Air Accidents Investigation Branch

AAIB Bulletin 2/2018

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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.

SERIOUS INCIDENT

Aircraft Type and Registration:	Boeing 767-36N, G-POWD
No & Type of Engines:	2 General Electric Co CF6-80C2B7F turbofan engines
Year of Manufacture:	2003 (Serial no: 30847)
Date & Time (UTC):	19 March 2017 at 0900 hrs
Location:	En route from London Stansted Airport to Rzeszow-Jasionka Airport, Poland
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 9 Passengers - 262
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	52
Commander's Flying Experience:	8,965 hours (of which 2,635 were on type) Last 90 days - 24 hours Last 28 days - 24 hours
Information Source:	AAIB Field Investigation

Synopsis

Shortly after entering the cruise at FL370 the cabin altitude audio siren sounded and the CABIN ALTITUDE red warning caption illuminated. The crew carried out the depressurisation drills before commencing an emergency descent and subsequent diversion to Amsterdam Schiphol Airport. It was established that the aircraft failed to pressurise correctly due to a faulty positive pressure relief valve (PPRV)[1]. Both PPRVs had been replaced with overhauled valves during recent maintenance.

Testing and strip examination of the faulty valve proved inconclusive, with no obvious reason for the malfunction being found. The possibility of debris trapped in a metering section of the valve could not be ruled out, although no evidence of this was found.

History of the flight

This was the aircraft's first revenue flight following heavy maintenance, during which both PPRVs were replaced. A 1-hour post-maintenance check flight was completed the day before the incident, which included a climb to FL350. No pressurisation problems were reported on the check flight.

Footnote

[1] Positive and negative pressure relief valves are provided to protect the cabin from excessive pressure differentials. There are two PPRVs on the Boeing 767, mounted above one another on the left side of the fuselage, ahead of the wing.

On the day of the incident, the aircraft was planned to conduct a charter flight to Jasionka Airport (EPRZ) in Poland, then return to Stansted. The crew included the two pilots and a maintenance engineer who had conducted the check flight the previous day; the engineer occupied the jump seat. As neither pilot had been to EPRZ before, the commander flew the outbound sector, with the co-pilot acting as pilot monitoring (PM). All the flight preparations were normal.

The aircraft departed at 0921 hrs and was step climbed to its cruising level of FL370. As they approached abeam the 'TULIP' waypoint at FL370, the co-pilot answered an interphone call from the cabin service director (CSD) about the seat belt signs having illuminated. On checking the passenger sign switch, he noted that it was in the AUTO position. At that moment, the cabin altitude aural warning sounded and the CABIN ALTITUDE red warning caption illuminated. In accordance with the operator's emergency procedure for '*Rapid depressurisation*', the pilots and engineer donned their oxygen masks and established communication with each other. The co-pilot had to be assisted with his mask and he thought he may have been suffering some degree of hypoxia. They noted that the cabin altitude was about 10,000 ft and the cabin differential pressure indicator was at about the seven o'clock position, which equates to about 7 psi cabin differential pressure. The co-pilot transmitted a MAYDAY call advising Maastricht ATC of the depressurisation and the crew's intention to carry out an emergency descent. This was acknowledged by ATC and the crew were given a radar heading to fly. As the aircraft had just passed Amsterdam, the crew elected to divert there.

The passenger oxygen system was deployed and an emergency descent was commenced, first to 20,000 ft, then 10,000 ft and finally levelling at 7,000 ft. The commander removed his oxygen mask at 10,000 ft, but the co-pilot remained on oxygen until level at 7,000 ft. The crew programmed the FMS for an arrival for Runway 27 at Schiphol Airport, where an uneventful landing was completed at 1007 hrs.

External inspection of the aircraft revealed that the indicator flag on the upper PPRV upper door flap was visible (Figure 1, arrowed), indicating that the valve had operated in flight, allowing cabin air to leak overboard.

Figure 1

Defective positive pressure relief valve,
as removed from G-POWD

Recorded information

The aircraft was fitted with a solid-state Flight Data Recorder (FDR) and Cockpit Voice Recorder (CVR), both of which were downloaded at the AAIB.

Flight Data

The downloaded data showed that the seat belt signs were activated at 09:40:59 hrs with the aircraft in cruise at FL370, followed 38 seconds later by the display of a cabin altitude EICAS[2] message in conjunction with a Master Warning. The crew's oxygen system reduced in pressure 25 seconds later, indicating that it was being used by the flight deck crew, and an initial descent to FL200 was started after a further 60 seconds.

The passenger oxygen system was deployed as the emergency descent was commenced, two minutes after the seat belt signs had illuminated. The average rate of descent during the emergency descent was approximately 4,500 fpm.

The FDR installation on G-POWD does not record the cabin pressure differential or altitude, nor does it record the position of the cabin outflow valve.

CVR examination and testing

The CVR recorded pre-flight preparations on the ground at Stansted, up until the point that external power to the aircraft was removed. The recording then resumed on the ground at Amsterdam when the aircraft was parked on the stand.

Footnote

2 Engine Indicating and Crew Alerting System.

Because the recorder stopped working after the external power had been removed from the aircraft, the CVR was subject to an examination at a manufacturer approved overhaul agent. This initial examination consisted of an external visual inspection of the CVR, a detailed visual inspection of the interior of the CVR and a full suite of functional checks using the manufacturer's approved acceptance test software. No defects were found during this examination.

The CVR which was fitted to the aircraft to ferry it back from Amsterdam to the operator's base at Stansted was also downloaded by the AAIB. This recorder was found to contain a complete recording of the ferry flight. Further testing was then carried out on the aircraft with a different CVR fitted, focussing on the routing of power to the CVR during removal of external power. No faults were identified during this testing.

The incident CVR was shipped to the manufacturer for a more detailed examination. Although this identified some anomalies with the operation of the unit, none of these anomalies were consistent with the unit stopping recording.

In consultation with the AAIB, the operator elected to introduce an additional CVR check which was conducted every flight, post-engine start. The aircraft was monitored over the next 100 days of operation and during this period no faults were recorded.

Recent maintenance history

The aircraft had recently completed a 'C' Check heavy maintenance input, during which both PPRVs were replaced with overhauled units. There was a scheduled maintenance requirement to test the PPRVs in situ on the aircraft, but the maintenance organisation's test equipment for this was unserviceable. These replacement valves were tested in accordance with a different procedure, contained in B767 Aircraft Maintenance Manual (AMM) Task 21-32-01-702-027, which details a procedure for conducting a leak check on the remote static pressure lines. The procedure states:

> *'… (3) If you replaced both positive pressure relief valves with two new valves which were successfully tested off-aircraft in the shop, you can use this procedure as an alternate test to the Positive Pressure Relief Valve – System Test ….'*

The PPRV involved in this incident had part number 103642-3 and serial number 69-A0674. It was removed from a Boeing 757 after being described as "inoperative". The valve had completed 25,270 hours and 16,162 cycles in service. The date of removal was not disclosed, but it was received at the manufacturer's UK facility on 3 January 2012, where it failed a bench test. Following an overhaul, it received its final inspection stamp on 26 January 2012, with its associated EASA Form 1, dated 27 January 2012. A note in the Component Maintenance Manual (CMM) for the PPRV stated that the unit should be re-tested if it was not fitted to an aircraft within twelve months. However, this instruction was not reproduced on the EASA Form 1 (which formed part of the release documentation), so maintenance personnel installing the valve on the aircraft would not have been aware of it. Until its fitment to G-POWD, the valve had not been fitted to an aircraft since being overhauled in 2012.

Positive Pressure Relief Valve

Figure 2 shows a schematic diagram of the PRPV, highlighting the principal components.

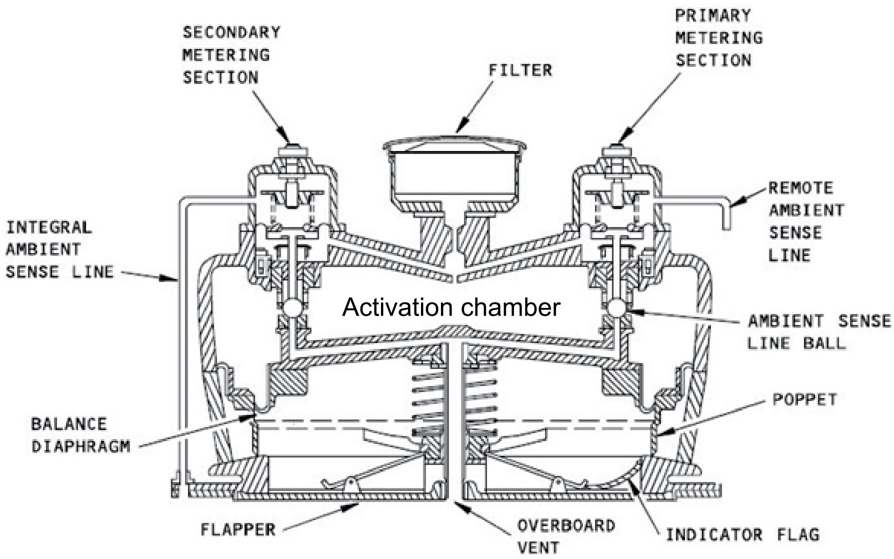

Figure 2
Schematic of the positive pressure relief valve

The PRPV uses two control metering sections, the primary and the secondary, which open at differential pressures of 8.95 and 9.42 psi, respectively. They are identical in construction, but the secondary unit is adjusted to the higher pressure so that it operates as a back-up in the event of a failure in the primary. One side of each metering section is supplied with an ambient pressure source: a remote line for the primary and an integral sense line for the secondary. Cabin pressure is applied to the opposite sides of the metering section and, at excess cabin pressures the ball valve attached to the metering section will lift, allowing air to pass into the activation chamber. This allows cabin pressure to open the poppet valve, which vents cabin air overboard. Associated movement of the flapper doors causes the spring-loaded indicator flags to pop out.

Testing and strip examination

The defective PPRV assembly was taken to the manufacturer's UK overhaul facility where it was tested and disassembled with the AAIB. The valve was installed in a test chamber that included a representation of an aircraft fuselage. A negative pressure was then applied to the 'outside', to simulate the aircraft climbing. With a correctly functioning unit there should be no flow through it until a pressure differential of at least 8.95 psi is reached. However, it was found that a flow became established at a pressure differential as low as 3.36 psi. This would result in cabin air being able to leak from the aircraft during a normal climb.

The tests pointed to a fundamental problem with the valve and a strip examination was performed. This proved inconclusive, with no obvious evidence found to explain the valve malfunction.

Whilst the reason for the PPRV's failure was not found, the manufacturer calculated that the valve would have opened at around 3.5 psi differential pressure if a piece of debris as small as 0.0033 inches in diameter had become trapped underneath the ball valve in either the primary or secondary metering section.

Analysis

The evidence shows that there was a failure of the cabin to pressurise correctly during the climb. The flight crew actioned the emergency procedure in a timely manner and, despite some difficulty experienced by the co-pilot in donning his oxygen mask, the crew successfully completed an emergency descent and diversion to Schiphol Airport.

The investigation concluded that there was a fault in one PPRV that would result in gradual cabin air leakage. The reason for the fault was not identified, despite testing and careful strip examination. The valve manufacturer surmised that a small piece of debris could have become trapped in a metering unit ball valve, thus propping it open. However, it was not established how such debris could have entered the valve after it was tested as serviceable following overhaul.

The valve had remained in storage for approximately five years before being fitted to G-POWD. The CMM states that the PPRV should be re-tested if it was not fitted to an aircraft within 12 months, but this information was not available outside the manufacturing organisation nor was it stated on the EASA Form 1.

During the recent maintenance and, in the absence of serviceable test equipment, the maintenance organisation had removed both PPRVs from the aircraft, replacing them with overhauled units. The AMM test of the replacement valves failed to detect any defect and it is likely that the aircraft departed for its first flight with the faulty valve leaking cabin air as soon as the cabin differential pressure exceeded approximately 3.4 psi. This would have led to a gradual loss of cabin pressure and the cabin altitude to climb to the level that triggered the cabin altitude warning.

It is not clear why the cabin pressurisation problem did not manifest itself during the post-maintenance check flight, during which the aircraft climbed to FL350 without any cabin pressure warning. However, it is possible that the leak rate may not have been enough for the cabin altitude to climb to a level that would have triggered the warning during this flight.

Conclusion

The failure of the cabin to pressurise correctly resulted from a faulty PPRV which was installed during recent maintenance. The maintenance checks of the replacement valves did not identify the defect with the faulty PPRV.

The event was a failure to pressurise correctly, rather than a sudden depressurisation and the crew's timely actions in identifying the problem and carrying out the appropriate emergency procedure ensured a safe outcome.

ACCIDENT

Aircraft Type and Registration:	EV-97 Teameurostar UK (Eurostar), G-GARB
No & Type of Engines:	1 Rotax 912-UL piston engine
Year of Manufacture:	2013 (Serial no: 2013-4104)
Date & Time (UTC):	18 September 2016 at 1058 hrs
Location:	Near Builth Wells, Powys
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Fatal) Passengers - 1 (Fatal)
Nature of Damage:	Destroyed
Commander's Licence:	National Private Pilot's Licence (Microlight)
Commander's Age:	55 years
Commander's Flying Experience:	316 hours (of which 316 were on type) Last 90 days - 58 hours Last 28 days - 22 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft was seen cruising at an altitude of around 2,500 ft. At a later point it was seen to pitch nose-up and enter a steep spinning-type descent before striking the ground, resulting in fatal injuries to the pilot and passenger.

The left wing had appeared to fold rearwards in the descent and this was attributed by the investigation to a structural failure near the root of this wing, caused by upward bending of the wing beyond its design limits. No pre-existing material defect, or significant design issue, was found in the wing structure. The failure is most likely to have occurred as a result of an attempted recovery from an inadvertent manoeuvre inducing a structural overload, although the cause of the manoeuvre could not be identified.

One Safety Recommendation is made, relating to the EV-97 Eurostar pitch trim mechanism.

History of the flight

The pilot had arranged to fly with a passenger from Arclid Airfield, Cheshire, to Swansea Airport; a flight expected to take approximately 1 hour 20 minutes.

On the morning of the accident he was seen to arrive at the airfield and park close to his aircraft. He had with him one or more jerry cans and it is likely that he refuelled the aircraft; his car was later seen parked in a different area. Several people spoke with the pilot that morning and later commented that he was in good spirits. Accompanying him on the flight was a passenger who was a friend of his son.

At about 0946 hrs G-GARB took off from Arclid Runway 20 and departed on a south-westerly course towards Swansea. Radar data later showed that the aircraft climbed gradually to an altitude of 3,300 ft amsl; the altitude during the flight varied but remained above 2,000 ft amsl up to the point of the accident. A plot of the vertical profile of the flight is shown in Figure 1.

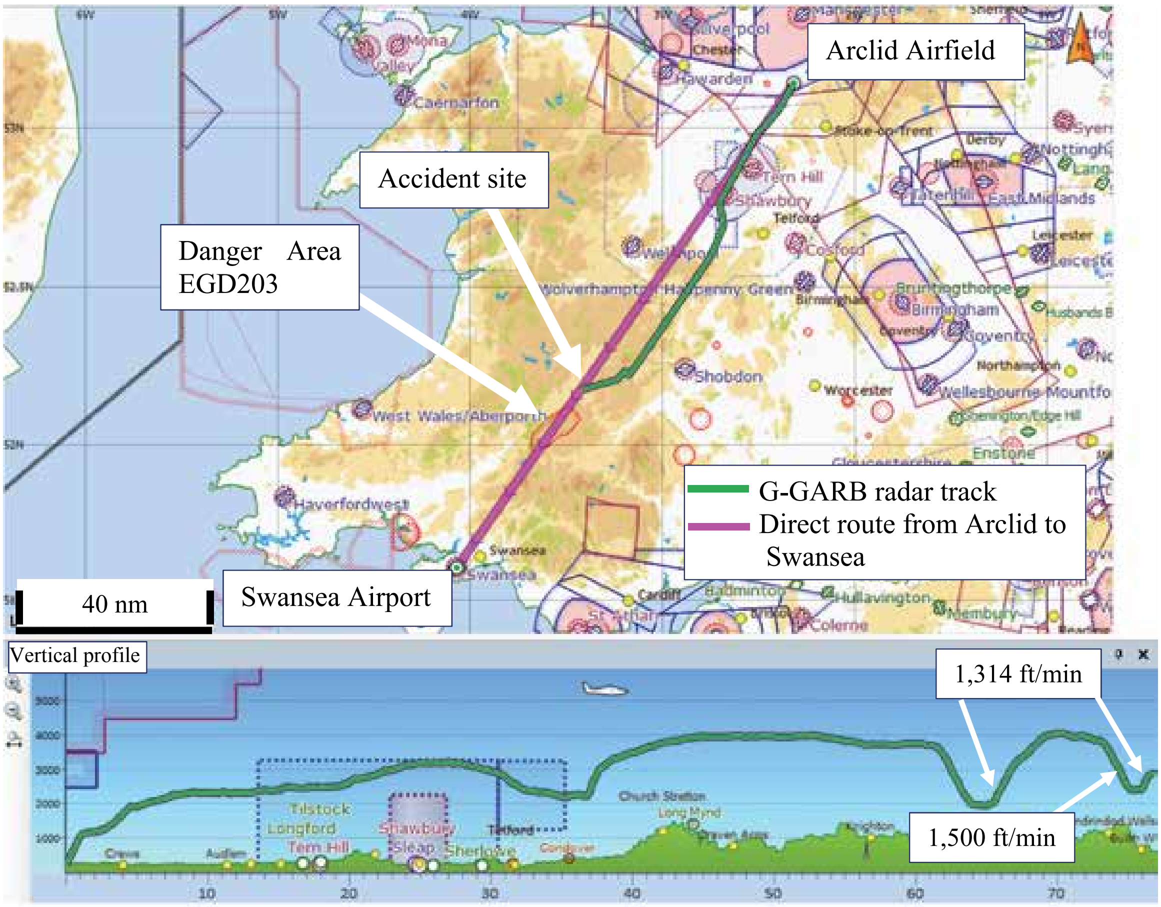

Figure 1

G-GARB recorded radar track with derived vertical speeds
(Chart produced by SkyDemon and used with permission)

The pilot made contact with London Flight Information Service at 0955 hrs. He advised of his route from Arclid to Swansea, his altitude of 2,500 ft amsl and requested a Basic Service[1]. Fifteen minutes later, at 1010 hrs, '*London Information'* contacted the pilot and asked for confirmation of his routeing and estimated time of arrival (ETA) at Swansea. The pilot replied that he was routeing directly to Swansea and gave an ETA of 1145 local time (1045 UTC)[2].

Footnote

1 A Flight Information Basic Service allows the pilot freedom to manoeuvre laterally and vertically.
2 In fact, this was an error, the likely ETA was 1105 UTC.

The pilot continued on the direct track towards Swansea and at 1015 hrs, approaching Shrewsbury, turned left and established on a course parallel to, but 3 nm east of the original track (Figure 1). At 1045 hrs the aircraft, which had been flown generally straight and level up to that point, started a descent followed by a climbing turn to the right, and then a climbing turn to the left, before turning right onto a course to intercept the original track between Arclid and Swansea.

At 1053 hrs, the aircraft started manoeuvring again, turning, descending and climbing before levelling at an altitude of 4,100 ft. Three minutes later, it descended again, levelled at 2,400 ft and then after half a minute started to climb again.

A group of witnesses was walking along a track half a mile to the east of the accident site. They reported that the aircraft had flown over them and at that time was in a normal level, or slightly climbing, attitude. After it had passed they decided to turn round and walk back down the track. As they did so, one of them noticed that the aircraft now appeared to be in a vertical, climbing attitude. After glancing away, this witness looked at the aircraft again and now saw it nose-down and rotating in a spiralling descent. The witness made an exclamation, which alerted the others to the aircraft; as she continued to watch she noticed that one wing had apparently "turned" and was pointing in the direction of the tail. The other witnesses in the group did not see the start of the nose-down rotating manoeuvre but all concurred that the wing position was not normal before the aircraft struck the ground.

Two other witnesses in the area reported having first heard an aircraft engine making an unusual noise when the aircraft was flying straight and level, before seeing the nose dropping and the aircraft "plummeting" down and spinning. Another witness saw the aircraft "corkscrewing" downwards and noted that a wing had "folded back". Several of the witnesses also commented on hearing changes in the engine noise.

A fuller flight track and description derived from radar is provided in the recorded data section of this report and at Figure 4.

The impact with the ground was not survivable.

Accident site

The aircraft wreckage was found in a field near Builth Wells, about 360 m and 102° from the last recorded radar return. The wreckage was resting in its initial impact crater, indicating that it had a high vertical speed and low forward speed at impact (Figure 2). The left wing had folded forwards and had sustained significant impact damage to its leading edge near the root but no damage to the outer portions. The right wing had suffered leading edge compression damage along its entire length, and there was an imprint from the right wing in the ground, indicating a steep nose-down impact. Behind the tail, about 50 m away, was a section of the left wing belly fairing (Figure 3). Between this point and the main wreckage site there were no other parts of wreckage.

Figure 2
Overhead view of the aircraft wreckage at the accident site

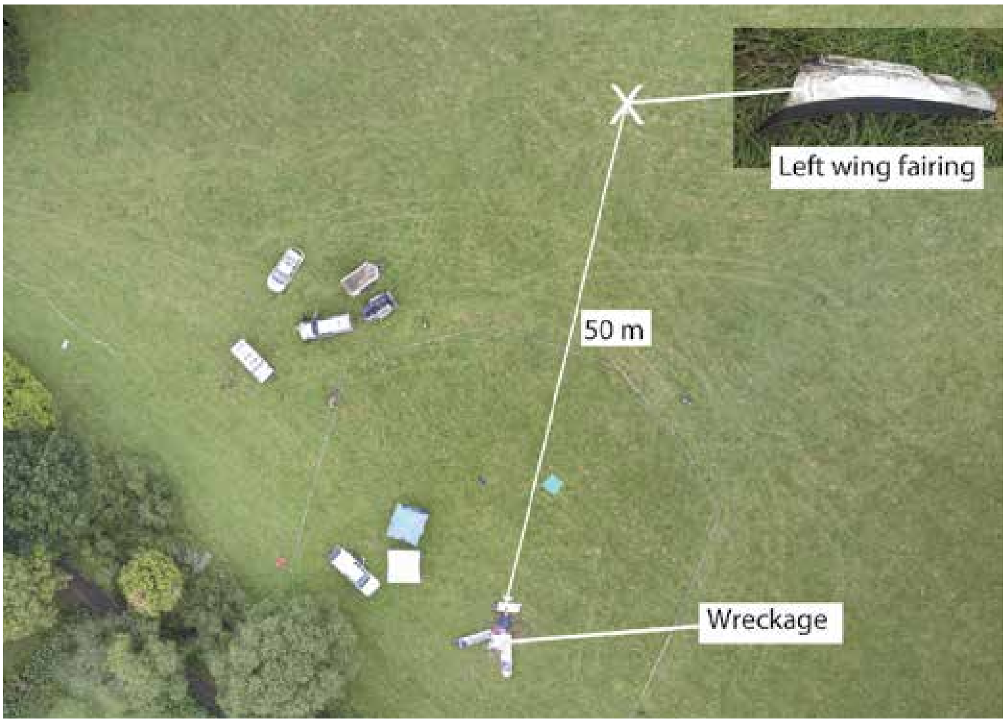

Figure 3
Overhead view of the accident site showing distance to the left wing lower fairing

Recorded information

The aircraft's position and Mode S altitude[3] was recorded by a number of radar heads throughout the flight, which was provided to the AAIB by NATS and is shown in Figures 1 and 4. Mode S altitude received from the aircraft's transponder uses a pressure datum of 1013 hPa which has been corrected to the reported QNH on the day of 1017 hPa. All altitudes are amsl unless stated otherwise.

Radar recording from the Manchester Airport radar head commenced at 0949:11 hrs with the aircraft located just south of Arclid Airfield. The aircraft tracked in a south-westerly direction, climbing initially to 3,300 ft. As the flight continued, the recorded altitude ranged from between 2,050 ft and 4,150 ft with a total recording time of 1 hour 7 minutes and 12 seconds.

As the flight progressed, the aircraft eventually tracked beyond the range of the Manchester radar but closer to the Clee Hill radar, located 33 nm from the accident site, which recorded position and altitude every 8 seconds. Radar position data is of limited accuracy[4] and this, combined with the 8 second sampling rate, meant a detailed flight path analysis was not possible to ascertain whether the aircraft undertook any abrupt manoeuvres during this flight.

Vertical speed was calculated by examining the altitude change over the 8 second recording period. This showed two climbs of +1,314 ft/min (+175 ft over 8 seconds) and a descent of 1,500 ft/min (-200 ft over 8 seconds (Figure 1)).

The final stage of the flight is illustrated in Figure 4, which includes 'error boxes', in red, denoting the limited accuracy of the radar position data. A minute and a half prior to the end of the radar recording, the aircraft started to fly at approximately level altitude and constant heading for 40 seconds. Calculated groundspeed for this period was 87 mph ±18 mph (depending on radar error). Considering the aircraft's approximate heading and a reported wind of 240°/ 10 kt, this equates to an airspeed of 97 mph ±18 mph. At 1055:27 hrs, the aircraft commenced a climb from 2,550 ft to 2,975 ft over 40 seconds. The maximum derived vertical speed during this climb was 1,314 ft/min with an average of 638 ft/min. Between the penultimate and final recorded radar returns, the aircraft descended 325 ft over 8 seconds; a descent rate of 2,440 ft/min. The final recorded radar return was at 1056:23 hrs with the aircraft at 2,625 ft (2,100 ft agl), almost overhead the accident site.

A review of the available radar data in the vicinity of the accident site showed no other recorded traffic visible to the radar heads within 10 minutes of the accident. Twenty minutes after the accident, a motor glider passed approximately 0.5 nm south of the accident site.

Footnote

3 Mode S altitude was recorded to the nearest 25 ft.

4 NATS have stated that they work to Eurocontrol standards and performance for random errors is usually within ±140 m for slant range and ± 0.16° for azimuth for 98% of cases

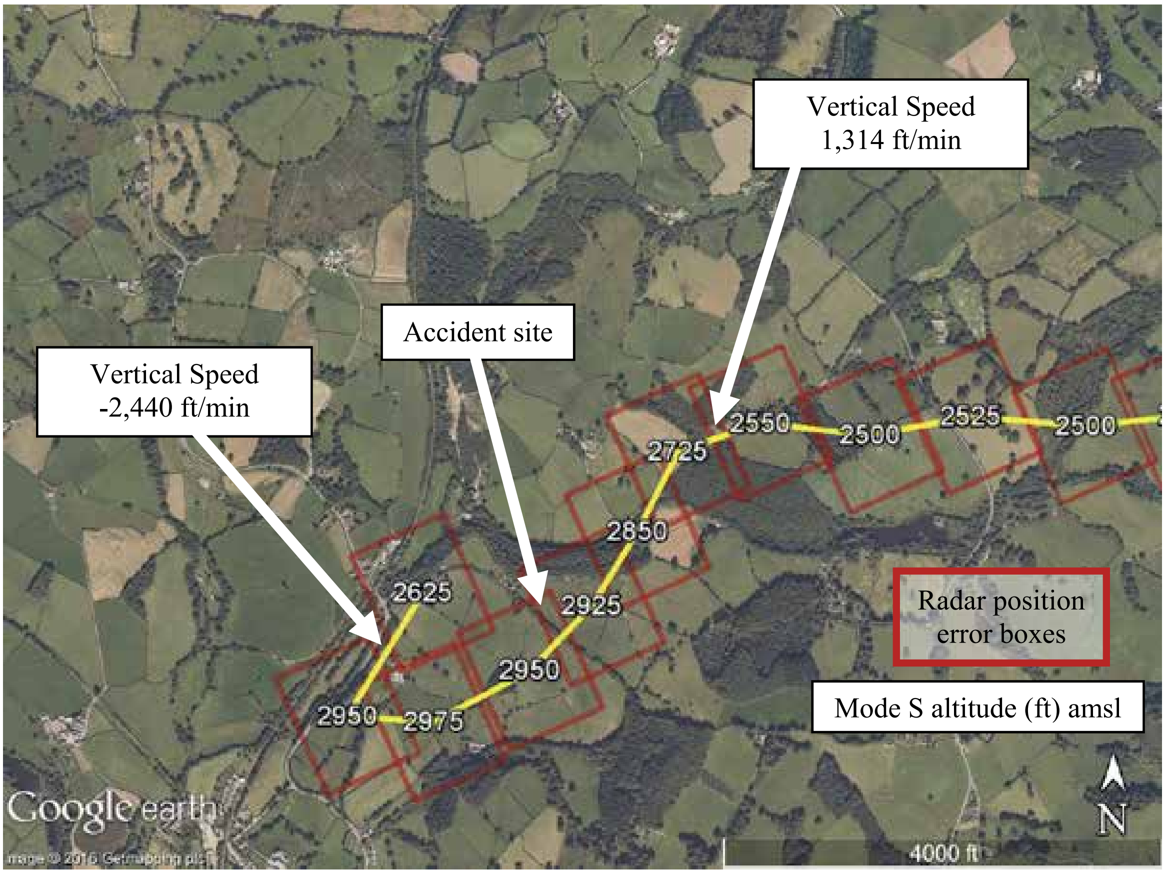

Figure 4
G-GARB recorded radar data showing altitude amsl and position error boxes in red

Flight planning and navigation app

The pilot was known to use SkyDemon, a flight planning and navigation app, on his mobile device. In navigation mode, SkyDemon is able to provide both visual and audio warnings if an aircraft trajectory takes it towards a number of airspace types, including a Danger Area. The default settings, which are then adjustable, will trigger the warning when the aircraft is within 3 minutes flight of a Danger Area.

Danger Area EGD203 (Figure 1) was located 3.5 nm from the end of the radar track and extends from the surface to 23,000 ft. With SkyDemon in navigation mode, and default settings applied, in an aircraft travelling at a groundspeed of 87 mph, the pilot would have received a Danger Area warning at around the end of the radar recording.

Three mobile devices were recovered from the wreckage, all of which were badly damaged in the impact. One had a Velcro strip on the back which matched a Velcro strip on the right side of the instrument panel but this mobile device was too badly damaged to allow extraction of any recorded data.

Meteorology

The weather conditions on the day of the accident were reported as fine with light winds and occasional cloud. An aftercast from the Met Office reported that the wind at 2,000 ft amsl was estimated as 240° at 10 kt. The pilot of the motorglider which flew through the area 20 minutes after the accident reported that any cloud present was above 2,500 ft and that the conditions for flying were fine with only light thermal activity.

Pilot information

The pilot had started flying training in October 2014 and qualified for his National Private Pilot's Licence (NPPL) in June 2015 after 73 hours of training. He purchased G-GARB in March 2015 and flew 20 hours in it as part of his training. A review of his recorded flying since qualifying for his licence showed that he flew regularly, typically several times a week. He flew around the area local to Arclid Airfield and also on longer cross-country flights to land at other airfields. The day before the accident he completed a solo flight from Arclid Airfield to Oban, on the west coast of Scotland, and back, a round trip of some 500 nm.

His flying instructor commented that the pilot was thorough, prepared well for his flights and was conservative in his flying. He had not shown any interest in aerobatics and the instructor did not think that he would have ever attempted aerobatic manoeuvres.

Medical and pathological information

A post-mortem examination of the pilot was carried out and the report noted that there was no evidence of any significant natural disease, such as might account for a sudden collapse whilst in control of an aircraft. Blood tests indicated that carbon monoxide toxicity was not a factor in the accident.

The passenger had not previously flown in a light aircraft. His medical history indicated that in December 2014 he had experienced a seizure which was subsequently diagnosed as a possible epileptic event; medication was not prescribed and there had been no further events.

Aircraft information

The EV-97, also known as the Eurostar, is a two-seat microlight aircraft that is designed and manufactured by Evektor in the Czech Republic. The 'EV-97 Teameurostar UK' version (such as G-GARB) is manufactured in kit form by Evektor and then shipped to the UK for final assembly by Light Sport Aviation Ltd (LSA), which is the UK CAA approved 'A8-1' primary company responsible for the UK design and manufacture. The UK CAA approved the design of the 'EV-97 Teameurostar UK' to be in accordance with '*British Civil Airworthiness Requirements (BCAR) Section S – Small Light Aeroplanes*'. Aeroplanes which have been shown to comply with BCAR Section S are eligible for a Permit to Fly and not a Certificate of Airworthiness.

The 'EV-97 Teameurostar UK' manufactured versions are overseen by the British Microlight Aircraft Association (BMAA), which revalidates their Permits to Fly, while the amateur-built versions of the EV-97 are overseen by the Light Aircraft Association (LAA). There are minor differences between the amateur-built EV-97 and the Teameurostar version but the wing structures are the same. In this report the term ‘manufacturer’ will be used for Evektor.

The accident aircraft, G-GARB (Figure 5), was built in 2013 and had accumulated 249 hours at the time of the accident, with its last annual inspection completed in January 2016. After the pilot’s purchase of G-GARB in 2015, it was initially kept outside at Arclid but was later moved to a hangar at Blackpool Airport during the winter of 2015/16. In April 2016 the pilot-owner brought it back to Arclid where it was parked outside.

Figure 5

The accident aircraft, EV-97 Teameurostar UK, G-GARB
(photo courtesy of and copyright Craig Duffy)

The aircraft was powered by a Rotax 912-UL piston engine and a 3-bladed fixed-pitch propeller. It had a Maximum Takeoff Weight (MTOW) of 450 kg and a CG range of 20 to 34% MAC[5]. According to the flight manual the cruise speed at maximum continuous power was 110 mph IAS (106 mph CAS) at 2,000 ft. The flight manual also listed the flaps-up stall speed V_{S1}, the manoeuvring speed V_A, the maximum structural cruising speed V_{NO}, the never-exceed speed V_{NE} and the design dive speed V_D (Table 1).

	IAS (mph)	CAS (mph)
V_{S1}	44	48
V_A	100	98
V_{NO}	118	114
V_{NE}	146	140
V_D	163	156

Table 1

Flight manual airspeeds

Footnote

5 Mean aerodynamic chord.

At speeds below V_A (manoeuvring speed) the aircraft will stall in a nose-up pitching manoeuvre before the structure exceeds its aerodynamic limit load factor. The limit load factors of the aircraft are +4g and -2g. These load factors should never be exceeded in operation, even though the aircraft is designed with a 1.5 factor of safety so that the wing structure should not fail catastrophically below +6g. The minimum airspeed required to pull 6g without stalling is 124 mph IAS[6] (120 mph CAS). Aerobatics and intentional spins are prohibited.

G-GARB had conventional dual flying controls, with side-by-side control sticks controlling the ailerons and elevator, via push-pull rods, and two sets of pedals operating the rudder via cables.

Pitch trim system

The elevator had a trim tab which was operated via a 'Bowden-type' cable and a lever mounted between the seats (Figure 6). This trim lever was pushed forward to generate nose-down trim and pulled aft to generate nose-up trim.

Figure 6

Pitch trim lever on another EV-97 aircraft

Most pitch/elevator trim systems in certified powered light aircraft are operated by a trim wheel, which allows fine adjustments of trim and makes it impossible to apply a sudden full-aft or full-forward trim input. The BMAA provided the AAIB with six examples[7] of other 3-axis microlight aircraft that have pitch trim levers, but none of these had the lever located between the seats, as on the EV-97. The trim levers were all further forward or, in one case, mounted to the roof.

Footnote

6 This figure was calculated by multiplying V_A in CAS (98 mph) by √(6/4), and then converting to IAS.
7 Flight Design CT, Sky Ranger Nynja, Sky Ranger Classic and Swift, EuroFOX, X'Air, Dynamic.

On the EV-97, pitch trim lever friction is not adjustable in flight. It can only be adjusted during maintenance by tightening a nut beneath the floor. According to the maintenance manual the nut should be adjusted to ensure that there is a minimum 1.0 kgf force required at the lever's end to move it.

BCAR Section S includes a requirement '*S 677 Trim System*' which states that:

> *'Proper precautions must be taken to prevent inadvertent, improper, or abrupt trim operation'.*

The position of the trim lever between the seats on the EV-97 has resulted in occasions of inadvertent movement (see flight evaluation section). The BMAA was not aware of any issues of inadvertent operation on the other six aircraft types that had trim levers.

Weight and balance

The empty weight of G-GARB was 267 kg. The pilot and passenger weighed 115 kg and 74 kg respectively, and there was 4.8 kg of baggage on-board at the time of the accident. The fuel on-board was unknown because the fuel tank had ruptured at impact, but if the tank had been full on departure then, based on estimated fuel burn, the maximum fuel at the time of the accident would have been about 35 kg. The minimum fuel on-board was estimated to be an amount sufficient to reach Swansea plus a 30-minute reserve; this was 9.4 kg. Therefore, the weight of G-GARB at the time of the accident was probably between 471 and 496 kg, at least 21 kg above the MTOW. The CG would have been within limits, between 28.9 and 31.2% MAC.

Aircraft examination

The flying controls were examined and there were no disconnections apart from overload failures associated with impact. The canopy appeared to have been in the closed and latched position at the impact with the ground. Two of the propeller blades were undamaged and one blade had snapped near its root, indicating that the engine was stopped, or producing low power, at impact. The engine strip examination did not reveal any faults that would have precluded normal operation.

The left aileron and its hinge were found undamaged, with no evidence of the aileron having hit its stops which could have been indicative of an aerodynamic 'flutter' situation. The right aileron had suffered some damage from striking the lower wing which most likely occurred at ground impact. The left side leading edge of the horizontal tail had crumple damage as did the leading edge of the vertical tail. The rudder was undamaged. As a result of the disruption of the cockpit structure, the pre-impact position of the pitch trim lever could not be determined.

The section of left wing belly fairing, which was found 50 m away from the main wreckage, had torn holes where it had been attached by screws to the underside of the left wing. This fairing is not physically attached to the fuselage, but rests against its underside with a strip of Velcro to avoid fretting. There was an indentation in the fairing consistent with it having been pulled against the flap control rod (Figure 7).

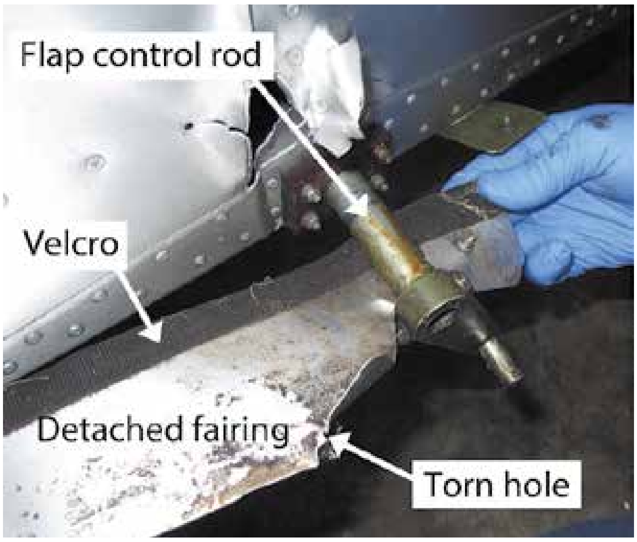

Figure 7

Detached left wing belly fairing held alongside the left fuselage of a different EV-97 aircraft

The right wing had remained attached and had suffered some internal damage as a result of crushing damage along the length of its leading edge. The left wing had suffered from a structural failure of its lower spar cap and the upper 'carry-through' spar cap in the fuselage had also failed (Figure 8). Both the upper and lower 'main-spar-to-fuselage' attachment fittings were intact; the lower fitting was cut on the fuselage side to enable the wing to be removed. The left wing aft attachment fitting had separated from inside the fuselage. These parts were sectioned and taken to a forensic organisation for detailed metallurgical examination.

The wings and the horizontal tail did not exhibit any signs of buckling.

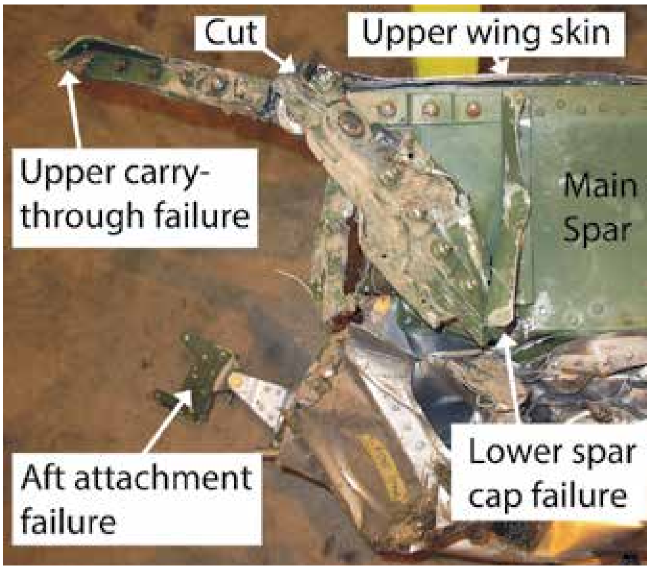

Figure 8

View of the forward face of the left wing main spar showing the three failure locations and where the lower forward fuselage attachment was cut in order to remove the wing

Metallurgical examination of left wing and attachments

The lower wing spar cap consisted of two strips of 2024 T3 aluminium plate fastened together. Each strip had a cross-section of 25 x 5 mm, with the forward facing strip, known as the ‘long cap’, having a machined radius on one edge. The aft facing strip was known as the ‘short cap’ due to its shorter length. At the inboard end of the cap, the two strips, along with the web, were sandwiched between two steel attachments which were held together by five 6 mm diameter bolts. The fracture of the spar cap had occurred at the fifth outer bolt (Figure 9).

There was mechanical damage on the forward face of the web in the area of the fracture which suggested that there had been forward movement of the outboard section of the spar cap relative to the inboard section after failure, when the outboard section of spar was inclined upwards by about 25°. Both spar cap fracture surfaces were found deformed in a manner consistent with upwards bending, and there was ‘necking’ which is characteristic of overload failure. The fracture surfaces were examined in a scanning electron microscope (SEM) which revealed that both had failed in tensile overload with no evidence of fatigue or corrosion.

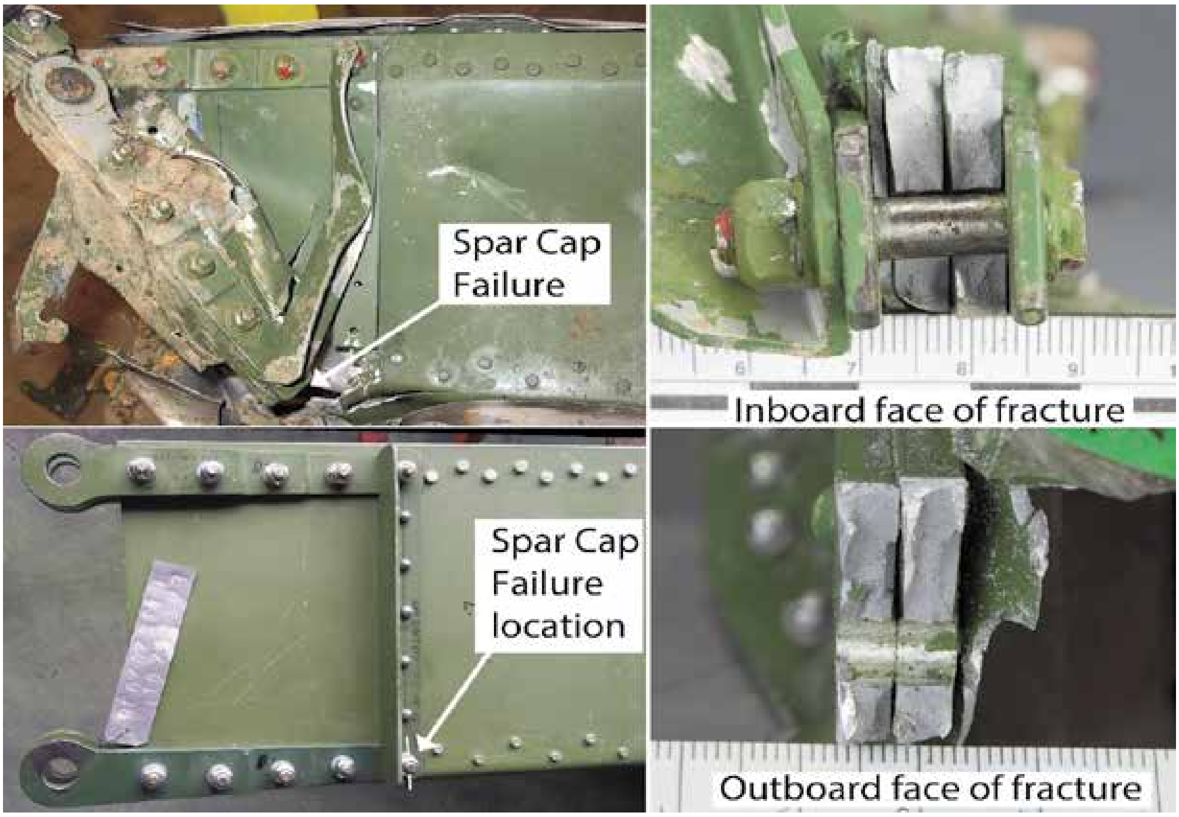

Figure 9

Top left: view of spar cap failure.
Bottom left: location of spar cap failure on a new main spar.
Top right: View of spar cap fracture looking inboard.
Bottom right: View of spar cap fracture looking outboard

Hardness tests were carried out at a location inboard of the failure and the average equivalent Brinell (HB) hardness was 120 HB for the short cap and 121 for the long cap; the typical hardness result for 2024 T3 is 120 HB. Tensile tests of three specimens from each of the long and short caps, from a location outboard of the failure, were carried out. A specimen from a new long cap supplied by the manufacturer was also tensile tested. The average results of the tensile tests are shown in Table 2. The '0.2% proof stress' is a standard indication of the stress at which the material starts to yield, and the ultimate tensile strength (UTS) is the stress at which failure occurs. The short and long caps on G-GARB exceeded the material specification's minimum UTS by 10%.

Section	0.2% Proof Stress (MPa)	UTS (MPa)	Elongation (%)
G-GARB - long cap	359	487	33
G-GARB - short cap	346	485	31
New - long cap	358	486	30
Specification 2024 T3	Min 290	Min 441	Min 15

Table 2

Average tensile strength test results from long and short caps compared to a new cap and the material specification

The microstructure of the failed long and short caps was also examined. The microstructures of the caps were similar and were typical for 2024 T3 aluminium alloy. There were no apparent metallurgical defects in the samples examined.

The dimensions of the spar caps were checked and the cross-section was found to be slightly larger than the manufacturer's specification, a minor difference in the 'safe' sense. The diameter of the spar cap holes were found to be within specification.

The upper carry-through spar had failed inside the fuselage beneath the left pilot's seat and this area had suffered significant crushing damage during the impact after the landing gear collapsed. There was extensive deformation of the lightweight aluminium structure around the fracture, which was consistent with the left wing moving forward. The steel centrepiece (Figure 10) was also found deformed, with an 'S' shape characteristic of buckling. However, SEM examination revealed that the fracture surfaces had ductile 'dimples' characteristic of tensile overload failure with no evidence of shear or compression. It appears that the upper spar was deformed in compression before failing in tension. There was no evidence of fatigue or corrosion.

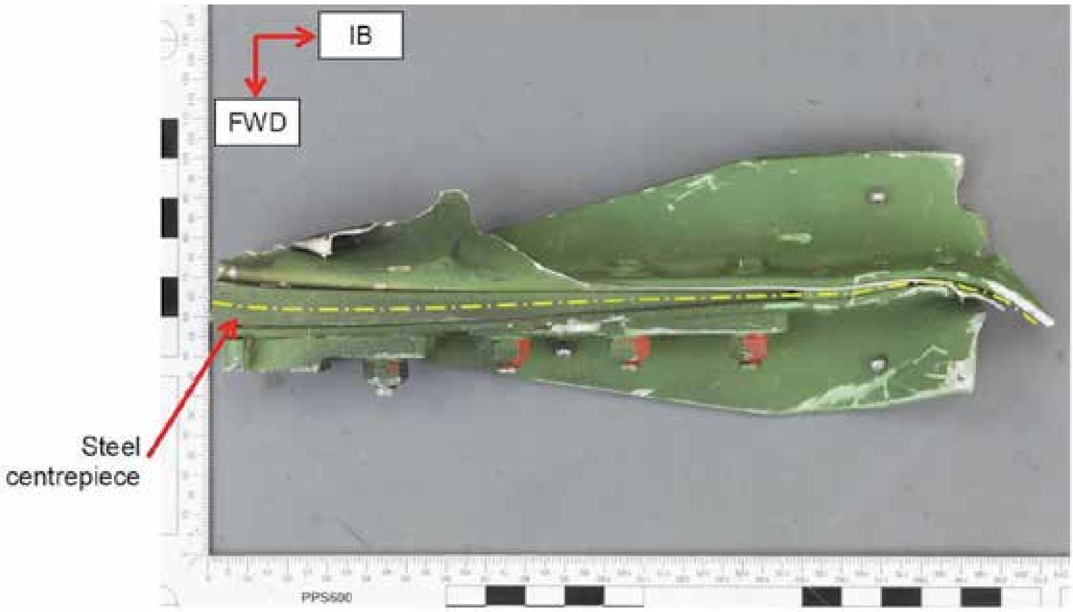

Figure 10

Lower surface of upper carry-through spar. Cut on left side and fractured on right side. Centre section is made of steel. Fractured parts are aluminium

The aft wing attachment fitting had separated from inside the fuselage and the lightweight structure around the fitting was fractured and severely deformed; the fitting itself was not fractured, although it had deformed. The lower surface of the fitting was relatively straight, whereas the upper edge was deformed in a forward direction. The fracture surfaces were examined under a stereo optical microscope and the surfaces were dull and fibrous, consistent with static overload failure. There was no evidence of fatigue or corrosion.

Previous EV-97 accident involving wing failure

On 24 June 2006 a Eurostar EV-97 model 2000 version R ultralight aircraft, with Danish registration 9-249, suffered an in-flight left wing separation 17 nm north-east of St. Moritz, Switzerland. The fatal accident was investigated by the Swiss Aircraft Accident Investigation Bureau and published in Report No. 2053[8]. The left wing failure was similar to that of G-GARB in that the lower spar cap had also failed at the outer fifth bolt (Figure 11). The upper carry-through spar had also failed in a similar location to that on G-GARB.

The Swiss investigation identified that there was an 'extrusion weld' in the short cap in the area of failure which would have weakened the strength properties of the material. The material strength at the failure location could not be determined but several hardness tests and tensile tests were performed away from the failure location which revealed a UTS range of 437 to 522 MPa. This aluminium material was different from that on G-GARB and was designated PA 7. According to the material manufacturer it was specified to have

Footnote

8 https://www.sust.admin.ch/inhalte/AV-berichte/2053_e.pdf

a UTS of 515 MPa. The Swiss investigators also tested the strength of the spar cap on another EV-97 which revealed a UTS of 366 to 385 MPa. As a result of these findings the spar caps on all new EV-97 aircraft, including G-GARB, were replaced with 2024 T3 material (minimum UTS 441 MPa) which was cut from plate instead of being extruded. An inspection programme was also carried out to check the strength of all in-service spar caps[9].

Figure 11

Left wing lower spar cap failure of EV-97 registration 9-249 in Switzerland in 2006

According to the Swiss investigators the wings on 9-249 did not exhibit any signs of buckling. The lower spar cap had failed in tension, and although the fracture face of the upper carry-through spar had not been examined, they stated that it had not failed in compression.

A significant factor to the accident to 9-249 was that it was flying through a mountainous valley in weather conditions that were forecast to have a high probability of significant convective activity. The pilot did not have experience of flying in mountainous terrain and the report concluded that:

> *'it is conceivable that the pilot was taken by surprise by local turbulence. In the process, the structure of the aircraft must have been overloaded as a result of the forces induced by turbulence or possibly during a corrective manoeuvre, after a brief loss of control'.*

Footnote

9 In the UK this inspection was mandated by the CAA. Mandatory Permit Directive 2010-003 published 29 April 2010.

Manufacturer's structural wing tests and calculations

The aircraft's wing structure was designed to a limit load factor of 4g and an ultimate load factor of 6g. Although microlights are restricted to 450 kg MTOW in the UK, the EV-97 was designed for an MTOW of 480 kg. At a weight of 480 kg and 6g loading, the stress in the wing must be less than the ultimate strength of the respective materials.

The manufacturer's structural design report on 'Wing Spar Load Capacity' included calculations for stress in the critical parts of the wing, including at the lower spar cap failure location on G-GARB. This location is at 0.703 m from the fuselage centreline so is referred to as the z=0.703 position. The critical upward bending moment in this location occurs at the design condition for dive speed V_D (186 mph, 300 km/hr) and load factor of 4g. At 1.5 times this condition (6g) the maximum bending moment was calculated to be 15,460 Nm[10]. This results in a calculated tensile force in the lower spar cap, at this location, of 97,848 N. This force is reacted over a cross-sectional area of spar and web (excluding the bolt) of 248.8 mm^2, with a resulting stress of 393.2 MPa. This is less than the minimum specified strength of the spar cap material of 441 MPa, so there is a positive calculated reserve factor of 1.12. The presence of the bolt hole in the spar cap is significant for fatigue calculations as it introduces stress concentrations, but according to structural experts the hole does not affect ultimate strength calculations apart from the reduction in cross-sectional area.

In 1999 the manufacturer conducted a wing strength static test to evaluate whether the wing design met the increased strength requirements to increase V_D from 156 mph (250 km/h) to 186 mph (300 km/h)[11] for its model 99 EV-97. One of the load cases involved a symmetric load to 4g at V_A and a mass of 480 kg. The fuselage was secured to the ground while a lifting force was applied to a series of collets around the left wing and an anti-drag force[12] was applied using load bags attached via cables and pulleys to the leading edge of the collets.[13] No permanent deformations were found after unloading from the limit load and no permanent deformations were found after unloading from the ultimate load (1.5 times higher than limit). The load was then further increased until, at 1.6 times the limit load, the upper carry-through spar buckled (Figure 12).

Footnote

[10] The figure of 15,460 Nm was determined by BRNO University after the accident in Switzerland to 9-249 in 2006, using the Glauert wing lift distribution. The original certification figure was 14,189 Nm using the less conservative, although still approved, Weissinger lift distribution.

[11] This would enable the never-exceed speed V_{NE} to be raised from 140 mph (225 km/hr) to 171 mph (275 km/hr) for the model 99. These speeds are equivalent airspeed (EAS). The V_{NE} for the EV-97 Teameurostar UK remained at 140 mph EAS which is 146 mph IAS. The reason for this is that the LAA-approved amateur-built EV-97 still had a V_{NE} of 146 mph IAS and it was considered that there was little mission requirement to increase it, and the safety margin would be higher by keeping the existing V_{NE}.

[12] The anti-drag force simulates the aerodynamic forward force, relative to the wing, that is applied at high angles of attack.

[13] The forces applied were those determined using the Weissinger lift distribution.

Figure 12

Upper carry-through spar buckling which occurred at 1.6 times limit load during the wing strength static test

The fuselage was not the subject of the test as it had been subjected to strength tests several times before, so the left wing was removed from the fuselage and attached to a stand welded to the floor. The wing loading method was the same as before and when the load was increased to 1.68 times limit load wing failure occurred. There was deformation of the upper wing skin, some main spar web buckling, and web failure around the attachment bolts (Figure 13). The lower main spar caps did not fail. There were no strain gauges fitted to the spar caps during the test, so as part of the G-GARB investigation, Evektor calculated that at wing failure (1.68 times limit load) the stress in the lower spar cap, at the outer bolt, would have been 402 MPa.

Figure 13

Upper wing skin buckling (left) and main spar web failure (right) at 1.68 times limit load during the wing strength static test

This wing strength static test was carried out with the original spar cap material, PA 7, which had a reported UTS of 515 MPa. Following the accident to 9-249 the spar caps from the test wing were examined for strength. According to conductivity and hardness tests the long cap was estimated to have a UTS of 465 to 560 MPa, while the short cap was estimated to have a UTS of 320 MPa to 430 MPa[14]. No tensile tests of the material from these caps were carried out, but the following year tensile tests were carried out on material from the same batch that was used to make those caps and the UTS was measured to be between 425 and 524 MPa.

The manufacturer's wing strength calculations and test reports were reviewed by the LAA as part of the AAIB G-GARB investigation. Their initial analysis concluded that there were no significant shortfalls and that no design changes were necessary, particularly with the more conservative V_D speed that was in place for both the LAA-approved amateur-built EV-97 and the Teameurostar version. However, during the draft consultation period for this report, the LAA carried out further analysis and discovered that a tip correction factor to the spanwise lift distribution had not been applied[15]. Applying this factor would reduce the reserve factor for the upper carry through spar which had been calculated to be 1.05. It would not affect the reserve factor for the lower spar as a more conservative lift distribution had been used for its analysis following the accident to the EV-97 (9-249) in Switzerland. The aircraft manufacturer stated that applying the tip correction factor would make a difference '*in the order of several percent*', but disputed the need to apply the tip correction factor for the calculation of the upper carry-through spar loads. It said that this method, without the tip correction factor, was widely used by aircraft manufacturers in the Czech Republic and other light aircraft manufacturers. At the time of publication discussion is continuing between the manufacturer and the LAA to resolve this issue.

Flutter analysis is not a requirement in BCAR Section S, but the aircraft manufacturer had carried out a flutter analysis to satisfy another country's requirements. This analysis revealed adequate flutter margins up to V_D.

Stick force requirements

BCAR Section S requires that the pitch control force required to impose the limit load factor on the structure be at least 70 N (7.1 kgf), from a 1g trimmed condition. According to an Evektor flight test report the force required to pull 4g was measured as 6.8 kgf at the top of the control stick and 8 kgf at the centre of the control stick. The CG during the test was 30.4% MAC, which meant that the forces would have been lower at the aft CG limit of 34% MAC. The certification 'Compliance Checklist Response' submitted by the UK manufacturer[16] stated that the aforementioned flight test:

> *'shows compliance with S155 and a stick force at 4g of 8 kg'.*

Footnote

[14] The higher values of UTS were determined based on conductivity and the lower values based on hardness. The more reliable method of determining strength is to conduct tensile tests.

[15] FAA AC23-19A refers to tip corrections required in accordance with NACA TN606 which will tend to increase the calculated spar bending moment when using the Weissinger method of lift distribution.

[16] The UK manufacturer was the predecessor to LSA.

There was no analysis to consider what the stick force might be at aft CG and, according to the CAA, the stick force would normally be measured close to the top of the stick to be conservative. The CAA accepted that the aircraft complied with S155 on the basis of the statement in the 'Compliance Checklist Response' and the fact that no non-compliances or partial compliances to S155 were declared.

The control force requirements for certified light aircraft are different from those approved under Section S and EASA[17] Certification Specification CS 23.155 has a different requirement depending on whether the control is a wheel or a stick. For a control wheel the minimum force to impose limit load must be greater than W/10N, or 89 N whichever is greater, where W is the MTOW in kg, and need not be greater than 222 N. For a control stick the minimum force must be greater than W/14N or 66.8 N, whichever is greater, and need not be greater than 156 N.

So, in theory, if a 450 kg microlight with a stick had to meet CS 23.155 it would only need a minimum stick force of 66.8 N, which is less than Section S. If a 450 kg microlight had a wheel it would need a minimum stick force of 89 N which is greater than Section S.

A typical certified light training aircraft like a Piper PA28-181, which has an MTOW of 1,159 kg and a control wheel, would be required to have a minimum control force of 115.9 N which is 65% higher than the Section S requirement. If an aircraft of the same weight had a stick, it would be 82.8 N, 18% higher than Section S.

Flight evaluation

During the AAIB investigation, a flight was carried out in an EV-97 aircraft with a professional test pilot to examine the effects of inadvertent pitch trim movement and to estimate what the pitch attitude might have been during the rapid climb that preceded the loss of radar data. The aircraft used was a newer SL variant of the EV-97 which had a different tail fin and canopy, and wing-mounted vortex generators, but the test pilot considered that it would perform and handle in effectively the same manner as the accident aircraft. The aircraft was loaded to 472.5 kg[18] and an aft CG of 29% MAC.

An EV-97 flight instructor informed the AAIB that he had experienced "a couple" of occasions when a student pilot or passenger had inadvertently pressed down on the trim lever causing a 'bunt type' manoeuvre. He said this could happen when someone was trying to shift their weight in the seat by pushing down with their left hand (Figure 6). The flight evaluation used an incremental approach to determine the effect of sudden changes in trim lever position from straight and level cruise flight. During trim changes the control stick was held loosely and allowed to move until recovery action was taken.

The total trim lever travel was measured at 12.1 cm and a scale was added with 0 full-aft and 12.1 full-forward. In straight and level flight at 2,800 ft and 104 mph IAS the trim

Footnote

[17] European Aviation Safety Agency.
[18] This aircraft had a ballistic recovery parachute which permitted the higher maximum takeoff weight of 472.5 kg.

position was 9.2. When full-forward trim was rapidly applied (a forward movement of 2.9 cm) the aircraft pitched down to 0.3 g in 1 second and reached a minimum pitch of -20° in 3 seconds before recovery action was taken. During the incremental aft trim tests it was found that a sudden aft trim input of 2.7 cm (from 9.9 cm) caused the aircraft to pitch up to 2 g in 1.2 seconds and reached a maximum pitch of 27° in 3 seconds before recovery action was taken. A further 7.2 cm of aft trim was available but the tests were stopped at the 2g point.

An attempt was also made to match the rapid 1,314 ft/min climb rate that preceded the loss of radar and also occurred earlier in the flight; in both cases this was a height gain of 175 ft in 8 seconds. At a power setting of 4,800 rpm and a cruise speed of 104 mph IAS, a pitch attitude of between 10° and 20° was required to achieve a 175 ft climb in 8 seconds, depending upon the pull rate. Adding full power while pitching up did not significantly reduce the pitch angle required. The pitch up was considered in excess of a normal cruise manoeuvre.

Analysis

The aircraft, while en route on a cross-country flight, was seen in apparently normal flight and then in a steep spiralling or spinning descent. At some point the left wing failed in upwards bending.

Structural failure of the wing

The investigation considered whether the left wing lower spar cap had failed in flight or at impact.

Metallurgical examination showed that the lower spar cap had failed in upwards bending as a result of a load that was in excess of its material strength. However, the outer portions of the left wing were found undamaged and all the impact damage was more consistent with aft loading, rather than an upwards bending load, at impact.

The left wing belly fairing was found 50 m aft of the main wreckage which indicated that it almost certainly detached in flight. An upwards bending of the wing in flight, while the fairing was initially snagged on the flap control rod, would create the tears around the holes seen in the fairing and there was no other practical explanation for this fairing damage or for its location. This physical evidence, from the upward bending failure and the belly fairing, combined with the evidence from a number of eye witnesses who reported observing something wrong with one wing as the aircraft descended, resulted in the investigation concluding that the left wing failed in upwards bending in flight. This would have caused a spinning-type descent as observed by the witnesses.

The upper carry-through spar may have suffered some compression damage in the air, but this was not conclusive and the final failure of the upper carry-through spar could have occurred in flight or at impact with the ground. The aft wing attachment probably pulled out at final impact when the wing was thrown forwards, although it may have also been damaged by the landing gear leg moving aft at impact.

Possible causes of the structural failure in flight

Metallurgical examination did not reveal any evidence of corrosion or fatigue on the left wing lower spar caps and there were no defects at the microstructure level. Tensile strength tests revealed that their strength was 10% more than the minimum specification of 441 MPa. Therefore, it was concluded that aerodynamic loads resulted in the stress in the lower spar caps exceeding their material strength.

The possibility of aerodynamic flutter was considered but there was no damage to the left aileron or its hinge, and although the ailerons are not mass-balanced, they are rod-operated (as opposed to cable-operated), which reduces the risk of flutter. Further, the aircraft manufacturer had carried out a flutter analysis which revealed adequate margins up to V_D.

Therefore, either the aircraft exceeded its limit load of 4g, possibly exceeding 6g, or there was an error in the structural design, or a combination of the two. The static wing test had revealed that the lower spar cap was capable of withstanding loads in excess of those experienced at 6g. This was carried out using a different spar cap material but with similar strength to the spar caps in G-GARB. A wing structure could respond differently when dynamic aerodynamic loads are applied. In a wing strength static test the loads are applied slowly, but in flight the loads could be applied quickly if a sudden and rapid control input were made, and this could affect the failure mode. However, the manufacturer's wing strength calculations were reviewed by the LAA, who concluded that there were no significant shortfalls in the calculations for the lower wing spar. At the time of publication there is an unresolved issue between the LAA and the aircraft manufacturer in relation to a tip correction factor which could reduce the reserve factor of the upper carry-through spar by several percent. This might mean that calculations will show that the upper carry-through spar could fail at slightly below 6 g. However, in the case of G-GARB, the lower spar cap has failed in tension and both calculations and ground tests indicate that this will occur above 6 g.

It is therefore concluded that the most probable cause of the left wing failure was a high aerodynamic load, in excess of the 4g limit load, probably closer to 6g and possibly exceeding 6g. An airspeed of 98 mph CAS is sufficient to pull 4g with a large aft stick input, and an airspeed of 120 mph CAS is sufficient to pull 6g, which is 20 mph less than V_{NE}. The aircraft's speed before it made the sudden right descending turn could not be accurately determined from radar data, but it was approximately 97 mph about a minute before the last recorded radar point. Airspeed can be gained by increasing power or descending, and it would not have taken a significant height loss at cruise power to increase speed from 97 mph to the 120 mph airspeed required to pull 6g. It is probable that some upset, or planned descent to increase airspeed, would have occurred first, before a significant nose-up elevator input to exceed 4g and approach 6g.

Possible reasons for the aerodynamic overload of the wing

One possibility for generating high structural loads would be embarking on planned or impromptu aerobatic manoeuvres. However, this would not match the perceived profile of the pilot, especially in the view of the flight instructor who knew him. The possibility that aerobatic manoeuvres were carried out intentionally cannot be entirely discounted, but it appears highly unlikely.

The low-wing configuration of this aircraft allows a good forward and upwards view but to see features on the ground below might require a turn. For much of the flight the aircraft was in straight and level flight, although there were several occasions en route where it changed height and direction quite rapidly, climbing or descending at rates in excess of 1,000 ft/min. On these occasions a climb or descent was associated with a turn; these turns could have been made to view ground features or may have been clearing turns prior to a change of height.

The reason for the final sudden deviation from straight and level flight was not determined but it is possible that the pilot was startled by an unknown event which led to excessive force being used on the flight controls, thereby overloading the wing structure. The elevator control forces are relatively light, 8 kgf to pull 4g at a CG of 30.4% MAC[19], and a substantial input could have the potential to exceed the structural limit of the aircraft, especially if combined with aileron loads in, for instance, a 'rolling pull-out'.

It is possible to envisage a number of events which could have startled the pilot and led to an instinctive action on the controls. The position and design of the elevator trim control is such that it is possible to move the lever accidentally through a large part of its range and, anecdotally, this has occurred in the past. The flight evaluation revealed that this can cause a significant nose drop in a short period of time. During the flight evaluation the nose drop was expected so the test pilot could respond to it quite quickly, but if it occurred unexpectedly a pilot would react more slowly and the nose attitude could drop further, with further speed increase. A natural reaction by a startled pilot would be to apply an immediate corrective control input by pulling back on the control stick, and if he was aware that the trim lever had been knocked forward, he might pull the trim lever aft rapidly as well. Moving the trim lever aft in these circumstances would have the effect of reducing the aft stick forces and, in conjunction with a pull back on the control stick, reduce the feedback leading to a greater possibility of an excessive aft control input.

The flight evaluation revealed that a sudden aft trim movement of just 2.7 cm was sufficient to generate 2g, with 7.2 cm of further aft travel remaining. So a sudden aft movement of the trim lever alone could also possibly cause the ultimate load of the wing to be exceeded.

Other possible events which could have affected the pilot's inputs to the flying controls include something within the aircraft taking the pilot by surprise, such as a SkyDemon alert as the aircraft approached Danger Area EGD203. A medical event or incapacitation of either pilot or passenger is possible or, alternatively, an unknown external event such as a potential collision with an object or bird, could have led the pilot to take abrupt avoiding action.

Footnote

[19] This is at the centre of the stick grip. The stick force would have been lower if the pilot had held the stick closer to the top. The accident cg was between 28.9 and 31.2% mac.

Pitch trim control design

It was not possible to determine what events led to the structural overload in this accident but it is of concern that the trim lever in this aircraft type is located in a position, and is of a design, where there is a potential for it to be moved rapidly full-range, either by accident or intent.

There are other microlight aircraft that have pitch trim levers but the LAA and BMAA were not aware of any other that had a pitch trim lever located between the seats as on the EV-97. There have been occasions of inadvertent operation of the trim lever on the EV-97 and the flight evaluation revealed the potential for this causing a significant upset. According to BCAR Section S 677, the trim system should be designed to prevent '*inadvertent, improper, or abrupt trim operation*'. Therefore:

Safety Recommendation 2018-001

It is recommended that the Civil Aviation Authority require the Light Aircraft Association, the British Microlight Aircraft Association, Light Sport Aviation Ltd and Evektor to conduct a joint review of the design and location of the pitch trim mechanism on the EV-97 Teameurostar UK, and the amateur-built EV-97 Eurostar, to identify whether modification is required to prevent inadvertent, improper or abrupt input.

Conclusion

The aircraft was seen to pitch steeply nose-up, enter a steep spinning-type descent and then strike the ground. The left wing appeared to fold rearwards in the descent after a structural failure near the root of this wing, caused by upward bending of that wing beyond its design limits.

No pre-existing material defect, or significant design issue, was found. The left wing failure was therefore probably as a result of a high aerodynamic load, in excess of the 4g limit load, probably closer to and possibly exceeding 6g. It is most likely to have occurred as a result of an attempted recovery from an inadvertent manoeuvre inducing the structural overload.

The cause of the manoeuvre could not be identified, but could have been due to inadvertent trim operation as there is a potential for the pitch-trim lever to be moved rapidly full-range by accident, for which a Safety Recommendation has been made. Other possible reasons include an event within the aircraft taking the pilot by surprise, a medical issue or incapacitation of either pilot or passenger, or avoiding a potential collision with an object or bird.

ACCIDENT

Aircraft Type and Registration:	Schleicher ASW 24, G-CFNG
No & Type of Engines:	None
Year of Manufacture:	1988 (Serial no: 24015)
Date & Time (UTC):	4 December 2016 at 1235 hrs
Location:	Brentor Airfield, Devon
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Fatal) Passengers - N/A
Nature of Damage:	Destroyed
Commander's Licence:	Sailplane Pilot's Licence (SPL) and Airline Transport Pilot's Licence
Commander's Age:	47 years
Commander's Gliding Experience:	1,500 glider hours 130 hours in the last 12 months (Approximate figures as it was not possible to access pilot's electronic logs)
Information Source:	AAIB Field Investigation

Synopsis

During a glider winch launch in turbulent conditions the weak link parted. The pilot attempted to fly a circuit to land near the launch point but the glider encountered significant sink and had insufficient energy to complete the intended circuit. The pilot sustained fatal injuries in the impact with the ground.

History of the flight

Background

The pilot, accompanied by other pilots from his regular gliding site, had taken his glider, G-CFNG, to the Dartmoor Gliding Society gliding site at Brentor Airfield. Two of the group had flown from this site before, three and five times respectively, but the accident pilot appears not to have done so. The group arrived at the site early in the morning, had a briefing from the local club duty instructor and walked the takeoff and landing area.

The group had self-briefed about the weather conditions which included strong winds from the east and 'rotor cloud' over the eastern end of the airfield; indicative of significant turbulence. This information was reinforced by the discussion with the Dartmoor Gliding Society duty instructor and during their walk of the airfield the visiting group noted the wind was "roaring" in the valley, to the east of the airfield, even during periods of reduced wind on the airfield itself.

The duty instructor had decided that, as the conditions were not suitable for the training gliders that the club owned, there would be no flying of club aircraft. However, this decision did not apply to privately owned gliders and the club facilities could still be used to launch them.

A Discus B glider, operated by a Dartmoor-based pilot, had been positioned as the first to launch. G-CFNG, a Schleicher ASW 24, was lined up as the second to launch, with a third glider arranged after it.

Witnesses later estimated that the wind was from the east in the region of 20 kt gusting to 30 kt and the visiting group watched as the Discus B was launched. From the perspective of the ground witnesses this launch seemed moderately steep but otherwise normal. However, the pilot of the Discus exceeded the maximum launch speed for his aircraft and so released the winch cable, reaching a peak airspeed of approximately 100 kt and a height of 420 ft. At this point he felt he had plenty of energy in the glider to complete a circuit and so immediately turned left to head downwind. The pilot of the Discus later reported that conditions were very turbulent and that he required three-quarters to full control deflections to maintain control of the glider. On the downwind leg the glider's airspeed was approximately 90 kt and, abeam the airfield windsock, the pilot of the Discus reported that he encountered "severe sink", with a rate of descent of around 29 fps[1] (the 'still air' sink rate for this aircraft is about 8 fps at 90 KIAS). The pilot cut the circuit short and due to the high sink rate did not use the airbrake during the turn to final approach. He used a much higher airspeed than normal for the approach and deployed the airbrake once below 100 ft aal. The pilot of the Discus flew over the launch point between 75 and 100 ft and landed further down the airfield than usual. He noted that the turbulence declined markedly below 30 ft aal. After landing, the pilot of the Discus decided that because of the severe conditions he would stow his aircraft for the day. After this flight the group decided to suspend launches.

The Discus pilot also provided some feedback to the winch driver, who commented that he had used about one-third throttle for the Discus when the maximum winch launch speed was exceeded and would therefore use less power for the next launch.

The accident flight

During the break, the group noticed the windsocks, mounted at either end of the site, were pointing in opposite directions. A little later the wind appeared to have dropped, with the windsock near the clubhouse hanging slack for a few minutes. The group walked the airfield again and, while at the winch end of the airfield, the winch crew suggested they make a decision about flying or cancelling for the day. It was now approximately one hour after the launch of the Discus and the conditions appeared much improved from the time of that launch, with the wind "reasonably steady" along the strip at about 20 kt. Following discussion the group decided to resume flying.

Footnote

1 feet per second.

G-CFNG was positioned for launch with the same cable and weak link[2] as were used for the Discus launch and the pilot completed his pre-flight activities, which included turning on three cameras[3]. He was assisted in strapping in by another of the group and his preparation appeared normal. The cockpit camera did not capture the pilot's contingency briefing but the external cameras did record the control checks, which appeared normal.

The slack in the winch cable was taken up, the 'all-out' signal was given and the launch commenced. The glider accelerated rapidly becoming airborne in about four seconds and rotated smoothly into a climb attitude. The group watched and, as the glider was at approximately 200 to 300 ft, the weak link parted. They saw the glider pitch gently forward over the top of an arc before starting a left turn. As the left turn progressed, through approximately north, the turn tightened and the glider started to sink to the left and then entered a very rapid descending left turn before disappearing out of sight in an area of gorse bushes to the north of the airfield.

The group ran to provide assistance, arriving at the glider shortly after the accident. The pilot had sustained severe injuries and members of the group attempted CPR until paramedics arrived some 25 minutes after the accident. The paramedics confirmed a few minutes later that the pilot had died.

Pilot information

The pilot held an EASA Sailplane Pilot's Licence (SPL) and a valid EU Class 1 Medical. In addition he held the following British Gliding Association (BGA) certificate and badges:

- Bronze Certificate completed in August 2007 with a cross country endorsement
- Silver Badge completed in May 2008
- Gold Badge completed in June 2010
- Three Diamond Badges, third diamond completed in October 2011.

The pilot was an experienced sporting glider pilot with substantial hill and mountain soaring experience both in the UK and other countries. He had demonstrated two launch failures with a club instructor at the North Hill site in April 2016 during an annual check flight. The pilot was known for his propensity to seek challenging conditions in his chosen sport, glider flying. In addition to flying gliders, the pilot held an Airline Transport Pilot's Licence (ATPL) and had command experience on Boeing 747-200, -400 and -8 aircraft.

The pilot's logbooks were maintained electronically and it was not possible to access them.

Footnote

[2] This is acceptable and normal practice.
[3] Mounted on the tail, right wingtip and in the cockpit. Details in the recorded information section.

Airfield information

The Dartmoor Gliding Society's site, known as Brentor Airfield, is located on a ridge 2.5 nm north of Tavistock, in Devon, at an approximate elevation of 820 ft. The grass runway is orientated approximately 110°/290° and is approximately 1,100 m long. The airfield is unlicensed.

The terrain in the area is dominated by the high moor of Dartmoor starting about 3 nm to the east of the gliding site and extending for over 10 nm. The southern part of the moor rises to an elevation of 1,600 ft with the northern area being around 2,000 ft. A north-south valley between the main high moor and the ridge line descends to an elevation of 490 ft.

On the day of the accident the winch was located at the eastern end of the site. The ground beyond the winch point drops off steeply, making an overrun an unattractive proposition. However, to the south of the site there is a series of fields offering a reasonable prospect of an off-airfield landing. The surface immediately to the north of airfield is soft moorland and high gorse (Figure 1).

Aircraft information

G-CFNG was a Schleicher ASW 24, a single-seat Standard Class sailplane with a wingspan of 15 m, with similar performance to the Discus B which had flown earlier. The ASW 24 is constructed from a combination of carbon and glass-reinforced fibre. It has a retractable monowheel, airbrakes and removable winglets which were found fitted at the time of the accident.

The glider can carry water ballast but there was no evidence that the pilot was carrying any on this flight. The empty weight of the glider was 254 kg and the pilot's weight was 105 kg, giving a total weight of 359 kg. The maximum weight is 500 kg.

The flight manual quotes stall speeds of 35 KIAS at 320 kg and 39.5 KIAS at 410 kg. For approach, the flight manual states '*maintain about 51 kts'* and '*in turbulence, the approach speed should be appropriately increased'.* The BGA Instructors' Manual recommends approach speeds as follows:

With low risk of speed loss - 50 kt
With small risk of speed loss – 55 kt
With moderate risk of speed loss – 60 kt

The Manual also indicates: '*higher speeds may be needed at hill sites or in extreme conditions'*.

Accident site

The aircraft wreckage was located 86 m north of the runway edge in an area of gorse-covered moorland (Figure 1). The impact marks and wreckage distribution were consistent with the aircraft having struck the ground in a 90° left bank with the nose down. The left wing had separated at the root and the cockpit area was destroyed.

Both ends of the 'blue' weak link were recovered. The fracture faces did not exhibit any corrosion or signs of metal fatigue. The weak link had necked in its centre indicating that the link had parted, consistent with its design, following a load application in excess of its yield strength.

Survivability and pathological information

Given the high speed, the extreme nose-down attitude at impact and the limited energy absorption of the front cockpit structure, the accident was not considered survivable. A subsequent post-mortem examination of the pilot identified that death resulted from multiple injuries consistent with the ground impact and there was no evidence of any pre-existing medical factor which would have contributed to the accident. The toxicological results were negative for drugs and alcohol.

Aircraft examination

The aircraft wreckage was recovered to Farnborough for detailed examination. There were no disconnections in the flight controls apart from overload failures associated with impact. No defects were found that would have contributed to or caused the accident.

Recorded information

Sources of information

The pilot had mounted three 'action' video cameras to his glider; one on the tail, one on the right wingtip and one internally in the cockpit that afforded a good view of the cockpit instrumentation and of the external view ahead and to the sides of the glider. All of these cameras were recovered from the accident site, downloaded and found to contain footage of the flight. In addition, the investigation also had access to two further video recordings of the flight, filmed from the ground on mobile phones.

The glider was fitted with a Naviter Oudie, a gliding computer which logged flight data to non-volatile memory and this was connected to a LXNAV V7 variometer[4]. The variometer computed true airspeed, groundspeed, ground track and performance metrics for the flight using the aircraft's pitot-static system[5] and GPS information. This data was in part recorded by the Oudie but, shortly after the apex of the climb, the recording of the flight stopped for unknown reasons. Figure 1 shows the vertical profile, ground track and true airspeed data recovered for the accident flight from the Oudie.

The Discus B glider was also equipped with a LXNAV FLARM[6] device which was downloaded and it was this analysed GPS data that indicated the rate of descent of approximately 29 fps which developed during the Discus pilot's turn from base leg onto finals.

Footnote

[4] A variometer is an instrument that indicates the vertical speed of a glider, usually incorporating an audio output.

[5] The pitot-static system used by the variometer was the same system used for the airspeed indicator, which is discussed below in the *Review of the cockpit video* section

[6] FLARM is a traffic awareness and collision avoidance technology for General Aviation, light aircraft, and UAVs.

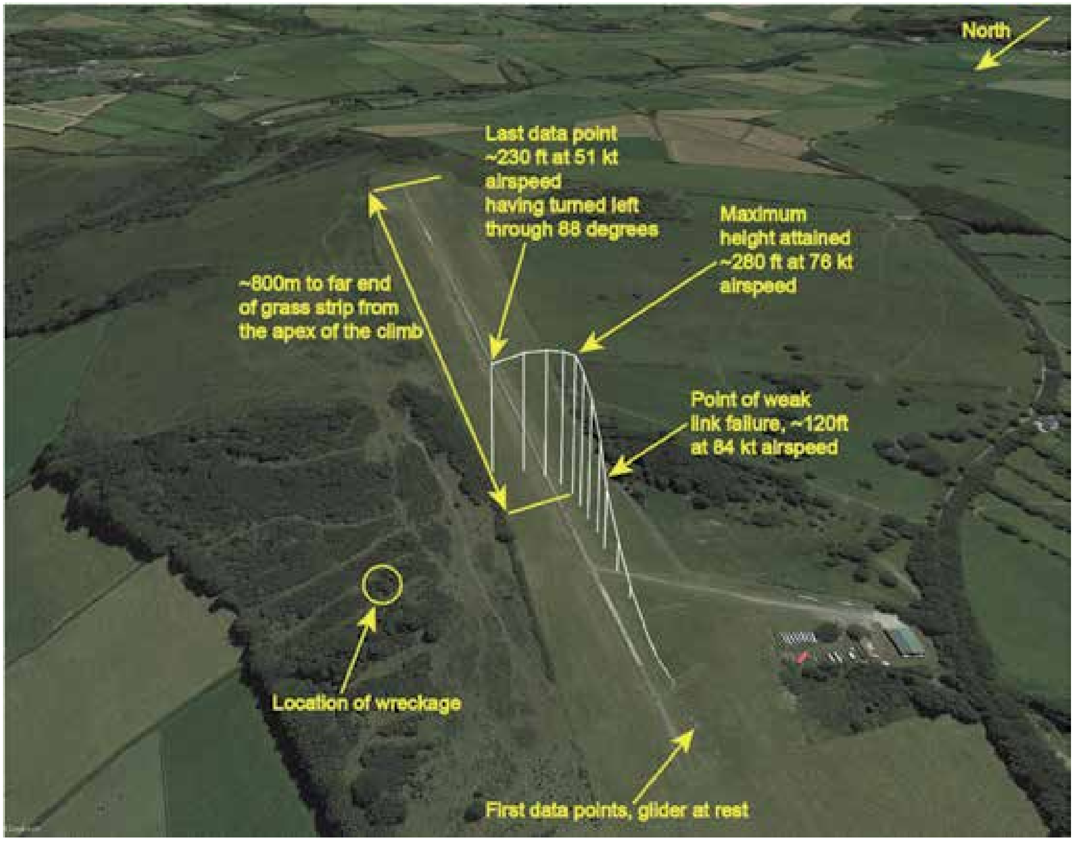

Figure 1

Vertical profile (ft aal[7]), ground track and true airspeed data for the accident flight

Review of the cockpit video

The airspeeds referred to in this section are approximate as they are derived from the images of the airspeed indicator on the video, therefore the interpretation is by visual determination and has not been corrected for instrument or position error. The altitudes were similarly derived from the altimeter in the recorded video and are not identical to those in the data recovered from the Oudie.

The windsock, when visible before and during the launch, varied from full to approximately ⅓ full and in direction from roughly aligned with the launch direction to 30° of crosswind from the left.

The initial launch appeared normal with the glider becoming airborne at about 53 KIAS, five seconds after the launch started. Three seconds after the glider became airborne it was at 78 KIAS, and about 100 ft aal, when the weak link parted (Figure 2). The pilot immediately looked left and looked left repeatedly from this point on. At no time did the pilot look to the right.

Footnote

[7] In this report, aal (above airfield level) is used to reference heights above the glider launch point on the day.

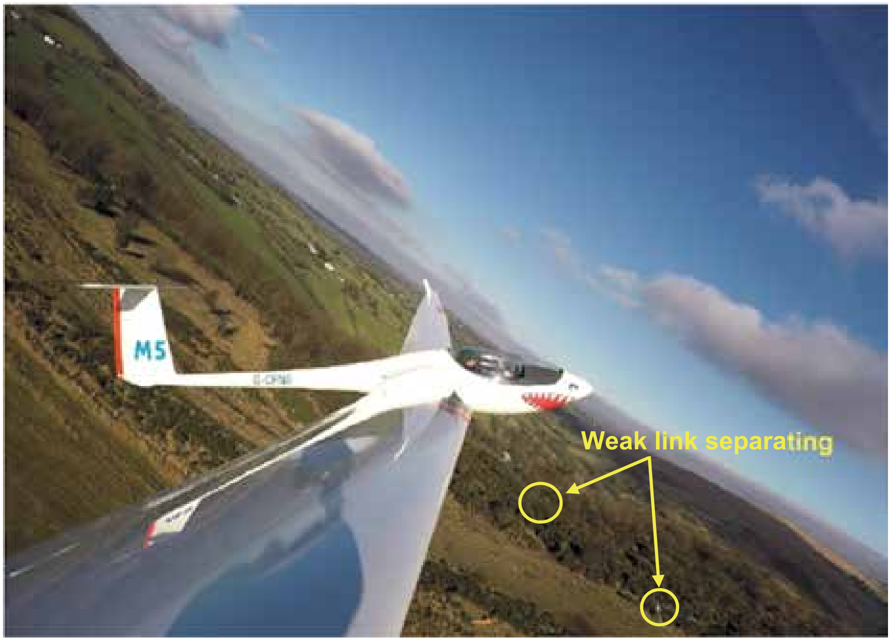

Figure 2

Glider at the moment of launch failure

Over the next four seconds the glider pitched gently nose down, gaining height while slowing to 60 KIAS[8]. This pitch-down manoeuvre brought the nose of the glider to approximately level with the horizon. The pilot then made an approximately half-to-two-thirds left roll input on the control stick, while sustaining a neutral to slightly forward pitch input. The glider rolled left, the nose dropped below the horizon and began to turn to the north during which the speed reduced to 51 KIAS (Figure 3).

Figure 3

Cockpit view as left roll input is being made

Footnote

[8] The figures in this section differ from the data extracted from the Oudie and the differences are not readily resolved.

Nine seconds after the launch failure, the glider was in an increasing 40° left roll with the nose slightly below the horizon and had turned 20° to the north, away from the launch heading and the speed had stabilised at 51 KIAS. The yaw string was neutral, showing a co-ordinated turn, and the pilot was commanding a further left roll with left stick resulting in the roll increasing to 60° over the next second.

Eleven seconds after the launch failure, the glider was in a sustained 60° left turn at 51 KIAS (Figure 4) and had turned through approximately 90° from the launch heading. The nose of the glider then dropped well below the horizon and the airspeed and the descent rate increased, with the glider rolling rapidly left through 80°, with the airspeed reaching 70 KIAS before it hit the ground 14 seconds after the launch failure.

Figure 4

11 seconds after launch failure, with significant left aileron input

Meteorology

Weather information was available from the group of glider pilots, the crews of the Police and Air Ambulance helicopters, the various video sources and FLARM downloads, a roadside wind sensor and an aftercast provided by the UK Met Office.

Helicopter crews

The helicopter crews were highly experienced in operating in the area around the accident site and particularly the low valley to the east of the site, which was a regular poor weather route between the north and south of Devon. They reported that around the time of the accident there was significant turbulence both across the high area of Dartmoor and in the low valley area immediately to the east of the glider site. One helicopter commander described it as the worst turbulence he had experienced in seven years of operating regularly in the area of that valley. There was up to 40 kt of wind from the east at 400 ft over the accident site.

Roadside sensor

The surface wind at the accident site was not recorded but a roadside weather station on the A386 road at Shortacombe village (4.6 nm north-east of the accident site) recorded a steady wind speed of 27 kt, with gusts to 35 kt, around the time of the accident.

Met Office

The UK Met Office provided an aftercast of the conditions across the south-west of England:

> *'The Exeter observations, to the east of Dartmoor, show east to north-easterly winds, relatively steady between 05 and 10 kt, generally good visibility, no significant weather and few or scattered amounts of cloud, with bases around 2000-2500FT. Pressure was relatively high for the time of year, at around 1020hPa.*
>
> *Meanwhile, the Newquay observations, to the west of Dartmoor, show brisk south-easterly winds. Although the direction remained steady between 100-120 degrees, the speeds were more variable, ranging between 20 and 27KT during the middle of the day, before easing from the 1350 UTC observation onwards. Furthermore a gust of 29KT was reported at 1320 UTC. Otherwise, visibility was generally good, with no significant weather and few amounts of cloud, with bases between 1800 and 3500FT. Pressure was relatively steady at around 1016 or 1017 hPA.'*

The forecast Metform 215 for the time of the accident (Figure 5) highlights at Area D the risk of mountain waves (MTW) and occasional moderate low-level turbulence near the accident site. In particular, it noted that mountain waves of 500 feet per minute were expected at around 4,000 ft.

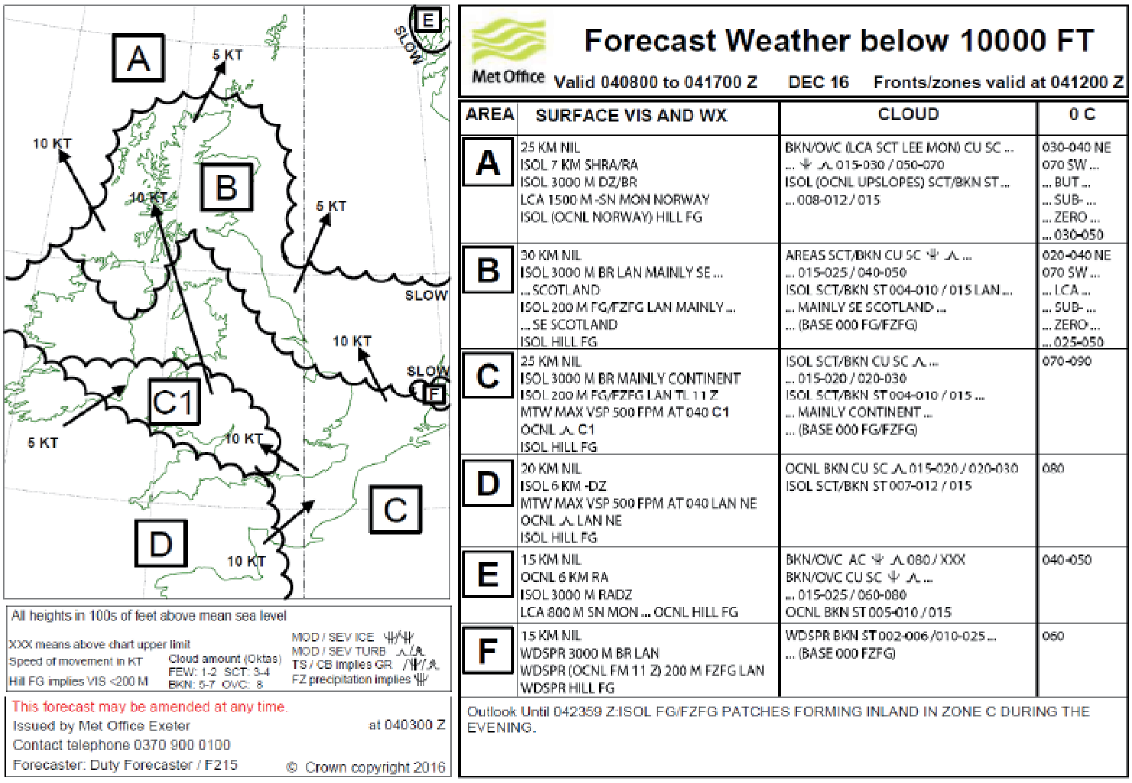

Figure 5

Forecast low-level weather, 4 December 2016

Satellite imagery of the area at the time of the incident confirms the presence of mountain wave activity in the Dartmoor area and therefore a high probability of significant turbulence at low levels (Figure 6).

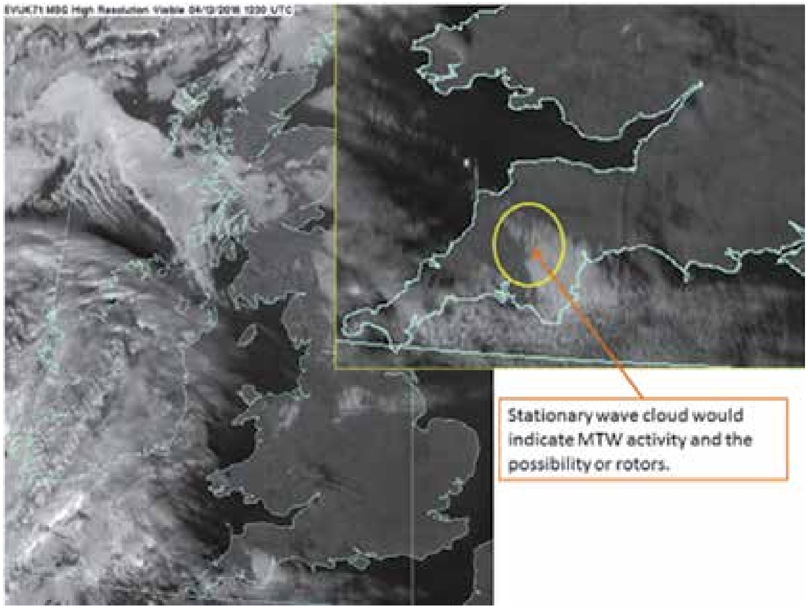

Figure 6
Satellite image

'Mountain wave' activity from high ground

In areas of mountain wave activity a low-level turbulent zone can extend many kilometres downwind from the high ground inducing the phenomena. Brentor Airfield would have been within this zone on the day of the accident (Figure 7).

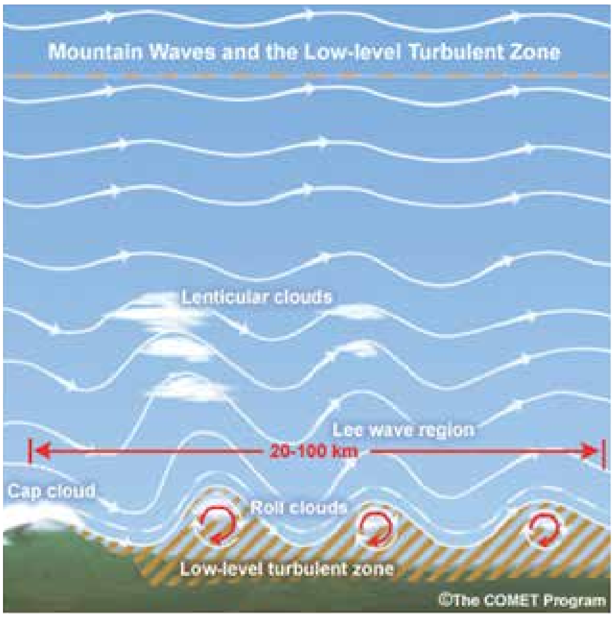

Figure 7
'Mountain Wave' diagram

Aircraft performance

As well as the meteorological conditions around the time of the accident, the investigation examined the glider's performance following the launch failure and whether it would have been possible to land straight ahead.

During an ASW 24 flight test in 1993, a maximum glide ratio of 44 to 1 was measured at 49 kt and a minimum sink rate of 108 ft/min (1.8 fps) was measured at 45 kt. No published landing distance figures were available but the AAIB had access to data logger information for an approach flown in an ASW 24. The airbrakes were half extended, the wheel was down and the airspeed was 70-75 KIAS. The data showed that a glide ratio of 8.9 was achieved (still air) with a ground roll of 154 m, although this could have been less with more aggressive braking. The pilot, whose data logger was used, estimated that a ground roll of 120 m would have been easily achievable.

The aircraft manufacturer provided airspeed and vertical speed data with full airbrake extension. At 54 KIAS the glide ratio was 6.9 and at 57 KIAS the glide ratio was 5.9. At higher speeds the glide ratio would have been lower but this data was not available.

Landing performance calculation

G-CFNG achieved a maximum height of about 280 ft after the weak link failure. If a landing had been initiated at this point, using half airbrake, the glide distance would have been about 760 m (using a glide ratio of 8.9) in still air. With a headwind of 20 kt this distance is reduced to 540 m. With a ground roll of 120 m, this would have resulted in a landing distance of 660 m. With full airbrake extended, using a glide ratio of 5.9 and a 20 kt headwind, the landing distance would have been 478 m. Figure 1 indicates that, at the apex of the glider's climb, the length of runway ahead was approximately 800 m.

Glider winch launching

Background

Winch launching involves using a cable to pull a glider towards the winch, accelerating it to flying speed and then, as the glider reaches an appropriate speed, the pilot rotates the glider into a climb. The climb continues until the maximum height available, or desired, from the launch has been achieved and the pilot releases the cable, which falls back to earth under a parachute, while the glider flight continues.

The height the glider will reach during the launch is determined by various factors but primarily by the length of the winch cable. The acceleration during launch is rapid and the glider is typically airborne within two or three aircraft lengths.

The cable is connected to the belly-hook of the glider via a weak link. This link is designed to protect the glider by parting in the event of too high a load being applied to it during the launch. Alternatively, if the pilot notices the glider is above its winch limit speed, he or she can release the cable early. Weak link separations are not uncommon, particularly in turbulent conditions.

Launch failures

Winch launch failures occur for a variety of reasons, ranging from mechanical failure of the winch to mishandling of the winch or aircraft. Regardless of the initiating event it results in the glider pilot having to manage the resultant situation to recover to a safe landing.

The failure handling can be broken down into phases depending on when it occurs. In the event of a failure during the initial stages of a winch launch the glider should be able to land ahead, on the gliding site (Figure 8). After a short period the glider will reach a height from which it is possible to return to the launch site via some form of abbreviated circuit. The glider site and conditions should be such that one option is always possible and to ensure this happens there will also be a period during which both options will be possible. This overlap is normally in the order of 200 to 300 ft deep and as the headwind or field length increases the depth of this overlap will also increase.

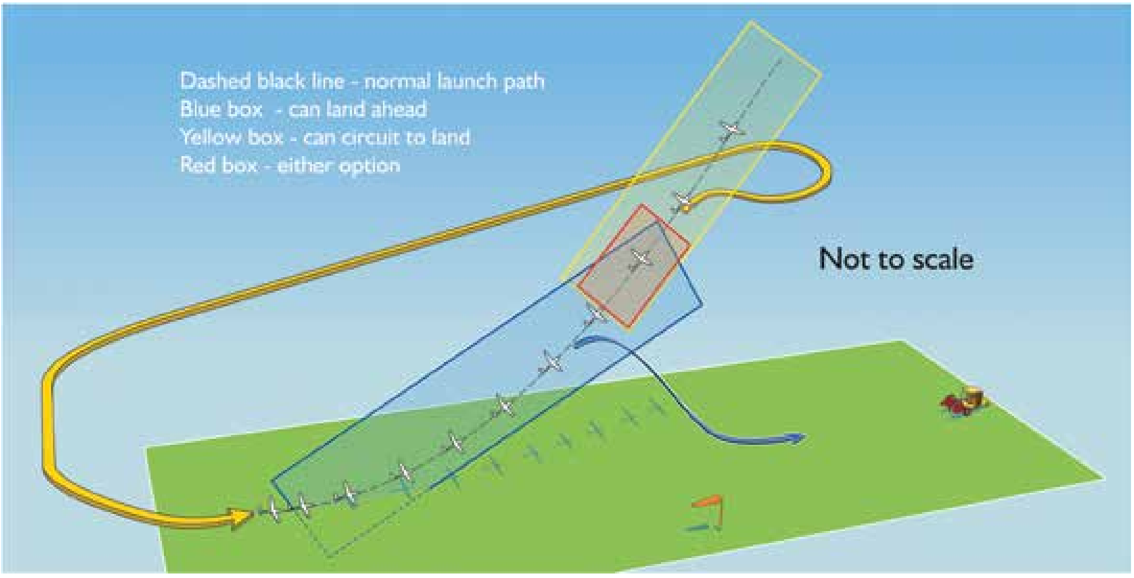

Figure 8

Launch options picture

In the event of a cable break, or weak link separating, the BGA recommended action is to immediately lower the nose to the recovery attitude. This is more nose-down than the normal approach attitude and is intended to achieve two separate but important objectives.

The steep nose-down attitude allows the glider to recover airspeed to a safe speed more rapidly than in the normal approach attitude. The second objective is to give the pilot a clear view of the remaining strip ahead to allow an effective decision on whether there is sufficient strip remaining to land ahead. This will depend on the height of the failure, the size of the field, the wind component and gradient and the glider type. If a turn is to be made BGA teaching recommends an initial turn away from the wind.

Safe winch launching initiative

In 2005 the BGA began a campaign to improve safety in the winch launching of gliders. This has developed further over the years and the BGA '*Safe Winch Launching*' leaflet published in 2015 included the following information:

> *'A winch launch accident is defined as an accident resulting from a winch launch which… does not proceed to the usual height…This can be for any reason including winch fault, cable break, cable snarl up and cable release by the pilot.*
>
> *BGA records show that there were 36 fatal and 72 serious injuries from accidents associated with incomplete winch launches between 1974 and 2005. 278 gliders, about 8 per year, were destroyed or substantially damaged in winch accidents in the same period.*
>
> *The main sources of fatal injury were a stall during rotation and a spin after power loss in mid launch. The main sources of serious injuries were these two groups and also a stall after power loss below 100ft.*
>
> *The BGA safe winch launch initiative began in October 2005, 9 years ago. In those 9 years there have been 5 fatal or serious injury winch accidents compared with the previous 9-year average of 27. Fatal or serious injury stall/ spin accidents declined from a 9-year average of 22 to 2.'*

Current information on this initiative is available on the safety pages of the BGA website, https://members.gliding.co.uk/bga-safety-management/safe-winching, which includes a current and downloadable version of the BGA leaflet, with practical safety guidance on all phases of a glider winch launch. This 2015 edition of the leaflet three '*critical elements for staying safe',* of which one is:

> *'After power loss in mid-launch, adopt the recovery attitude, wait until the glider regains a safe approach speed, and land ahead if it is safe to do so.'*

AAIB experience

An AAIB Inspector undertook a cable break exercise with a BGA Instructor to gain an understanding of the flight dynamics of a winch launch failure. During this sortie the instructor emphasised that at low heights the preferred choice should always be to land ahead.

Following a cable break the training focusses on the importance of adopting the "Recovery Attitude", both to guarantee sufficient airspeed and to open the view of the landing area, prior to making a decision to turn.

Analysis

Factors in the accident

The winch cable weak link parted due to a load application that was in excess of its yield strength. Weak link separations in turbulent conditions are not uncommon and it is highly likely that the weak link parted due to the turbulent conditions.

The weak link parted at around 120 ft aal, though with a comparatively high speed at the separation point and with the additional energy the aircraft climbed to a peak of approximately 280 ft aal. At this point the pilot promptly began a turn to the left. Very soon after starting the left turn it appears that the aircraft was affected by a significant downdraft and probably a significant decay in airspeed due to wind shear. As a result the aircraft did not gain airspeed for several seconds despite a pronounced nose-down attitude. This increased the rate of descent to a very high value and at this point the situation was beyond recovery.

From the glider performance calculations, up to the point where the pilot turned to the left, there would have been sufficient strip remaining for a landing ahead to be safely executed, even with half airbrake. However, given the achieved height, the performance of the aircraft and the pilot's experience it is clear he believed that an abbreviated circuit to return to the launch point was viable.

It is not possible to determine which factors contributed to the pilot's decision to turn. One way his decision making may have been influenced was by the fact that a landing ahead would have stopped further launches and also resulted in a lengthy retrieval exercise. Two other possible factors may have been that, at an unfamiliar airfield, he was concerned about the unforgiving terrain beyond the winch end of the strip, if he over-ran, and that a locally-based Discus glider had managed an abbreviated circuit earlier that day, in what appeared to have been worse conditions.

As it was, the pilot in G-CFNG did not fully adopt the aircraft recovery attitude recommended by the BGA, probably because his airspeed was already close to a normal approach speed. However, part of the philosophy of this recovery attitude is to offer the pilot a clear view of a prospective area in which to land ahead. In this case the aircraft still had sufficient speed to manoeuvre, though the higher-than-recommended pitch attitude would have constrained the pilot's view of the remaining length of airfield. He may therefore have had a false impression of the landing area ahead and this may have contributed to his decision to make an immediate turn.

The pilot chose to make a turn left toward the downwind leg of the circuit and this meant that his initial turn was upwind and therefore contrary to general BGA teaching. BGA teaching is to make an initial turn away from the wind, this allows the aircraft to be into wind after a smaller amount of turn should a crossfield landing be possible and also gives a reduced groundspeed during the base leg portion of the circuit. However, in this case the merits of turning right, away from the wind, would have been more limited than in the general case.

Context for the decision to fly

Following the accident, two members of the pilot's group, supported by two other experienced glider pilots who knew the accident pilot well, discussed with the AAIB some of the context on which they had based their decision to fly.

Favouring their decision to fly on that day was the generally sunny weather and that there was likely to be "epic wave". The flying conditions near the ground were likely to be "sporting" and "challenging" but the group had flown in such conditions previously and had always coped with them. The group had been gliding in similar conditions the previous month in Wales and they had all been gliding in windier conditions elsewhere.

The subtle messages against gliding were that the weather was somewhat unpredictable and that there was a significant probability of low-level turbulence over the launch site; this was reinforced by the flight of the Discus B.

The pilot in this accident was experienced, was current and was known for his interest in seeking out challenging flight conditions. He and his group had travelled to the site precisely because of the conditions as they believed this would offer them the opportunity for high performance gliding. The pilot had flown in very demanding conditions previously. At this level, gliding is a high performance sporting activity and the pilot knew of and accepted the degree of hazard to achieve high performance flight. Given the experience of the pilot, the decision to launch appears a reasonable choice.

Conclusion

When the winch launch failed there was sufficient distance available to land directly ahead and turning away from the landing area committed the pilot to attempting a circuit in unpredictable conditions. Assessment of the data from the Discus B shows that there were regions of significant sinking air. While it is difficult to be certain of the exact conditions for the accident flight, the general meteorological situation remained and therefore it is highly probable that there would have been significant areas of turbulent and downdraughting air in the area at the time of the accident. Sinking air of a similar magnitude to the conditions encountered by the Discus B would have removed any chance of completing a circuit from the height achieved by the accident aircraft. Regardless of the pilot's significant experience the area of sinking air meant that the glider did not have the performance to complete the circuit safely.

The BGA's winch launch safety campaign has significantly reduced the accident and fatality rate from the typical forms of launch failure. While this accident was somewhat unusual, given the highly turbulent conditions, the overall guidance in the Safe Launch Initiative remains relevant.

Safety actions

Safety action taken

Following this accident the BGA has issued additional guidance related to launch failures and the hazard associated with sink during the circuit.

In February 2017 the BGA published a leaflet *'Safe Winch Launching – Land ahead if safe to do so'* and this material was put on the BGA Website[9]. It contained the following text:

> *'The instructors' manual and the safe winch launch leaflet/booklet teach:*
>
> *After power loss in mid-launch, adopt the recovery attitude, wait until the glider regains a safe approach speed, and land ahead if it is safe to do so.*
>
> *Why not turn? The BGA has been teaching 'do not turn' because:*
>
> > *after a push-over the airspeed can be less than the attitude would suggest*
> >
> > *turning before the glider has accelerated to a safe speed after a launch failure can cause the glider to spin.*
>
> *After commencing a turn, although the glider may have sufficient airspeed to avoid a stall and spin, no landing area may be immediately available, and this can expose the glider to other hazards which can prevent a safe landing. Sink is one such hazard, often associated with strong winds and wave. A glider making a 360° turn in still air at a bank angle of 35° and 50kt typically descends by only 70ft. But with 15ft/second sink the height loss in a 360° turn is over 400ft. If the launch failure was at 300ft the glider would crash before completing a 360° turn.*
>
> *The existence of additional hazards from a turn adds force to the advice:*
>
> *LAND AHEAD IF IT IS SAFE TO DO SO.*
>
> *If you are very experienced, you may sometimes be winch launching in challenging conditions. If you have a launch failure we would urge you to land ahead if it is safe to do so..'*

In October 2017 the BGA updated and published the leaflet titled '*Safe Winch Launching'*, in its 6th edition.

Footnote

9 https://members.gliding.co.uk/library/safety-briefings/land-ahead-safe

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:	Beech 200 Super Kingair, G-KVIP
No & Type of Engines:	2 Pratt & Whitney Canada PT6A-41 turboprop engines
Year of Manufacture:	1979 (Serial no: BB-487)
Date & Time (UTC):	26 July 2017 at 1145 hrs
Location:	En route Exeter to Faro, Portugal
Type of Flight:	Commercial Air Transport (Non-Revenue)
Persons on Board:	Crew - 1 Passengers - 2
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	33 years
Commander's Flying Experience:	3,000 hours (of which 1,125 were on type) Last 90 days - 89 hours Last 28 days - 36 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The aircraft was being flown from Exeter to Faro in Portugal and whilst passing FL275, cleared to FL280, the ALT warning illuminated on the flight deck. The passenger oxygen masks dropped down and the passengers successfully put them on. The pilot had difficulty donning his mask, which had become entangled on items behind the pilot's seat. He informed ATC of the situation and carried out an emergency descent to FL100 and diverted back to Exeter, which was also the operator's maintenance base. The return to Exeter was uneventful and a normal approach and landing was made on Runway 26. On shutting down the aircraft, the pilot felt unwell but he thought this may have been a result of the incident.

The maintenance organisation identified two sources of cabin pressurisation loss; the outflow valve and a landing gear seal. Both were replaced and an air test confirmed the problem was rectified. The operator issued a notice to aircrew reminding them to ensure the oxygen mask was unobstructed before flight, and a new mask holder was installed in the flight deck roof to ensure its unimpeded use.

SERIOUS INCIDENT

Aircraft Type and Registration:	Boeing 737-8K5, G-FDZJ
No & Type of Engines:	2 CFM56-7B27/3 turbofan engines
Year of Manufacture:	2007 (Serial no: 34690)
Date & Time (UTC):	28 September 2017 at 1804 hrs
Location:	Malta International Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 6 Passengers - 136
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	39 years
Commander's Flying Experience:	9,699 hours (of which 782 were on type) Last 90 days - 277 hours Last 28 days - 85 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

Synopsis

G-FDZJ was operating a charter flight from Malta to Manchester on behalf of a cruise ship company. On takeoff the pilot flying found the aircraft required significantly more aft control column movement than normal to rotate. The available evidence indicates that the aircraft was out of trim due to an incorrect MACTOW[1] on the load sheet. This occurred because passenger's actual seating positions were not passed to the handling agent. When producing the load sheet the handling agent assumed an even distribution of passengers within the cabin, when the actual distribution created a forward bias.

History of the flight

G-FDZJ was operating a charter flight from Malta to Manchester. The aircraft, with a capacity for 189 passengers, had 136 passengers, 2 pilots and 4 cabin crew on board.

The load sheet recorded a takeoff weight of 65.6 tonnes and MACTOW of 23.4%. The pilots elected to take off from intersection F for Runway 13 and calculated the following speeds for takeoff with Flap 10: V_1 141 kt, V_R 142 kt and V_2 145 kt. Stabiliser trim was set to 4.5 units based on the load sheet information entered into the Flight Management Computer (FMC). Although not certain, the crew believe that all the passengers sat in their allocated seats.

Footnote

[1] MACTOW – Mean Aerodynamic Chord Takeoff Weight – this is the centre of gravity position at takeoff expressed as a percentage of the wing chord.

The takeoff acceleration was normal. At V_R, the commander, who was pilot flying (PF), pulled back on the control column, but no rotation occurred with the normal pull effort. The PF continued to pull back and then with approximately ¾ elevator deflection the aircraft started a slow rotation. The aircraft was airborne with approximately 300 m of runway remaining. Once the aircraft was safely climbing away the PF applied rearward trim to remove the control force.

The flight proceeded without further incident.

Recorded data

The FDR data showed that the elevator deflection required for the rotation for this takeoff was 10.9º. Typical elevator deflections were 8.3º (based on the previous 6 flights).

The data showed the aircraft was trimmed, once airborne, from the pre-takeoff setting of 4.5 units to approximately 7 units.

Organisational information

The flight was operated on behalf of a cruise ship company. The passengers checked in for the flight and were allocated their seats by the cruise operator whilst aboard the cruise ship. Passenger loading details were passed from the cruise ship operator to the handling agent at Malta. These details gave the number of males, females and infants but did not specify the seating locations. Normally these flights are full so the seating locations are not required. For non-cruise flights, the handling agent checks in the passengers and consequently knows the passenger seating positions. Because the passengers were checked in by the cruise operator the handling agent did not have this information. Without it the handling agent assumed the passengers were evenly distributed throughout the cabin. The handling agent produced the electronic load sheet based on this incorrect assumption. The actual passenger distribution was biased towards the front of the aircraft.

Weight and balance

A manual load sheet, produced for the investigation and using the actual passenger distribution, indicated a MACTOW of 17%. A manual load sheet using an even distribution indicated a MACTOW of 23.5%, in line with the load sheet given to the flight crew.

The flight crew loaded the FMC using the load sheet provided, resulting in a takeoff trim setting of 4.5. The performance calculations performed by the flight crew were correct for the load sheet they received.

Operator safety action

Following its review into this incident, the operator indicated it would take the following safety action:

1. Update the existing process to ensure the position of any empty seats on a cruise flight (or any flight where check in and seating is not completed by the handling agent) is communicated by the cruise line representative to the load controller.
2. Ensure all handling agents that deal with cruise flights (or any flight where they do not handle the check in themselves) have a method of determining the actual seating position of passengers on any partly loaded flight in order to produce an accurate load sheet.

Conclusion

The aircraft took off with incorrect stabiliser trim set because an incorrect MACTOW was shown on the load sheet. This occurred because the seating position of the passengers was not passed to the handling agent. The handling agent assumed an even distribution of passengers within the cabin, when the actual loading created a forward bias.

ACCIDENT

Aircraft Type and Registration:	Cessna 208B Grand Caravan, G-CPSS	
No & Type of Engines:	1 Pratt & Whitney Canada PT6A-114A turboprop engine	
Year of Manufacture:	2004 (Serial no: 208B1059)	
Date & Time (UTC):	16 August 2017 at 1125 hrs	
Location:	Runway 22, Air Camp, Netheravon, Wiltshire	
Type of Flight:	Non-commercial	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Nosewheel, propeller and propeller hub	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	57 years	
Commander's Flying Experience:	489 hours (of which 146 were on type) Last 90 days - 6 hours Last 28 days - 2 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

The aircraft was being operated by a sport parachute club and was on the fifth sortie of the day dropping parachutists over Netheravon Airfield from heights up to 13,000 ft. Following a rapid descent, the aircraft was stabilised for the final approach to Runway 22 with FLAP 30 set, airspeed 85 kt and propeller rpm set to MAX. The weather was good with a surface wind from 200º at 13 kt. The aircraft was stabilized but, on short finals at about 150 to 200 ft, the aircraft started to drop, which the pilot described as "the sensation … of being rapidly pushed down", or windshear. He tried to pull up to correct the descent but landed heavily in a flat, nose down attitude. The aircraft skidded along the grass runway, veering off to the right and coming to a halt alongside the runway. During the landing, the nose landing gear broke off and the propeller contacted the ground. When the aircraft stopped, the pilot isolated the fuel and electrical systems and vacated through the normal exit.

An internal investigation identified that the aircraft had touched down in the undershoot and the nose landing gear had probably broken when it encountered a shallow drainage ditch.

ACCIDENT

Aircraft Type and Registration:	Spitfire TR9, G-ILDA
No & Type of Engines:	1 Packard Motor Car Co Merlin 266 piston engine
Year of Manufacture:	1945 (Serial no: CBAF 10164)
Date & Time (UTC):	27 October 2017 at 1103 hrs
Location:	Goodwood Aerodrome, West Sussex
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Pitot mast distorted and slight damage to left wing tip
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	48 years
Commander's Flying Experience:	4,100 hours (of which 73 were on type) Last 90 days - 24 hours Last 28 days - 1 hour
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

While flaring to land on a grass runway, the aircraft rolled left and the left wing tip and the pitot mast made ground contact before the pilot made an appropriate correction and completed the landing.

History of the flight

At the end of a 20 minute passenger flight, the aircraft was returning to land on grass Runway 32 in good visibility with the reported wind from 010° at 8 kt. The pilot made his final approach aiming to touch down just past the displaced threshold but, at approximately 100 ft agl and at a speed close to 90 mph (85 mph was the target approach speed), he encountered some turbulence which he believed was due to a change in the wind. He continued the approach but, while flaring to land, the right wing lifted, the aircraft dropped and the left wheel contacted the runway, short of the displaced threshold.

The grass was damp and the ground was soft, and the wheel seemed to dig in, pivoting the aircraft left and increasing the angle of bank before the pilot was able to make an appropriate correction and then to complete the landing without further incident. After the flight, minor damage was discovered on the left wingtip while the pitot head, which protrudes approximately 25 cm below the left wing and is near the wingtip, was distorted.

Examination of the grass surface revealed a mark from the left wheel plus an indentation approximately one metre long caused by the pitot mast. It was then apparent that the aircraft bounced before further landing marks were left by both mainwheels.

Pilot's assessment

The aircraft was fitted with an aft-facing video camera which recorded some instability in roll as the aircraft approached the airfield boundary and then, during the flare, the aircraft rolled to the right before rolling left quickly, just before the left wing apparently touched the surface.

Throughout the morning, the surface wind at Goodwood had been reported as being from 010º, with an indicated strength of 6-8 kt and, while the pilot believes the Runway 32 approach is not usually susceptible to turbulence in such a wind, he recalled feeling the wind dying away and then picking up again during his final approach. Over the preceding months he had been used to landing on alternative, shorter runways at Goodwood and had not experienced any difficulty operating in crosswinds up to the relevant limit of 15 kt.

Other pilots, with extensive type-experience, helped the pilot analyse the possible contributing factors, including limited forward visibility while in the landing attitude. However, he is fairly sure the instigating factor was the changing wind, which caused the aircraft to roll left, although he also believes that when the left wheel dug into the soft, damp surface the roll to the left was accentuated.

ACCIDENT

Aircraft Type and Registration:	Cessna F150L, G-BABC
No & Type of Engines:	1 Continental Motors Corp O-200-A piston engine
Year of Manufacture:	1972 (Serial no: 831)
Date & Time (UTC):	14 November 2017 at 1330 hrs
Location:	RAF Henlow, Bedfordshire
Type of Flight:	Training
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Nose leg detached and propeller, engine, forward lower fuselage and right wing damaged
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	71 years
Commander's Flying Experience:	16,288 hours (of which 1,125 were on type) Last 90 days - 23 hours Last 28 days - 12 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

A high rate of descent developed when landing with flaps set to 30º and, despite intervention from the instructor, the aircraft struck the ground in a nose-down attitude. The nose leg detached and the propeller sustained damaged, but the aircraft bounced and landed heavily on its mainwheels before coming to rest in a nose-down attitude.

History of the flight

The student pilot was being taught short field landing techniques, using flaps set to 30º but, during the first approach to grass Runway 26L[1],a high rate of descent developed shortly before touchdown so the instructor took control and went around. Following an in-flight re-brief, the student's second approach was better until approximately 30 ft agl when idle power was selected, with the result that the nose pitched down and the descent rate increased rapidly.

Although the instructor took over control and selected full power, he was unable to change the flap setting or to prevent the nosewheel from striking the runway. The aircraft bounced to approximately 20 ft agl but, because the propeller had been damaged, maximum thrust

Footnote

[1] Runway 26L is the left of two parallel grass runways at RAF Henlow.

was not available. The instructor was therefore unable to prevent the aircraft descending but he held the control column fully back, to prevent the aircraft diving towards the ground and to try to cushion the subsequent touchdown. It landed heavily on both mainwheels but the nose leg had already detached and it pitched forward and both the nose and the right wing tip contacted the ground. The tail rose until the fuselage was inclined almost vertically, for a few seconds, before the aircraft toppled back onto its mainwheels (Figure 1). The occupants then switched off the fuel and electrics before opening their doors and vacating without difficulty.

Figure 1
G-BABC resting on its lower engine cowling

Instructor's assessment

In previous training the student had only landed with the flaps set to 20º and had not appreciated the effects of selecting idle power with the flaps set to 30º. The instructor resolved to give future students more landing practice with the flaps set to 30º before trying to teach them short field techniques.

ACCIDENT

Aircraft Type and Registration:	Cessna R172K Hawk XP, G-XPII	
No & Type of Engines:	1 Continental Motors Corp IO-360-KB piston engine	
Year of Manufacture:	1979 (Serial no: R172-3071)	
Date & Time (UTC):	4 November 2017 at 1415 hrs	
Location:	Nottingham City Airport	
Type of Flight:	Training	
Persons on Board:	Crew - 2	Passengers - 1
Injuries:	Crew - None	Passengers - 1 (Minor)
Nature of Damage:	Engine frame and firewall distorted, creasing of left outer wing and skin damage to lower forward fuselage	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	58 years	
Commander's Flying Experience:	691 hours (of which 82 were on type) Last 90 days - 15 hours Last 28 days - 7 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

A qualified pilot was receiving instruction on flying from the right seat and the first approach to land resulted in a go-around because the aircraft was too high and too slow. During the latter part of the second circuit, the airspeed fluctuated and the instructor prompted the pilot several times when he saw the speed reducing towards the targeted minimum. At 20-30 feet and with a low power setting, the pilot began to flare, causing the aircraft to decelerate further and then sink. The instructor took control but was unable to prevent the aircraft from striking the ground heavily and bouncing before the landing was completed.

After the flight, the aircraft was found to be damaged and the pilot undergoing training stated that she had difficulty in monitoring the airspeed indicator from the right seat. The instructor assessed that the pilot was unaware the aircraft was high and slow at the beginning of the landing flare, because of being unfamiliar with flying from this seat.

ACCIDENT

Aircraft Type and Registration:	Eurofox 912(IS), G-ODGC
No & Type of Engines:	1 Rotax 912 IS Sport piston engine
Year of Manufacture:	2014 (Serial no: LAA 376-15274)
Date & Time (UTC):	28 May 2017 at 0900 hrs
Location:	Near Puddletown, Wareham, Dorset
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Propeller, landing gear, rear fuselage, fin and rudder
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	78 years
Commander's Flying Experience:	833 hours (of which 59 were on type) Last 90 days - 10 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The engine of the glider tug stopped abruptly at about 300 ft whilst launching a glider. The tug pilot released the glider's tow rope and turned back towards the airfield. Despite two attempts, he was unsuccessful in restarting the engine. The aircraft hit a tall shrub outside the airfield boundary which spun the aircraft and it landed backwards in long grass. The pilot was uninjured but the aircraft sustained significant damage.

The electronic injection engine had recently been installed in this aircraft to replace a carburetted one. The injected engine required a different engine restart procedure, and the pilot advised that he had forgotten to perform one step of the restart checklist in the limited time that he had had available.

History of the flight

The aircraft was operating as a glider tug. The engine stopped at about 300 ft after takeoff, having already initiated a right turn at about 150 ft. The tug pilot released the glider's tow rope and continued the turn back towards the airfield. He attempted to restart the engine twice but was unsuccessful. Short of the airfield boundary, the right wing hit a tall shrub and spun the aircraft before it landed, backwards, in long grass. The pilot was uninjured but the aircraft sustained significant damage. In the immediate aftermath, the pilot noted that the main fuel valve did not appear to have been quite vertical, but it is possible that it may have moved during the landing.

Engine restart procedure

The electronic fuel injection engine had been recently installed in the aircraft, replacing the previous carburetted version. The different engine types have different engine restart procedures. For the injected engine, the pilot advised that the "backup battery" is turned OFF after start and, in order to restart an engine, the checklist requires this battery to be selected ON. The pilot stated that this procedure was different from all the other aircraft that he had flown and that, in the short time he had available, he had forgotten to carry out this particular checklist item.

The Light Aircraft Association, in their November 2017 edition of *'Light Aviation'* published an article about the increased complexity of this engine type and the importance of understanding it before flying. For this accident, it is not known whether a correctly-followed engine restart procedure would have been successful.

Engine and fuel

The engine was inspected at a repair facility where debris of unknown origin was found in, and removed from, the fuel pressure regulator. The engine was run and the repair facility reported no issues with its performance but a variation in fuel pressure led to a re-inspection of the fuel pressure regulator, where debris was again found; debris was also found in the fuel filters. Fuel tests indicated a higher than normal level of silicon but there is no evidence that this, or the presence of the debris, caused the engine to stop.

Turning back

The aircraft was already established in a right turn when the engine stopped and the pilot decided to continue the turn back towards the airfield. The AAIB has investigated a number of accidents where pilots have attempted to turn back following an engine failure after takeoff. Although it resulted in a landing outside the airfield boundary, the pilot, in this case, prevented the aircraft from stalling which would have been likely to have resulted in a more serious outcome.

BULLETIN CORRECTION

There was a typographical error in the Commander's Flying Experience on the first page of this report. The text should read:

> 'Last 90 days – **10** hours.'

The online version of this report was corrected on 8 February 2018.

ACCIDENT

Aircraft Type and Registration:	Jodel DR1050-M Excellence, G-JODL
No & Type of Engines:	1 Continental Motors Corp O-200-A piston engine
Year of Manufacture:	1960 (Serial no: 99)
Date & Time (UTC):	24 September 2017 at 1730 hrs
Location:	Lashenden (Headcorn) Airfield, Kent
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Wing, stabilator, main and tail landing gear and propeller damaged. Probable shock-loading of engine
Commander's Licence:	Private Pilot's Licence
Commander's Age:	48 years
Commander's Flying Experience:	144 hours (of which 19 were on type) Last 90 days - 25 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and enquiries made by the AAIB

Synopsis

The pilot, who had limited experience flying tailwheel aircraft, initiated a baulked landing when he experienced directional control difficulties. The aircraft departed the side of the runway, struck a fence and came to rest in a hedgerow. Three sheep were injured, two fatally.

History of the flight

After completing a tailwheel aircraft conversion course during the morning, the pilot was returning to Lashenden in the late afternoon, from a consolidation flight around the local area. His first approach to the grass Runway 10 was made in a light south-easterly wind, but he initiated a go-around prior to touchdown, because he was not confident of a satisfactory landing. Following a further circuit of the airfield, he set the aircraft down onto the runway but then sensed the groundspeed was faster than he expected.

As the aircraft rolled along the runway, it became evident that the landing run was longer than expected and the pilot thought this might be due to an element of tailwind. He then encountered difficulty maintaining directional control and sensed that a gust of wind caused the aircraft to turn left. Aware that he was now heading towards the side of the runway, he initiated a baulked landing by advancing the throttle and by applying right rudder pedal to try and overcome the aircraft's tendency to turn further left as the power increased. Despite his efforts the aircraft continued to turn left, departed the runway and accelerated over an adjacent area of mown grass.

The pilot saw a wire fence and trees ahead but managed to lift off, heading for a clear area between the trees. As the aircraft approached the fence he thought he had gained sufficient airspeed and pulled the nose back to climb over the fence. Although the mainwheels did not appear to make contact, he heard the underside of the fuselage rub the wire and the tailwheel was snagged momentarily, turning the aircraft further left and causing the nose to drop. The aircraft then touched down again on the far side of the fence and traversed an adjacent field, at high power, striking three sheep in its path. It then crossed a stream and came to rest in an overgrown hedgerow on the northern bank (Figure 1). The pilot undid his lapstrap and diagonal shoulder strap, made a radio call, and turned off the fuel and electrics before climbing out un-injured. Two of the sheep suffered fatal injuries.

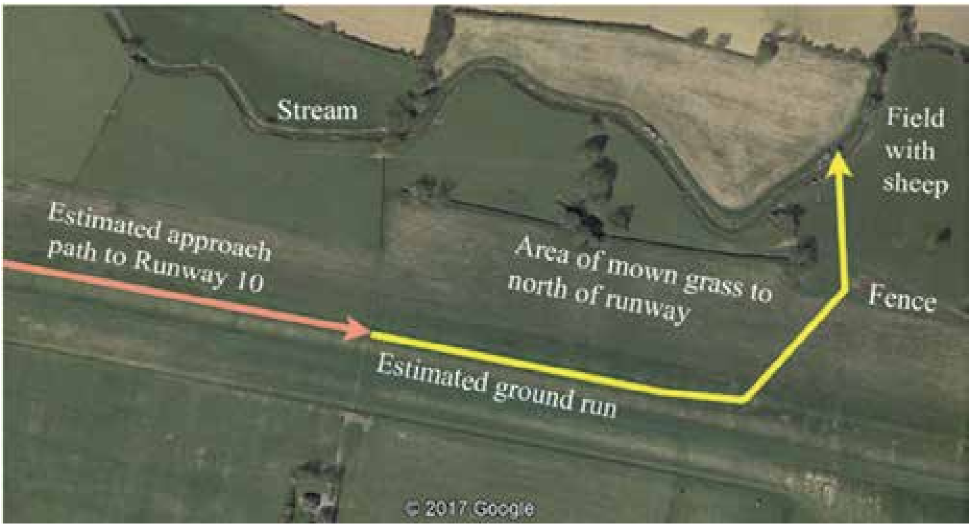

Figure 1

Aerial view of the eastern portion of Lashenden airfield with G-JODL's estimated track ©2017Google, Image © DigitalGlobe

Recorded information

A Closed Circuit TV (CCTV) system recorded the aircraft touchdown, on its mainwheels only, approximately 40% of the way along the 1,250 m runway and adjacent to a windsock, which was hanging limp. After approximately 250 m, the tailwheel made ground contact and the aircraft began to turn left. The right wing then lifted and the aircraft headed towards the left side of the runway and out of the camera's field of view.

The recorded wind data for the airfield indicated that at the time of the accident the wind was from approximately 110° at less than 5 kt. There was no indication of any large fluctuation in the wind direction throughout the afternoon or early evening.

Pilot's assessment

After gaining his licence on nosewheel aircraft, the pilot commenced tailwheel differences training, on another Jodel type, almost six months before the accident. His training later switched to the accident aircraft and he had logged approximately 19 instructional hours in this aircraft, during which he was made familiar with circuit flying at Lashenden. That morning the pilot completed approximately 2.5 hrs of dual training, in a wind that was gusting up to 14 kt, before the instructor signed-off his differences training.

Although the pilot initially thought that a tailwind component increased his groundspeed, he later decided that his approach speed may have been faster than the circumstances required; the aircraft was relatively light and there was little wind. After reviewing the CCTV recording, he recalled that, during the landing, he thought the aircraft was going to balloon if he raised the nose, but he had not appreciated that only the mainwheels were on the ground. This probably explained why he thought there were directional control "difficulties" and he realised the left turn was not initiated by a gust of wind but more likely occurred when the tailwheel eventually made ground contact.

During the earlier go-around, the pilot stated that he had kept the aircraft straight by applying sufficient right pedal to overcome the aircraft's tendency to turn left. However, he realised that he did not manage to achieve the same result during the attempted baulked landing. A contributory factor in this may have been the gyroscopic force which, when the tail of a tailwheel aircraft is raised during takeoff, augments the other forces that try to turn the aircraft left with a power increase.

In retrospect the pilot decided that he should have initiated a go-around or baulked landing sooner. He also assessed that, by trying to take off again when he was heading towards the side of the runway, the outcome had probably been worse than if he had stopped the aircraft, even though this might have led to a ground loop.

ACCIDENT

Aircraft Type and Registration:	Piper PA-39 Twin Comanche C/R, G-LARE
No & Type of Engines:	2 Lycoming IO-320-B1A piston engines
Year of Manufacture:	1970 (Serial no: 39-16)
Date & Time (UTC):	15 September 2017 at 1150 hrs
Location:	Biggin Hill Airport, Bromley
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Propellers and ADF antenna broken, air-scoop squashed, slight scruff on tail tiedown
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	61 years
Commander's Flying Experience:	18,000 hours (of which 80 were on type) Last 90 days - 20 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and examiner

Synopsis

The pilot flying and examiner were on the final circuit of a two-hour flight to revalidate an instrument rating and a multi-engine proficiency check. Downwind, the aircraft was configured for a simulated asymmetric approach and landing, with intermediate flaps selected and undercarriage down. They were instructed by ATC to orbit to the left once, late downwind, due to two aircraft ahead of them joining the circuit to land. During the orbit the pilot flying retracted the flaps and undercarriage and neither he nor the examiner realised they were still retracted on the approach to land. During the flare the propellers and rear fuselage contacted the ground and a go-around was immediately initiated. A circuit was flown and an uneventful landing made.

History of the flight

After flying to Southend, where the pilot flying had just revalidated his instrument rating, the pilot and examiner returned towards Biggin Hill for the pilot to complete a multi-engine proficiency check. The check concluded at Biggin Hill where a number of circuits were to be flown.

Downwind on the final circuit, the aircraft was configured for a simulated asymmetric approach and landing, with intermediate flaps selected and undercarriage down. ATC informed them that they were number two to a Spitfire and Hurricane (based at Biggin Hill) ahead of them and instructed them to orbit to the left once, late downwind. During the orbit, the pilot retracted the flaps and undercarriage; however, the examiner, whose attention was on the aircraft ahead of them and was not expecting a change in configuration, missed this. After receiving clearance to land, the pilot positioned the aircraft for the approach to land, but neither he nor the examiner realised that the flaps and undercarriage were retracted, and no further landing checks were made. As the aircraft flared, they both heard the propellers and rear fuselage contact the ground and a go-around was immediately initiated. During the ensuing circuit, they realised that the undercarriage was retracted. This was then extended and the aircraft landed without further incident.

The examiner, who was the commander for the flight[1], attributed the loss of awareness of the fact that the undercarriage had been retracted to a high workload at the end of a busy two-hour flight, with an unusual ATC instruction to orbit late downwind. Both he and the pilot flying were pre-occupied with carrying out this instruction while trying to make visual contact with the aircraft ahead of them and did not give any thought to making additional checks prior to landing.

Footnote

[1] The pilot flying was acting as Pilot in Command for the revalidation and check-out flight.

ACCIDENT

Aircraft Type and Registration:	Taylor Titch, G-BARN	
No & Type of Engines:	1 Continental Motors Corp C90-12F piston engine	
Year of Manufacture:	1986 (Serial no: PFA 060-11136)	
Date & Time (UTC):	14 October 2017 at 1400 hrs	
Location:	Ripe-Kittyhawk Farm Airfield, Sussex	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - None
Injuries:	Crew - None	Passengers - N/A
Nature of Damage:	Landing gear collapse, ground contact damage to the aircraft underside, lower cowling and propeller	
Commander's Licence:	National Private Pilot's Licence	
Commander's Age:	79 years	
Commander's Flying Experience:	1,027 hours (of which 337 were on type) Last 90 days - 15 hours Last 28 days - 5 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Synopsis

The pilot was landing his aircraft at an airfield which he had flown into on numerous previous occasions and after an apparently normal touchdown, the landing gear collapsed. The aircraft then slid along the ground on its underside for several metres before coming to stop. The pilot made the aircraft safe and vacated the cockpit unaided. The aircraft sustained damage to its underside, lower cowling and propeller. The landing gear collapse was due to breakage of the centre re-enforcing bracket in the landing gear attachment, caused by a failure in a welded joint.

Engineering discussion

The aircraft was built in 1986 by its current owner and had accrued 337 hours and 605 landings. The aircraft is fitted with a non-retractable two-piece spring steel 'blade' undercarriage mounted on a wooden plate in front of the main spar. Three steel re-enforcing brackets transfer the landing loads from the undercarriage through its mounting plate and into the main spar. The brackets are a simple right-angle plate, braced on each side by a web welded in place. The brackets are arranged so that the centre bracket takes a tensile load and the left and right outer brackets take compressive loads during landing. In this case the centre bracket welded joints, which held the side webs in place, failed, allowing them to open out. With no centre bracing the mounting plate could not sustain the landing loads, resulting in the collapse of the landing gear blades.

An examination of the failed bracket revealed poor penetration of the weld on the side web outer edges, where they attach to the right-angle section of the bracket. The presence of light corrosion on the inner edge faces of the failed joints support this diagnosis.

Cause

The aircraft had accrued 605 landings prior to the landing gear collapse so it is likely that a fatigue process within the weakened welds led to the eventual bracket failure.

ACCIDENT

Aircraft Type and Registration:	Titan T-51B Mustang, G-CIXK
No & Type of Engines:	1 Suzuki V6 Mini Merlin piston engine
Year of Manufacture:	2016 (Serial no: LAA 355-15207)
Date & Time (UTC):	24 November 2017 at 1240 hrs
Location:	Shacklewell Airfield, Lincolnshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damaged beyond economic repair
Commander's Licence:	Light Aircraft Pilot's Licence
Commander's Age:	53 years
Commander's Flying Experience:	646 hours (of which 26 were on type) Last 90 days - 12 hours Last 28 days - 4 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

During the takeoff roll, and after the tailwheel had lifted, the aircraft swung left and headed towards a fence/hedge in an adjacent field. The pilot was unable to correct the swing using right rudder pedal and there was insufficient space to abandon the takeoff, so he attempted to lift the aircraft off the ground and clear the fence/hedge. However, the main landing gear struck the fence/hedge, and the aircraft fell into the next field (Figure 1) where it came to rest with its nose and left wing resting on the ground.

Inspection of the aircraft's tyre marks along the grass runway, revealed that those on the left side were deeper than those on the right because the grass there was wetter and softer. The pilot assessed that the drag on the left main gear was increased by the soft ground and he had insufficient rudder authority to overcome this. Earlier that day, when he arrived, he landed further along the runway and the ground there had been firmer. He believed that if he had inspected the threshold area before leaving he might have noticed the soft ground and avoided it, by taking off along the right side of the 15 m wide runway.

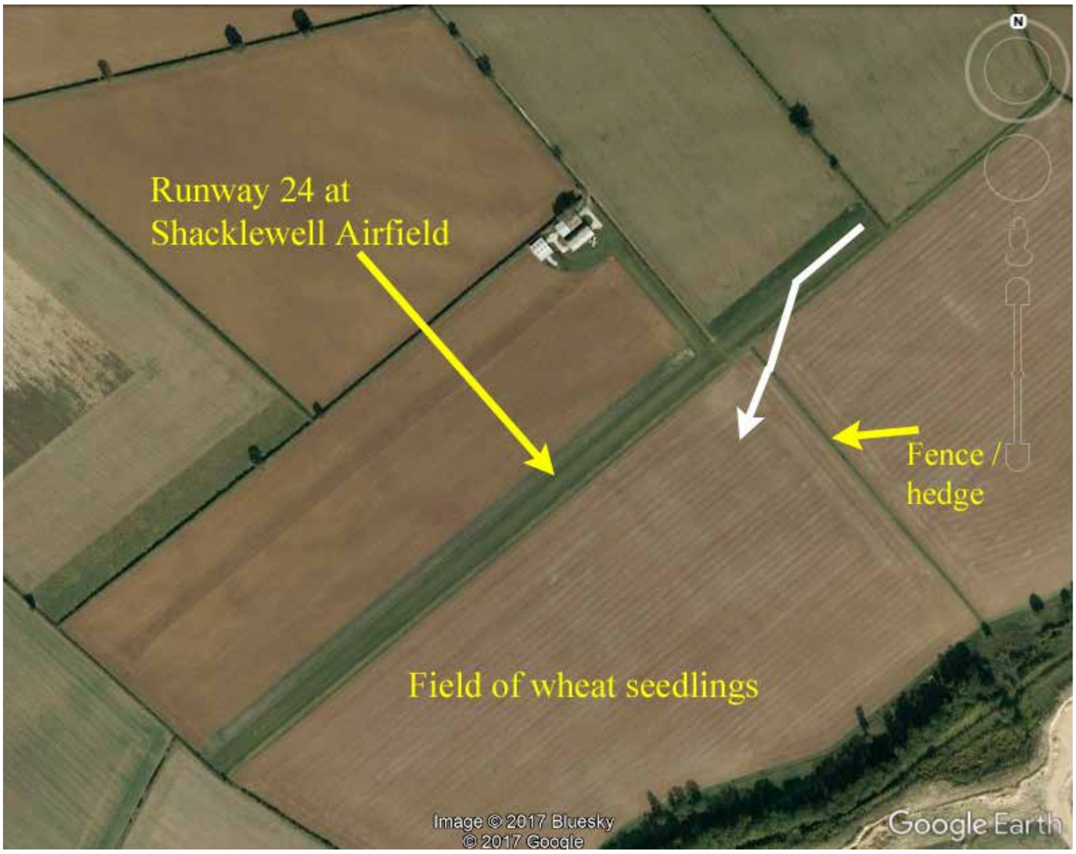

Figure 1

White line indicates aircraft's approximate path

ACCIDENT

Aircraft Type and Registration:	Eurofox 912(1), G-CIPS
No & Type of Engines:	1 Rotax 912UL piston engine
Year of Manufacture:	2015 (Serial no: BMAA/HB/661)
Date & Time (UTC):	16 September 2017 at 1500 hrs
Location:	Farm Strip, Haringe Court, East of Ashford, Kent
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Landing gear and left wing damaged. Minor damage to spinner, cowlings and propeller
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	74 years
Commander's Flying Experience:	553 hours (of which 180 were on type) Last 90 days - 44 hours Last 28 days - 7 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot reported that there were sheep on the farm landing strip, around two thirds along its length. He continued with the landing because the sheep were moving away from the aircraft noise, and because the first part of the runway was clear. As the aircraft touched down, a sheep ran on to the runway. The pilot performed a go-around and as the aircraft lifted off, its left wheel struck the animal. This caused the left gear leg to shear off, and the pilot stated that onlookers could see the leg and wheel hanging from the brake hose. The pilot completed a circuit and, on landing, the aircraft slewed to the left, impacted a fence and came to rest.

The pilot reported that sheep normally ran away from the aircraft noise and in future he would be prepared for the unexpected.

ACCIDENT

Aircraft Type and Registration:	Mercury, G-MYUB
No & Type of Engines:	1 Rotax 503 piston engine
Year of Manufacture:	1995 (Serial no: 1014-1194-7-W812)
Date & Time (UTC):	2 July 2017 at 1450 hrs
Location:	Otherton Airfield, Staffordshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Minor) Passengers - None
Nature of Damage:	Pod/trike unit, nose gear, wing, propeller
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	42 years
Commander's Flying Experience:	38 hours (all on type) Last 90 days - 6 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

During a landing on grass Runway 34 at Otherton Airfield, the pilot reported that the microlight touched down initially on the main wheels followed, shortly after, by the nosewheel. As the nosewheel touched down, the nose gear collapsed and the aircraft tipped onto its left side; it travelled a further 10 ft before coming to rest. The passenger was uninjured but the pilot suffered minor injuries. The aircraft suffered significant damage.

A later inspection by a third party organisation identified a fatigue crack at the edge of a weld on the nose gear which failed under load during the landing.

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:	Bombardier BD-700-1A11 (Global 5000), VP-CKM
Date & Time (UTC):	15 November 2016
Location:	On approach to Hong Kong International Airport
Information Source:	AAIB Field Investigation

AAIB Bulletin No 12/2017, page 60 refers

The report states incorrectly that the aircraft involved in the serious incident was a Bombardier Global Express BD700. The aircraft was a **Bombardier BD-700-1A11 (Global 5000)**.

The online version of the report was amended on 22 December 2017.

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

2/2011 Aerospatiale (Eurocopter) AS332 L2 Super Puma, G-REDL
11 nm NE of Peterhead, Scotland
on 1 April 2009.

Published November 2011.

1/2014 Airbus A330-343, G-VSXY
at London Gatwick Airport
on 16 April 2012.

Published February 2014.

2/2014 Eurocopter EC225 LP Super Puma
G-REDW, 34 nm east of Aberdeen, Scotland on 10 May 2012
and
G-CHCN, 32 nm south-west of Sumburgh, Shetland Islands
on 22 October 2012.

Published June 2014.

3/2014 Agusta A109E, G-CRST
Near Vauxhall Bridge,
Central London
on 16 January 2013.

Published September 2014.

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.

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 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
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)
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
PNF	Pilot Not Flying
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
TGT	Turbine Gas Temperature
TODA	Takeoff Distance Available
UAS	Unmanned Aircraft System
UHF	Ultra High Frequency
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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