitly stated that it was '*not intended as an alternative to reading the Flight Manual.*' In relation to getting airborne, the notes stated that '*the glider will typically lift off when the indicated airspeed of 90~100 kph (48~53 kt) is reached*' and recommended that pilots '*maintain air-speed 90~100 kph (48~53 kt) for the duration of the climb-out*'. The accident pilot used the combined advice from both these sources to inform his approach to flying the Silent 2 Electro. He reported using flap +1 for self-launched takeoffs and 50 kt as his target climb speed.

The accident pilot first flew G-CIRK during his self-launch training, which he completed with a third-party training organisation in January 2020. This training, which was not conducted at Wormingford, comprised dual instruction with a flying instructor (FI) in a Super Dimona (Figure 11) followed by five solo self-launches in G-CIRK, all from a paved runway and supervised by the same FI. The dual elements of the training included five self-launched takeoffs and practise aborted takeoffs on the ground in the Super Dimona. The Super Dimona differed significantly from the Silent 2 Electro in that it was a Touring Motor Glider (TMG)[15] rather than an SLMG. It had side-by-side seating, tricycle undercarriage and a piston engine operated by a conventional throttle lever which moved forward and aft. The AAIB is not aware of any two-seat tandem self-launch FES-equipped sailplanes in production and the FI had not flown the Silent 2 Electro type.

During his first flights from Wormingford in G-CIRK, the pilot had undertaken a series of self-familiarisation exercises, including exploring the power-off stalling characteristics of the glider. He had not carried out any power-on stalls. He was aware that the LX navigation flight computer could be configured to provide an aural low speed warning but he did not use it as it provided nuisance warnings in the turbulence of thermalling.

The pilot reported that, compared with other gliders he had flown, G-CIRK required a higher level of active pilot input to hold a steady gliding attitude. This he ascribed to the glider not having any pilot-operable manual pitch trim control.

**Footnote**

[14] See section *Flight and Maintenance Manual.*

[15] A Touring Motor Glider (TMG) is an aircraft with the characteristics of a non-power-driven glider which has one or more integrally mounted, non-retractable power units, one or more non-retractable propellers and is designed or intended to take off under its own power.


**Figure 11**

Super Dimona (image used with permission)

While the glider was self-launch capable, the pilot generally preferred to winch launch to conserve battery power in case he ran out of natural lift while cross-country flying. Prior to 23 April 2021 (the day of the accident), the pilot's previous self-launch was 8 months earlier, and that had been his first self-launch since completing his initial training in January 2020 (Figure 12).

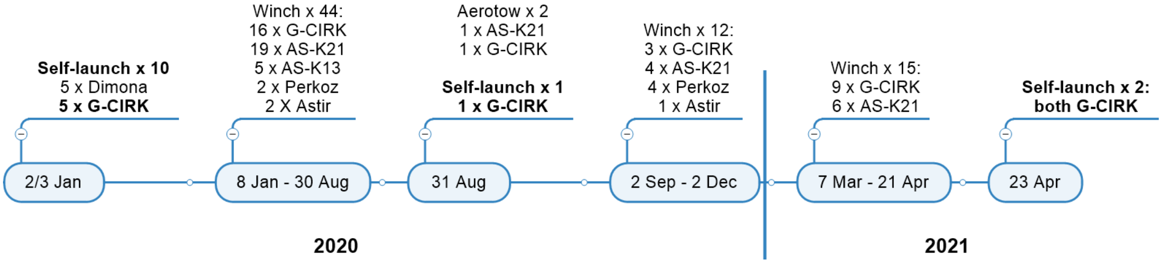


**Figure 12**

Summary of accident pilot's flying from start of self-launch training

While the pilot had no recollection of events on the day of the accident, he speculated that he elected to self-launch for the purpose of adding qualifying takeoffs toward the regulatory currency requirement of five self-launches in a rolling 24-month period. The pilot reported that, because the glider had a wingtip wheel and unlike for a more-dynamic winch launch, he would not have been overly concerned by a wing drop during the early stages of a self-launch, although he had not experienced a wing drop before the day of the accident.

The pilot had not charged the FES batteries between launches on the day of the accident and reported being unaware the FMM stated that self-launches should be carried out with fully charged batteries.

The pilot explained that for a self-launch, after the tailplane became effective during the ground roll, he would raise the glider's tail thereby lowering the wing angle of attack to avoid lifting off prematurely. He reported being aware of the propeller strike risk and that he would have aimed for a neutral pitch attitude when raising the tail.

The pilot was more familiar with winch, rather than self, launching in G-CIRK. He described the glider as having good winch-launch characteristics and said it was a "very natural" action to select and hold the climb attitude after liftoff. Once established in the climb the stick would be in a "neutral" position and, generally, only small pitch inputs were needed to maintain the target climb speed of 50 kt. The pilot reported preferring flap 0 for winch launches because it helped to prevent the glider lifting off prematurely and had "better control" characteristics than with flap +1.

The pilot observed that for an aborted takeoff, when compared with a standard cable release mechanism, the ergonomics of the FES control system were less intuitive. In an emergency requiring immediate motor shutdown, diverting attention away from flying the aircraft to locating and operating the FES throttle knob would be highly distracting at a critical stage of flight. Unlike pulling a cable release toggle, shutting down the FES was neither an instantaneous nor instinctive action. He considered that it would be safer if future designs for FES gliders incorporated a more intuitive and ergonomic means of cutting engine power.

**Silent 2 Electro Flight Evaluation**

The AAIB organised a series of evaluation flights on a Silent 2 Electro to explore the glider's handling characteristics, with specific focus on those flight regimes most pertinent to the accident flight. The evaluation pilot was a current military test pilot with extensive gliding experience[16]. The flight evaluations were conducted from a tarmac runway with a glider ballasted to give a representative CG position close to that of the accident glider. A portable sensor was used to record pitch angle, barometric pressure and GPS data. A camera was used to record the instruments and cockpit control positions, and a digital force sensor was used to record control stick forces. The significant findings from the flight evaluation were as follows:

*Stick control forces*

On the ground the stick could be placed in all positions and would not return to neutral when released. A force of 0.4 dAN[17] was required to pull the stick full aft, 0.6 dAN to push the stick full forward, and 1.6 dAN to apply full left or right stick. These forces were similar to the forces experienced in flight at low airspeeds. In the 40 to 50 kt airspeed range the stick could be displaced at least 2.5 cm forward or aft without returning to neutral when released.

The stick force versus airspeed relationship was measured at low airspeed and full power (the takeoff scenario) and is shown in Figure 13. The slope was very flat at 0.1 dAN per

**Footnote**

16 Graduate of the Empire Test Pilots School, 6,700 hrs total time, BGA Full Category Instructor, 3 Diamonds and 1,100 hrs on gliders.

17 1 daN is a unit of force equal to 10 Newtons which is 2.2 lb or 1.02 kgf.

10 kt in the nose-down direction, and 0.06 dAN per 10 kt in the nose-up direction. And the break-out friction force[18] of 0.1 dAN was high in comparison to the additional force required to change airspeed.

The test pilot reported that the flat stick force gradient and high break-out friction has two effects: it means that the pilot receives minimal feedback through the stick about how the aircraft is manoeuvring or its attitude, and it is difficult for the pilot to feel where the stick needs to be positioned to adopt a specific aircraft attitude or fly the aircraft smoothly and predictably.

The glider had weak positive longitudinal static stability at a CG that was 40 mm forward of the aft CG limit, so the stability would have been even less at the aft limit.

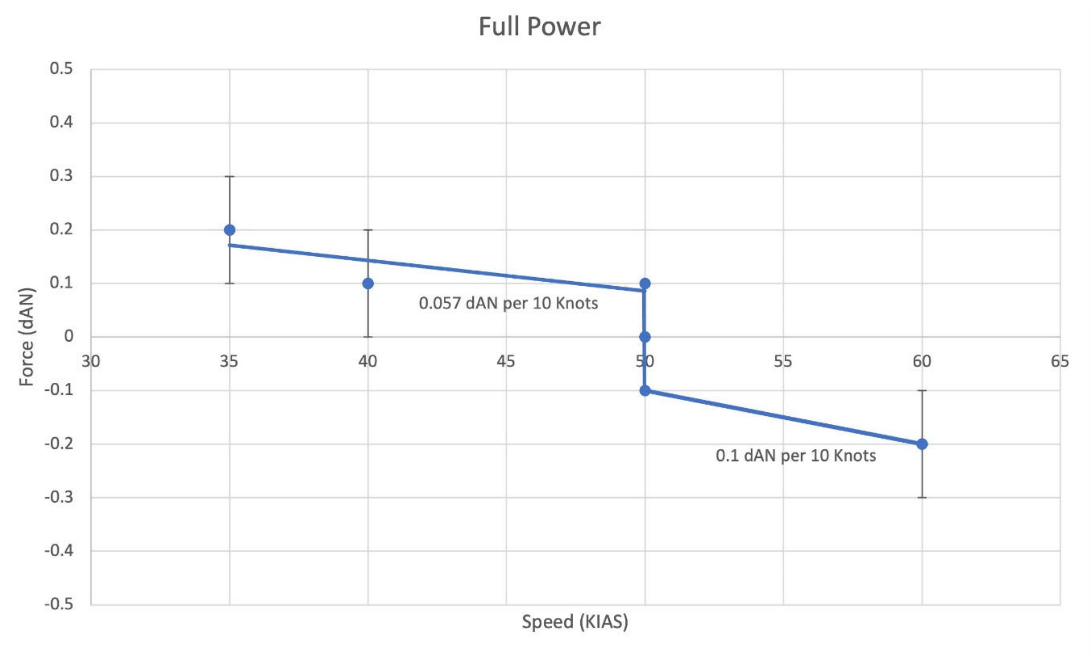


**Figure 13**

Stick force versus airspeed measurements

*Stall characteristics and stall warning*

During power off stalls from level flight, at flaps +1, decelerating at 1 kt/sec, there was light buffet at 38 KIAS and then the glider stalled at 37 KIAS in a nose-up attitude, with the nose dropping 2 seconds later. The stick force and displacement were not an obvious indicator of an impending stall. Beyond the point of stall, the glider typically yawed 10-15° and then rolled in the same direction before pitching down. Centralised forward movement of the stick led to a rapid recovery with a typical height loss of 150 to 200 ft. Significantly, there was only minimal pre-stall buffet and the test pilot found that buffet was not a good indicator to pilots that they were approaching the stall.

**Footnote**

[18] The break-out friction force is the force that must be applied to the stick before the stick starts to move.

During full power stalls the airspeed indicator would sometimes fluctuate and indicate an erroneously high airspeed, sometimes jumping from 37 KIAS to 60 KIAS at the stall and displaying up to 80 KIAS after wing drop, so only the initial stall speed was reliable.

The full power stalls occurred in three main phases. During the first phase the glider decelerated to approximately 35 to 38 KIAS at flap 0 and flap + 1, while the attitude rose to 20 to 25° nose-up. The horizon was not visible from the cockpit, making it difficult to visually assess the attitude. Airframe pre-stall buffet was subtle, typically occurring only 1 kt and 1 second before the stall. This buffet was easily masked by the noise and vibration from the propeller and motor. Approaching the stall stick forces were light even when the stick was fully aft. If the stick remained fully aft the second phase of the stall occurred, the glider's nose dropped 10° below the horizon and the airspeed indicator jumped up to an erroneous 60 KIAS. This occurred over a 2 to 3 second period and at a rate that did not trigger a sensation of falling as a tactile cue for the pilot. Buffet levels increased during this phase. If the stick remained fully aft the aircraft entered the third phase, where the airspeed indicator erroneously showed 80 KIAS and the glider rolled rapidly to approximately 50° angle of bank.

According to the test pilot the pre-stall buffet during the full power stalls was '*minimal, subtle, inconsistent and not a reliable indicator of an impending stall*'. The typical height loss was 220 to 270 ft.

The test pilot concluded that, '*under the conditions tested, a startled, task-saturated and inexperienced pilot or one with a lack of stalling currency, could easily miss the natural pre-stall warning cues inherent in the Silent 2 Electro.*'

*Rapid climbs*

Rapid climbs were performed from entry speeds between 40 and 50 KIAS, with full power and flap +1 to see what pitch angle would produce the height gain observed in the accident takeoff, while allowing the airspeed to decelerate to a stall.

An interpolation of the data revealed that a gentle pull from about 41-44 KIAS would result in a 100 ft height gain prior to stalling at a pitch angle between 30° and 35°. The stick pull force to achieve this was only about 0.3 daN.

The climbs demonstrated that a 100 ft height gain from a speed of 41 to 44 KIAS would not have been achievable without power.

| Entry Airspeed (KIAS) | Peak Pitch Attitude (degrees) | Height Gain (ft) |
|---|---|---|
| 40 | 35 | 49 ft |
| 40 | 38 | 75 ft |
| 40 | 30 | 79 ft |
| 40 | 35 | 82 ft |
| 45 | 30 | 110 ft |
| 47 | 25 | 133 ft |
| 50 | 30 | 156 ft |

**Table 3**

Height gain and peak pitch attitude during rapid climbs

*Self-launch assessment*

The test pilot's first flight on type was a self-launch at flap +1 which the test pilot found to involve a high workload due to unfamiliarity with the FES operation and trying to maintain the wings level in an 8 to 10 kt crosswind. The left wing tip wheel briefly touched the runway prior to liftoff. The test pilot found that raising the tail during the self-launch resulted in pitch and directional oscillations while the pilot was attempting to select the desired attitude and maintain runway heading. It was easy to overcontrol in pitch, resulting in the tail being raised more than planned. The climb after liftoff was flown at about 48 to 50 KIAS which resulted in a pitch angle of 10° and a climb rate of about 470 ft/min.

*Aborted takeoff assessment*

Four simulated takeoff aborts were performed. The abort speeds for the first three were 20, 30 and 35 KIAS, and these were undertaken before the test pilot had gained any experience on type. The tailwheel was kept on the ground and the pilot kept his hand on the FCU throttle knob during the acceleration phase. The pilot found that when aborting it took him time to select 0 rpm and found that managing the FES while maintaining directional control led to a high pilot workload but was safely achievable.

The fourth aborted takeoff was performed later in the day after the test pilot had gained experience operating the FES in flight. This time the pilot placed his left hand on his left thigh after setting power and initiated the abort at 35 KIAS. He found that locating the throttle knob and executing the abort was simple, as he had performed this physical action many times while airborne that day.

The test pilot assessed that, for an inexperienced pilot or one not current on type, the workload during an aborted takeoff on the ground was high. Once experience was gained on the glider and the operation of its FES, ground aborts during takeoff were more straightforward. Airborne aborts were not attempted.

*Winch launch assessment*

A winch launch was flown with flap 0[19] and was described by the test pilot as '*uneventful*.' The initial peak pitch attitude was 34° nose-up.

**Airworthiness requirements**

*Certification Specifications for sailplanes*

The EASA certification requirements for sailplanes are in Certification Specification (CS) 22. The Silent 2 Electro was not certified to CS 22 and nor was it required to be; however, CS-22 regulations are designed to ensure a certain level of safety so they are useful to compare an uncertified aircraft to.

CS 22.173[20] on 'Static Longitudinal Stability' states that the slope of the stick force versus speed curve must be positive and '*have a value such that any significant speed change will cause a variation in stick force plainly perceptible to the pilot.*' The 'Acceptable Means of Compliance' (AMC) to this requirement state that: '*Compliance with this requirement can be assumed, if the slope of the curve, stick force versus speed, is at least 1 N per 10 km/h at all speeds up to $V_{NE}$.*' $V_{NE}$ is the 'never-exceed speed' and 1 N per 10 km/h equates to 0.19 daN per 10 kt or 0.19 kgf per 10 kt.

CS 22.207 on 'Stall warning' states that there '*must be a clear and distinctive stall warning'* through the *'inherent aerodynamic qualities of the sailplane (e.g. buffeting) or by a device that will give clearly distinguishable indications'*. The stall warning must begin between a speed of 5% above and 10% above the stall speed, or between 2 and 5 seconds before the stall occurs when the speed is reduced at 2 km/h per second. Compliance with this requirement is not required if, when the stall occurs, '*no appreciable wing-dropping occurs when both ailerons and rudder are held*' neutral. EASA were asked what a 'appreciable wing drop' consists of and they said 30° angle of bank. They also stated that a noticeable nose drop would be a trigger point for recovery, and if pushing the stick forwards at that point prevented more than 30° of bank then the requirement would be met.

CS 22.779 specifies the motion and effect of cockpit controls for sailplanes and powered sailplanes. It states: '*Cockpit controls must be designed so that they operate as follows: Throttle control – Forward to increase power*.'

**Footnote**

19 Flap 0 was used for the winch launch as recommended by the aircraft owner.

20 European Union Aviation Safety Agency (2021). *Certification Specifications, Acceptable Means of Compliance and Guidance Material for Sailplanes and Powered Sailplanes (CS-22)*. Amendment 3 https://www.easa.europa.eu/document-library/certification-specifications/cs-22-amendment-3 [accessed March 2022]

*DAeC ultralight airworthiness requirements*

The DAeC approved the Silent 2 Electro to LTF-UL[21] which contain airworthiness requirements for three-axis controlled ultralight aircraft. The DAeC provided the AAIB with an English translation of the 2003 version of these requirements, which were used to assess the Silent 2 Electro. The stall warning requirements in it are similar to CS 22 in that no stall warning is required if there is no 'appreciable wing-dropping'. However, the static longitudinal stability requirements are different in that LTF-UL 173 states that the slope of the curve, stick force versus speed, *'must be positive and have a value such that any significant speed change will cause a variation in stick force plainly perceptible to the pilot'*, without providing a specific minimum figure of stick force versus speed.

LTF-UL 779 on *'Motion and effect of cockpit controls'* is similar to CS 22.779 and states that cockpit controls must be designed such that *'Power lever: forward to increase forward thrust'*. However, the DAeC stated that their interpretation of the rule is that it only applies to a power lever and that the rotary knob on the Silent 2 Electro is not a power lever.

**Aircraft manufacturer comments**

The aircraft manufacturer assisted the AAIB with the investigation but as they had only recently acquired the aircraft type, they could not answer questions about its development and DAeC approval. They stated that they were not responsible for aircraft such as G-CIRK which were manufactured by the original aircraft manufacturer, but that the design had not changed since they started manufacturing the type.

The aircraft manufacturer acknowledged that the stick forces were very light, like some other ultralight aircraft, and that not having much stick centring force can be "difficult for the average pilot", but that most of their customers want the light forces for comfort reasons, especially for long soaring flights. However, if the manufacturer resumes production of the aircraft type, they will consider adding a spring to the pitch control system to increase stick forces.

The manufacturer also acknowledged that there is little buffet prior to stall to warn a pilot. Most powered light aircraft have a stall warning vane or suction port on the leading edge of the wing which provides an aural warning when an angle of attack close to stall is reached. This is not fitted to most gliders as it adversely affects the drag and therefore the glide performance of the wing.

Pilots typically practice power-off stalls when learning to fly a new aircraft type, and the manufacturer considered that there could be a safety benefit for Silent 2 Electro pilots to practice full power stalls to help them recognise the onset of stall in the takeoff scenario.

The manufacturer was unaware of an erroneous airspeed issue during power-on stalls and considered that it might be related to an older type of pitot tube that was fitted to the aircraft

**Footnote**

[21] LTF-UL is a German acronym for Lufttüchtigkeitsforderungen für aerodynamisch gesteuerte Ultraleichtflugzeuge, meaning 'Airworthiness requirements for three axes standard control ultralight aircraft'

the AAIB used for the flight evaluation and to G-CIRK. The manufacturer said they would investigate this issue if they resumed production.

Although not specified in the flight manual, the manufacturer considered that pilots new to the type should fly the aircraft with a more forward CG to increase longitudinal stability and increase the stick forces.

The manufacturer's test pilot stated that he almost always does a self-launch takeoff with flap 0. This is not one of the takeoff flap settings in the flight manual, but he stated that it provides a higher trim speed with negligible increase in stall speed compared to flap +1, so it provides a higher speed and stick force margin to stall. If the best climb angle was needed to clear an obstacle, then he recommended using flap +1.

The flight manual does not provide a lift-off or initial climb speed. The manufacturer stated that lift-off and initial climb is 90 km/h which is 49 kt. But they also stated that the takeoff should be conducted at the speed indicated by a yellow triangle on the air speed indicator which is 46 kt and is the glider's approach speed.

Regarding the takeoff technique the flight manual states a tail down attitude should be used to avoid a propeller strike. The manufacturer's test pilot said that some Silent 2 Electro's are fitted with a steerable tailwheel which can result in steering issues if the tailwheel is held on the ground during the takeoff roll so lifting the tail is preferable. He stated that all Silent 2 Electro's sold to the UK had a fixed tailwheel.

The manufacturer was aware of other propeller strike events during takeoff. They were aware of a few events where the propeller tips touched a concrete runway, and the aircraft took off without any issues. They did not consider that a light propeller touch on a grass runway would cause any significant issues. However, they considered that aborting the takeoff would normally be the safest option following a propeller strike.

The flight manual does not include an aborted takeoff on the ground procedure, but the manufacturer stated that the technique would be to cut the power by twisting the FCU throttle control knob, and then applying the wheel brake.

The manufacturer was asked to provide information on the nose ballast arm used to calculate the weight and balance tables to help explain the discrepancy found, but this information has not been provided yet.

If the manufacturer resumes production, they stated that they would update the flight manual with an aborted takeoff procedure, add a section on pilot training, add a takeoff and climb speed, add information about airspeed errors, and will consider adding flap 0 as a takeoff setting and recommending new pilots fly at a more forward CG.

## Other accidents to Silent 2 Electro

On 19 October 2015 a Silent 2 Electro, registration G-CIYA, experienced a similar accident on takeoff from Husbands Bosworth Airfield in Leicestershire. During the initial climb following a self-launch, the aircraft entered an incipient spin. One wing struck the roof of a farm building, before the other wing and fuselage struck the ground. The pilot was seriously injured. The investigation did not reveal any malfunction or defect to account for the accident. Although the pilot was experienced and current in light aircraft, gliders and motor-gliders, he had not flown the aircraft type before. The full details are published in AAIB Bulletin 7/2016[22]. The report did not mention any indications of a propeller strike.

On 1 May 2017 a Silent 2 Electro suffered a stall and spin shortly after takeoff from Skövde Airport in Sweden. The pilot was seriously injured. The accident was not investigated by the Swedish Accident Investigation Authority but the AAIB obtained some information from the Swedish Soaring Federation that the takeoff was carried out with low batteries, and that the pilot may have reduced power in response to a low voltage warning, which resulted in the aircraft climbing poorly followed by a stall and spin.

On 22 July 2021 there was a fatal accident involving a Silent 2 Electro, registration D-MANS, near Conthey, Switzerland. The aircraft appeared to have stalled while ridge soaring. This accident is the subject of an ongoing investigation by the Swiss Transportation Safety Board.

## Pilot licensing

When the pilot bought the glider, he gained the understanding from various sources that he needed to qualify for solo self-launching before he could fly the glider without direct supervision using another launch method such as winch-launch or aero-tow. This was not the case. The investigation found evidence of other pilots also being confused over licensing requirements for self-launched SSDR gliders. A CAA Information Notice[23] (IN) covering licensing for SSDR powered sailplanes, published in 2014, and rescinded following the publication of ANO 2016 (due to the transfer of regulatory powers from the CAA to EASA), stated that:

> *'…the valid licences for aircraft that are within both the SLMG definition and the microlight aeroplane definition are:*
>
> > *… 3. any Part-FCL Light Aircraft Pilot Licence (Sailplanes) (LAPL(S)) or Sailplane Pilot Licence (SPL) that includes 'self' as a launching method.'*

The wording of the IN could be interpreted as meaning LAPL(S) and SPL holders wishing to fly SSDR gliders, including the Silent 2 Electro type, were required to hold and maintain self-launching privileges irrespective of launch method being used. This contrasts with the

**Footnote**

22 https://www.gov.uk/aaib-reports/aaib-investigation-to-silent-2-electro-g-ciya [accessed March 2022]
23 Civil Aviation Authority Information Notice Number: IN–2014/139 Pilot Licences for Flying Single-Seat Powered Sailplanes that are within the Microlight Mass Limit issued 19 August 2014.

wording of the superseding regulation, EASA.SFCL.155 (covering launch methods), which was not specific to SLMG and stated:

> *'…SPL holders shall exercise their privileges only by using those launching methods for which they have completed specific training either during [their] training course …or during additional training provided by an instructor after the issue of the SPL. This specific training shall consist of the following:*
>
>> *…(2) in the case of aerotow or self-launch, a minimum of five launches in dual flight instruction, and five solo launches under supervision. In the case of self-launch, dual flight instruction may be conducted in TMGs'*

BGA licensing experts reported that the rules surrounding self-launching had been in place since at least 2012 and that self-launching privileges were only required if the pilot wished to use that method of launch. At the time of the accident, the BGA website hosted a document containing a précis of various guidance sources related to self-launching, including an extract drawn from the *'Aircrew* [Commission] *Regulation Reg(EU) 1178/2011*[24] *FCL.130.S LAPL(S) – Launch Methods*.' This document[25] also included a template syllabus and record for self-launch endorsement training. The guidance document was replaced in August 2021 with a webpage, titled '*SFCL Compliant Pilot Training'*[26]*,* containing links to source documents to avoid the risk of publishing a locally collated document that might not reflect contemporary amendments to the regulatory framework. The revised webpage included the following specific guidance on launch privileges for pilots of self-launching sailplanes:

> *'SFCL permits a sailplane to be flown by an SPL holder using winch or aerotow or bungee or self-launch, providing that the pilot holds the appropriate launch type privileges and recency. This means that a pilot new to self-launching may fly a self-launching sailplane using aerotow or winch, which can be a helpful way of becoming familiar with handling characteristics prior to the first self-launch on type.'*

**Ballistic Parachute Recovery System (BPRS) Awareness**

The Magnum 300 BPRS installation on G-CIRK consisted of a rocket and parachute located in compartments behind the pilot seat, and an activation handle on the right side of the cockpit which was connected by a cable to the rocket. The activation handle had a safety pin to prevent inadvertent operation and this was to be removed before flight. The BPRS is activated by pulling the activation handle.

The damage to the cockpit of G-CIRK had exposed the activation cable, and the pin was not inserted, so the rocket presented a hazard to the emergency services attending the

**Footnote**

[24] Commission Regulation (EU) No 1178/2011 dated 3 November 2011 which lays down technical requirements and administrative procedures related to civil aviation aircrew pursuant to Regulation (EC) No 216/2008 of the European Parliament and of the Council. Available at https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32011R1178&from=EN [accessed March 2022].

[25] Dated 12 October 2017.

[26] https://members.gliding.co.uk/flying-information-and-resources/pilot-licensing/declared-training-organisation-easa-compliant-training [accessed March 2022].

scene. Fortunately, gliding club members who were at the airfield at the time of the accident and were aware of the BPRS, arrived at the accident site first and were able to secure the activation handle[27] and subsequently warn the emergency services paramedics about the hazard.

Two placards were affixed to the fuselage aft of the cockpit to warn people about the hazards from the rocket and parachute (Figure 14). These placards conformed to the requirements in ASTM F2316-12[28]. They did not conform to the placard requirements in BCAR Section S[29], sub-section K on *'Microlight Parachute Recovery Systems'*, which require the 'DANGER' placard to be larger than that specified in ASTM F2316-12[30], and which also require a double offset black and yellow chequered line to surround the parachute and rocket exit area (Figure 15). As an SSDR the Silent 2 Electro is not required to meet BCAR Section S; however, the CAA published Skywise article SW2021/91[31] on 29 April 2021 which stated that: '*The CAA strongly recommends that owners of SSDRs fitted with a BPRS comply with the requirements of BCAR Section S, Sub-Section K, to clearly identify the presence of the BPRS to emergency services and first responders in the event of an accident.*'


**Figure 14**

BPRS placards on G-CIRK

**Footnote**

27 The pin could not be inserted into the activation handle due to impact damage of a surrounding bracket, so the club members tied some string through the pin hole.

28 ASTM F2316-12, Standard Specification for Airframe Emergency Parachutes.

29 CAP 482 British Civil Airworthiness Requirements (BCAR) Section S – Small Light Aeroplanes, Issue 7 https://publicapps.caa.co.uk/modalapplication.aspx?appid=11&mode=detail&id=5575 [accessed March 2022]

30 BCAR Section S requires the dimensions of the triangular part of the placard to be a height 130 mm and width 150 mm, whereas ASTM F2316-12 requires the triangular placard to have a minimum size of 3 inches (76.2 mm).

31 http://skywise.caa.co.uk/marking-and-placarding-of-ballistic-parachute-recovery-systems-on-single-seat-deregulated-ssdr-aircraft/ [accessed March 2022]

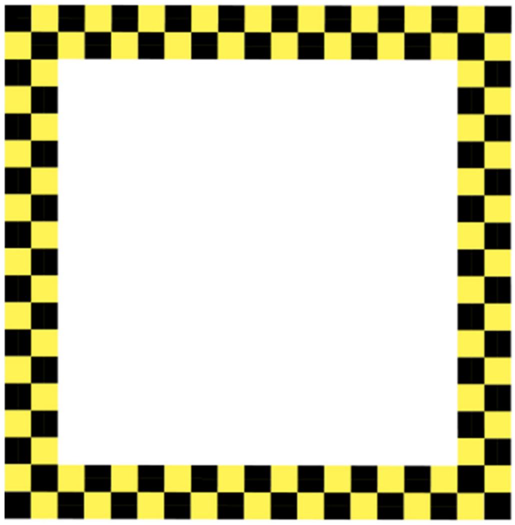

**Figure 15**

From BCAR Section S, sub-section K, sample of double offset black and yellow chequered line which should surround the parachute and rocket exit area

In some accidents the placards can be obscured as a result of structural damage, wreckage orientation or due to fire. Following an accident to a CZAW SportCruiser (G-EWZZ) which was equipped with a BPRS and suffered a post-impact fire, the AAIB published the following Safety Recommendation on 11 June 2015[32]:

**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.

At the time there were technical difficulties to modify the UK's aircraft registration database 'G-INFO'[33] to include details about an aircraft's BPRS, and other reasons which resulted in this recommendation not being acted upon[34]. However, since the accident to G-CIRK the AAIB revisited this recommendation with the CAA, and the CAA have taken the following safety action:

**Footnote**

32 Report in AAIB Bulletin 5/2015 https://www.gov.uk/aaib-reports/aaib-investigation-to-czaw-sportcruiser-g-ewzz [accessed March 2022]
33 https://www.caa.co.uk/aircraft-register/g-info/ [accessed March 2022]
34 CAA Factor F3/2015 contains the full CAA response on Safety Recommendation 2015-011 https://publicapps.caa.co.uk/docs/33/F3-2015%20G-EWZZ%20Issue%202.pdf [accessed March 2022]

**Safety Action**

On 24 January 2022 the CAA updated G-INFO to show when an aircraft is fitted with an Emergency Ballistic Device, such as a Ballistic Parachute Recovery System (BPRS), an active ejector seat or canopy miniature detonating cord. The CAA undertook the task of identifying UK-registered aircraft fitted with such devices to support this change. To capture newly-registered aircraft with an Emergency Ballistic Device in the future, the CAA is updating the aircraft registration process to specifically require owners to declare the aircraft status with respect to an Emergency Ballistic Device.

The AAIB also plans to update its guidance document to the emergency services to inform them of the availability of this new information on the G-INFO database.

As some owners of SSDR aircraft fitted with BPRS may not be aware of the recommended BPRS placard types and sizes that should be fitted, the CAA are planning the following:

**Safety Action**

The CAA are planning to contact the registered owners of SSDR aircraft, which are fitted with a BPRS device, to inform them about Sky Wise article SW2021/91 which strongly recommends that owners of these aircraft comply with the requirements of BCAR Section S, Sub-Section K, to clearly identify the presence of the BPRS.

**Effects of high workload and stress on human performance**

CAP 737 *Flight crew human factors handbook*[35] provides examples of processes that result in high workload such as '*doing an unfamiliar or novel task, doing a new or unlearned task, doing a challenging task*' and '*making a decision.*'

CAP 737 discusses the symptoms of increasing workload which include *'Attentional and task focusing.'* Attentional focusing is a cognitive strategy that has evolved to maximise concentration on a problem or threat but can have the negative consequence that '*other events and stimuli that would normally draw attention, fail to do so.*'

Another symptom is '*Task shedding and reprioritisation'* where some aspects of a task with concurrent elements are omitted, such as monitoring the airspeed indicator (ASI).

It also mentions that '*Very high workload (particularly fast onset) and feelings of not coping with the workload can cause high arousal or stress.*' Stress and high workload have similar effects on human performance including '*omission*', '*error*' and '*coning of attention.*' Additionally, CAP 737 mentions '*regression*' where, under stress, behaviour may regress to the earliest learnt.

**Footnote**

35 Civil Aviation Authority (2014), *Flight-crew human factors handbook*, CAP 737. https://publicapps.caa.co.uk/docs/33/CAP%20737%20DEC16.pdf [accessed March 2022]

## Analysis

*Accident flight*

The accident occurred following a self-launched takeoff. It was the pilot's third self-launch takeoff since completing training more than a year previously. During the takeoff roll the propeller struck the runway and then the aircraft climbed at an excessively steep angle for a self-launch. From comparing the recorded data of the accident flight with the flight evaluation data, the pitch angle was estimated to be between 30 and 35°, when a normal pitch angle after takeoff would be about 10°. The flight evaluation data showed that climbing at this angle from an initiating speed of 41 to 44 KIAS leads to a height gain of about 100 ft with power applied, followed by a stall and wing drop if recovery action is not taken in time.

The eyewitness evidence and recorded data showed that the aircraft climbed about 100 ft before stalling and entering an incipient spin to the left. The flight evaluation showed that 100 ft was insufficient height to recover from a power-on stall. The aircraft struck the ground nose-first and the pilot suffered serious injuries, in part due to the lack of energy absorbing structure ahead of the pilot's seat.

No mechanical fault or defect was found that would explain the aircraft pitching up excessively after takeoff. The 100 ft climb after takeoff indicates that power was applied and that the propeller had only suffered minor damage during the propeller strike. Although the batteries were not fully charged, the recorded data did not reveal a significant difference in the initial acceleration profile compared to the previous takeoff, so this did not appear to have been a factor in the accident.

The pilot had no recollection of the flight and there was no evidence from recorded data or eyewitness sources to explain the steep climb which led to the accident. Recorded data evidence showed that the pilot's previous self-launch, two hours earlier, followed a typical climb profile, as described by other Silent 2 Electro pilots.

The test pilot concluded from the flight evaluation that a self-launch takeoff in the Silent 2 Electro can be a high workload event for an inexperienced pilot or one not current on the launch type. They also found that the glider had a flat stick force gradient and high break-out friction which meant that the pilot receives minimal feedback through the stick about how the aircraft is manoeuvring, and it is difficult for the pilot to feel where the stick needs to be positioned to adopt a specific aircraft attitude. With little control feedback, any distraction diverting a pilot's attention away from the aircraft's attitude could lead to inadvertent stick inputs leading to undetected flight path deviations. The brief and subtle pre-stall indications seen during power on stalls would give a pilot only limited time to recognise and recover from a rapidly approaching stall in a steep nose-up attitude, or they could be missed entirely.

While the investigation could not determine the reason for the steep climb it considered that it most likely resulted from a single or combination of factors outlined in Figure 16 and explained below.

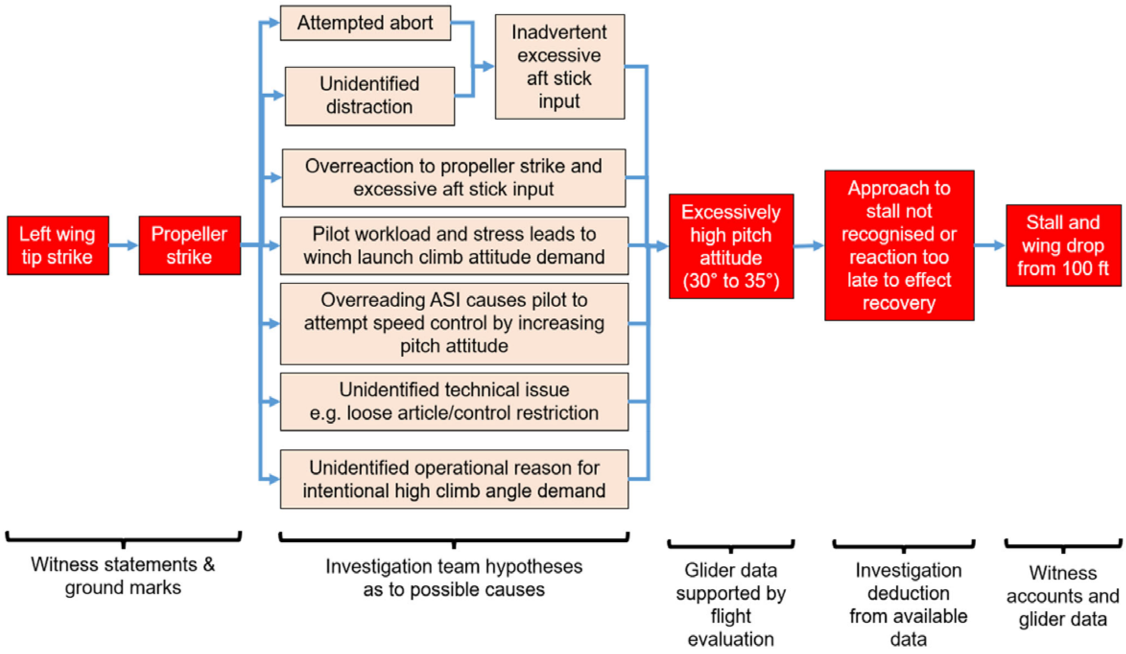


**Figure 16**

Sequence of events: actual (in red boxes) and possible (in pink boxes)

Inadvertent excessive aft stick input

It was possible that the pilot inadvertently applied an excessive aft stick input shortly after liftoff because a compelling stimulus diverted his attention away from the primary flying task and monitoring the glider's climb attitude. One possible scenario was considered to be the pilot focusing on the FCU following the propeller strike, either to check motor performance or to abort the launch. This would be an example of attentional focusing and task shedding or reprioritisation which are both likely to be experienced under high workload. The design of the FCU throttle knob was not ideally suited to the task of aborting a takeoff in an emergency. It required visual attention and a degree of manual precision to locate and control the rotary knob.

The investigation could not exclude the possibility of some other form of unidentified distraction.

Overreaction to propeller strike and excessive aft stick input

The investigation considered that if the pilot responded to the propeller strike more forcefully than required it might have resulted in an excessive aft stick input. The minimal control feedback in pitch could have masked an overcontrolling stick input. The imbalance in control forces between the control axes might also have contributed to any element of overcontrolling. The pilot would likely have been using heavier and more coarse control inputs to regain lateral and directional control during the takeoff roll but the required pitch input at liftoff would have been more subtle. However, the observed shallow climb established immediately after liftoff suggested that an initial overreaction to the propeller strike was less likely.

Pilot workload and stress

It was considered likely that the pilot experienced high workload during the takeoff run, because of his inexperience of self-launching this aircraft type and the crosswind. The video of the takeoff prior to the accident takeoff showed that the pilot needed to correct oscillations in all axes and lift the wing after a wing drop. During the accident takeoff, eyewitnesses reported a wing drop and a yaw which the pilot successfully corrected. However, workload likely further increased when the propeller struck the ground. This high workload might have led to him experiencing stress. Any resultant stress could have resulted in a regressive response by the pilot of selecting a more-familiar, winch-launch pitch attitude of 30 to 35° rather than the lower climb attitude required for a self-launch. CAP 737 describes *'regression'* as going back to the *'earliest learnt'*, and the pilot had learnt winch launches well before self-launches and he had conducted many more winch launches than self-launches in G-CIRK.

Overreading ASI

The flight evaluation revealed that the ASI can overread during power-on stalls. This is probably caused by the propeller slipstream hitting the pitot tube on the vertical tail. If the ASI had overread during the takeoff climb this might have caused the pilot to increase the pitch attitude to reduce the speed back to his target. However, the ASI was only seen to overread close to stall, so if it was a factor in the accident, it would probably have occurred late when the pilot had already reached an excessively high pitch attitude for a different reason.

Unidentified technical issue

The investigation did not find any evidence of a technical failure or control restriction but could not conclusively rule out an unidentified transient failure such as might be caused by a loose article affecting a control run.

Unidentified operational reason

One potential operational cause that could not be conclusively ruled out was distraction caused by the presence of birds after takeoff, although none of the eyewitness reports mentioned birds.

*Light stick forces*

Regardless of the reason for the excessive aft stick input, the aircraft's very light longitudinal stick forces make an excessive aft input more likely. The flight evaluation revealed that a force of 0.3 dAN, relative to a break-out force of 0.1 dAN, was sufficient to cause an excessively high pitch attitude that would lead to a stall from an entry speed of 41 to 44 KIAS. 0.3 dAN is a pull force that can be generated with a 300 g weight. The stick force gradient is also very flat at 0.1 dAN per 10 kt nose-down and 0.06 dAN per 10 kt nose-up (at low speeds). This is less than half of the CS-22 requirement of 0.19 dAN per 10 kt. The requirements in LTF-UL are more subjective and only require that the gradient be positive which might explain why it was approved.

The manufacturer stated that other ultralights have light stick forces and that their customers like it for comfort reasons, but this comes at a cost to safety. Light stick forces mean that excessive pitch deviations are more likely, which can lead to an inadvertent stall. The manufacturer stated that they will consider adding a spring to the pitch control system to increase the stick forces if they resume production. Adding a standard pitch trim system would also help to compensate for any increase in stick forces.

Pilots can also increase the stick forces by applying more nose ballast to move the CG forwards which increases longitudinal stability. The aircraft manufacturer suggested that low time pilots in particular should consider doing this.

As a result of this investigation, the BGA sent a *'Safety Briefing'*, based on the information from the flight evaluation and investigation findings, to Silent 2 Electro owners in the UK and published it on their website[36] on 28 January 2022. They also sent it to the European Gliding Union (EGU) on 2 February 2022, for onward dissemination to 20 other European gliding associations and to the EGU safety working group. The BGA does not regulate SSDR's but does provide guidance to all sailplane operators to help to maintain and improve safety. The *'Safety Briefing'* is at Appendix A, and it states the following regarding stick forces:

> *'Very light stick forces in pitch combined with high levels of friction in the controls. This means the pilot receives minimal feedback on how the aircraft is responding to control inputs. Flying with a more forward cg should increase stability and stick forces.'*

*Stall characteristics and stall warning*

The excessive pitch attitude after takeoff which reached a maximum of about 30° to 35° might have been avoided if the aircraft characteristics had provided the pilot with a strong indication that the aircraft was approaching the stall. There was no artificial stall warning device fitted and the aerodynamic buffet was very subtle and only occurred about 1 kt or 1 second above stall.

This accident is similar to the accident to G-CIYA where the pilot also adopted a high pitch attitude after takeoff and either did not recognise the approach to stall or reacted too late to it.

CS-22 states that there must be a clear and distinctive stall warning via natural buffet or an artificial device, and that the warning must begin 2 to 5 seconds before the stall occurs (or 5% to 10% above stall speed). The buffet during the flight evaluation was not distinctive and did not occur within the time or speed parameters. However, it appears that this may have

**Footnote**

[36] https://members.gliding.co.uk/bga-safety-management/managing-flying-risk-index/motorgliders-self-launching-and-self-sustainer-sailplanes/ [accessed March 2022]

 

still met the CS-22 requirements as no stall warning is required if there is no appreciable wing drop if recovery action is taken at the first indication of stall. But when you stall from a low height the lack of appreciable wing drop is not necessarily going to assure a safe outcome. A stall in the Silent 2 Electro cannot be recovered from 100 ft even without a wing drop. The only way to help prevent a low altitude stall is to provide a distinctive stall warning with a sufficient margin.

A stall warning vane or suction port could be added to the aircraft, or aerodynamics strips could be added to the wing to trigger more natural buffet near stall. However, these affect the glide performance, so the manufacturer was not considering them.

Pilots typically practice power-off stalls when learning to fly a new aircraft type, and the manufacturer considered that there could be a safety benefit for Silent 2 Electro pilots to practice full power stalls to help them recognise the onset of stall in the takeoff scenario.

The BGA's *'Safety Briefing'* about the Silent 2 Electro therefore includes the following:

> *'Very little physical or aural indication that a stall is approaching with full power. Practising power-on stalls at a safe height can teach the pilot how to recognise the subtle indications of an approach to a stall with full power (and with other power settings).'*

The aircraft manufacturer's test pilot stated that an additional measure that could be taken to reduce the risk of a stall on takeoff is to do a self-launch with flap 0. He stated that it provides a higher trim speed with negligible increase in stall speed compared to flap +1, so it provides a higher speed and stick force margin to stall. The manufacturer stated that they would consider adding flap 0 as a takeoff setting to the flight manual if they resume production.

As an interim measure the BGA's *'Safety Briefing'* about the Silent 2 Electro includes the following guidance for pilots to consider:

> *'Self-launching with Flap 0 instead of Flap +1 (Flap +1 is recommended in the flight manual) may be helpful. There is very little difference in stall speed between Flap 0 and Flap +1, but the trim speed is higher with Flap 0, which means that there is a higher trim margin to stall. The angle of climb will be shallower with Flap 0.'*

Taking off with sufficient airspeed can help reduce the risk of a stall. The flight manual does not provide a takeoff or climb speed and the aircraft manufacturer provided some conflicting advice on what this speed should be. They stated that they would add some speeds to the flight manual if they resumed production. The test pilot who carried out the flight evaluation recommended a 50 KIAS initial climb speed which was also what the accident pilot said he targeted.

The BGA's *'Safety Briefing'* about the Silent 2 Electro therefore includes the following:

> *'The flight manual does not provide a take-off or climb speed. A climb speed of 50 kts provides normal handling and should ensure a good margin to stall.'*

*FCU throttle design*

The test pilot found that during an aborted takeoff it took him time to select 0 rpm using the rotary throttle knob and that doing this while maintaining directional control involved a high pilot workload, but that practice and familiarity made it easier. The accident pilot also said that in an emergency requiring immediate motor shutdown, operating the throttle knob would be highly distracting and divert attention away from flying the aircraft. Both CS-22 and LTF-UL state that the throttle control must move forward to increase power, and by implication aft to reduce power. The FES throttle control was initially designed to be used as a 'sustainer' motor, meaning that it would be turned on in flight and turned off before landing. For a purely airborne operation a rotary throttle knob may be appropriate and it takes up less cockpit space, but for a throttle that is used for takeoff and where a takeoff may need to be suddenly aborted, its operation is not quick or as intuitive. However, rehearsing the physical actions of an aborted takeoff may help.

The BGA's *'Safety Briefing'* about the Silent 2 Electro therefore includes the following:

> *'Procedure for an aborted take-off. Cutting the power quickly using the FES rotary knob is not as easy or as intuitive as pulling back on a throttle lever (for example in a TMG). Pilots should on all occasions complete a comprehensive self-brief for the take-off and any eventualities. This should always contain a point on the take-off run where the acceleration of the aircraft can be checked. Pilots should mentally rehearse what they would do in the event of needing to abort a take-off so as to be able to quickly and correctly react to a problem.'*

The BGA have also published the following guidance on their website[37]:

> *'Note 2. Flight training for self-launching privileges is likely to take place in a TMG. It should be noted that the forward and aft moving throttle lever in a TMG operates differently from the rotary knob which is a feature in many electrically powered self-launching sailplanes. The difference should be carefully considered, including rehearsing how to abandon a takeoff, eg rotate the knob fully anti-clockwise, and how to manage a total or partial power failure on takeoff in a very light aircraft where the aircraft may take longer than expected to accelerate following recovery from the power failure.'*

**Footnote**

[37] https://members.gliding.co.uk/flying-information-and-resources/pilot-licensing/declared-training-organisation-easa-compliant-training [accessed March 2022]

*Takeoff technique*

The FMM guidance is to maintain a '*tail down attitude* [during the takeoff roll] *to avoid a prop*[eller] *strike*' but it does not specify whether the tail wheel should be held on the ground or to what degree it can, or should, be raised as airspeed increases. The pilot of G-CIRK reported that he aimed for a neutral pitch attitude when raising the tail, but this could increase the risk of a propeller strike.

The BGA's *'Safety Briefing'* about the Silent 2 Electro therefore includes the following:

> *Take-off technique. Keeping the tailwheel on the ground, or just above it, until lift-off reduces the chance of a propeller strike. Aggressive use of large forward stick inputs early in the ground run should be avoided, particularly on uneven surfaces, as this increases the likelihood of overcontrolling in pitch and a prop strike.*

*Erroneous airspeed during a stall*

The flight evaluation revealed that during power-on stalls the propeller slipstream impinged on the pitot tube and caused erroneous overreadings on the ASI. The aircraft manufacturer was not aware of this issue and stated that they would investigate it if they resumed production. They believed that the pitot tube had been changed by the original aircraft manufacturer from an angled pitot tube to a straight pitot tube to reduce aerodynamic drag, but it is possible the change was also to address ASI overreadings.

The BGA's *'Safety Briefing'* about the Silent 2 Electro therefore includes the following:

> *'Indicated airspeed can increase erroneously during and post stall when full power is set.'*

*Weight and balance*

Measurements on another Silent 2 Electro revealed a discrepancy between the measured moment arm of the nose ballast and the moment arm used in its weight and balance table. The moment arm measured between the centre of the nose ballast and the wing leading edge datum was 10 cm more forward than the figure used in the table. The manufacturer was asked to provide information to help explain the discrepancy, but this information has not been provided yet. It is possible that the datum being used in the tables is different to the datum shown in the flight manual. Silent 2 Electro owners should be made aware of this potential discrepancy.

The BGA's *'Safety Briefing'* about the Silent 2 Electro therefore includes the following:

> *Weight & balance. The weight and balance tables for one aircraft seem to be using a moment arm for the nose ballast that is 10 cm greater than the physical distance measured. This would mean that the W&B tables are indicating a more forward CG than reality.*

*SSDR Pilot licensing*

The pilot was correctly licenced and qualified for self-launch takeoffs in the Silent 2 Electro and held a current flight medical at the time of the accident. Although the pilot's understanding of the rules regarding flight without a current self-launching privilege was incorrect, this did not affect his approach to flying G-CIRK. The pilot reported that his intention had been to maintain his self-launch qualification to give increased flexibility in selecting the most appropriate launch method for a given day's flying. While the pilot had no recollection of the events on the day of the accident, he surmised that he was carrying out self-launches for the purpose of maintaining the launch-type privilege.

The investigation found that some confusion remained in the glider pilot community regarding the regulatory requirements for flying SSDR gliders. It was likely that this confusion had, in part, stemmed from the wording of CAA Information Note 2014/139 which was rescinded in 2016. Contrary to some pilots' understanding, the regulations in force at the time of the accident did not require them to gain a self-launch endorsement for their first flights on this type of glider. Launch type privileges earned on other gliders were transferable to SSDRs. If he had chosen to do so, the accident pilot could have undertaken his first flights in G-CIRK at his home club by winch launching, for which his licence was already suitably endorsed. There is no enduring requirement for SSDR glider pilots to maintain self-launch currency provided they do not use that launch method if the privilege has lapsed. The BGA have added additional guidance to their website to make this clear.

*FMM guidance*

While the FMM could have been more comprehensive, it exceeded UK regulatory requirements at the time of the accident. The flight notes developed by the manufacturer's UK agent were well-intentioned but were also an implicit acknowledgement that the FMM lacked detail in some areas. The aircraft manufacturer has stated that it will amend the FMM if it resumes production. In the meantime, the BGA's 'Safety Briefing' provides useful guidance.

*BPRS awareness*

Emergency services first responders attending the accident were initially unaware of the potential risk to life posed by the undeployed BPRS system fitted to G-CIRK. Had the accident occurred in a more remote location without BPRS-aware bystanders emergency services personnel would have only had the BPRS placards to alert them of the hazard. In some accidents the placards can be obscured as a result of structural damage, wreckage orientation or due to fire. An additional layer of safety would be to have an information system that can be used by the emergency services to identify aircraft fitted with a BPRS before the emergency services arrive at the scene. As a result the CAA have updated the aircraft register, G-INFO, to indicate if an aircraft is fitted with a BPRS or other ballistic recovery system such as an ejection seat. The CAA are also planning to contact the registered owners of SSDR aircraft, which are fitted with a BPRS device, to inform them of the BPRS placard types and sizes that should be fitted.

The AAIB also plans to update its guidance document to the emergency services to inform them of the availability of this new information on the G-INFO database.

## Conclusion

The accident was the result of an excessively steep climb after takeoff which resulted in a stall that was not recognised or the reaction to it was too late to effect recovery. No mechanical fault or defect was found that would explain the aircraft pitching up excessively after takeoff. The steep climb was most likely the result of an excessive aft stick input that was not corrected.

While the investigation could not positively identify the cause of the aft stick input, it is likely that distraction, pilot workload or stress were factors in the accident. These factors coupled with the aircraft's characteristics of low stick forces with low sensory feedback, and poor stall warning indications made the accident more likely to occur.

### Safety actions

The BGA has published and sent a *'Safety Briefing'* to Silent 2 Electro owners in the UK and to the EGU which provides guidance on operating the Silent 2 Electro (Appendix A). It covers ways to address the aircraft's stick force characteristics, its stall characteristics, recommendations on takeoff handling, takeoff flap and takeoff speeds, as well as recommendations on mentally rehearsing aborted takeoffs.

On 24 January 2022 the CAA updated G-INFO to show when an aircraft is fitted with an Emergency Ballistic Device, such as a Ballistic Parachute Recovery System (BPRS), an active ejector seat or canopy miniature detonating cord. The CAA undertook the task of identifying UK-registered aircraft fitted with such devices to support this change. To capture newly-registered aircraft with an Emergency Ballistic Device in the future, the CAA is updating the aircraft registration process to specifically require owners to declare the aircraft status with respect to an Emergency Ballistic Device.

The CAA are planning to contact the registered owners of SSDR aircraft, which are fitted with a BPRS device, to inform them about Sky Wise article SW2021/91 which strongly recommends that owners of these aircraft comply with the requirements of BCAR Section S, Sub-Section K, to clearly identify the presence of the BPRS.

*Published: 7 April 2022.*

## Appendix A

Copy of BGA Safety Briefing sent to UK-based Silent 2 Electro owners and published on the BGA website on 28 January 2022[38]. A link to the briefing was also provided via BGA e-news[39]. This document was also sent to the European Gliding Union (EGU) on 2 February 2022 for onward dissemination to 20 other European gliding associations and to the EGU safety working group.

### GUIDANCE FOR PILOTS OF SSDR SELF-LAUNCHING SAILPLANES

#### Single Seat De-Regulated (SSDR) aircraft

There are very few formal requirements surrounding SSDR's. They are freed from the burden of airworthiness regulation because they pose negligible risk to third parties. However, they are not required to be designed and built to the same standard or have the same level of crashworthiness as conventionally designed CS22 sailplanes and powered sailplanes. The fact that there is no legal requirement for design evaluation, maintenance or flight testing does not mean that these should not be done. It is entirely up to the owner to decide on his or her own approach to these activities; BGA inspectors can provide guidance to owners.

Licencing and medical requirements apply. Flight training for self-launching privileges is likely to take place in a TMG. Launch type training and conversion guidance applicable to pilots of all self-launching sailplanes including SSDR's is available from the BGA website[40] and is recommended to all new pilots of self-launching sailplanes including SSDR's. BGA instructors can provide guidance.

#### Guidance specific to the Silent 2 Electro

Test flying of a Silent 2 Electro in support of an accident investigation has identified several features associated with the type that pilots may not be aware of:

1. <u>Very light stick forces in pitch combined with high levels of friction in the controls.</u> This means the pilot receives minimal feedback on how the aircraft is responding to control inputs. Flying with a more forward cg should increase stability and stick forces.

**Footnote**

[38] https://members.gliding.co.uk/bga-safety-management/managing-flying-risk-index/motorgliders-self-launching-and-self-sustainer-sailplanes/ [accessed March 2022]
[39] https://members.gliding.co.uk/2022/01/28/guidance-for-pilots-and-owners-of-ssdr-aircraft/ [accessed March 2022]
[40] https://members.gliding.co.uk/flying-information-and-resources/pilot-licensing/declared-training-organisation-easa-compliant-training/?web=1&wdLOR=c3C4F391C-EFC3-47B7-B3CB-B459A073B23B [accessed March 2022]

2. Very little physical or aural indication that a stall is approaching with full power. Practising power-on stalls at a safe height can teach the pilot how to recognise the subtle indications of an approach to a stall with full power (and with other power settings).

3. Indicated airspeed can increase erroneously during and post stall when full power is set.

4. Self-launching with Flap 0 instead of Flap +1 (Flap +1 is recommended in the flight manual) may be helpful. There is very little difference in stall speed between Flap 0 and Flap +1, but the trim speed is higher with Flap 0, which means that there is a higher trim margin to stall. The angle of climb will be shallower with Flap 0.

5. The flight manual does not provide a take-off or climb speed. A climb speed of 50 kts provides normal handling and should ensure a good margin to stall.

6. Take-off technique. Keeping the tailwheel on the ground, or just above it, until lift-off reduces the chance of a propeller strike. Aggressive use of large forward stick inputs early in the ground run should be avoided, particularly on uneven surfaces, as this increases the likelihood of overcontrolling in pitch and a prop strike.

7. Procedure for an aborted take-off. Cutting the power quickly using the FES rotary knob is not as easy or as intuitive as pulling back on a throttle lever (for example in a TMG). Pilots should on all occasions complete a comprehensive self-brief for the take-off and any eventualities. This should always contain a point on the take-off run where the acceleration of the aircraft can be checked. Pilots should mentally rehearse what they would do in the event of needing to abort a take-off to be able to correctly react to a problem.

8. Weight and balance. The weight and balance tables for one aircraft seem to be using a moment arm for the nose ballast that is 10 cm greater than the physical distance measured. This would mean that the W&B tables are indicating a more forward CG than reality.

Risk management guidance for flying motor gliders, self-launching and self-sustainer sailplanes is available from the BGA website[41].

**Footnote**

[41] https://members.gliding.co.uk/bga-safety-management/managing-flying-risk-index/motorgliders-self-launching-and-self-sustainer-sailplanes/ [accessed March 2022]

## ACCIDENT

| | |
|---|---|
| **Aircraft Type and Registration:** | DJI Matrice M210 Version 1 (UAS, registration n/a) |
| **No & Type of Engines:** | 4 electric motors |
| **Year of Manufacture:** | 2017 (Serial no: 0G0DECG0230007) |
| **Date & Time (UTC):** | 19 November 2020 at 1150 hrs |
| **Location:** | Poole, Dorset |
| **Type of Flight:** | Emergency services operations |
| **Persons on Board:** | Crew - None Passengers - None |
| **Injuries:** | Crew - N/A Passengers - N/A |
| **Nature of Damage:** | Damage to right leg and propeller blades |
| **Commander's Licence:** | Other |
| **Commander's Age:** | 38 years |
| **Commander's Flying Experience:** | 14 hours (of which 5 were on type)<br>Last 90 days - 2 hours<br>Last 28 days - 1 hours |
| **Information Source:** | AAIB Field Investigation |

### Synopsis

The quadcopter unmanned aircraft (UA) was being flown over the city of Poole during a police operation when the wind at 400 ft exceeded the forecast wind, the manufacturer's wind limit and the maximum restricted speed of the UA. The UA drifted beyond visual line of sight and then communication with it was lost. When the battery level was low it entered an auto-land mode but collided with the wall of a house, damaging its propeller blades before coming to rest on a balcony.

The investigation revealed that shortly after takeoff one of the UA's two batteries had disconnected which resulted in its maximum speed being restricted, but this restriction is not referenced in the user manual and neither the remote pilot nor operator were aware of it. When the UA detected that the manufacturer's wind limit had been exceeded, the message triggered on the pilot's controller display was '*Fly with caution, strong wind'* instead of advising the pilot that the limit had been exceeded and that the UA should be landed as soon as possible.

Three Safety Recommendations are made to the UAS manufacturer and one to the CAA on Visual Line of Sight guidance.

**History of the flight**

The DJI Matrice M210 Version 1 is a quadcopter UAS with a maximum takeoff mass of 6.14 kg. It was being used for a police operation over the city of Poole. The remote pilot was working with an observer who had a slave controller. At 1108 hrs the remote pilot obtained a wind forecast at 400 ft of 24 mph from the north-west using a UAS weather forecast app. At 1117 hrs, a flight towards the south-west was carried out with no issues. The two batteries were replaced and then at 1145 hrs the UA took off again. Standard control checks were carried out at a height of 10 m before climbing to 120 m (400 ft) and flying south-east towards a target location that was 500 m away.

The remote pilot reported that he maintained a good visual sight of the UA and referred to his controller for flight and aircraft information. He then noticed two messages on the controller screen: one stating '*Battery communication error'* and then another stating '*Fly with caution, strong wind'*. He noted that one of the batteries was showing 97% state of charge (SOC) while the other battery SOC was decreasing faster than normal. The pilot tried to fly the aircraft back towards him, but it did not appear to be moving any closer. He then noted that one battery was showing 58% SOC while the other was still showing 97%. The pilot used the map function to check the aircraft's orientation and confirmed it was correct, but it was still not returning. The aircraft's distance from the pilot began to increase beyond 500 m which is not normally possible because the maximum flight distance from the remote pilot had been set to 500 m using the DJI Pilot app.

The pilot was now very concerned and activated the *'Return to home (RTH)*' feature on the controller, but it did not appear to engage despite being operated multiple times. RTH then appeared to activate but the aircraft did not move any closer. The pilot then switched to *'Sport Mode'* as per their emergency procedure which he expected would give him a top speed of 51 mph, allowing a greater ability to overcome the headwind. This cancelled the RTH feature so he pressed RTH again, but it would not re-engage. The remote pilot asked the observer to try engaging it using his slave controller, but this did not work either. At this stage neither the pilot nor the observer could see the aircraft, but they could see it on the moving map heading slowly towards Poole Park boating lake in a south-easterly direction (Figure 1). Both controllers then lost communication with the aircraft.

The pilot and observer packed their kit and drove to the last location of the aircraft shown on the map display. When they arrived in the area of the last position, the controllers regained communication with the aircraft and displayed its GPS coordinates. They found the aircraft on a first-floor balcony of a house (Figure 2). There was no one at the front of the property but there was light foot traffic along the path by the lake, about 30 m from the aircraft's location. The aircraft's right leg had snapped at the mounting bracket, three propeller blades had shattered, and one propeller had detached but was located next to the aircraft.


**Figure 1**

Accident flight ground track

Underlying image © Google Earth ™

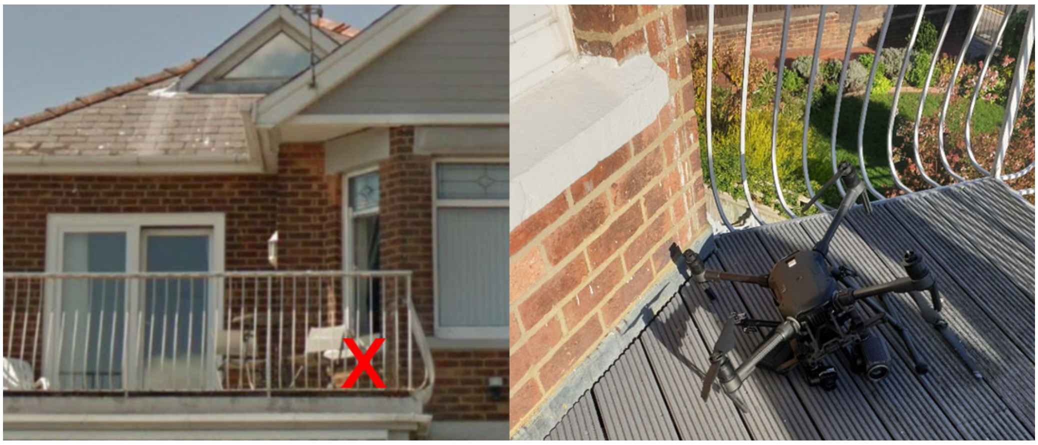

**Figure 2**

Accident site location and damage to UA

**Remote pilot comments**

The pilot reported that he could not recall the exact wording of the warning that flashed up regarding the battery and that he had not seen it before or since. He said that the messages flash up on the screen of the controller for a few seconds, then go into a temporary alarm stack that can be reopened but they also disappear from this stack in a matter of "seconds rather than minutes". He stated that there is no audio alarm for any messages which is an issue because the pilot needs to spend more time looking at the UA than looking at the controller screen.

The pilot reported that his pre-flight check involved a full check of both batteries for damage, operational use and full charge, but a future consideration would be an additional safety check where both pilot and observer independently check both batteries are secured.

He also said he would recommend that every operator perform a battery/power check at the beginning of a flight by monitoring the screen, to ensure both batteries are reducing charge at the same rate prior to climbing away.

**Recorded information**

The operator sent the data log files from the master controller and the aircraft to the AAIB and the aircraft manufacturer for analysis. The data revealed the following sequence of events:

> 24 seconds after takeoff, at a height of 266 ft[1], Battery 1 lost communication with the UA. The manufacturer stated that this was probably caused by a physical loss of connection between the battery and battery terminal. This resulted in the battery no longer supplying power to the aircraft and the display of its SOC remained frozen at 97% for the rest of the flight. Battery 2 was now supplying sole power and its SOC started reducing faster than normal from 96% down to 16% by the end of the flight about 11 minutes later.
>
> According to the manufacturer the message displayed on the controller 24 seconds after takeoff was: '*The communication to the battery is abnormal. Please land as soon as possible and check if the battery is installed properly.*' However, the pilot did not recall seeing that level of detail.
>
> When Battery 1 became disconnected the total battery percentage figure dropped from 97% to 48% but this recorded parameter was not displayed on the pilot's controller. This drop in total battery capacity triggered a limitation on the aircraft's pitch attitude. The aircraft manufacturer stated that this was to ensure flight safety. The restricted aircraft pitch attitude resulted in the maximum airspeed also being restricted. The data shows that the pitch and roll attitude was always below 15° during the flight apart from momentary spikes up to 18° (the normal limit is 25°).
>
> 48 seconds after takeoff, at a height of 325 ft, and 181 m south-east of the pilot, the following message was displayed on the controller: '*High Wind Velocity. Fly with caution.*' This message is triggered when the aircraft has calculated[2] that the wind speed has reached 10 m/s (22.4 mph). This is referred to by the manufacturer as a 'Level 1 warning'.

**Footnote**

[1] The height shown in this report is the recorded parameter 'GPS:heightMSL'. The takeoff figure was -1 ft and the end of flight figure was 5 feet. The ground level at takeoff was 6 ft above sea level and the ground level at the end of flight was 0 ft above sea level, so the altitude (amsl) and height (agl) were considered equal in this report.

[2] The UA cannot measure windspeed directly, but it knows its groundspeed and direction from GPS, and it can estimate its airspeed and direction based on the aircraft's pitch attitude and motor speeds. When both groundspeed, airspeed, and their directions are known, the windspeed and direction can be calculated.

1 minute and 11 seconds after takeoff, a wind 'Level 2 warning' was triggered when the windspeed reached 12 m/s (26.8 mph), but the message displayed to the pilot was the same as a 'Level 1 warning': '*High Wind Velocity. Fly with caution*.'

None of the above three alerts were accompanied with an aural alarm, and the manufacturer was unable to say how long the alert messages would remain visible for on the controller screen.

The UA calculated wind profile for the flight is shown at Figure 3.

6 minutes and 37 seconds after takeoff, at a height of 393 ft and 552 m south-east of the pilot, with the recorded windspeed at 33 mph and increasing, the aircraft was drifting in the direction of the wind at a groundspeed of 7 mph with no pilot input, while pitched 13° into wind. With no pilot input the groundspeed would normally be zero.

7 minutes and 0 seconds after takeoff, at a height of 393 ft and 633 m away, the UA entered RTH mode, but the UA did not start to move towards the takeoff location because it could not overcome the wind with its limited pitch attitude.

8 minutes 28 seconds after takeoff, at a height of 232 ft and 806 m away, communication between the controller and UA was lost. At this time the UA was drifting south-east at 3 mph. When communications are lost the UA would normally enter a 'Failsafe RTH' mode, but it could not return home due to the wind and limited pitch attitude.

10 minutes 5 seconds after takeoff, at a height of 297 ft, the UA entered an 'Auto Land' mode and started a descent. Battery 1 SOC was still 97% and battery 2 SOC was at 23%.

11 minutes 17 seconds after takeoff, the descent ends at a height of 3 ft, and the motors stop. The final 30 ft of descent was at an average descent rate of 1.7 ft/second.

## Aircraft information

The DJI Matrice M210 Version 1 is operated using a tablet device running either the DJI GO4 app or the DJI Pilot app. The pilot in this accident was using the DJI Pilot app. The aircraft user manual[3] contains some information and screenshots for the DJI GO4 app but none for the DJI Pilot app and there is no separate user manual for the DJI Pilot app. The aircraft user manual does not provide any information on the caution or warning messages that can appear in either app.

**Footnote**

[3] Matrice 200 Series M210/M210 RTK User Manual V1.4 (2018.11) – latest version at the time of the accident.

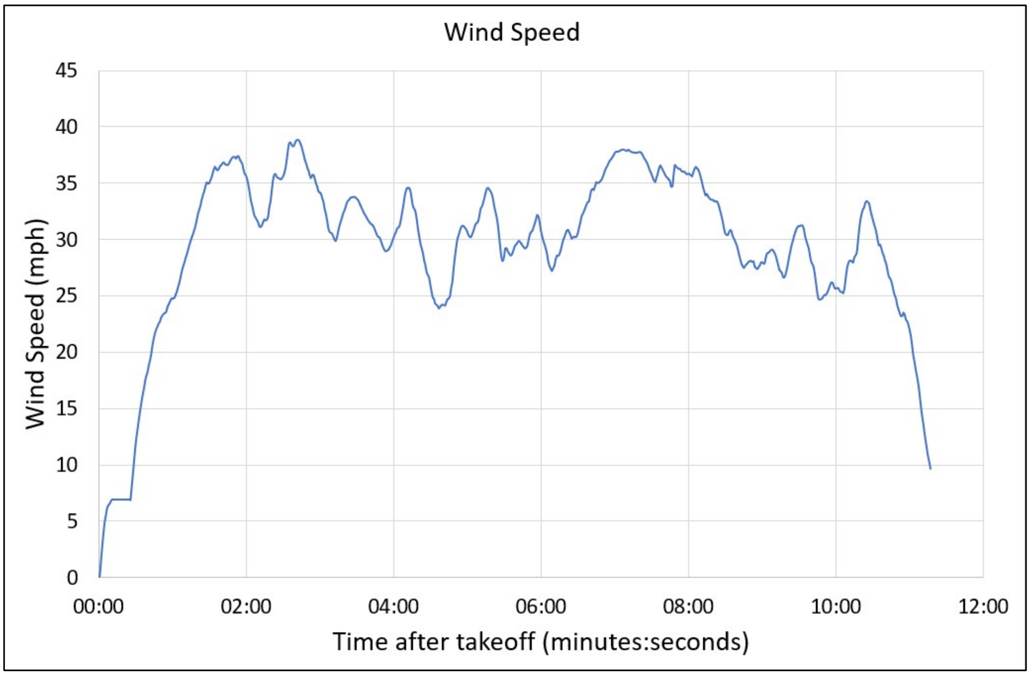


**Figure 3**

Calculated Wind Speed recorded by UAS (mph)
Peak wind is 39 mph at time 02:41

The aircraft has three operating modes: (1) P-mode is the normal control mode; (2) A-mode is a manual mode without position holding; and (3) S-mode is the 'sport mode' which provides for a higher top speed. The user manual states the following speed and pitch angle limits:

| | Max Speed | Max Pitch Angle |
|---|---|---|
| P-mode | 35.8 mph | 25° |
| A-mode | 35.8 mph | 25° |
| S-mode | 40.3 mph | 30° |

**Table 1**

Matrice M210 speed and pitch angle limits (from aircraft user manual)

The accident aircraft was fitted with dual camera gimbals with a Z30 Zenmuse camera and a XT2 Zenmuse thermal camera. The manufacturer's website provides different speed limits depending on whether one or two camera gimbals are fitted, whereas the user manual only provides one set of figures. In P or A mode, with dual gimbals, the website states a maximum speed of 38 mph, which is 2.2 mph higher than that in the user manual. With a single gimbal the website states a maximum speed of 51.4 mph in both A-mode and S-mode, and 38 mph in P-mode.

The user manual does not state that the aircraft's pitch attitude or top speed are restricted below a certain battery level. The aircraft manufacturer was unable to provide further information on the battery capacity trigger figure, the pitch limit in degrees or the resulting airspeed limit. According to the accident recorded data the aircraft appears to limit its pitch and roll attitudes to 15°, which is 10° less than the limit specified in the user manual for A and P modes.

The user manual and website state a *'Max Wind Resistance'* figure of 12 m/s which is equal to 26.8 mph. The *'Matrice 200 Series Disclaimer and Safety Guidelines v1.6'* states: *'Do not fly when the wind speed exceeds 12 m/s or 27 mph'*. Whereas a section of the user manual entitled *'Flight Environment Requirements'* states *'Do not use the aircraft in severe weather conditions. These include wind speeds exceeding 10 m/s, rain, and fog'*. 10 m/s is equal to 22.4 mph.

The Matrice 200 series of UAS are no longer produced. They have been replaced by the Matrice 300 series UAS.

**Operator information**

After the accident the operator removed the batteries, re-charged them, and installed them in a Matrice M210 Version 2 which has some differences to the Version 1 but the motors are the same. The aircraft was flown in a hover until the batteries had reduced from 100% to 20%. They repeated the test three times and the flight times varied between 23 minutes 44 seconds and 25 minutes 33 seconds. The air temperature during the tests was between 9° to 11° C.

The operator had an Emergency Procedure for *'Loss of GPS or Fly Away'*. The symptom was described as '*Drone not holding position and/or drone drifting with the wind*'. The first four pilot actions were:

> '1. *If using M210 or Inspire, ensure the switch in controller is set to P-GPS and not ATTI (top left side of the controller).*
>
> 2. *Consider putting drone in to Sport Mode if wind is strong to give extra motor power to drone.*
>
> 3. *Activate RTH if able.*
>
> 4. *Attempt to regain control of drone using stick inputs. If control is regained, land immediately. Verbalise input commands so observer can note any actions.*[4]'
>
> The subsequent actions involve activating the pilot's body-worn video camera, considering stopping the motors, using the moving map to determine its location and orientation, and notifying other airspace users.

**Footnote**

4 The following is a note which was not part of the text: 'Sport Mode' or 'S-mode' does not 'give extra motor power'. It increases the pitch limit to 30° which increases its capable speed.

The operator stated that they operate to the 12 m/s (27 mph) manufacturer wind limit. They routinely operated the Matrice out to a distance of 500 m, in part they stated because 500 m was a distance that the CAA had established as being the accepted range for VLOS operations. They stated that the Matrice is “easily visible” in the sky at 500 m but that it is much more difficult to identify forward and backwards movement purely by line of sight. They stated that the orientation can be obtained by trial and error. If you move the stick left and the UA moves right then you know it is facing towards you. If there is no apparent movement then you know it is side-on and moving the stick forwards can then establish its orientation. The operator also stated that, if necessary to avoid collision, the pilot can also increase or decrease the height of the UA as required. But if the video and telemetry feed is available then this would be used to confirm orientation.

After this accident the operator started training their pilots to be able to recover the Matrice from a distance of 500 m without reference to the video or telemetry, and also in manual A-mode to simulate a loss of position holding capability that could result from a loss of GPS or compass interference.

In October 2021 the operator notified the AAIB that they had retired their Matrice M210 UAS and were using the newer Matrice M300. They also stated that they have implemented the following measures:

- *‘All our pilots have recently had their annual CPD where they received a specific classroom input and practical familiarisation on the M300, its capabilities and limitations. This is approximately 90 minutes in the classroom and then a practical flight with an instructor. As part of this all pilots are reminded about reading notifications on the screen and the fact there is a bell in the top left corner so any new notifications are highlighted with a red number, so if a pilot missed one they can click the bell to see any warnings that have been shown.*
- *We have now introduced a buddy check system so both crew members have to confirm the integrity of the battery and that it is secured in to the drone correctly – on the M300 there is now a safety clip that secures the batteries in place and the drone will not allow a pilot to start the motors or take-off unless this clip is in place.*
- *The M300 also displays wind speed and wind direction in the pilot app (in metres/second) whilst flying so all our pilots are aware of the maximum operating limits and are trained to keep an eye on this during flight.’*

**Visual Line of Sight (VLOS) rules**

The UAS Implementing Regulation (EU) 2019/947[5] states that:

> *'Visual line of sight operation' ('VLOS') means a type of UAS operation in which, the remote pilot is able to maintain continuous unaided visual contact with the unmanned aircraft, allowing the remote pilot to control the flight path of the unmanned aircraft in relation to other aircraft, people and obstacles for the purpose of avoiding collisions.'*

The CAA's document on *'Unmanned Aircraft System Operations in UK Airspace – Guidance'* (CAP 722)[6] provides the following additional guidance on VLOS in section 2.1.1:

> *'Operating within Visual Line of Sight (VLOS) means that the remote pilot must be able to clearly see the unmanned aircraft and the surrounding airspace at all times while it is airborne. The key requirement of any flight is to avoid collisions and a VLOS operation ensures that the remote pilot is able to monitor the aircraft's flight path and so manoeuvre it clear of anything that it might collide with. While corrective lenses may be used, the use of binoculars, telescopes, or any other forms of image enhancing devices are not permitted. Putting things in very simple terms, when operating VLOS, the aircraft must not be flown out of sight of the remote pilot's eyes.*
>
> *The CAA will normally accept that the VLOS requirement is met when the UA is flown out to a distance of 500 metres horizontally from the remote pilot, but only if the aircraft can still be seen at this distance.*
>
> *The 'operating height' is limited to a maximum distance of 400 feet (120 metres) from the closest point of the earth's surface (see para 2.1.1.1 below). Operations at a greater distance from the remote pilot may be permitted if an acceptable safety case is submitted. For example, if the aircraft is large it may be justifiable that its flight path can be monitored visually at a greater distance than 500 metres. Conversely, for some small aircraft, operations out to a distance of 500 metres may mean it is not possible to assure or maintain adequate visual contact, and so the aircraft must obviously be kept closer to the remote pilot.'*

The CAA were asked why a figure of 500 m was chosen as the normally acceptable distance for VLOS. The CAA stated that it was not based on any calculations of size of a typical UAS at that distance, but rather it was a '*pragmatic anchor point'* in guidance from one of their UAS policy experts.

The CAA were of the view that if you needed to rely on the controller screen to determine the UA's orientation then that would not satisfy VLOS rules.

**Footnote**

[5] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32019R0947 [Accessed 18 February 2022]
[6] CAP 722, Eighth Edition, 5 November 2020

The Matrice M210 has dimensions of 0.51 x 0.51 x 0.38 m without the propellers. Its height is 0.38 m so when it is flying level and viewed from a distance, it presents a profile of 0.51 m by 0.38 m. At a horizontal distance of 500 m this dimension would present an angular size of 0.06° by 0.04°[7]. On a piece of paper held at a normal reading distance[8] of 35 cm, the size of the Matrice can be represented by a small square of dimensions 0.4 by 0.3 mm.

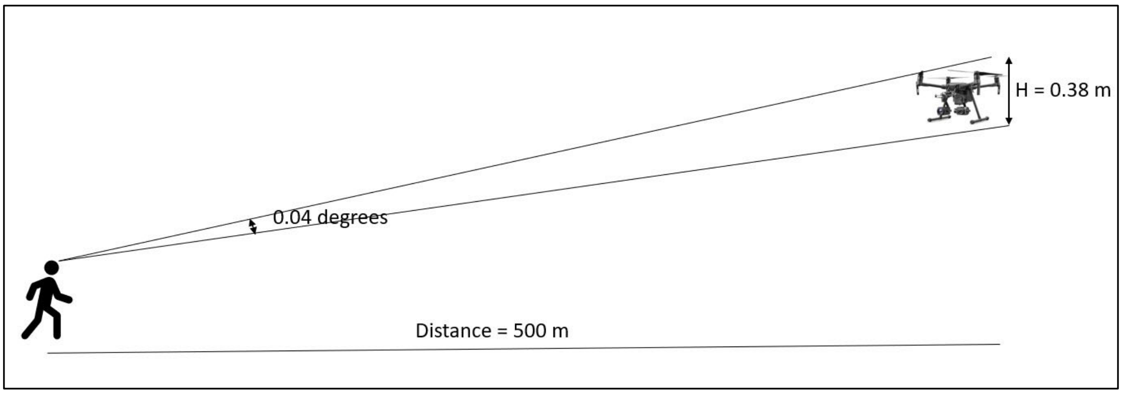


**Figure 4**

Angular height of Matrice M210 at a distance of 500 m

### UAS manufacturer support

The UAS manufacturer has provided support to this investigation and has assisted in analysing some of the data. However, a number of follow-up questions were posed to the UAS manufacturer in July 2021 which had still not all been answered by December 2021 despite multiple chases. In a report on a DJI Matrice 200 accident[9], published on 18 February 2021 the AAIB issued the following safety recommendation to the manufacturer:

> **Safety Recommendation 2021-016**
>
> It is recommended that DJI introduce an effective system for providing timely technical support to State safety investigations.

The manufacturer's response on 30 June 2021 included the following:

> *'DJI has over the past 15 years developed and refined drone technology that has been widely adopted by professional and recreational users alike. Based on our user experience data, we estimate there are tens of millions of drone flights every year. Since no one in the world has ever died as a result of a drone flight,*

**Footnote**

7 How to calculate angular size is explained in https://www.open.edu/openlearn/science-maths-technology/the-sun/content-section-3.2 ( [Accessed 18 February 2022]

8 Normal reading distance from https://www.ncbi.nlm.nih.gov/books/NBK423833/ [Accessed 18 February 2022]

9 Link to report: https://www.gov.uk/aaib-reports/aaib-investigation-to-dji-matrice-200-v1-uas-registration-n-slash-a-210919 [Accessed 18 February 2022]

*this means the accidental fatality rate for drones is zero – making it the safest form of aviation the world has ever known.*

*While this and other data reaffirms our conviction that our products are safe and reliable, we have long believed that incidents and accidents involving drone safety must be investigated to understand their causal factors. DJI routinely participates in regulatory efforts around the world to gather safety data on drone performance, study drone safety factors in academic experimentation, and investigate drone incidents.*

*As previously discussed, DJI has introduced a process for how to coordinate our different teams, gather information systematically under firm timelines, and ensure we can respond appropriately. DJI's main contact point for AAIB will remain our European Policy team, which will coordinate internal investigations and occasionally organize direct meetings or exchanges between AAIB and the expert engineering teams.'*

On 3 December 2021 the AAIB had a meeting with the DJI's European point of contact. They said they had developed additional new processes to improve the timeliness of responses to AAIB questions for future investigations.

## Analysis

*Cause of the fly away accident*

The fly-away event was caused by a number of factors. Battery 1 became disconnected shortly after takeoff which resulted in the UA being powered by Battery 2 alone. The cause of the battery disconnection could not be determined, but the battery functioned normally when fitted to another UA so it is probable that it was not fully pushed into place before takeoff.

The battery disconnection meant that the UA sensed a large drop in total battery capacity which triggered a restriction in its pitch limit and therefore its top speed. From the data the pitch limit appeared to be about 15°.

The wind at 400 ft increased beyond the 24 mph speed forecast by the pilot's UAS weather forecast app. The wind reached a calculated peak of 39 mph, but varied mainly between 25 mph and 35 mph. The UA's top speed in P-mode was either 35.8 or 38 mph. If it had been able to achieve 38 mph then it would not have drifted away in the wind. Even at a top speed of 35.8 mph there were periods when it would have made progress back towards the home point. However, with the restricted pitch attitude that was about 10° less than normal, this was not possible. The pilot's attempt to use S-mode as per the operator's emergency procedure did not allow an increase in speed as the restricted pitch limit also applied in S-mode.

The UA drifted beyond visual line of sight and communication was lost which meant that a recovery was no longer possible. The UA could not auto-return-home due to the wind.

When the battery 2 level dropped to 23% the UA entered an auto-land mode but was unable to avoid the wall of a house resulting in damage to the propeller blades and a subsequent impact with the balcony. If the balcony had been occupied, people could have been seriously injured by the propeller blades.

The following were contributory factors to the accident:

*Awareness of the wind speed*

The wind at 400 feet cannot be directly measured so the pilot was reliant on a wind forecast. The forecast was for a wind 3 mph below their operational limit and the manufacturer's limit. The pilot believed that S-mode would give him a top speed of 51 mph, so he may have considered that he had a significant safety margin if the wind increased beyond the forecast. But with both camera gimbals fitted the speed limit was 40.3 mph. However, this was still higher than the peak wind of 39 mph so recovery would still have been possible.

The pilot also believed that he would receive a wind warning that would tell him to land if the wind increased excessively. He reasonably interpreted the '*High Wind Velocity. Fly with caution'* message to mean that he could continue the flight. The user manual does not provide any information on the alert messages that can appear, or the appropriate actions to take.

The manufacturer appears to have used the same message for both a Level 1 and a Level 2 wind warning, causing confusion to the remote pilot on the action to take. The manufacturer had set a wind limit of 27 mph, and therefore the Level 2 wind warning should have advised the pilot to land as soon as possible. Therefore, the AAIB makes the following Safety Recommendation:

**Safety Recommendation 2022-001**

It is recommended that DJI amend the DJI Pilot and DJI GO4 apps to warn the remote pilot when the wind limit has been exceeded and that the UA should be landed as soon as possible.

The pilot is required to maintain visual line of sight with the UA and therefore could miss an alert message on the controller screen if they are concentrating on manoeuvring the UA visually. If messages related to safety of flight had an associated aural warning the pilot's attention could be drawn to them. Therefore, the AAIB makes the following Safety Recommendation:

**Safety Recommendation 2022-002**

It is recommended that DJI amend the DJI Pilot and DJI GO4 apps so that an aural alert is triggered when alert messages relating to safety of flight appear.

The pilot's awareness of the wind would also be improved if the controlling apps displayed the wind speed that is calculated by the UA. This is a feature on the newer Matrice 300 series UAS.

*Awareness of the pitch attitude restriction*

Neither the operator nor the pilot was aware that below a certain total battery SOC, the aircraft's pitch attitude is restricted to about 15°, 10° less than normal, and 15° less than in S-mode; and that this results in a lower top speed. These facts are not mentioned in the UAS user manual or on the manufacturer's website. The limit is also triggered at a total battery capacity level which is not displayed to the pilot. The total battery capacity figure had logic to ignore the capacity of battery 1 which was not connected, whereas the DJI Pilot app only displayed two separate battery levels, and battery 1 was still showing 97%.

Operators and pilots need to be made aware of the pitch attitude limit, the reduced speed limit, and at what battery levels this is triggered. Otherwise, more operators will be caught out by stronger than forecast winds. Therefore, the AAIB makes the following Safety Recommendation:

**Safety Recommendation 2022-003**

It is recommended that DJI amend the Matrice 200 series user manual to provide information on the pitch attitude limiting system, including the new maximum speed which results from the limit, and the battery level at which it triggers; and communicate this change widely to pilots and operators.

*Visual line of sight rules*

The VLOS regulation requires the pilot to maintain '*continuous unaided visual contact'* with the UA which allows them to control the flight path in order to avoid collisions. To be able to take avoiding action to avoid a collision a pilot needs to know the orientation of the UA. At a certain distance the UA will appear as just a dot in the sky with no orientation information apparent. The pilot might recall which orientation it is in so can take rapid avoiding action, but if they lose track of its orientation then accurate and rapid flight path control becomes impossible. The regulation requires interpretation to establish the acceptable distance for VLOS. CAP 722 is designed to provide guidance to help pilots interpret the regulation and provide guidance on safe practices. CAP 722 states that:

> *'The CAA will normally accept that the VLOS requirement is met when the UA is flown out to a distance of 500 metres horizontally from the remote pilot, but only if the aircraft can still be seen at this distance.'*

It is not clear why the CAA considers 500 m as a normally acceptable distance. A distance cannot be considered normally acceptable without specifying what a normal size is, which CAP 722 does not do. CAP 722 emphasises the importance of being able to avoid collisions but does not state anything about the importance of being able to recover the UA from that distance following a loss of position holding or telemetry. The smaller the apparent size of the UA in the sky the more difficult it will be to recover it manually, particularly in strong winds.

The operator had adopted a distance of 500 m for their VLOS operations in part because of the CAA's guidance in CAP 722. The Matrice M210 was the largest UA they operated at the time, and they accepted that its orientation could not be seen at that distance - at 500 m it has an apparent size of just 0.4 by 0.3 mm on a piece of paper held at normal reading distance. It is not entirely clear from the regulation or CAP 722 whether this is acceptable. The operator now trains its pilots to manually recover their UA from 500 m under manual mode without use of telemetry which helps to mitigate the risk, but this guidance on training is not in CAP 722.

Therefore, the AAIB makes the following Safety Recommendation:

**Safety Recommendation 2022-004**

It is recommended that the Civil Aviation Authority review the Visual Line of Sight distance figures in CAP 722 and amend the guidance to make it clear that just being able to see an unmanned aircraft is not sufficient for Visual Line of Sight operations and that pilots need to be able to demonstrate that at the distance they are flying, they can manoeuvre it rapidly to avoid a collision and can also land the unmanned aircraft safely following a loss of position-holding without reference to video or telemetry.

## Conclusions

The fly away accident was the result of the following main causal factors:

1. Battery 1 became disconnected shortly after takeoff which reduced the UA's maximum pitch attitude and maximum speed.
2. The pilot did not notice that the 'battery communication' message included the words '*land as soon as possible*'.
3. When the wind measured by the UA exceeded the manufacturer's wind limit the alert message to the pilot advised him to '*fly with caution*' instead of to '*land as soon as possible*'.
4. The wind at 400 ft was stronger than forecast and at times above the UA's restricted maximum speed so the pilot could not fly it back towards him.
5. The wind speed calculated by the UA was not displayed to the pilot on his controller app so he did not know that the wind limit had been exceeded.
6. After communication was lost, the UA entered an auto-land mode but it was unable to avoid colliding with a wall.

The following factors contributed to the accident:

1. The pilot and operator were not aware that the UA's maximum pitch attitude and maximum speed were restricted at low battery levels as this information is not in the UAS user manual.
2. The pilot may have missed the '*land as soon as possible'* part of the battery message because it did not stay visible for long enough. An aural alert may have helped draw the pilot's attention to the seriousness of the message.
3. The disconnected battery was still showing a high SOC instead of showing zero or blank which would have been a clearer indication of a battery issue.
4. The pilot probably did not fully push battery 1 into place and the UA was not fitted with a battery safety clip which is a new part on the updated version of the UA.
5. The pilot's decided to launch from a position that would require flying downwind in a wind that was close to limits.

The operator has taken steps to mitigate the risks for future flights and has retired its Matrice M210 UA and replaced them with updated Matrice 300 series UA which have a battery safety clip and display wind speed on the controller app. Three Safety Recommendations have been made to the manufacturer.

The issues identified with the guidance on VLOS in CAP 722 were not a direct factor in this accident as the UA may not have been recoverable at a closer distance; however, the guidance should be improved to help reduce the chance of other types of VLOS fly away accidents which could result in injuries to people.

*Published: 7 April 2022.*

## AAIB Correspondence Reports

These are reports on accidents and incidents which were not subject to a Field Investigation.

They are wholly, or largely, based on information provided by the aircraft commander in an Aircraft Accident Report Form (AARF) and in some cases additional information from other sources.

The accuracy of the information provided cannot be assured.

## SERIOUS INCIDENT

| | |
|---|---|
| **Aircraft Type and Registration:** | Airbus A319-111, G-EZAJ |
| **No & Type of Engines:** | 2 CFM CFM56-5B5/P turbofan engines |
| **Year of Manufacture:** | 2006 (Serial no: 2742) |
| **Date & Time (UTC):** | 26 May 2021 at 0840 hrs |
| **Location:** | Lasham Airfield, Hampshire |
| **Type of Flight:** | Other |
| **Persons on Board:** | Crew - 2 Passengers - None |
| **Injuries:** | Crew - None Passengers - N/A |
| **Nature of Damage:** | None |
| **Commander's Licence:** | Airline Transport Pilot's Licence |
| **Commander's Age:** | 35 years |
| **Commander's Flying Experience:** | over 5,000 hours (of which 5,000 were on type)<br>Last 90 days - 129 hours<br>Last 28 days - 44 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot and MOR submitted by the aerodrome |

### Synopsis

An airliner landed on Runway 27 at Lasham Airfield while winch-launch cables were present on the grass abeam the southern edge. The gliding club and maintenance organisation have taken action to improve communication between relevant parties and to emphasise the importance of securing the runway area during heavy aircraft movements.

### History of the flight

On 25 May 2021, the aircraft operator sent a 'Pre-Allocation Report' to the operations department of the maintenance organisation (MRO) at Lasham Airfield indicating that Airbus A319 G-EZAJ was scheduled to arrive from Gatwick Airport at 0900 hrs the following day. This information was passed to the gliding club at the aerodrome by email. Later in the afternoon, a 'Final Allocation Report' confirmed these timings. At 2235 hrs that night, the air operations department of the MRO received the flight plan which gave an Estimated Off Blocks Time[1] (EOBT) of 0800 hrs and a Scheduled Time of Arrival of 0817 hrs, 43 minutes earlier than previously indicated by the operator. The flight plan was subsequently transmitted by email to the various parties on the airfield, including the duty instructor (DI) of the gliding club but not any member of the winch team.

**Footnote**

[1] The time that the brakes are released for the purpose of the aircraft being pushed-back from the gate or parking spot is referred to as 'off-blocks'.

At 0730 hrs on the morning of the flight, gliding club staff began preparing for flying. The DI noted the updated scheduled arrival time for G-EZAJ but was not aware that the winch team planned to carry out maintenance on the winch cables; consequently, the DI did not update the winch team on the change.

The commander of G-EZAJ rang the duty Air-Ground Operator (AGO) at Lasham at 0753 hrs to inform him that the aircraft would arrive 25 minutes later. Meanwhile, the winch team went onto the airfield, set up the winch along the south side of Runway 27 and towed out the winch cables. G-EZAJ taxied at Gatwick at 0800 hrs as scheduled and at 0801 hrs the AGO at Lasham sounded the siren to deploy the airfield fire service.

At 0807 hrs, the Farnborough Radar controller (FRC) called the AGO to let him know that G-EZAJ was about to depart Gatwick. The AGO advised him that the airfield was still being secured and the runway was not yet available. G-EZAJ departed Gatwick at 0809 hrs and a minute later the AGO advised the duty Senior Fire Officer (SFO) at Lasham that the aircraft was airborne but that he "might have to hold him off".

At 0811 hrs, the AGO advised the FRC that the runway was still unavailable. A minute later the AGO determined from the SFO that the runway would be available in 4 minutes and passed this on to the FRC. The FRC and AGO agreed to position G-EZAJ onto the final approach for Runway 27 to fly a visual circuit if the runway remained unavailable.

At 0813 hrs, the winch team advised the SFO that the winch cables could not be retrieved immediately because they had been cut from the winch as part of the maintenance procedure and they would have to be re-spliced before they could be wound in.

At 0817 hrs, the AGO requested a range check from the FRC. At the same time, the SFO contacted the AGO advising him that a further 5 minutes would be required before the runway would be available due to the winch cables. The AGO advised the FRC, who in turn stated that he would advise the crew of G-EZAJ to expect to fly a visual circuit. The AGO passed this to the SFO.

At 0819 hrs, the crew of G-EZAJ contacted Lasham Radio and, advised they were on the approach at 6 nm distant and expected to join a visual circuit at 2,000 ft. In response, Lasham Radio advised the crew that there was a delay in runway availability because of winch cables on the ground.

At 0820 hrs, the SFO considered that there was insufficient time to recover the cables while G-EZAJ flew a visual circuit; consequently, the attempt to recover the cables was abandoned. The SFO then declared to the AGO that the runway was available. No mention was made of the position of the winch cables.

At 0827 hrs, G-EZAJ landed within the touchdown zone on Runway 27 with the winch cables still on the grass aside the southern edge of the runway.

**Aerodrome information**

Lasham airfield is 32 nm west of Gatwick Airport, situated within the Odiham Military Air Traffic Zone. The airfield is a major centre for gliding and is owned by the local gliding society, which leases part of the land to an MRO for large commercial aircraft. Responsibilities for airfield operations are shared between the airfield owner and the MRO.

The MRO is responsible for the provision of functions pertaining to large aircraft movements, including the Air-Ground communication service (AGCS), the airfield fire service (AFS), and ground handling and fuelling services. The AFS deploys portable Precision Approach Path Indicator (PAPI) units for large aircraft movements.

The MRO utilises the asphalt main runway, Runway 09/27, which is unlicensed. The airfield information plate provided by Jeppesen Charts includes the following warning:

> *'Intensive glider operations every day with simultaneous RH* [right hand] *and LH* [left hand] *circuits by up to 20 gliders and tug ACFT* [aircraft]*, and danger of launch cables both on the ground and in the air up to 3,000 ft AAL. Occasional movements by large jets.'*

Although Lasham airfield is unlicensed, the MRO seeks to maintain a protected runway strip clear of infrangible objects, vehicles, persons and aircraft during heavy aircraft operations to or from Runway 09/27. The strip is equivalent to that required by a non-instrument code 3 runway for licensed airfields, extending to 75 m either side of the runway centreline and 60 m beyond each runway threshold.

**Winch-launch cables**

The winch-launch cables were 6 mm thick and made of synthetic plastic, with a parachute attached on the end connected to gliders for launch. The parachute allows for a controlled descent of the cable following release from the glider.

The cables were subject to a maintenance procedure known as a cable reversal, whereby the cables are reeled out to their full extent, the end of the cable attached to the winch is cut and the winch is then reattached with a splice to the opposite end of the cable. The procedure requires use of the longest part of the airfield, which is adjacent to Runway 09/27, and typically takes 10 minutes; however, it is recognised that the re-splicing of the cable back on to the winch should not be rushed due to its safety-critical nature (Figure1).

**MRO investigation**

The investigation by the MRO found there was an absence of coordination between airfield users. This resulted in information not being shared between the flying operation and other sections of the gliding club. Consequently, the winch team was unaware that the arrival time of G-EZAJ was earlier than originally advised, while the flying staff were unaware of the planned winch cable maintenance.

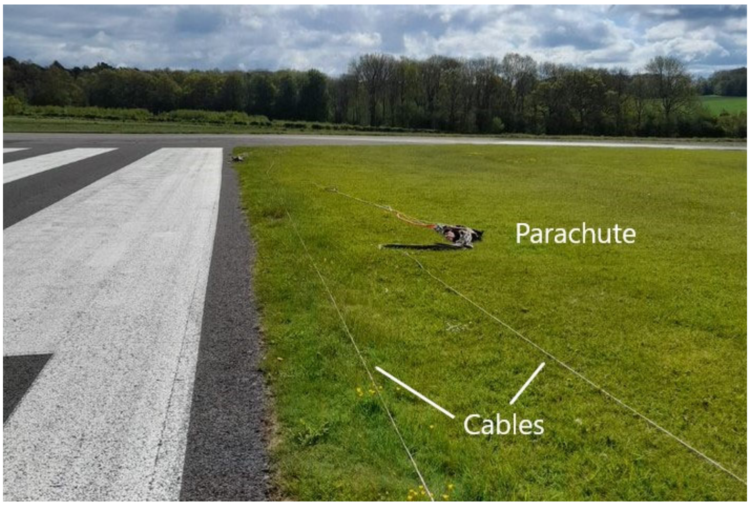


**Figure 1**

Winch cables with parachutes laid on grass along southern edge of Runway 27 abeam the landing threshold

The MRO investigation also found that the AGO was unaware of the continued presence of winch cables abeam the runway when he advised the crew of G-EZAJ that the runway was available. Although the SFO had previously advised the AGO that more time was required to clear the cables, he subsequently declared the runway as available, but gave no update on the position of the cables. This was attributed to the absence of written guidance to the SFO as to what constituted a secure runway strip. Instead, the SFO had the discretion to determine whether the position of an object or person was safe.

The MRO investigation found that it was also likely that the SFO felt pressure to declare the runway available owing to the arrival of the aircraft in the circuit. The aircraft's presence had arisen from the agreement between the AGO and the FRC to continue to vector the aircraft towards the airfield instead of instructing the aircraft to hold pending runway availability.

The MRO investigation also noted that the winch team conducting the maintenance was likely to have been less current at performing these maintenance tasks due to a significant reduction in winch launching during public health restrictions.

**Analysis**

The location of the winch cables along the southern edge of the runway posed a potential hazard to the landing aircraft because the parachute at the end of the cables lying abeam the landing threshold might become inflated by the jet wash of the landing aircraft. This risk was only likely to manifest itself if the landing aircraft had landed close to the threshold rather than in the touchdown zone. However, the commander commented that he considered this unlikely owing to the treeline in the undershoot, which deters landings in that location. In addition, the portable PAPIs would have provided appropriate glidepath guidance to the crew.

The commander had been alerted to the issue of the cables along the southern edge of the runway when he first spoke with Lasham Radio. However, the subsequent declaration by the SFO that the runway was available, without an update on the cables, may have given the impression that the cables no longer posed a hazard. The commander was not told that the cables remained along the southern edge of the runway, so had an incomplete picture on which to base his decisions. He might otherwise have considered flying a further visual circuit or holding while the runway strip was secured.

**Conclusion**

The Airbus A319 landed while winch-launch cables were present on the grass abeam the southern edge of the runway. This resulted from a lack of coordination between users of the airfield and insufficient guidance on what constituted a secure runway strip.

It is likely the Senior Fire Officer felt pressure to declare the runway available for the arriving aircraft, which was in the circuit. The Air-Ground Operator was not told that the cables remained abeam the southern edge of the runway when the Senior Fire Officer declared the runway available. Consequently, the commander of G-EZAJ did not have the opportunity to manage the threat posed by the presence of the cables.

The following safety actions have been taken:

The airfield owner stated that:

- Individuals are required to contact the DI for a brief on relevant airfield information and any aircraft movements if there is a need to enter the operational area prior to the daily briefing.
- Planned winch maintenance will be notified the day before it is due to take place.
- Any winch maintenance should be conducted as far away from the main runway as the circumstances allow.

The MRO has:

- issued an information bulletin to provide guidance on the importance of securing the runway during heavy aircraft movements and what constitutes a secure runway strip. This will be incorporated into the AFS manual which is currently undergoing revision.
- briefed Fire Crew Commanders on the event and on the guidance about runway strips, the procedures to be used, and how to determine that a runway strip is secure. This will be incorporated into future Fire Crew Commander training.
- briefed all members of the AGCS on the incident and how the handover from FRC before the runway was available contributed to the incident.

**ACCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Cessna 402C, Businessliner, VQ-TIN |
| **No & Type of Engines:** | 2 TSIO-520-VB piston engines |
| **Year of Manufacture:** | 1979 |
| **Date & Time (UTC):** | 17 July 2021 at 1923 hrs |
| **Location:** | Ambergris Cay International Airport, Turks and Caicos Islands |
| **Type of Flight:** | Commercial air transport |
| **Persons on Board:** | Crew - 1 Passengers - 5 |
| **Injuries:** | Crew - None Passengers - None |
| **Nature of Damage:** | Extensive damage to flaps, propellers and underside of fuselage. Both engines were shock-loaded |
| **Commander's Licence:** | Airline Transport Pilot's Licence |
| **Commander's Age:** | 33 years |
| **Commander's Flying Experience:** | 10,500 hours (of which 400 were on type)<br>Last 90 days - 90 hours<br>Last 28 days - 45 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB |

**Synopsis**

The aircraft landed without its landing gear being extended. The landing gear warning horn was found to be unserviceable after the accident. However, while it could not be determined when it failed, it was not tested prior to the flight, as prescribed in the operators' *Normal Procedures* checklist. In addition, the *Normal Procedures* checklist was not used during the flight. Had it been, the pilot may have noticed the landing gear was not down, despite the warning horn not being serviceable.

**History of the flight**

The pilot and five passengers were on a scheduled flight from Providenciales International Airport, Turks and Caicos Islands to Harold Charles International Airport, Ambergris Cay, Turks and Caicos Islands. This was the pilot's seventh flight of the day.

The pilot reported that after he and the passengers had boarded their assigned aircraft, its engines were "reluctant to start". As another Cessna 402C (C402C) was available, the pilot elected to change aircraft. The replacement aircraft had previously flown two sectors that day with another pilot.

After the pilot and passengers had changed aircraft, one of the passengers sat in the co-pilot's seat, after the pilot had offered it to him. The pilot reported that he did a visual check of the outside of the replacement aircraft but did not do a thorough internal pre-flight check. This meant that the landing gear warning horn[1] was not tested. The subsequent departure and cruise were uneventful. Runway 07 was in use at Harold Charles International Airport, the weather was good, and the wind was from 070° at 13 kt.

At about 3 nm to land, the pilot selected FLAPS 45 and stated subsequently that he believed he selected the landing gear down and saw three green lights, to indicate that the landing gear was down and locked. The approach continued without event until at the point of landing, when he felt that the landing gear touched down "gently". However, the aircraft then began to skid on its underside and the propellers made contact with the runway. The aircraft slid down the runway before coming to a stop (Figure 1). The pilot advised ATC of the situation and the airport's RFFS were quickly in attendance. Four passengers and the pilot exited through the pilot's/front left side window, while one exited through the window of the main cabin door. There were no injuries.

The aircraft sustained extensive damage to its flaps, propellers and underside, and both engines were shock-loaded.

**Figure 1**
VQ-TIN after landing

## Aircraft information

The C402C's *Pilot's Operating Handbook* contains the following information:

> *'LANDING GEAR WARNING HORN*
>
> *The landing gear warning horn is controlled by the throttles and the wing flap position. The warning horn will sound intermittently if either throttle is retarded*

**Footnote**

1 See *Aircraft information* section for more details on the landing gear warning horn.

*below approximately 13.0 inches Hg manifold pressure with the landing gear retracted or if the wing flaps are lowered past the 15° position with the landing gear in any position except extended and locked. The warning horn can be activated by either the wing flap position switch or by throttle position as each functions independently of the other…The system can be checked by activating the PRESS-TO-TEST button…located near the annunciator panel while retarding one throttle at a time. Also, lowering the wing flaps past 15° position with the PRESS-TO-TEST button activated will cause the landing gear warning horn to sound.'*

*'ANNUNCIATOR PANEL*

*A press-to-test button is provided to the left of the annunciator panel. When the button is pressed, all annunciator panel lights, landing gear position and unlocked lights…will be tested and should illuminate. If the throttles are retarded or flaps are extended more than 15 degrees, the gear waning horn will sound when the button is pressed.'*

The pilot that previously flew the aircraft stated that he successfully tested the landing gear warning horn on those flights.

**Operator's Operations Manual**

Part A, Chapter 8.3, *Flight Procedures*, of the operator's operations manual states:

*'It is the responsibility of the reader of the checklist to ensure that the check item is correctly completed and any switch position or instrument setting is correctly set…as dictated by the checklist.'*

An abbreviated version of the *Normal Procedures* checklist was carried on all aircraft. The '*BEFORE STARTING ENGINES'* section of the checklist includes:

*'ANNUNCIATOR PANEL……….PRESS-TO-TEST'*

The '*BEFORE TAXIING'* section includes:

*'PASSENGER BRIEFING……….COMPLETE'*

The '*BEFORE LANDING'* checklist includes:

*'LANDING GEAR……DOWN'*

The operator issued a memo to all its pilots on 18 July 2021, reminding them of the importance of the *Normal Procedures* checklist and to reinforce that it should be used during all phases of flight.

### Pilot's comments

The pilot commented that he usually tests the landing gear warning horn with the annunciator press-to-test button on every flight. He added that he "tries to use" the *Normal Procedures* checklist in the aircraft on every flight but "probably didn't use it" on the accident flight.

The pilot believed he gave the passengers a safety briefing in the first aircraft but thought he also gave a briefing in the replacement aircraft.

### Passengers' statements

All the passengers were contacted by the AAIB.

The passenger in the co-pilot's seat stated that he did not remember any sounds associated with any pre-flight testing of any systems while on the aircraft. He added that once the pilot boarded the aircraft, it was taxiing in under 2 minutes. He also did not recall seeing the pilot use any checklists, nor did the pilot do an engine run-up/test prior to takeoff. There was no pre-flight safety briefing.

Another passenger that was seated to the rear of the aircraft stated that she did not recall if the pilot provided a safety briefing but added that they were not shown a passenger safety card[2] at any time.

As with the departure, the passenger in the co-pilot's seat did not see the pilot perform any checklists during the approach and landing. Additionally, he did not recall any noise associated with the landing gear being lowered. He was attentive to this on the return flight, where the noise was noticeable. He added that the first indication of a problem was the aircraft's tail contacting the runway, followed by the propellers striking the runway. Once the aircraft came to a stop, he ordered his family members to exit immediately and did not recall the pilot offering any instructions. Smoke then entered the aircraft through an open window, creating fear of a possible fire or explosion. He then assisted his family out of the front left side window, before exiting himself.

The passenger in the rear of the cabin initially tried to open the main cabin door to evacuate the aircraft. While the upper portion opened, the lower stairs did not fully lower as the landing gear was not down. She added that the pilot helped the other passengers out of the aircraft before following them out of the front left side window. Having initially had some difficultly opening the side exit she climbed out of the window in the partially opened main cabin door and was the last person out of the aircraft.

### Aircraft examination

The maintenance organisation inspected the aircraft soon after the accident.

In the cockpit, it was noted that the landing gear handle was in the down position. After subsequently lifting the aircraft and securing it on jacks, the main landing gear and the nose

**Footnote**

2 Passenger safety cards were located in the rear of the passenger seat pockets.

wheel were found in the up and locked position. There was also no damage to the landing gear doors, indicating they were in the up and locked position.

When power was applied to the aircraft the landing gear indicator lights indicated landing gear up and locked. The unlocked light was not illuminated, nor was the landing gear in transit light. After the emergency blow down was activated the lights indicating transit/unlocked illuminated followed by three green (down and locked) lights.

It was subsequently discovered that landing gear warning horn was unserviceable. This was found to be due to a broken wire that routes close to the flap selector lever. This is an area that is in constant motion, as some of the horn's wires move as the lever is moved. It was not determined when the wire broke, but it was likely to have failed when the flaps were selected on the landing of the previous flight or that of the accident flight.

**Analysis**

The pilot commented that he usually tests the landing gear warning horn on every flight but did not do so on the accident flight. After the accident it was discovered that the landing gear warning horn was unserviceable. While it could not be determined when it failed, had it been found to be unserviceable by conducting a pre-departure annunciator test, the pilot would have had an opportunity to seek engineering assistance, and possibly get it rectified, prior to departure.

With the warning horn not working, there was no alarm available to the pilot on the approach when FLAPS 45 were selected to indicate that the landing gear was not down and locked. Had he heard the horn, he would have probably either lowered the landing gear while on the approach or initiated a go-around before making another approach with it selected down.

The pilot said that he probably did not use the *Normal Procedures* checklist on the accident flight, and this was noticed by the passenger in the co-pilot's seat. Checklists are there to assist pilots from forgetting to do essential actions during each phase of flight that, if not completed, could have had an adverse effect on the safety of the aircraft. It was likely that he was distracted and/or rushing due to the aircraft change, and this led to him not doing a thorough internal pre-flight check.

There were conflicting accounts between the pilot and some of the passengers as to whether a safety briefing had been given, or whether a safety card was shown. Had there been no safety briefing given to the passengers, they would have been ill equipped to deal with any evacuation. Had the pilot been incapacitated this could have led to unexpected delays to the evacuation that may have led to serious injuries had there been a fire, or the damage been more severe.

The pilot believed he lowered the landing gear prior to landing but did not use the checklist to confirm this. One passenger stated he did not feel or hear the sounds associated with the lowering of the landing gear, which he experienced on his next flight. While the landing gear handle was discovered in the down position it was more likely it was moved after the accident. However, it could not be determined when or by whom.

Given the physical evidence discovered by the maintenance organisation and the statements of a passenger it was concluded that the landing gear was not extended prior to the landing.

## Conclusion

The aircraft landed without its landing gear being extended. This was principally due to the pilot not using the *Normal Procedures* checklist prior to landing, to confirm it was down and locked.

Checklists are an important tool that support a pilot's airmanship and memory and ensure that all required actions are performed without omission and in an orderly manner. Not using or following them can have serious consequences as was seen in this accident. If they are not used it can potentially put an aircraft and its occupants at risk of experiencing a critical, adverse event.

## ACCIDENT

| | |
|---|---|
| **Aircraft Type and Registration:** | DH82A Tiger Moth, G-ANMO |
| **No & Type of Engines:** | 1 De Havilland Gipsy Major 1C piston engine |
| **Year of Manufacture:** | 1935 (Serial no: 3255) |
| **Date & Time (UTC):** | 26 August 2021 at 0940 hrs |
| **Location:** | Headcorn Aerodrome, Kent |
| **Type of Flight:** | Training |
| **Persons on Board:** | Crew - 2 Passengers - None |
| **Injuries:** | Crew - 2 (Minor) Passengers - N/A |
| **Nature of Damage:** | Damage to landing gear, propeller, wings and fuselage |
| **Commander's Licence:** | Private Pilot's Licence |
| **Commander's Age:** | 73 years |
| **Commander's Flying Experience:** | 21,154 hours (of which 770 were on type)<br>Last 90 days - 29 hours<br>Last 28 days - 5 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot and subsequent AAIB enquiries |

### Synopsis

During a flight to teach a qualified pilot to land on a short unlicensed grass strip, the aircraft was low and slow on short final. It contacted a tree followed by a power line, which was atop wooden pylons, before toppling to the ground onto its back. Both occupants were uninjured apart from a few scratches. The instructor was sat in the front cockpit where both the altimeter and airspeed indicator (ASI) were unserviceable, and his seating position meant that he had difficulty seeing the strut-mounted ASI and he did not have a clear forward view to offer appropriate instruction to the pilot flying (PF). This information was not communicated to the PF, nor were the PF's own concerns communicated to the instructor before or during the flight. As a consequence, several opportunities were lost, both on the ground and in the air, to discuss these before commencing or continuing the flight.

### Background

The instructor was teaching a qualified pilot (who was PF and with 21 hours on type in the previous 30 days) to take off and land on Runway 03 of the unlicenced grass strip (03/21) at the airfield (Figure 1). The instruction was a familiarisation flight to meet a requirement within the Aerodrome Operations Manual. Both the instructor and PF were instructors for the aircraft's operator and the instruction being given was conducted under the operator's training organisation approval (ATO).

To the north of the main grass strip (10/28), Runway 03 is used by biplanes when the crosswind component across Runway 10 is too strong. The use of this short grass strip (269 m) is restricted to pilots who have received instruction and have been formally checked out. The start of Runway 03 is 323 m north of a tree line and power lines (atop wooden pylons) that are either side of the road at the entrance to the airfield. The last third of the runway slopes gently towards a river on the northern boundary of the airfield, giving a foreshortened view of the runway on the approach.

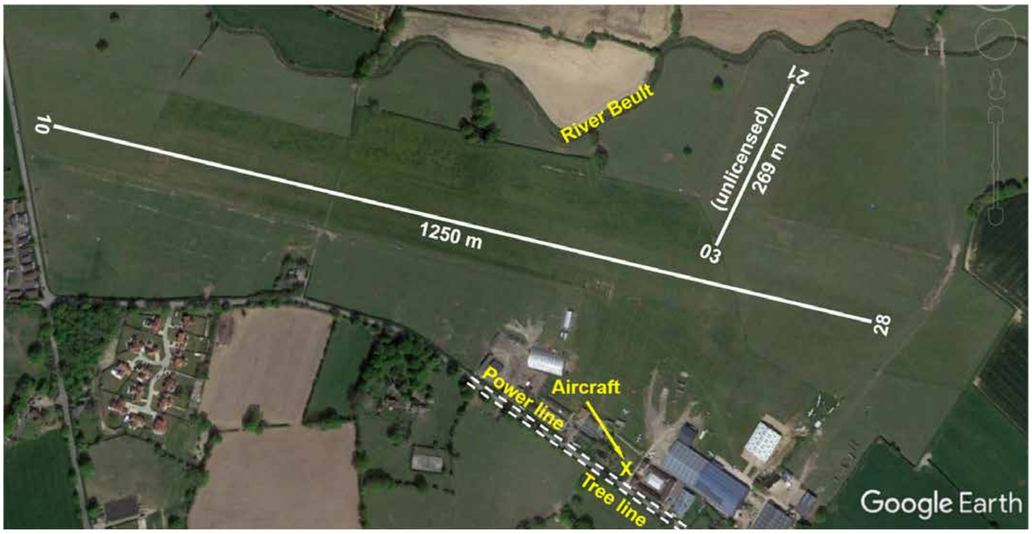


**Figure 1**

Overview of airfield and approach to Runway 03

## History of the flight

The instructor and PF briefed the landing technique for about 5 minutes at the aircraft and about 10 minutes before engine start. There were time pressures on the instructor that morning and so he was keen to fly. The technique he taught was to be over the trees at 50-60 ft and 50 kt (5 kt below the normal approach speed and at least 15 kt above the stall speed) with some power and, when just clear of the trees, to close the throttle fully while at the same time easing the stick forward to maintain speed. Finally, the aircraft should be flared for a three-point landing where Runways 10/28 and 03/21 intersect. If the touchdown was delayed, given the runway's downward slope towards the river and the lack of brakes on the aircraft, then a go-around would be necessary.

So that the PF could familiarise himself with the unusual approach and foreshortened view of the runway they planned to go around from the first approach regardless.

In the forward cockpit, where the instructor was seated, there was an altimeter and ASI both of which were unserviceable. The PF's altimeter and ASI in the rear cockpit were both serviceable. The aircraft was equipped with a strut-mounted spring-operated ASI, but did not have leading-edge slats that, from the forward cockpit, can give visible clues that the aircraft is approaching the stall. The instructor was sitting on a parachute rather than the taller cushion in the rear cockpit that he was used to and had his head to one side to give the PF "a better view." However, this meant that the instructor's perspective of the approach was compromised as well as the view of the strut-mounted ASI. The PF was aware that the front ASI was unserviceable but understood that the instructor used the strut-mounted ASI. However, he was unaware that the instructor did not have a good view of this and so was unable to monitor the airspeed.

The aircraft took off from Runway 03 and the wind during the flight (recorded by the weather station at the airfield) was from the north between 7 and 10 kt.

On the initial part of the first approach to Runway 03 the PF was told that the aircraft was too high and was instructed to "slip" off some height. The PF did this but felt uncomfortable with how low they then were but assumed, as he was under instruction, that this was the correct flight profile for landing. After the flight, observers on the ground advised the instructor that the aircraft had been low and, in his statement, he commented that he had "failed to notice" this.

The go-around appeared "OK" to the instructor, but he was unaware of the speeds flown.

During the downwind leg, the instructor commented to the PF on the initial high approach but seemed happy with the rest of descent profile. There was no discussion about airspeed.

For the second approach the instructor again told the PF they were too high so the PF sideslipped the aircraft slightly to the right to lose some height. The PF, feeling the aircraft was getting low checked the altitude on his instruments, and noted they were descending through 300 ft aal at 50 kt. He then turned his attention to the touchdown point. By the time the aircraft neared the trees, the airspeed had decayed to near stalling speed. The PF felt the aircraft sinking and applied full power. In the meantime, the instructor hadn't noticed that the aircraft was again low but also slow over the trees. The aircraft then started to buffet, which is an indication of an approaching stall, so the instructor took control just as the left wingtip hit a tree and the tailskid caught the power line. The aircraft pitched down and hit the ground, with very little forward speed, on the undercarriage and the nose, and finally onto its back (Figure 2).

Both pilots were wearing a full harness and helmet and were uninjured apart from a few scratches. They were helped from the aircraft by witnesses and members of the airport fire service.

**Pilots' assessments**

The instructor stated that, having already checked the PF out to fly the Tiger Moth a few months earlier without any concern during "two very good flights", he was complacent with his expectations of how the flight would proceed, particularly on the approach, even though the approach was "unusual" and of "high" workload. He noted that had the ASI in the front cockpit been serviceable and he "had taken a more normal position in the cockpit" the accident would have probably been avoided.

**Figure 2**

The aircraft with the trees and power line on the approach to Runway 03

The PF felt that briefing could have been more thorough given the fact that he had no experience of landing on Runway 03 and was totally reliant on the instruction given. He also did not feel comfortable with using the runway in the wind conditions, which he thought favoured Runway 28 on occasion. In hindsight he realised that he should have expressed and discussed his concerns, and perhaps rescheduled the flight for another day, rather than feeling "pressured to not waste time" given the instructor's own time pressures that morning. Following the first (intentional) go-around, he felt the "approach was wrong" and that the instructor's comments downwind did not reflect his own assessment of how it had been flown. He stated that, with the benefit of hindsight, he should have either handed control to the instructor or landed on Runway 28.

## Discussion

Both pilots failed to notice that they were too slow on the approach until the aircraft started to stall. By the time the aircraft was nearing the trees, the PF was focussed on looking out of the aircraft at the landing point, and no longer monitoring the airspeed on his cockpit ASI. He was, therefore, reliant on the instructor to say if the speed and position of the aircraft was wrong for the approach. The instructor was unaware of the reliance placed on him and given that his view of the approach and the strut-mounted ASI was compromised by his seating position, and with no serviceable altimeter or ASI in his cockpit, he was unable to monitor the progress of the approach and give effective instruction. The instrument unserviceabilities and compromised view would have been evident before the flight commenced and so this was an opportunity for the intended flight to have been rescheduled.

The instructor was also unaware of the PF's concerns about the flight, which in hindsight the PF stated that he should have voiced. As such, opportunities were lost, both on the ground and in the air, to discuss these to the satisfaction of both before commencing or continuing with the instructional flight.

The AAIB sought the opinion of another Qualified Flying Instructor regarding the technique for this approach. He advised that, although the approach is challenging, it is not difficult. He advises pilots new to this runway to come in high rather than fly the aircraft in under power (as this helps to avoid losing sight of the trees), and to aim to land as they cross the main 10/28 runway.

## ACCIDENT

| | |
|---|---|
| **Aircraft Type and Registration:** | Eurofox 912(S), G-CGYG |
| **No & Type of Engines:** | 1 Rotax 912 ULS piston engine |
| **Year of Manufacture:** | 2011 (Serial no: LAA 376-15081) |
| **Date & Time (UTC):** | 29 May 2021 at 1040 hrs |
| **Location:** | Highland Gliding Club, Easterton Airfield, Elgin |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - None |
| **Injuries:** | Crew - 1 (Minor) Passengers - N/A |
| **Nature of Damage:** | Nose leg broken and damage to engine cowling, wing struts and airframe |
| **Commander's Licence:** | Commercial Pilot's Licence |
| **Commander's Age:** | 31 years |
| **Commander's Flying Experience:** | 499 hours (of which 132 were on type)<br>Last 90 days - 22 hours<br>Last 28 days - 6 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB |

### Synopsis

During the third landing following the replacement of the nosewheel tyre, the nosewheel detached from the aircraft and the nose leg fork dug into the soft ground. The nose leg broke and the aircraft flipped over onto its roof causing substantial damage. The investigation determined that the nosewheel had not been refitted correctly to the aircraft following the tyre change.

Three safety actions have been taken by the manufacturer and the LAA.

### History of the flight

The aircraft was on its third landing following the replacement of the nosewheel tyre. Shortly after touching down the nosewheel and fairing detached from the nose leg fork which then dug into the ground and snapped. The remains of the leg, still attached to the aircraft, also dug into the ground flipping the aircraft onto its roof (Figure 1).

The pilot suffered a blow to the arm but was held in the seat by the harness. After releasing the harness, the pilot exited the aircraft without assistance or further injury and was taken to the local hospital and discharged the same day.

**Examination of nosewheel assembly**

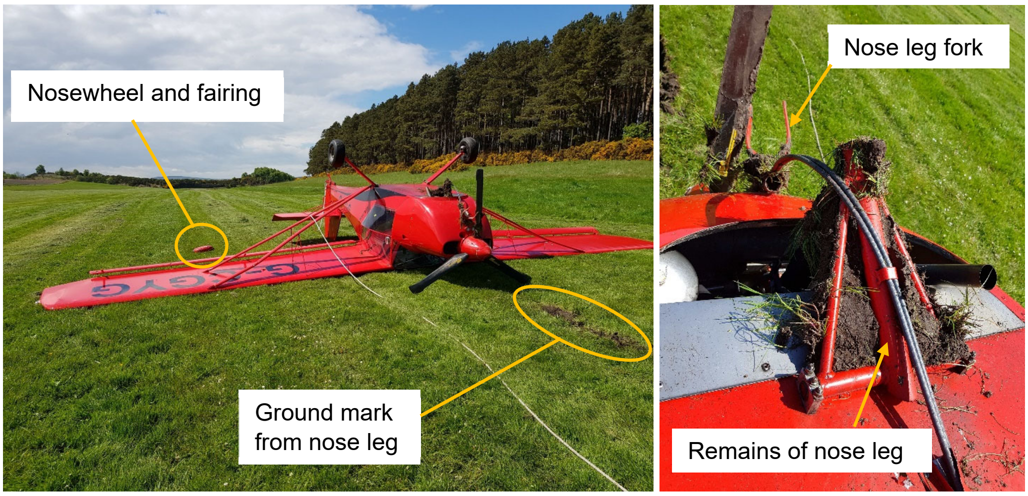


**Figure 1**

The aircraft pitched over onto its roof and, right, the snapped nose leg

The nosewheel fairing was found a short distance from the aircraft with the nose wheel and axle still fitted. There was evidence of paint transfer between the wheel hub and fairing (Figure 2) and the nose leg fork had paint worn away around the axle holes. Both wheel axle locating holes in the nose leg fork were undamaged.

The nose leg was bent downwards from its fitted orientation and had snapped at the point where the shock absorber bracket had been welded to the upper surface of the nose leg. Examination of the leg and the fracture surfaces showed that it failed in overload.

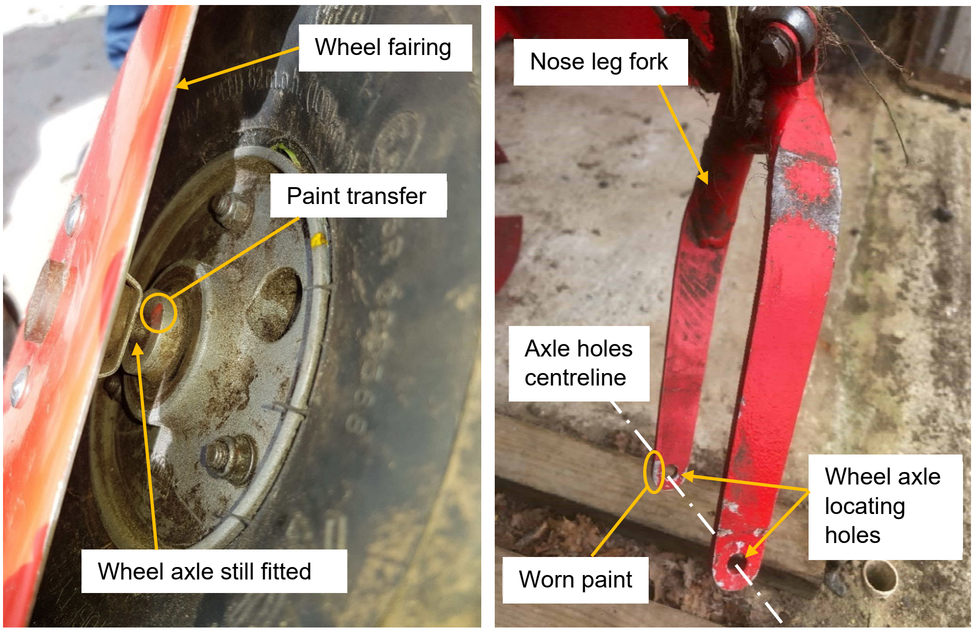


**Figure 2**

Nosewheel and fairing showing paint transfer and nose leg fork showing paint wear

## Replacing the nosewheel tyre

Two of the club's pilots, who were experienced in LAA pilot authorised maintenance, had replaced the nosewheel tyre three days earlier. The aircraft's maintenance manual (AMM) had been checked prior to starting the task and the pilot's noted that there was a procedure for removing the nosewheel and replacing the tyre, but there was no procedure for refitting the wheel.

The pilot's reported that a visual check through the axle holes in the fairing appeared to show clear daylight indicating that the fairing and nose leg fork axle holes were aligned. Once the tyre was replaced, the wheel was offered up to the nose leg fork and fairing. The wheel axle was inserted through the fairing until it protruded through the opposite side and then bolted into place. The wheel spun freely and appeared to be firmly located when pulled. The route of the axle through the nose leg and wheel assembly was not visually checked.

## Fitting the nosewheel incorrectly

The potential to incorrectly fit the nosewheel to the leg fork was recreated during a visit to the manufacturer's UK facility. Figure 3 shows a correctly assembled nosewheel and Figure 4 is a view from underneath the fairing with the axle in place, but the wheel removed.

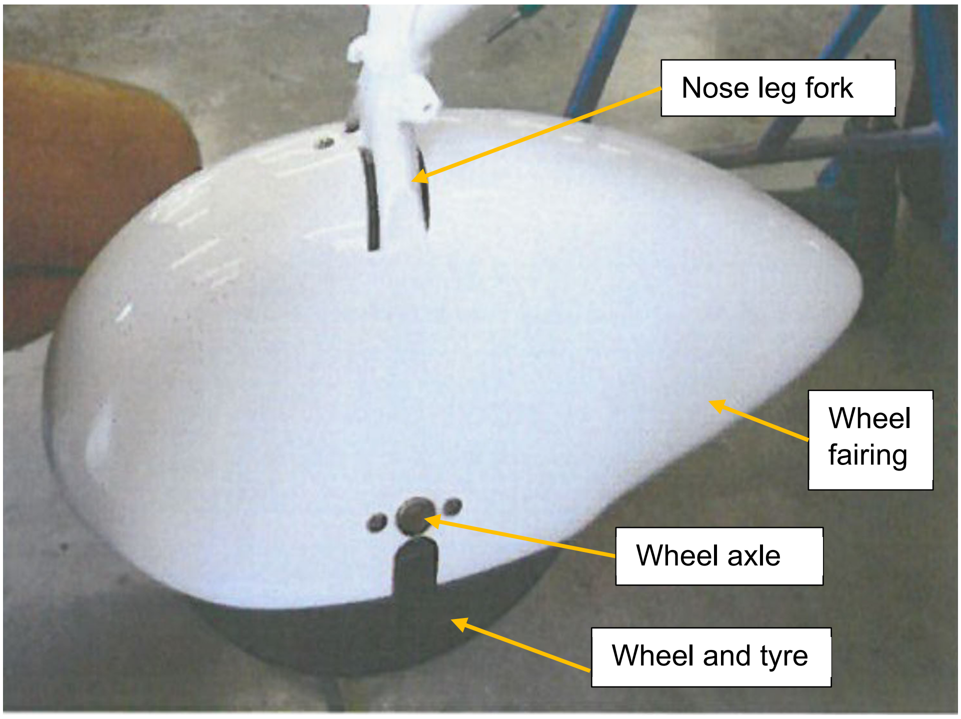


**Figure 3**

Example of an assembled nosewheel

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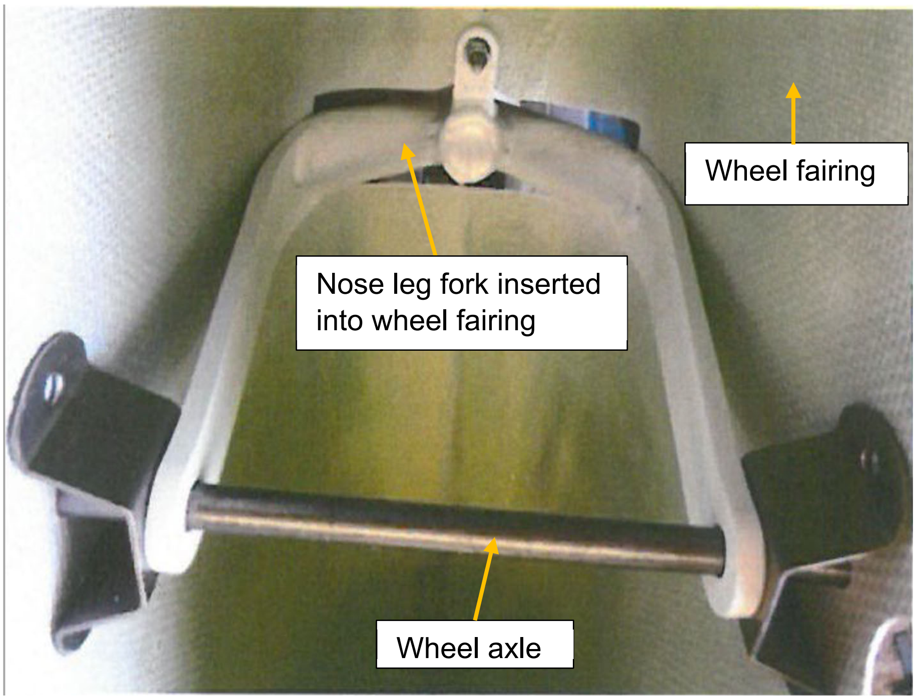


**Figure 4**

Nose leg fork and axle with the wheel removed

Figure 5 shows the axle not routed through the nose leg fork. Instead, the nose leg fork is clamped between the wheel hub bearings and the fairing.

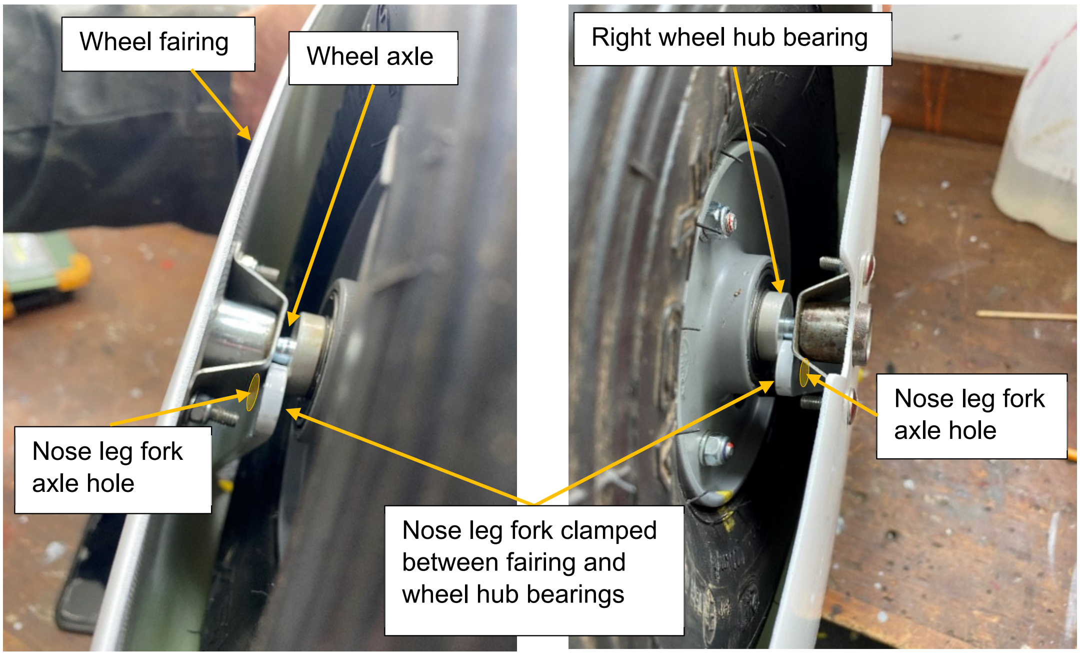


**Figure 5**

Nose leg fork clamped between the fairing and left and right hub bearings but with the wheel axle not routed through the nose leg fork axle holes

When clamped in this position, the wheel feels like it is firmly attached to the nose leg when force is applied and the wheel spins freely.

## Comment

Both wheel axle holes in the nose leg fork were still intact after the accident and showed that the axle could not have been routed through the fork. Paint transfer between the nose leg fork and wheel bearing indicated that the nose leg fork might have been clamped to the wheel assembly between the fairing and the wheel bearing.

There were no instructions in the AMM for refitting the nosewheel to the nose leg. The LAA has included an Engineering Matters article in their January 2022 edition of the Light Aviation magazine to inform pilots of the possibility of incorrectly fitting the nosewheel. They have also updated the aircraft's Type Acceptance Data Sheet, TADS 376, to include reference to fitting the nosewheel.

## Safety actions

The following safety actions have been taken by the manufacturer and the LAA:

The manufacturer will amend Section 5 of the AMM to include the procedure to refit the nosewheel and to highlight the potential for clamping the wheel onto the nose leg without correctly routing the wheel axle through the nose leg fork.

The LAA has produced an Engineering Matters article in their monthly Light Aviation magazine highlighting the potential to incorrectly fit the Eurofox 912(S) 3K nosewheel.

The LAA has updated the aircraft's Type Acceptance Data Sheet, TADS 376, to include reference to an incorrectly fitted nosewheel in paragraph 3.4 – *'Special Inspection Points.'*

## ACCIDENT

| | |
|---|---|
| **Aircraft Type and Registration:** | Jodel D120, G-BCGM |
| **No & Type of Engines:** | 1 Continental Motors Corp C90-14F (Modified) piston engine |
| **Year of Manufacture:** | 1957 (Serial no: 50) |
| **Date & Time (UTC):** | 28 September 2021 at 1054 hrs |
| **Location:** | Felton, Northumberland |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - None |
| **Injuries:** | Crew - 1 (Minor) Passengers - N/A |
| **Nature of Damage:** | Right landing gear, right wing, nose cowling, propeller, carburettor and airbox damaged and engine shock-loaded |
| **Commander's Licence:** | Private Pilot's Licence |
| **Commander's Age:** | 33 years |
| **Commander's Flying Experience:** | 1,469 hours (of which 15 were on type)<br>Last 90 days - 7 hours<br>Last 28 days - 2 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot |

### Synopsis

Following an engine failure on final approach to land at Eshott Airfield, the pilot landed the aircraft in a field, during which it was damaged.

### History of the flight

The pilot was returning to Eshott Airfield following a local flight. At approximately 2 nm on the final approach to Runway 19, whilst the aircraft was 700 ft agl, the engine rpm suddenly and smoothly reduced from 2,000 to 600, without any engine control input from the pilot. The pilot stated that he had completed the pre-landing checks which included setting the carburettor heat to HOT and the mixture to full rich. He confirmed that the fuel was selected ON, with approximately 80 litres remaining, and the magnetos were set to BOTH. He exercised the throttle, but the engine did not respond.

The pilot made a forced landing in a field 1.3 nm from the Runway 19 threshold, near to the village of Felton. He stated that he had selected the field based on it being into-wind and with the longest available landing distance of the fields ahead of the aircraft. On short final, he observed that the field was heavily rutted. The aircraft touched down in the field and struck a rut, causing it to become airborne again. This occurred numerous times during the landing roll, before the right mainwheel detached and the aircraft came to an abrupt stop as the right landing gear leg dug into the ground (Figure 1). The pilot was not injured and was able to vacate the aircraft without difficulty.


**Figure 1**
G-BCGM following the forced landing

**Aircraft information**

The Jodel D120 is a two-seat monoplane powered by a Continental C90-14F piston engine, with dual ignition systems. The aircraft is fitted with a single fuel tank of 115 litre capacity. Fuel is pumped from the tank to the engine by a mechanical fuel pump fitted to the engine. A secondary electric fuel pump is available for installation by an optional LAA modification, but was not installed on G-BCGM.

**Aircraft examination**

The aircraft was examined by the owner and an engineer following the accident, but no cause for the loss of engine power was found. The engine-driven mechanical fuel pump appeared to be operable, with no obvious signs of damage.

**Pilot's comments**

The pilot commented that he was approximately 10 kt fast on the approach to his chosen field and that he had become "target-fixated" on landing in the field. He stated that given the rutted surface of the field, he did not think a lower landing speed would have significantly altered the outcome of the forced landing.

**Analysis**

The pilot was compelled to make a forced landing following a loss of engine power during the final approach to land at Eshott Airfield. The field he selected was of sufficient length and into-wind, however the rutted surface of the field damaged the aircraft during the landing roll. The cause of the loss of engine power was not established.

## ACCIDENT

| | |
|---|---|
| **Aircraft Type and Registration:** | Piper PA-28-161, G-BRBA |
| **No & Type of Engines:** | 1 Lycoming O-320-D3G piston engine |
| **Year of Manufacture:** | 1979 (Serial no: 28-7916109) |
| **Date & Time (UTC):** | 4 September 2021 at 1110 hrs |
| **Location:** | Wycombe Air Park, Buckinghamshire |
| **Type of Flight:** | Training |
| **Persons on Board:** | Crew - 1 Passengers - 1 |
| **Injuries:** | Crew - None Passengers - None |
| **Nature of Damage:** | Damage to the right landing gear leg, right lower wing skin and right flap |
| **Commander's Licence:** | Commercial Pilot's Licence |
| **Commander's Age:** | 56 years |
| **Commander's Flying Experience:** | 1,287 hours (of which 998 were on type)<br>Last 90 days - 7 hours<br>Last 28 days - 3 hours |
| **Information Source:** | Information provided by the pilot and further enquiries made by the AAIB |

### Synopsis

When the instructor selected landing flaps and reduced speed the aircraft started to handle in an unusual way. It became apparent on landing that the right main landing gear had failed. Both occupants escaped without injury.

The investigation found that the right landing gear torque link upper attachment lugs had failed due to fatigue. Following previous reports of cracking in this location on several related aircraft types, the manufacturer had issued a Service Bulletin describing a regular inspection procedure.

### History of the flight

A flying instructor was scheduled to fly a trial lesson with a new student pilot from Wycombe Air Park. The weather was not ideal for a normal trial lesson but the student was keen to fly so the instructor agreed to fly a few circuits. The instructor and student took off from Runway 06L at 1100 hrs with the instructor flying the aircraft. He reported that the takeoff, climb and downwind leg all seemed normal. He turned onto base leg, selected two stages of flap and reduced speed to 75 kt as normal. However, as he did this, he felt something was wrong with the aircraft, which he described as "surging". He initially thought he was experiencing a rough running engine so tried changing fuel tanks, checking the mixture and selecting carburettor heat. He told Wycombe Radio that he had a rough running engine and continued the approach. However, as he continued, he realised that the engine was running normally but the aircraft still had an unusual "surging" motion.

As the aircraft touched down on Runway 06L it was immediately obvious to the instructor that the right landing gear had failed. He described the landing as a "very gentle touchdown". He applied left aileron and closed the mixture and, as the aircraft slowed and the right wing dropped, it turned though 180° and slid onto the grass (Figure 1). The instructor made the aircraft safe and helped the student exit the aircraft. Neither was injured.

**Figure 1**
G-BRBA after the accident

### Accident site

Inspection of the aircraft showed that the lower section of the right landing gear oleo had come out of the upper cylinder. The wheel assembly had remained attached to the aircraft by the flexible brake hose. The assembly had become wedged on the back of the right-wing flap (Figure 2 and 3). Abrasion on the brake calliper showed that as the aircraft landed and the right wing dropped, the aircraft slid on the underside of the wedged wheel assembly. The remaining upper portion of the landing gear oleo was undamaged and did not appear to have contacted the runway.

**Figure 2**
Right wheel assembly and lower portion of the oleo wedged on the flap

The right flap was damaged where the wheel assembly had become wedged on the flap. There were also puncher marks on the underside of the wing where the loose wheel assembly had been flailing below the wing.


**Figure 3**

Right wheel assembly viewed when the wing was lifted after the accident, showing the taut brake line

Further damage was caused to the lower wing surface during recovery of the aircraft.

## Aircraft information

The Piper PA-28 has a fixed tricycle landing gear. Each main landing gear consists of an oleo with a single wheel and brake calliper. The lower part of the oleo is retained within the upper part by a toque link and flexible brake pipe. The torque link also maintains the alignment of the main landing gear wheels. Figure 4 shows the normal assembly (the photograph is of the left land gear of G-BRBA).

There are two types of oleo leg fitted to PA-28's. The original, fitted to aircraft manufactured between 1961 and 1977, used a cast landing gear cylinder. Aircraft manufactured since 1977 were equipped with a forged cylinder. G-BRBA was fitted with the original cast landing gear cylinders. The forged cylinder can be fitted to earlier aircraft.

The original cast cylinders have a history of fatigue cracks developing in the torque link attachment lugs of the upper cylinder. Following previous failures of the lugs, the CAA issued an Airworthiness Directive (AD) requiring the inspection of the landing gear castings for cracks (AD 002-06-99).


**Figure 4**
PA-28 left main landing gear

On 18 August 2003 the aircraft manufacturer issued Service Bulletin (SB) 1131 providing instruction for the inspection of the oleo lugs at 100-hour intervals. The inspection required the torque link to be removed and the lugs to be inspected visually using a 10x magnifying glass. If no cracks were found the SB required the area to be inspected using liquid dye penetrant. On 18 August 2016, an updated SB (SB 1131A) was issued which added illustrations and further instructions to clarify the inspection procedure. Figure 5 is extracted from the SB and shows the area which required inspection.

On 30 December 2005, the EASA issued AD 2005-0035 which retained and superseded the CAA AD. This AD was cancelled on 20 February 2020. The reasons given for the cancellation were:

> *'1. The service history of the affected aeroplanes with respect to this failure mode (in particular the consequence of the failure in the reported occurrences) and criticality of a main landing gear failure,*
>
> *2. the reduced probability of such failure occurring on the remaining fleet, due to the available improved inspection instructions in Piper SB 1131A, and*
>
> *3. the gradual fleet replacement of cast MLG with forged MLG.'*

The cancellation notice stated that '*EASA has determined that an acceptable level of safety exists and an AD was no longer necessary*'.

The maintenance organisation responsible for G-BRBA reported that the inspection detailed in SB 1131A was completed during the last 100-hour inspection on 10 August 2021 and no cracks were found. Since then, the aircraft had flown 33 hours and completed 110 landings.

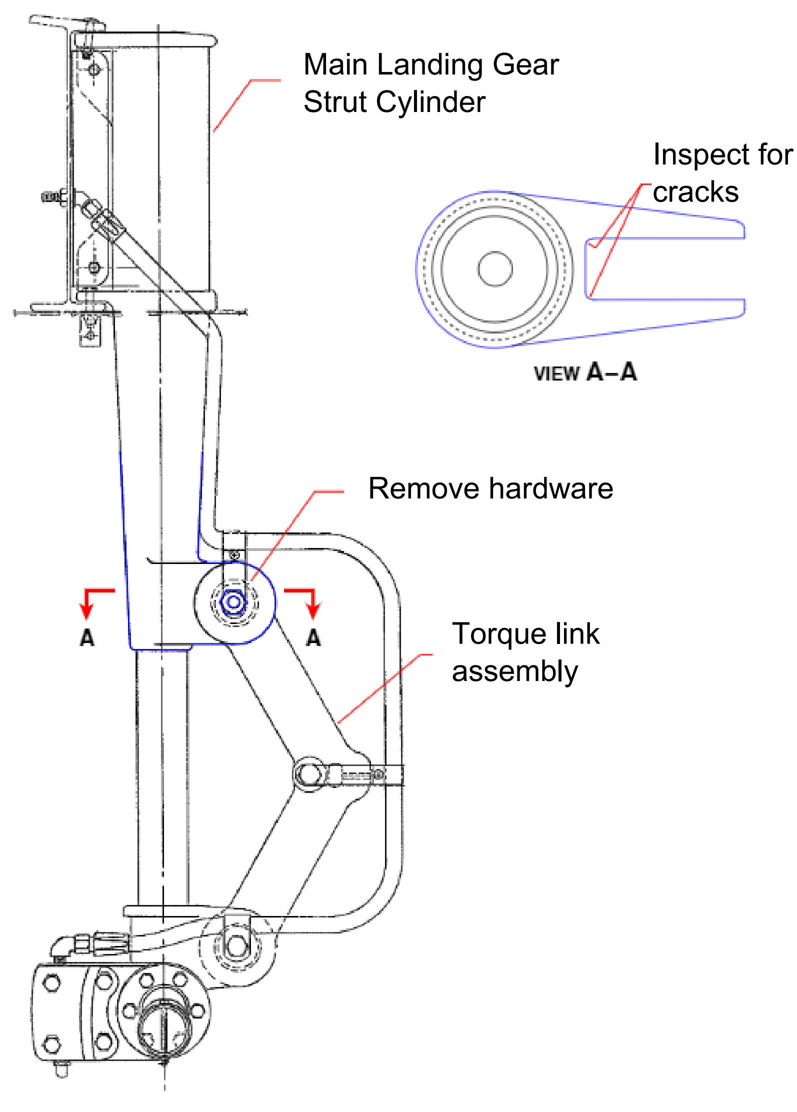


**Figure 5**

Extract from SB 1131A showing the area requiring inspection

## Aircraft examination

Examination of the landing gear oleo on G-BRBA showed that the torque link upper attachment lugs had broken away from the upper cylinder (Figure 6) disconnecting the torque link.

The failed lugs were sent to a metallurgist for a detailed analysis of the fracture surfaces.

**Figure 6**

Right landing gear assembly showed the failed upper torque link attachment lugs

**Analysis of fracture surfaces**

The fracture surfaces were examined using a scanning electron microscope. Macroscopic radial markings on the fracture surface indicated that, on each lug, the fracture had initiated at the lower end of the inner radius (Figure 7 and 8). At the locations of fracture initiation, faint crack progression markings indicated the presence of fatigue cracks. The fatigue crack fronts extended inwards from the surface to a maximum depth of 2 mm. The appearance of the remainder of the fracture surface area was consistent with final separation, when the remaining uncracked cross-section became overloaded, due to the advancing fatigue cracks. There was no evidence of pre-existing material or mechanical defects associated with the fatigue crack initiation.

At higher magnifications, fine fatigue striations could be seen within the regions of the fatigue crack growth but they were too numerous for each individual striation to correspond to a single landing. It is therefore likely that they corresponded to both landings and vibrations in the landing gear. It was not possible to identify a pattern or periodicity in the striations that could be correlated to the number of landings.

**Liquid penetrant inspection**

SB 1131A required an inspection by liquid penetrant if cracks could not be seen with a magnifying glass. Aluminium alloy castings typically have a degree of porosity. Surface breaking porosity often produces a degree of background fluorescence during dye penetrant inspection. In some cases, it can be difficult to differentiate such porosity from very small cracks. The inspections are conducted with the component on the aircraft which can also make it harder to see very small cracks.

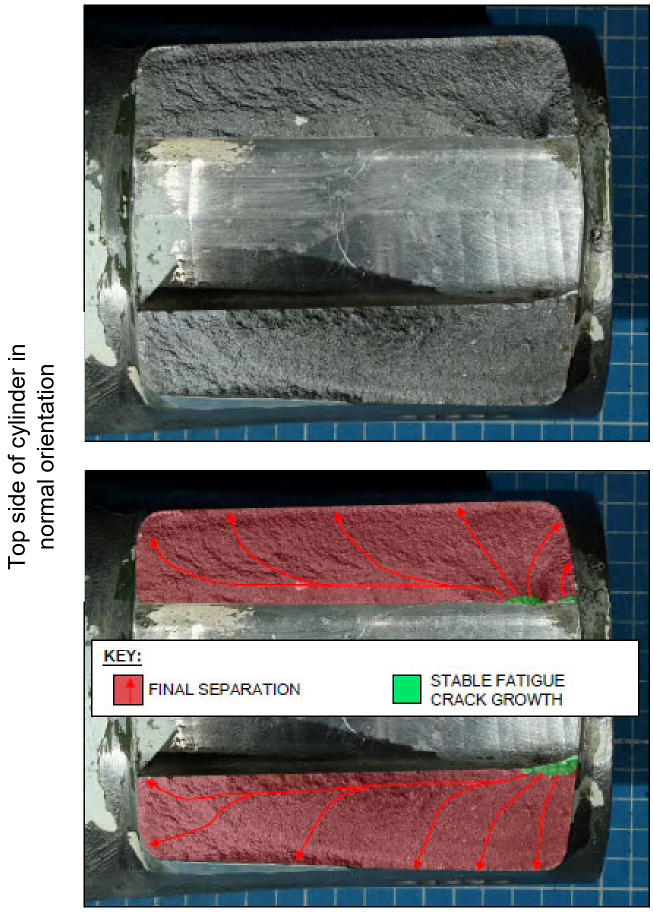


**Figure 7**

Fracture surface on the landing gear upper cylinder

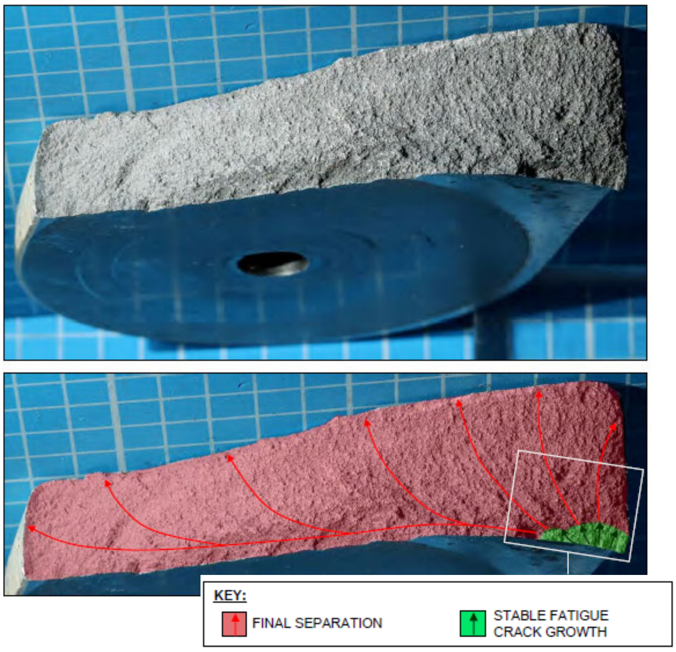


**Figure 8**

View of the left lug (similar cracks were found on the right lug)

## Analysis

The upper attachment lugs of the right landing gear torque link failed allowing the lower portion of the oleo and wheel assembly to slide out, only remaining attached to the aircraft by the brake hose. The lugs could have failed on the takeoff roll or in flight, but it only became apparent to the pilot that something was wrong when he selected flap and reduced speed as the aircraft turned onto base leg.

Analysis of the failed attachment lugs showed that fatigue cracks had formed in the lower inner corner of both lugs and these had grown until they failed in overload. The fatigue crack had grown to a maximum depth of 2 mm prior to the failure. It was not possible to determine how long the fatigue crack had been growing.

The original cast landing gear leg fitted to this and similar Piper aircraft, had a history of fatigue cracking in this location. In 2003 the aircraft manufacturer issued a SB requiring inspection of the lugs for cracks every 100 hours. The CAA issued an AD mandating the SB and in 2005 this was adopted by the EASA but was cancelled in 2020 because the EASA determined that an acceptable level of safety existed.

The SB was completed on G-BRBA during its previous 100-hour inspection (33 hours and 110 landing prior to the accident) and no cracks were detected. It could not be determined if the cracks were present during this inspection and were not detected, or if the crack formed later. It is possible that the crack, if present, was not detected because of background fluorescence caused by surface breaking porosity of the cast aluminium alloy.

The inspection interval is based on hours rather than number of landings. The manufacturer does not require the number of landings to be recorded, so do not specify inspections based on landings. The aircraft had completed 110 landings since the inspection and it is possible that this number of landings was sufficient to allow the crack to develop.

## Conclusion

The right main landing gear torque link attachment lugs failed due to fatigue cracking, causing the lower part of the oleo to slide out of the upper part. This component has a history of cracking in this area and a SB exists to regularly inspect the area.

## AAIB Comment

This accident shows that fatigue cracking of the torque link attachment lugs continues to occur, and that this can lead to an accident. It highlights the importance that operators of the affected aircraft continue to inspect their aircraft in accordance with the SB. It also suggests that it may be prudent for operators whose aircraft accumulate a significant number of landings to inspect their aircraft more frequently than required by the SB.

## ACCIDENT

| | |
|---|---|
| **Aircraft Type and Registration:** | Piper PA-28-236, G-CSBD |
| **No & Type of Engines:** | 1 Lycoming O-540-J3A5D piston engine |
| **Year of Manufacture:** | 1981 (Serial no: 28-8211019) |
| **Date & Time (UTC):** | 27 February 2022 at 1300 hrs |
| **Location:** | Old Buckenham Airfield, Norfolk |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - 1 |
| **Injuries:** | Crew - None Passengers - None |
| **Nature of Damage:** | Rudder damaged |
| **Commander's Licence:** | Private Pilot's Licence |
| **Commander's Age:** | 64 years |
| **Commander's Flying Experience:** | 4,330 hours (of which 1,000 were on type)<br>Last 90 days - 32 hours<br>Last 28 days - 1 hour |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot and enquiries made by the AAIB |

### Synopsis

On roll out, after landing, the pilot made a rudder input to counter a crosswind gust. As he did so there was an immediate onset of a violent nosewheel shimmy which dissipated as the aircraft slowed to 20 kt. The shimmy appeared to have been caused by a foreign object becoming trapped between the nosewheel tyre and the wheel spat.

### History of the flight

The aircraft had landed at Old Buckenham Airfield with a 15 kt crosswind. During the rollout the pilot described encountering a crosswind gust which he corrected with a rudder input. This immediately initiated a violent nosewheel shimmy which the pilot felt made the aircraft "virtually uncontrollable". As the aircraft slowed to 20 kt, the shimmy subsided, and it continued to taxi normally.

### Subsequent investigation

Examination of the aircraft found that the rudder had been damaged and that the nosewheel tyre sidewall had also been severely damaged. This sidewall damage appeared to have been caused by a foreign object, probably a stone, getting trapped between the wheel spat and tyre. In the absence of any other faults with the nosewheel steering and rudder system, it is suspected that this caused the shimmy which then led to the rudder damage.

**AAIB Observation**

In this case it is not known when, how or where the foreign object was picked up. However, the AAIB have reported on several occurrences where aircraft wheel spats have been causal or contributory factors to accidents. In one case, wheel spat mud contamination was a contributory factor in a fatal accident.

As a result of these previous accidents, the CAA drew attention to *'Safety Sense Leaflet 12 - Strip Flying'* and reminded owners of aircraft fitted with wheel spats to take account of ground conditions and to take care to ensure wheel spats are clear of contamination.

## ACCIDENT

| | |
|---|---|
| **Aircraft Type and Registration:** | P84 Jet Provost Mk 5, G-VIVM |
| **No & Type of Engines:** | 1 Rolls-Royce Viper 20201 turbojet engine |
| **Year of Manufacture:** | 1967 (Serial no: PAC/W/23907) |
| **Date & Time (UTC):** | 16 June 2021 at 1300 hrs |
| **Location:** | North Weald Airport, Essex |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - 1 |
| **Injuries:** | Crew - None Passengers - None |
| **Nature of Damage:** | Damage to aircraft nose structure and main landing gear. Nose landing gear collapsed |
| **Commander's Licence:** | Private Pilot's Licence |
| **Commander's Age:** | 69 years |
| **Commander's Flying Experience:** | 15,000 hours (of which 350 were on type)<br>Last 90 days - 42 hours<br>Last 28 days - 16 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot and further AAIB enquiries |

### Synopsis

The commander performed a rejected takeoff (RTO) due to a reported lack of indication on the air speed indicator (ASI). Despite braking, the aircraft did not come to a stop before the end of the runway. It departed the paved surface into a grassy area and came to rest after striking a shallow earth bank and the airport perimeter fence. There were no injuries.

Examination and testing did not identify any defects with the aircraft's airspeed indicator or pitot/static system. Examination of the wheels and brakes did not identify any defects but accident damage prevented testing of the braking system. Damage to the wheels and brakes was consistent with the application of heavy braking during a high energy RTO.

The investigation considered that the braking demand arising from the rejected takeoff exceeded the ability of the aircraft braking system to bring the aircraft to a stop, in the available distance remaining.

### History of the flight

The flight was intended to be a post-maintenance check flight. The commander, occupying the right seat, was accompanied by a passenger in the left seat. The passenger was also a pilot with experience on the Jet Provost, but whose pilot's licence was not current at the time. Earlier that morning, maintenance staff had towed the aircraft out of the hangar in preparation for the flight. The commander then carried out a pre-flight inspection.

The commander reported that the start-up and taxi out to the runway was normal and he lined-up for a full length departure. He stated that during the takeoff roll, the ASI, which normally starts to indicate at 50 kt, showed no indication. He decided to abort the takeoff when the aircraft was approximately one third the way down the runway, brought the aircraft to a halt and taxied back to the maintenance area, where he reported a lack of airspeed indication to the engineers.

Maintenance staff carried out a leak check of the pitot/static system and a functional check of the ASI using a hand-held leak-and-sense checker. When a pressure equivalent to approximately 130 kt[1] was applied to the system, the ASI was observed to indicate approximately 130 kt. When the commander returned to the aircraft, one of the maintenance staff also stood some distance in front of the aircraft and gently blew towards the pitot probe to demonstrate to him that the ASI needle moved in the appropriate sense. The commander observed this and was content to accept the aircraft.

The commander checked the brakes and tyres for any indications of residual heat remaining after the RTO and was satisfied that there were none. He also checked the brake wear indicator pins. After what he estimated to be an elapsed time of 1.0 to 1.5 hours since the first RTO, he taxied the aircraft to Runway 20 for a second takeoff attempt. As the aircraft accelerated, he again observed that there was no speed indication on the ASI and initiated an RTO. He estimated that at this point the aircraft was travelling at approximately 70 – 80 kt, with approximately 4,000 ft of runway remaining. He reported that initial gentle to moderate braking application had little effect, so increased the braking effort, again with no effect. He then applied full pressure on each brake in turn but it did not result in any lateral movement of the nose.

The aircraft departed the end of the runway at a speed of approximately 10 – 15 kt, into a grass area and came to rest after striking a shallow earth bank and the airport perimeter fence (Figure 1). Both occupants were unhurt and exited the aircraft without assistance. A small grass fire initiated next to each wheel as a result of the hot brakes. These were extinguished by the ARFFS.

The maintenance organisation indicated that the aircraft had initially departed the maintenance area at 1203 hrs, returning to the hangar after the first RTO at 1214 hrs. Following the completion of maintenance, the aircraft departed again at 1317 hrs and the accident occurred at approximately 1324 hrs.

**Footnote**

1 The leak-and-sense checker was not calibrated, but the 130 kt setting on the test kit was selected.

**Figure 1**
G-VIVM final position

**Airfield information**

North Weald Airfield is an unlicensed aerodrome, with grass and paved runways and an airfield elevation of 321 ft amsl. The main runway, Runway 02/20 has a paved surface and is 1,881 m (6,171 ft) long.

There is a 55 ft difference in elevation between each end of the runway, Runway 20 having an upslope and Runway 02 a downslope.

**Additional information from the flight crew**

The commander commented that as part of the pre-flight preparation he checked the hydraulic fluid level on the four brake foot motors, one on each brake pedal. He also recalled the hydraulic system pressure being within the normal range. He reported that the brakes appeared to operate normally during taxiing and engine run-up on both occasions and during the first RTO.

The commander commented that on the second takeoff attempt he wanted to give the ASI ample time to register an indication, and therefore allowed the aircraft to accelerate to what he estimated to be 70 – 80 kt. He estimated that he initiated the RTO and commenced braking when the aircraft was approximately abeam the intersection with Taxiway A2, from which point there would have been 1,433 m (4,700 ft) of runway remaining. He described "hardly any retardation" from the brakes during the RTO and considered that the aircraft should have stopped comfortably in the remaining distance.

After the accident, he reviewed information from Skydemon software operated on an iPad device which had been mounted in the cockpit and was surprised to learn that the aircraft had actually reached a groundspeed of approximately 105 kt during the takeoff roll. While normal takeoff speed for the aircraft configuration and conditions on the day is in the range of 80 – 90 kt, he commented that the aircraft did not feel light on its landing gear as if it was at flying speed and this might be why he underestimated the speed which the aircraft had achieved. In retrospect the commander commented that he could have referred to the ground speed display on the iPad as a secondary source of speed information. With hindsight he also considered that it may have been appropriate to continue the takeoff and fly a circuit to land, but at the time he had been reluctant to do so without a valid speed indication. He also stated that, based on the first RTO, he had no reason to expect that the aircraft would not stop in the available distance.

The passenger stated that they had also been monitoring the ASI during both takeoff runs and confirmed that the needle did not move. On the second RTO, they described the brakes as "partly working but they ran out of ability."

**Aircraft information**

The Jet Provost Mk 5 is two seat ex-military jet trainer, with a side-by-side seating arrangement. On G-VIVM, the ASI occupied the top left position in a cluster of six instruments centrally grouped on the instrument panel (Figure 2). The ASI speed scale indicates from 50 to 500 kt.


**Figure 2**

G-VIVM central instrument cluster showing position of ASI

Each main landing gear has a single wheel, equipped with a hydraulic brake unit, consisting of a brake calliper mounted on the brake disc. The calliper incorporates three pistons, each of which drive a 'floating' friction pad against the outboard face of the disc when hydraulic pressure is applied. This drives the brake disc against three fixed friction pads mounted on the inboard side of the brake calliper.

The floating friction pads are not mechanically attached to the pistons but sit within a recess in the piston housing forming a contact fit. In normal operation, piston travel increases to compensate for increasing wear of the friction pads and a brake wear indicator pin at the centre of each piston, indicates when the brake pads need to be replaced.

G-VIVM was not equipped with an anti-skid system. The Aircrew Manual did not specify a minimum brake cooling period following an RTO.

**Aircraft maintenance history**

Prior to the accident, the aircraft had last flown on 4 November 2020. The aircraft's annual maintenance / 'Primary Star' inspection commenced in December 2020, but completion of the maintenance was delayed awaiting parts. Following completion of the maintenance, the aircraft was assessed as needing a post-maintenance check flight and the permit maintenance release was signed on 10 June 2021.

The aircraft remained hangared throughout this period with covers installed on the pitot/static ports. No pitot/static system inspections were called up in the maintenance schedule for the Primary Star inspection. The brakes were inspected and declared serviceable at the beginning of the maintenance input in December 2020. This included inspection of the brake wear indicator pins.

**Aircraft damage**

The nose light was damaged when the aircraft struck the airport perimeter fence. The nose landing gear had collapsed and the stabilising/retraction arm was broken. The pitot probe was bent upwards and cracked and the surrounding support structure deformed. The left main landing gear support strut had failed. Damage to both main landing gear wheels is described in the 'Aircraft Examination' section of this report.

**Aircraft examination**

Following the accident, the maintenance organisation tested the pitot/static system, in the presence of a CAA Airworthiness Surveyor. It was not possible to perform a full functional test due to the damage sustained by the pitot probe but the outer casing was blanked-off to prevent/reduce leakage. A leak-and-sense checker was attached to the pitot probe and when pressure was applied, the ASI needle responded in the correct sense. The pitot/static system was subsequently reverse-flushed using compressed air and a plastic bag over the end of the pitot tube to collect any debris. No evidence of a blockage or debris in the system was detected.

The water drain traps in the pitot/static system were examined and were found to be dry, with no water or condensation present.

The ASI was removed and sent to a specialist organisation for inspection and test, which reported that the unit was received in good condition with no fault found. It passed the functional test and was within calibration limits.

The wheels and brakes were examined in-situ by the maintenance organisation in the presence of an AAIB inspector and were then removed for further examination at the AAIB facilities. The left and right main landing gear wheels rotated freely and the tyres had remained inflated. There was no evidence of scuffing or flat spots on the tyres, indicating that they had been turning throughout.

Both wheels showed signs of heat exposure, including blistering of the surface coating on the wheels and brake callipers. The outboard sidewalls of each tyre exhibited areas of charred and cracked rubber. Both brake discs displayed heat damage and heavy scoring and gouging with the surface plating removed. On each calliper the inboard fixed friction pads had remained in place and were heavily worn, while all the floating friction pads had become dislodged from the pistons. The pistons had travelled all the way through the piston housing and one piston on each calliper had over-travelled, such that there was metal-to-metal contact between the piston crown and disc (Figures 3 and 4).

On the right wheel, two of the floating friction pads had fused to the disc and one was absent. Two pads found in the grass close to the left landing gear exhibited heavy wear; the third was absent. The recovered floating friction pads were not evenly worn across the entire surface area, but measured thickness ranged from 3.71 mm – 5.80 mm. This compared to a thickness of 16.05 mm for a new floating friction pad.

**Figure 3**

Right main landing gear wheel and brake disc.
Inset shows brake calliper and pistons

**Figure 4**

Left main landing gear brake disc.
Inset shows brake calliper and pistons

The maintenance organisation was unable to perform a functional test of the braking system following the accident due to the extensive damage to the wheels and brakes and the loss of hydraulic fluid from the system.

## Landing and stopping performance

G-VIVM's takeoff weight prior to the first takeoff attempt was 7,500 lbs. The commander recalled the ambient temperature on the day being around 24 - 25 °C. The landing performance section of the Aircrew Manual gives a minimum ground run distance of 1,790 ft on a dry runway for an aircraft weight of 7,000 lb, with a threshold speed of 95 kt and a temperature of 25 ºC, with no wind[2]. Some adjustment of this figure would be required to take account of G-VIVM's weight, the speed achieved during the takeoff roll and the effect of wind/runway slope. However, it provides an approximate indication of the stopping distance from the point at which the RTO was initiated, which the commander expected G-VIVM to achieve.

## Discussion

*ASI*

Examination and testing of the pitot/static system by the maintenance organisation and independent testing of the ASI, did not identify any defects which could explain the lack of airspeed indication reported by the commander. The reason for the absence of airspeed indication was not determined.

**Footnote**

2 This figure was derived by linearly interpolating between the published landing performance figures for an ambient temperature of 20 and 30 °C.

*Brakes*

No problems were noted with the brakes during ground manoeuvring or the first RTO. The commander reported no evidence of residual heat in the brakes prior to the second takeoff attempt and the Aircrew Manual did not specify a minimum period for brake cooling.

Examination did not reveal any defects which might have led to a sudden loss of braking, although accident damage prevented post-accident testing of the braking system. The absence of flat spots on the tyres indicates that the brakes were not locked and the wheels continued to turn, rather than skidding during the RTO. The commander considered that it was normally possible to apply sufficiently heavy braking on the Jet Provost to cause flat spots on the tyres, given that it did not have an anti-skid system. He considered the absence of flat spots as evidence that the brakes were not functioning as expected.

Displacement of the brake pistons was consistent with hydraulic pressure being applied at the callipers and the extent of piston travel suggests heavy braking. Mechanical and heat damage to the wheels and brakes was consistent with the application of heavy braking, such as might occur during a high energy (high speed) RTO.

All six floating friction pads were displaced from the pistons, and four of them were found on or close to their respective wheels. Two were not retrieved and it is not known at what point these were liberated. The loss of one or more floating friction pads would substantially reduce braking efficiency and increase the temperature and wear rate experienced by the remaining friction pads. Disruption to the friction surface of the disc from direct contact with a piston would also have exacerbated this. It is therefore likely that this would have had an adverse effect on braking efficiency, which would have reduced throughout the ground run of the RTO.

The maintenance organisation commented that the design of the Jet Provost braking system was not considered particularly robust and some Jet Provost owners had replaced the original brakes with those from the Strikemaster[3], which were considered superior.

*Decision-making*

Having already experienced an earlier RTO due to a lack of airspeed indication, the commander was focused on the ASI during the second takeoff attempt and wanted to give it ample opportunity to indicate. In doing so the aircraft accelerated to a higher speed than the commander estimated, and likely a higher speed than during the first takeoff roll.

Although he didn't consider using it at the time, the commander later considered that it may have been prudent to refer to the ground speed display on the iPad as a secondary speed source during the second takeoff attempt. This may have facilitated the RTO being initiated at an earlier point.

**Footnote**

3 The BAC 167 Strikemaster was a ground-attack derivative of the Jet Provost T Mk.5.

In planning for the second takeoff attempt, it may have been prudent to review the aircraft stopping performance and identify a fixed reference point on the runway by which the takeoff would be rejected if the same fault recurred. The commander considered that the second RTO was initiated at approximately the same point on the runway as the first RTO and assessed that there was sufficient runway remaining in which to bring the aircraft to a stop. However, given that the aircraft had reached a groundspeed of approximately 105 kt, it is quite possible that the aircraft had travelled further along the runway than the commander recalled.

It was not possible to reconcile all the various sources of evidence available to the investigation to provide a complete understanding of why the aircraft did not stop before the end of the runway, but the investigation considered that the braking demand during the RTO exceeded the ability of the aircraft's braking system to bring the aircraft to a stop within the remaining runway distance available. Displacement of the floating friction pads during the ground run would also have had an adverse effect on braking efficiency.

## Conclusion

The reason for the absence of airspeed indication was not determined. At the point at which the rejected takeoff was initiated, the braking demand exceeded the ability of the aircraft's braking system to bring the aircraft to a stop within the remaining runway distance available. Displacement of the floating friction pads during the ground run would also have had an adverse effect on braking efficiency.

# AAIB Record-Only Investigations

This section provides details of accidents and incidents which were not subject to a Field or full Correspondence Investigation.

They are wholly, or largely, based on information provided by the aircraft commander at the time of reporting and in some cases additional information from other sources.

The accuracy of the information provided cannot be assured.

## Record-only UAS investigations reviewed: February - March 2022

**5 Jul 2021** **Cobra** Spadeadam, Cumbria

The 8.4 kg fixed-wing UA was being operated on a Beyond Visual Line Of Sight (BVLOS) flight within a Danger Area. At 490 ft agl the UA departed controlled flight and struck the ground. The UA's flight control system relied on GPS for primary control. If a loss of GPS was detected it reverted to a secondary control mode. The loss of control was caused by a loss of GPS and the system's failure to detect it. The manufacturer has since changed the loss of GPS trigger thresholds, upgraded the GPS antenna and switched the primary control to use barometric altitude instead of GPS altitude.

**23 Nov 2021** **DJI Mavic 2** Old Oxsted, Surrey

The UA was being operated commercially to capture footage of residential properties when, from a height of about 100 m, it suddenly entered a rapid spin which the pilot could not control, and it fell into the garden of a property. The remote pilot considered that the accident occurred because of a failure of either a motor, or a motor support arm.

**4 Feb 2022** **Evolve Skymantis** Eastbourne, East Sussex

During landing the operator inadvertently turned the power off causing the UA to drop from 2 m agl.

**5 Feb 2022** **DJI Mavic Mini 2** Bridgend

The pilot misjudged the height of a nearby power line. At a height of about 37 m, the UA collided with the top wire of the power line, fell to the ground and suffered substantial damage. The power line was undamaged.

**8 Feb 2022** **DJI Mavic 2 Enterprise** Bury St Edmunds, Suffolk

The UA clipped a tree in a field. It fell through the tree, landed heavily on a country road, and was substantially damaged.

**11 Feb 2022** **DJI Inspire 2 X5S** Sutton Bank, North Yorkshire

Six minutes into a flight that was filming for a television task, the gimbal of the UA disconnected in flight. This generated a 'Gimbal Disconnected' alert, and the UA dropped to the ground from 70 m agl.

**18 Feb 2022** **DJI Mavic Mini** Huntington, Cheshire

The drone was caught by a sudden gust of wind, it had previously been calm on take-off. The drone was pulled out of range and was not recovered.

**25 Feb 2022** **DJI Inspire 2** Honister Pass, Cumbria

Whilst carrying out a filming flight the remote pilot flew the UA backwards which resulted in the UA hitting an undulating rock face. The UA suffered significant damage.

**Record-only UAS investigations reviewed: February - March 2022 cont**

**1 Mar 2022** **DJI Mavic 2 Enterprise** Llandarcy, Neath Port Talbot

The UA was carrying out close inspection work when it clipped a dangling wire and became uncontrollable. The pilot regained control but was unable to prevent the UA from striking a metal fence.

**1 Mar 2022** **Wingtra One** Leeds

The UAS was carrying out an aerial survey. Shortly after takeoff on the fourth flight of the day, both motors stopped suddenly. The UA fell to the ground from a height of approximately 30 m and was destroyed.

**12 Mar 2022** **DJI Mavic Zoom 2** White City, London

The UAS was being used for calibration of a Fire Alarm Beam Detector within an atrium. While hovering at a height of 15 m the UA suddenly moved closer to the building and struck a wall, before falling to the ground. The legs, camera and body of the UA sustained significant damage.

**24 Mar 2022** **DJI Matrice M300** Manchester

Due to lack of GPS signal two attempts to take-off were aborted. After obtaining a satisfactory GPS signal the UA took off normally. While hovering at a height of 5 m the UAS handset began beeping and the UA fell to the ground breaking two motor arms.

# Miscellaneous

This section contains Addenda, Corrections and a list of the ten most recent Aircraft Accident ('Formal') Reports published by the AAIB.

The complete reports can be downloaded from the AAIB website (www.aaib.gov.uk).

**BULLETIN CORRECTION**

| | |
|---|---|
| **Aircraft Type and Registration:** | Druine D.31 Turbulent (modified), G-AREZ |
| **Date & Time (UTC):** | 8 July 2021 at 1730 hrs |
| **Location:** | Easterton Airfield, Birnie, Elgin |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot and LAA Report |

**AAIB Bulletin No 2/2022, page 72 refers**

Following publication of AAIB Bulletin 2/2022, the Light Aircraft Association (LAA) amended its report into this accident to reflect its updated view on the cause of the engine failure. Since the AAIB report was based on the LAA report, this correction reflects that change.

The following sections of the report have been amended:

**Page 72: Synopsis (second paragraph)**

Original text:

The loss of power was possibly caused by an interruption of electrical power to the ignition system.

Corrected text:

Although not positively determined, it appeared likely that a magnet detached from the propellor spinner back plate during takeoff, and this combined with incorrect wiring within the ignition system to stop the engine.

**Page 75: Aircraft examination (second paragraph)**

Original text:

The aircraft's ignition system was extensively examined and, while some loose connections were found, both ignition controllers passed bench tests. Hypotheses for the simultaneous failure of both electronic ignition controllers were considered, but no definitive cause for the engine failure was determined.

Corrected text:

The aircraft's ignition system was extensively examined and, while some loose connections were found, both Leburg ignition controllers passed bench tests. The Leburg controllers receive timing information from sensors which detect the passage of magnets fitted to the propellor spinner back plate. The spinner backplate was damaged and one of these magnets was missing. There was evidence it had not been effectively glued in position. The wires connecting the controller to the magnet sensors should be arranged so that the connector responding to north magnet pole in one wiring harness is connected to the sensor for a south magnet pole in the opposite controller wiring harness. The controllers require an alternating sequence of poles passing the sensors, ie north–south-north-south, to operate correctly. If this sequence is not apparent the controller will not initiate the ignition spark.

**Page 75: Aircraft examination (new third paragraph)**

Corrected text:

In G-AREZ the wiring harness for both controllers were wired so the north magnet pole sensors were on identical connectors, so if a magnet was lost the engine would stop. The LAA Inspector made the following statement in his report: '*I believe that in-flight loss of one magnet during take-off, together with the unfortunate alignment of the aircraft's wiring between the controllers and their coils, is the most likely cause of the engine stop on Turbulent G-AREZ.*'

**Page 76: Conclusion**

Original text:

The engine suffered a total loss of power at low altitude, the cause of which was not positively determined. During a manoeuvre to avoid obstacles, the aircraft stalled and control was lost. The pilot suffered serious injuries during the touchdown and the aircraft was damaged beyond economic repair.

Corrected text:

The engine suffered a total loss of power at low altitude, the most likely cause of which was a loss of a magnet from a timing sensor, combined with incorrect wiring within the ignition system. During a manoeuvre to avoid obstacles, the aircraft stalled and control was lost. The pilot suffered serious injuries during the touchdown and the aircraft was damaged beyond economic repair.

The online version of this report was corrected when published on 17 March 2022.

# TEN MOST RECENTLY PUBLISHED FORMAL REPORTS ISSUED BY THE AIR ACCIDENTS INVESTIGATION BRANCH

1/2015 Airbus A319-131, G-EUOE
London Heathrow Airport
on 24 May 2013.

Published July 2015.

2/2015 Boeing B787-8, ET-AOP
London Heathrow Airport
on 12 July 2013.

Published August 2015.

3/2015 Eurocopter (Deutschland) EC135 T2+, G-SPAO
Glasgow City Centre, Scotland
on 29 November 2013.

Published October 2015.

1/2016 AS332 L2 Super Puma, G-WNSB
on approach to Sumburgh Airport
on 23 August 2013.

Published March 2016.

2/2016 Saab 2000, G-LGNO
approximately 7 nm east of Sumburgh Airport, Shetland
on 15 December 2014.

Published September 2016.

1/2017 Hawker Hunter T7, G-BXFI
near Shoreham Airport
on 22 August 2015.

Published March 2017.

1/2018 Sikorsky S-92A, G-WNSR
West Franklin wellhead platform, North Sea
on 28 December 2016.

Published March 2018.

2/2018 Boeing 737-86J, C-FWGH
Belfast International Airport
on 21 July 2017.

Published November 2018.

1/2020 Piper PA-46-310P Malibu, N264DB
22 nm north-north-west of Guernsey
on 21 January 2019.

Published March 2020.

1/2021 Airbus A321-211, G-POWN
London Gatwick Airport
on 26 February 2020.

Published May 2021.

Unabridged versions of all AAIB Formal Reports, published back to and including 1971, are available in full on the AAIB Website

http://www.aaib.gov.uk

# GLOSSARY OF ABBREVIATIONS

| | |
|---|---|
| aal | above airfield level |
| ACAS | Airborne Collision Avoidance System |
| ACARS | Automatic Communications And Reporting System |
| ADF | Automatic Direction Finding equipment |
| AFIS(O) | Aerodrome Flight Information Service (Officer) |
| agl | above ground level |
| AIC | Aeronautical Information Circular |
| amsl | above mean sea level |
| AOM | Aerodrome Operating Minima |
| APU | Auxiliary Power Unit |
| ASI | airspeed indicator |
| ATC(C)(O) | Air Traffic Control (Centre)( Officer) |
| ATIS | Automatic Terminal Information Service |
| ATPL | Airline Transport Pilot's Licence |
| BMAA | British Microlight Aircraft Association |
| BGA | British Gliding Association |
| BBAC | British Balloon and Airship Club |
| BHPA | British Hang Gliding & Paragliding Association |
| CAA | Civil Aviation Authority |
| CAVOK | Ceiling And Visibility OK (for VFR flight) |
| CAS | calibrated airspeed |
| cc | cubic centimetres |
| CG | Centre of Gravity |
| cm | centimetre(s) |
| CPL | Commercial Pilot's Licence |
| °C,F,M,T | Celsius, Fahrenheit, magnetic, true |
| CVR | Cockpit Voice Recorder |
| DME | Distance Measuring Equipment |
| EAS | equivalent airspeed |
| EASA | European Union Aviation Safety Agency |
| ECAM | Electronic Centralised Aircraft Monitoring |
| EGPWS | Enhanced GPWS |
| EGT | Exhaust Gas Temperature |
| EICAS | Engine Indication and Crew Alerting System |
| EPR | Engine Pressure Ratio |
| ETA | Estimated Time of Arrival |
| ETD | Estimated Time of Departure |
| FAA | Federal Aviation Administration (USA) |
| FDR | Flight Data Recorder |
| FIR | Flight Information Region |
| FL | Flight Level |
| ft | feet |
| ft/min | feet per minute |
| g | acceleration due to Earth's gravity |
| GNSS | Global Navigation Satellite System |
| GPS | Global Positioning System |
| GPWS | Ground Proximity Warning System |
| hrs | hours (clock time as in 1200 hrs) |
| HP | high pressure |
| hPa | hectopascal (equivalent unit to mb) |
| IAS | indicated airspeed |
| IFR | Instrument Flight Rules |
| ILS | Instrument Landing System |
| IMC | Instrument Meteorological Conditions |
| IP | Intermediate Pressure |
| IR | Instrument Rating |
| ISA | International Standard Atmosphere |
| kg | kilogram(s) |
| KCAS | knots calibrated airspeed |
| KIAS | knots indicated airspeed |
| KTAS | knots true airspeed |
| km | kilometre(s) |
| kt | knot(s) |
| lb | pound(s) |
| LP | low pressure |
| LAA | Light Aircraft Association |
| LDA | Landing Distance Available |
| LPC | Licence Proficiency Check |
| m | metre(s) |
| mb | millibar(s) |
| MDA | Minimum Descent Altitude |
| METAR | a timed aerodrome meteorological report |
| min | minutes |
| mm | millimetre(s) |
| mph | miles per hour |
| MTWA | Maximum Total Weight Authorised |
| N | Newtons |
| $N_R$ | Main rotor rotation speed (rotorcraft) |
| $N_g$ | Gas generator rotation speed (rotorcraft) |
| $N_1$ | engine fan or LP compressor speed |
| NDB | Non-Directional radio Beacon |
| nm | nautical mile(s) |
| NOTAM | Notice to Airmen |
| OAT | Outside Air Temperature |
| OPC | Operator Proficiency Check |
| PAPI | Precision Approach Path Indicator |
| PF | Pilot Flying |
| PIC | Pilot in Command |
| PM | Pilot Monitoring |
| POH | Pilot's Operating Handbook |
| PPL | Private Pilot's Licence |
| psi | pounds per square inch |
| QFE | altimeter pressure setting to indicate height above aerodrome |
| QNH | altimeter pressure setting to indicate elevation amsl |
| RA | Resolution Advisory |
| RFFS | Rescue and Fire Fighting Service |
| rpm | revolutions per minute |
| RTF | radiotelephony |
| RVR | Runway Visual Range |
| SAR | Search and Rescue |
| SB | Service Bulletin |
| SSR | Secondary Surveillance Radar |
| TA | Traffic Advisory |
| TAF | Terminal Aerodrome Forecast |
| TAS | true airspeed |
| TAWS | Terrain Awareness and Warning System |
| TCAS | Traffic Collision Avoidance System |
| TODA | Takeoff Distance Available |
| UA | Unmanned Aircraft |
| UAS | Unmanned Aircraft System |
| USG | US gallons |
| UTC | Co-ordinated Universal Time (GMT) |
| V | Volt(s) |
| $V_1$ | Takeoff decision speed |
| $V_2$ | Takeoff safety speed |
| $V_R$ | Rotation speed |
| $V_{REF}$ | Reference airspeed (approach) |
| $V_{NE}$ | Never Exceed airspeed |
| VASI | Visual Approach Slope Indicator |
| VFR | Visual Flight Rules |
| VHF | Very High Frequency |
| VMC | Visual Meteorological Conditions |
| VOR | VHF Omnidirectional radio Range |

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