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# ***AAIB Bulletin***

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***3/2018***

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Published 8 March 2018

Cover picture courtesy of Stephen R Lynn  
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ISSN 0309-4278

Published by the Air Accidents Investigation Branch, Department for Transport  
Printed in the UK on paper containing at least 75% recycled fibre

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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.



**ACCIDENT**

<b>Aircraft Type and Registration:</b>	Cessna 402C, N603AB
<b>No &amp; Type of Engines:</b>	2 Continental TSIO-520-VB piston engines
<b>Year of Manufacture:</b>	1997 (Serial no: 402C0603)
<b>Date &amp; Time (UTC):</b>	11 February 2017 at 2004 hrs
<b>Location:</b>	Virgin Gorda Airport, British Virgin Islands (BVI)
<b>Type of Flight:</b>	Commercial Air Transport (Passenger)
<b>Persons on Board:</b>	Crew - 1                      Passengers - 8
<b>Injuries:</b>	Crew - None                      Passengers - None
<b>Nature of Damage:</b>	Extensive damage to the landing gear and aircraft structure
<b>Commander's Licence:</b>	Commercial pilot's licence (FAA)
<b>Commander's Age:</b>	29 years
<b>Commander's Flying Experience:</b>	5,458 hours (of which 809 were on type) Last 90 days - 225 hours Last 28 days - 80 hours
<b>Information Source:</b>	AAIB Field Investigation

**Synopsis**

After landing on Runway 03 at Virgin Gorda Airport, the pilot was unable to stop the aircraft on the runway and it came to rest on a bank at the edge of the ramp. The aircraft was extensively damaged but none of the nine occupants, including the pilot, were injured. The investigation generated a number of concerns both in the maintenance and operation of this aircraft, which was engaged in international public transport.

Two Safety Recommendations are made to the Federal Aviation Administration.

**History of the flight**

The aircraft was flying from St Thomas in the US Virgin Islands to Virgin Gorda (VIJ) in the British Virgin Islands. There were eight passengers on board, together with the pilot. It was the pilot's eleventh flight of the day, and his fourth flight to Virgin Gorda. All these flights were short, with the longest flight being about 40 minutes duration and the shortest just a few minutes. The flight from St Thomas to Virgin Gorda took 35 minutes.

The weather in Virgin Gorda was excellent with a light easterly wind and little cloud. The pilot commenced his approach to Virgin Gorda using his usual turning and configuration points. The aircraft touched down normally and the pilot retracted the flaps before applying the brakes. The brakes responded, although the pilot commented that the right brake did not seem to respond as positively as he expected. The pilot reapplied the brakes but the

left brake pedal “flopped to the floor”. Judging he had insufficient room to abort the landing, the pilot continued to pump the brakes which he did not consider to be responding. He shut down the engines before the aircraft left the paved surface, struck signage and then a low wall before coming to rest on a bank.

The pilot vacated the aircraft through the side window and then opened the main door to allow the passengers to exit the aircraft. None of the occupants was injured. The aircraft was extensively damaged.

## **Aircraft information**

### *General*

The Cessna 402C is a low-wing, twin-engine aircraft equipped with a retractable, tricycle landing gear. The structure is of an all-metal semi-monocoque construction and, in its passenger carrying configuration, the aircraft can accommodate a maximum of ten people. The aircraft is certified for single-crew operation.

Maximum takeoff mass is 6,850 lb but, with the addition of vortex generators, this can be increased to 7,210 lb. Landing performance in terms of weight and distance can be improved by ‘short-field operations’ modifications to the flaps and landing gear. Modifications that have been approved by the Federal Aviation Administration (FAA) have an individual Supplemental Type Certificate (STC).

### *Brakes*

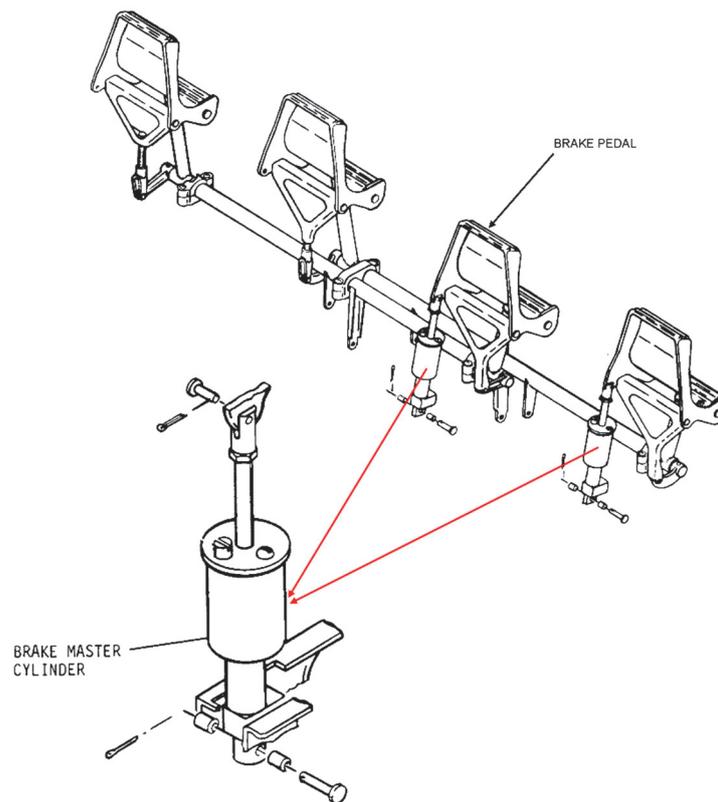
The aircraft has an independent hydraulically-actuated brake system for each mainwheel and the brakes can be operated from either the pilot’s or the co-pilot’s rudder pedals. A parking brake consists of a manually-operated handle. When brake pressure is applied and the handle is pulled, the brakes remain pressurised until the parking brake is released.

There are two hydraulic master cylinders, one for each brake, connected to the pilot’s rudder pedals. The master cylinders have integral oil reservoirs and depressing the top of a rudder pedal causes the corresponding piston rod to push the piston into the cylinder, thereby pressurising the brakes (Figure 1).

### *N603AB (manufacturer’s serial number 402C0603)*

The aircraft had accrued approximately 20,200 flying hours. It was equipped with an Aircraft Payload Extender/Short Takeoff and Landing (APE STOL) modification, which is approved under STC SA02208SE. The modification increases the maximum landing weight to 7,210 lb and, according to the manufacturer, ‘provides landing field length reductions up to 25%’.

The operator had recently completed an extensive programme of maintenance over a period of approximately three years. When the accident occurred, the aircraft had accrued 41 hours and 95 flight cycles since it was returned into service in January 2017.



**Figure 1**

Schematic of the brake master cylinder installation

The aircraft had been involved in a previous accident at Virgin Gorda in March 2008. The official narrative of the event states:

*'The pilot attempted to stop the aircraft but the left brake failed during the second application. In an effort to avoid running off the end of the runway and into the ocean the pilot applied left rudder and made a turn in the direction of the apron. The aircraft crossed the apron and struck the terminal building with the right wing, the tail of a parked Aztec with the left wing and came to rest after hitting the security gate at the end of the terminal building. The aircraft sustained substantial damage to the nose as well as the right wing. The Aztec, terminal building, and security gate were also damaged.'*

The AAIB was asked to assist with the examination of the brake units and records indicate that they were extensively corroded. The operator advised that they *'serviced the brake and repaired the minor damage to the wing'* before the aircraft was returned into service.

## On-site examination

In the accident of 11 February 2017 the aircraft came to rest on a grassy slope within the airport perimeter and adjacent to the northern edge of the tarmac apron (Figure 2).



**Figure 2**

General view of the accident site

Distinct tyre marks from all three wheels were visible across the apron and grass and this indicated heavy sideward loading as the pilot tried to turn to avoid over-running into the sea. There was no evidence of locked brakes, such as pronounced skid marks or marks caused by loose stones dragged across the surface.

As the aircraft traversed the grass it struck a frangible runway sign before passing through a low retaining wall. The nose landing gear collapsed and the right main landing gear was broken off. After encountering rising ground and colliding with a group of substantial rocks, the aircraft slewed to rest through about 45°.

Damage sustained by the left propeller indicated that it was not rotating when the accident occurred, that engine having already been shut down by the pilot. The right propeller had been rotating with very little energy, shortly after its engine was shut down.

### *Brake system test following aircraft recovery*

The left brake worked when tested and the brake pedal action was considered normal.

The right brake could not be tested because the right main landing gear had detached and the hydraulic pipes were broken. The brake unit and disc appeared to be in satisfactory visual condition and fluid had leaked from the broken pipes.

The brake master cylinders, brake units and parking brake control valve were removed and taken to the AAIB facility for further examination and testing.

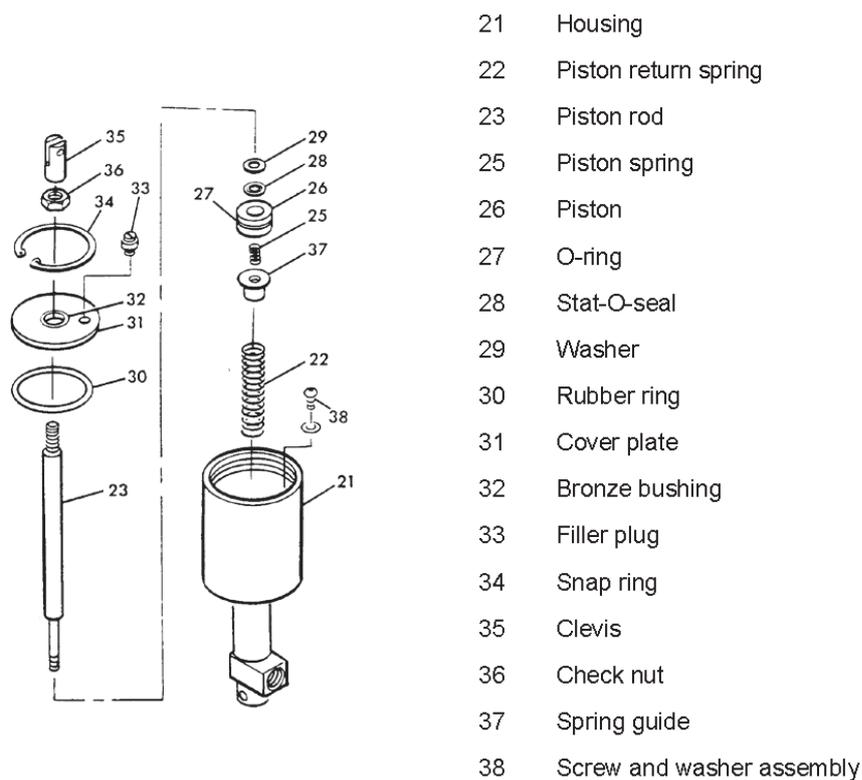
## Equipment investigation

### *Brake master cylinders*

The operator stated that both master cylinders were overhauled when the aircraft underwent its most recent maintenance. This was reported to have involved cleaning the units and installing new seals and springs. The Federal Aviation Administration requires (FAR 91.417) that maintenance records are retained for a period of one year. The operator advised that the aircraft had been in maintenance for approximately three years and records for the master cylinders were not available.

### *Left master cylinder*

Damage on the identification plate obscured most of the details but the unit was manufactured by Cleveland in August 1994. Figure 3 is a schematic depicting the internal construction of a Cleveland master cylinder.



**Figure 3**

Schematic of the Cleveland brake master cylinder

The filler plug was missing and the cover plate could be rotated using finger pressure. When the snap ring and cover plate were removed, it was apparent that the rubber ring was missing.

Debris and contamination inside the oil reservoir was analysed and identified to be general environmental dirt and aluminium flakes (Figure 4).



**Figure 4**

Debris in the left master cylinder oil reservoir

A basic functional test established that the master cylinder could generate and hold pressure.

The piston rod and return spring were removed, revealing two pieces of a broken return spring in the lowest section of the housing bore. The broken pieces, when placed end to end, had a combined length that was approximately half a complete spring (Figure 5). The coil was wound in the opposite direction to the intact spring.



**Figure 5**

The intact piston return spring and the remains of the broken spring

Examination of the piston rod revealed debris trapped between the stat-o-seal and the washer (Figure 6a). This was subsequently identified to be part of the stat-o-seal, which was in poor condition (Figure 6b).

The piston rod spring guide was found to be secured to the piston rod by means of a roll pin. This is contrary to the Cleveland design, but conformed to units manufactured by Gerdes Product Co, which was the predecessor to Cleveland.



**Figures 6a and 6b**

Trapped seal debris and general condition of the stat-o-seal

#### *Right master cylinder*

The right master cylinder was manufactured by Gerdes Product Co in December 1979.

The filler plug was missing and a tooth-lock washer had been fitted to secure the bronze bushing, which was otherwise loose in the cover plate; the bush is supposed to be an interference fit. Debris and contaminants found inside the oil reservoir were identified to be general environmental dirt and aluminium flakes.

A basic functional test of the master cylinder showed no anomalies and the unit could generate and hold pressure. Disassembly revealed stat-o-seal degradation, but to a lesser extent than the left master cylinder.

The joint between the piston rod guide and the piston rod was found to be threaded, which was contrary to the Gerdes Product Co, but conformed to the Cleveland design.

#### *Master cylinder servicing requirements*

The Cessna maintenance schedule requires a visual inspection of the brake system and a functional test every 200 hours of operation or 12 months, whichever occurs first. The master cylinders should be serviced at the same time; this requires removal of the filler plugs, replenishing the oil reservoir with hydraulic oil, and refitting the filler plugs.

There are no scheduled requirements to change the brake fluid or to periodically overhaul the brake system components.

## Weight and balance

The aircraft was under the maximum landing weight and within the approved centre of gravity. The loading sheet had been completed incorrectly but the aircraft was in balance and this had no bearing on the accident.

## Regulatory oversight of the operator

The operator was registered in the state of Florida, USA and was regulated by the US Federal Aviation Administration (FAA). The operator's headquarters was in Fort Lauderdale, Florida but its operating base was in San Juan, Puerto Rico, an unincorporated territory of the USA. The FAA regulates airlines through various Flight Standards District Offices (FSDO) which are spread geographically around the USA. The operator was regulated by the San Juan FSDO. The FSDO is responsible for certification and operations of an air carrier and performs a variety of compliance actions in regards to procedures, pilot certification, aircraft maintenance and certification.

The British Virgin Islands Airports Authority set the rules for operations into Virgin Gorda Airport which are published in the Air Navigation (Overseas Territories) Order 2007. This sets out the requirements for aircraft performance, pilot qualification and operating limitations. It is the responsibility of the operator to ensure that these requirements are met and ultimately the regulator (in this case the FAA) to ensure the operator is complying with the instructions.

## Airfield information

Due to issues of topography, length and surface conditions, Virgin Gorda Airport is restricted by the instructions issued under the Air Navigation (Overseas Territories) Order, 2007. This means the pilot in command must have:

- A commercial licence
- Minimum total flying hours of 1,500
- Minimum of 100 hours multi-engine piston aircraft, including at least 50 hours of the type being flown
- Made at least 10 previous landings at the aerodrome
- Made at least 3 landings at the aerodrome in the previous 90 days

Due to the terrain in the approach, an offset right base approach is flown meaning the aircraft is aligned with the runway centreline at around 700 ft aal. The runway itself is made of compacted fine gravel, with a tarmac turning area at each end and there is a small tarmac ramp off to the side. The landing distance available (LDA) on Runway 03 is 795 m (2,608 feet).

## Aircraft performance

To meet the requirements of the approval to operate into Virgin Gorda, the operator had to ensure that the aircraft could stop in 70% of the LDA. The only figures provided by the operator for the Cessna 402C were from the Pilots Operating Handbook (POH). These figures were based on a level, hard-surface runway using maximum effective braking. They were also based on the Cessna 402C before it was modified with wing vortex generators to allow for higher weights as well as a further modification to improve the short takeoff and landing performance of the aircraft. The figures available were therefore not valid for the aircraft.

The figures also did not account for the gravel surface at Virgin Gorda. The surface conditions of a gravel runway may have an adverse effect on stopping distance as the loose unbounded material of the runway may degrade braking performance compared to a hard surface. Very little guidance could be found on the use of gravel runways, with the exception of Canada which has a number of gravel runways. Transport Canada specifies a factor of 10% for propeller driven aircraft with a MTOW less than 5,700 kg (AC 700-011).

Using the figures in the Flight Manual Supplement for the Aircraft Payload Extender STOL System (STC SA02208SE), the Cessna 402C could not meet the 70% requirement as laid down in the Virgin Gorda approval even before the distance was factored for the gravel runway performance. Whilst the aircraft could stop in the distance available, the safety margin which should have been applied was being used on normal landings.

On the accident flight the flaps were retracted after touchdown, which is contrary to the guidance in the Flight Manual Supplement. Retraction is only suggested for light weights, with this aircraft touching down only 170 lbs below MLW. This retraction would have compromised the landing performance as set out in the performance tables. This was a common company procedure.

No guidance was provided to the pilots on how to calculate the landing distance required (LDR), how to factor for the gravel surface, or any guidance that a LDR was to be calculated.

## Meteorology

There was no weather reporting station at Virgin Gorda and no ATC service. The weather at Beef Island Airport which is 6 nm to the west of Virgin Gorda reported excellent conditions with the wind easterly, less than 10 kt. The temperature was 30°C.

## Pilot information

The pilot had completed over 800 landings at Virgin Gorda over the preceding twelve months. He was appropriately qualified, and met all the experience limitations. He had received no training on how to calculate a landing performance figure for the gravel runway.

## Analysis

### *Engineering*

The pilot reported that the left brake pedal “flopped to the floor” on his second brake application. The symptoms are similar to those reported by another pilot who was involved in an accident to the same aircraft at the same airport in 2008. The cause of this previous occurrence is not recorded but records cite extensive corrosion and the operator reported that they serviced the brakes when the aircraft was repaired.

A ‘troubleshooting chart’ in the Cessna 402C maintenance manual outlines the recommended diagnostics if the ‘*brake pedal bottoms*’. The initial action is to check the fluid content in the brake system and, if this is satisfactory, the condition of the stat-o-seal should be checked. If both features are satisfactory, the chart recommends checking the brake disc for warping.

The left brake system was found to work after the aircraft was recovered, thereby eliminating insufficient fluid as the cause. Examination of the brake disc showed no evidence of distortion or warping.

A basic functional test of the master cylinders established they could generate and hold pressure but subsequent strip examination identified several anomalies, some of which could have a significant detrimental effect on braking performance. The omission of the filler plugs created an entry point for debris and contaminants that were found in the oil reservoirs of both master cylinders. Analysis established that the debris was a combination of general environmental dirt and aluminium flakes; the latter most likely originating from the internal wall of the oil reservoir. The aircraft manufacturer considered that the presence of debris, if trapped between the sealing faces, could compromise the quality of the seal. This would have an adverse effect on braking performance but the symptoms would only be apparent whilst the debris remained trapped.

The omission of the rubber ring seal from the left master cylinder would have had no effect on braking performance but was indicative of a shortfall during maintenance. The remains of a broken spring in the left master cylinder was unlikely to have interfered with system operation but they also were indicative of a shortfall during maintenance. The operator did not know when the spring failure occurred and considered the omission to remove the broken parts to be an error on their part.

In the case of both cylinders, the method used to attach the spring guides to the piston rods was contrary to that expected by the manufacturer. The evidence indicated that the internal components from one manufacturer’s cylinder had been transposed with those of the other, that is, that the Cleveland parts had been installed in the Gerdes Product Co unit and vice versa. Whilst not influencing the performance of the master cylinders, the error was indicative of a shortfall during maintenance.

The stat-o-seal in the left master cylinder was degraded to the extent that it was breaking apart and its ability to create a reliable, effective seal would be compromised. A leak past

the stat-o-seal will have an adverse effect on brake performance and, in the worst-case scenario, will result in the brake pedal bottoming and total brake failure on the affected system.

The master cylinders were reported to have been dismantled, cleaned and rebuilt when the aircraft was last on maintenance. This included cleaning the units and installing new springs and seals. Records of the work were not available but regulations only require such to be retained for a period of 12 months and the aircraft was on maintenance for approximately three years. However, the contamination in the oil reservoir and the condition of the stat-o-seal is not considered typical of a master cylinder that has only accrued 41 hours since overhaul.

### *Operations*

The pilot was experienced and suitably qualified for the flight. He had completed over 800 landings at the airport without incident. There is no evidence to suggest that the landing was long, or beyond the normal touchdown position.

He had no opportunity to calculate or assess the landing performance of the aircraft as there were no valid performance charts in the aircraft or the operations manual. There was also no guidance on what factor to use for a gravel runway.

Once the aircraft landed and it became apparent there was an issue with the brakes, the pilot attempted to steer the aircraft to avoid departing the end into the sea. He shut down both engines before the impact. There was no emergency procedure for loss of braking or brake failure for the Cessna 402C.

In view of the shortfalls noted both in the maintenance and the operation of this aircraft, the following two Safety Recommendations are made:

#### **Safety Recommendation 2018-002**

It is recommended that the Federal Aviation Administration review the maintenance capability, processes and planning of Air Sunshine to ensure that they are sufficiently robust for conducting international passenger charter services.

#### **Safety Recommendation 2018-003**

It is recommended that the Federal Aviation Administration review the operations data management and operating procedures of Air Sunshine to ensure that they are sufficiently robust for conducting international passenger charter services.

## Conclusions

The aircraft landed at Virgin Gorda in conditions (of weight, altitude, temperature and surface condition) where the landing distance required was very close to the landing distance available and without the required safety margin. Hence, when the performance of the brakes was not as expected, probably due to debris in the braking system, the aircraft could not be stopped on the runway.

Analysis of the maintenance state of the aircraft involved in this accident indicated that the maintenance capability, processes and planning of its operator were not consistent with the standards expected in conducting international passenger charter services. This appeared also to be the case for the operational procedures and data management.

**ACCIDENT**

<b>Aircraft Type and Registration:</b>	DH110 Sea Vixen FAW Mk 2, G-CVIX	
<b>No &amp; Type of Engines:</b>	2 Rolls-Royce Avon Mk 208 turbojet engines	
<b>Year of Manufacture:</b>	1963 (Serial no: 10125)	
<b>Date &amp; Time (UTC):</b>	27 May 2017 at 1655 hrs	
<b>Location:</b>	RNAS Yeovilton, Somerset	
<b>Type of Flight:</b>	Private	
<b>Persons on Board:</b>	Crew - 1	Passengers - None
<b>Injuries:</b>	Crew - None	Passengers - N/A
<b>Nature of Damage:</b>	Hydraulic pump disintegration, overload fuel tanks destroyed, and fuselage and accessory gearbox abrasion	
<b>Commander's Licence:</b>	Airline Transport Pilot's Licence	
<b>Commander's Age:</b>	60 years	
<b>Commander's Flying Experience:</b>	8,690 hours (of which 58 were on type) Last 90 days - 34 hours Last 28 days - 11 hours	
<b>Information Source:</b>	Aircraft Accident Report Form submitted by the pilot and inquiries made by the AAIB	

**Synopsis**

The aircraft had returned to Royal Naval Air Station (RNAS) Yeovilton after completing an air show display at the Imperial War Museum (IWM) Duxford. The pilot had slowed the aircraft and was configuring it for landing but despite several attempts, using the normal (Green) and standby (Red) hydraulic systems, the landing gear failed to unlock and lower. After consultation between the pilot, air traffic control (ATC) and the operator's Chief Engineer, the decision was taken to do a wheels-up landing. This was carried out; the pilot landed the aircraft and came to a stop on the runway without further incident. The pilot made the aircraft safe and vacated the cockpit unaided.

The landing gear failed to lower because of a mechanical break-up within both the normal and standby hydraulic systems pumps. The break-up was caused by seizure of the pistons within the hydraulic pumps, probably due to the presence of a contaminant. Forensic work is continuing to identify the contaminant and its source.

**History of the flight**

The aircraft was being flown as part of an air show at the IWM Duxford. During its display, the pilot carried out several manoeuvres which included lowering and retracting the landing gear, flaps and arrestor hook. After the display, the aircraft was flown back to RNAS Yeovilton

and carried out a visual run-in and break (VRIAB) for Runway 27 at 360 kt indicated airspeed (KIAS). The airbrake was deployed during this manoeuvre and as the aircraft speed decayed through 220 KIAS, the airbrake was selected IN, takeoff flap was selected and the landing gear control set to DOWN on the normal (Green) hydraulic system. The landing gear did not unlock and the pilot made several reselections to DOWN. At this point he also noted that the flaps had not moved to the takeoff setting. He checked the Green hydraulic pressure gauge and found it to be reading zero pressure in the system. The pilot carried out a fly-by of the control tower and ATC confirmed that the landing gear had not lowered. The pilot checked the standby (Red) hydraulic system pressure gauge which, although its position made it difficult to read accurately, appeared to be showing that the system was pressurised. He then reselected DOWN in standby mode but as before, the landing gear remained locked in the up position and now the standby system hydraulic pressure had also fallen to zero. The pilot was concerned the other two hydraulic systems (Blue and Yellow), which power the flying controls and autopilot system, could also malfunction and deployed the ram air turbine (RAT) as a precaution.

After consultation over the radio with the operator's Chief Engineer, the pilot considered the fuel state within the aircraft, in particular the drop tanks being empty, and took the decision to carry out a wheels-up landing. The pilot formally declared an emergency to ATC and prepared for the landing in accordance with the flight reference cards, flying the approach at the recommended speeds. He shut the left engine down at two feet above ground level and shut the right engine down at touchdown. Shortly afterwards he jettisoned the canopy and the aircraft continued to track down the runway centre line during which the drop tanks disintegrated. After the aircraft had stopped the pilot made the aircraft safe, satisfied himself there was no imminent danger and replaced the ejection seat safety pins. He then vacated the aircraft, by which time the airfield fire and rescue team had arrived.

There was no fire or fuel leakage but the aircraft had sustained significant damage to its fuselage underside, particularly in its engine bay area including the accessory gearbox casing. Figure 1 shows the aircraft on the runway.



**Figure 1**  
G-CVIX on the runway prior to recovery

## Aircraft and systems description

The De Havilland Sea Vixen Fighter All Weather (FAW) Mk 2 is an all-metal twin-engine, twin tail boom aircraft designed for Fleet Air Arm aircraft carrier operations. The type was in service between 1963 and 1972. This example was on the military register as XP924 and on completion of front-line flying was converted to a pilotless drone for range and test use. The aircraft was reverted to pilot control and in 1996 was placed onto the civil register as G-CVIX. At the time of the accident, the aircraft was on a valid permit to fly and had a CAA ANO exemption to display its original military registration.

The aircraft has a conventional flying control system and includes features which enabled it to undertake carrier borne operations such as wing fold and an arrester hook.

### *Hydraulic systems*

The aircraft depends on four hydraulic systems for flying controls and its utility equipment. The Blue and Yellow hydraulic systems power the ailerons, rudder, elevator and an autopilot. The Green hydraulic system powers the nosewheel steering, airbrake, right fuel filter de-icing, the right alternator, wheel brakes, landing gear, flaps, wing fold and arrester hook. The Red hydraulic system powers the scanner and radome, the left alternator and left fuel filter de-icing. The Red system automatically powers the flap system if the Green system pressure falls 500 psi below the Red system pressure and can be selected in the cockpit to power the wheel brakes, landing gear and arrester hook in the event of a Green system malfunction. The Red and Green systems are supplied from separate chambers within a combined pressurised reservoir. In G-CVIX the alternators are no longer fitted and have had their Red and Green system control equipment inhibited and blanked off. Similarly, the scanner and radome components in the Red system have been inhibited and blanked off.

Hydraulic pressure is produced by variable swashplate pumps driven by the accessory gearbox via splined quill drives. System pressure is maintained between 2,650 and 3,200 psi. All the hydraulic systems use Oil Mineral 15 (OM15) which is the military equivalent to Aeroshell 41.

### *Variable swashplate pump*

The variable swashplate hydraulic pumps are designed to maintain a constant system pressure regardless of demand or rotational speed. They consist of a set of seven pistons which move within cylinders equally spaced around the periphery of a rotating drum. The axes of the pistons and cylinders are slightly inclined to the axis of the rotating drum and a swashplate is fitted above the pistons and across the axis of rotation. The piston heads are fitted with followers attached to the pistons via a ball joint. The piston heads are held in contact with the variable angle swashplate by a synchronising plate which ensures piston reciprocation as the carrier rotates. The swashplate angle is controlled by a small servo piston which reacts to system demands. During rotation, the piston carrier causes the base of each piston in its cylinder to pass over two ports. The geometry of the pump is such that when the swashplate angle or 'tilt' increases, the piston is drawn up its cylinder as it passes

over the inlet port, sucking fluid in. As it continues to rotate through 180° the piston is forced back down its cylinder as it passes over the outlet port, thereby expelling its fluid and pressurising the system. The stroke of the pistons is proportional to the swashplate angle. When there is no demand on the system, the swashplate will be horizontal to the plane of rotation and the pistons will not move up or down their cylinders, so no fluid will be drawn in or expelled. However, to prevent the trapped fluid overheating, a small bypass cooling flow is maintained during off-load pump rotation.

### *Fuel system*

Fuel is carried in 12 internal tanks distributed around the aircraft in the fuselage, wing and forward boom projections. In addition, the aircraft can be fitted with two under-wing drop tanks constructed from a composite material and carried on the outboard pylons. The total capacity of the fuel system is approximately 13,500 lbs.

### *Landing gear*

The aircraft is fitted with a retractable tricycle landing gear which is extended and retracted by hydraulic jacks controlled by electro-hydraulic valves. There is no emergency stored gas blow-down facility but there is a hydraulic emergency down selection which directs Red system hydraulic pressure to the various sequencing valves and actuation jacks whilst the Green system is opened to return.

### **Damage to the aircraft**

In the accident the pilot stabilised the aircraft approach and touched down on Runway 27 near a runway intersection opposite the ATC tower. The aircraft was wings level and the weight of the aircraft was initially taken on the underside of the drop tanks. These quickly abraded on the concrete runway surface and the nose and tail of each tank detached, leaving a trail of material behind the aircraft. The weight was then taken on the underside of the fuselage on areas of structure directly beneath the two engines and on the two 'bump pads' at the base of the fins on the ends of each tail boom. The aircraft stayed on the centre line and the distance from touchdown to stop was approximately 1,000 metres. The aircraft was later recovered by crane to the operator's hangar at Yeovilton for examination.

The surface of the runway had caused severe abrasion through the aluminium alloy fuselage skin, stringers and frames and into the casing of the accessory gearbox, to the extent that some of the gear train was exposed. The reinforced section, which attaches the drop tanks to the pylons, was all that remained of the left and right drop tanks still attached the aircraft. The canopy and its frame sustained damage consistent with being ejected from the aircraft whilst still at speed and landing behind the aircraft. There was no fuel leakage or fire during the landing. Figure 2 shows the damage to the underside of the aircraft.



**Figure 2**

Damage to the underside of G-CVIX.

(This picture was taken after the landing gear had extended during fault diagnosis.)

### **Engineering investigation**

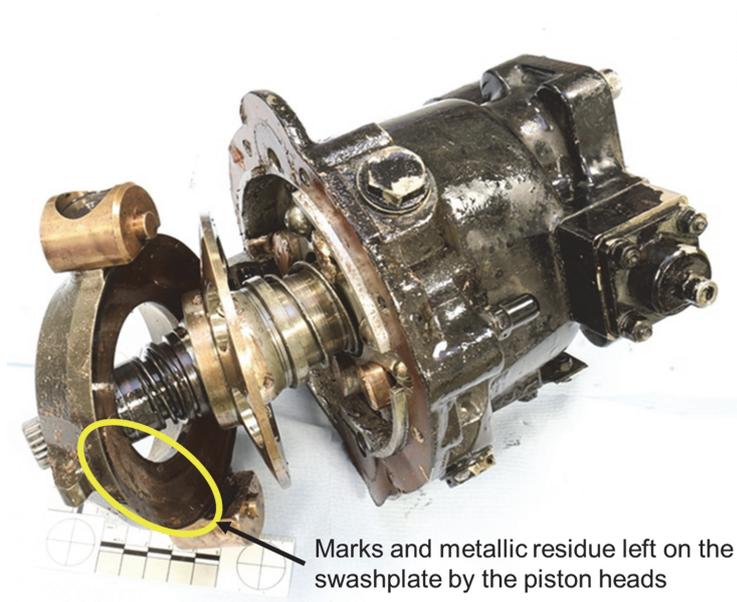
Immediately after the accident, work was carried out on the Red and Green systems to establish the cause of the loss of hydraulic pressure, using a hydraulic servicing rig to pressurise the systems. It was noted that when pressure was applied, the landing gear lowered and locked down normally, indicating a problem with the aircraft hydraulic pumps.

Whilst the systems were pressurised, a whirring or circulatory noise was heard coming from the hydraulic fuel filter heater circuit. Subsequent investigation found the heater switch in the cockpit was partially 'made' despite still having its unbroken copper wire tell-tale in place. It was not known why or how this switch got into this position.

The Red and the Green hydraulic system pressure pumps were removed for further examination. It was found that the Green pump quill drive had failed and the Red pump quill drive was intact. The Red and the Green pumps were disassembled and their internal components examined.

The Red pump was disassembled first and although it showed no outward signs of damage or malfunction, there was metallic debris present in the supply and return pipe connections. The disassembly revealed that the outer casing, cover plate and piston carrier were damaged internally with substantial amounts of non-ferrous material of various sizes throughout the pump. All seven of the pistons were present, but most of them were seized in the piston carrier. The swashplate piston track had significant metal scuffing and pick-up from the piston heads on its surface (Figure 3). Otherwise the swashplate, its pivot blocks and piston

synchronising plate, were free to move and were undamaged. The servo piston and linkage to the swashplate was also seized. All the piston head collars had fragmented leaving just the ball and socket at the top of each piston (Figure 4).



**Figure 3**

The Red pump shown with its cover plate removed



**Figure 4**

Damage to the Red hydraulic pump piston heads

The Green pump was also disassembled. It showed no outward signs of damage and internally was in better condition than the Red pump, with minimal debris present. The swashplate piston track also exhibited non-ferrous metallic scuffing and pick-up from the piston heads but to a far lesser extent than the Red pump. All the pistons were present and some were seized in their carrier. The piston heads showed some signs of wear and scuffing

where they contacted the swashplate but were otherwise intact and correctly positioned in the synchronising plate. The servo piston was correctly attached to the swashplate and free to move. Figures 5 and 6 show the Green pump components.



**Figure 5**

Green pump piston heads and synchronising plate



**Figure 6**

Associated swashplate piston track marks

Forensic analysis of the piston surfaces from both hydraulic pumps, showed the presence of microscopic silver particles.

### *Hydraulic fluid condition*

Testing of the hydraulic fluid showed there was no significant decline in the quality of the fluid, and water content was within acceptable levels. The Yellow and Red systems contained no visible material. However, the Blue system contained a small amount of suspended material and the Green system contained a significantly greater amount. This material was extracted from the Green system sample and predominately found to be a fine grey silt. There was no evidence of suspended metallic debris.

### *Hydraulic system history*

Shortly before the accident, routine maintenance had revealed a fault with the landing gear control valves. This was rectified and during this work the Red and Green hydraulic systems were drained and replenished with new fluid. Other than routine fluid level checks, no other work had been carried out.

## **Analysis**

It is not known exactly when either of the pump pistons seized. However, since the landing gear, flaps and airbrake appeared to be working during the flying display, it is likely the hydraulic pump problem arose during the flight back to Yeovilton.

Most of the Green hydraulic pump pistons had seized in their carrier bores whilst either in their minimum stroke position or as they increased to their maximum stroke in response to demand. That demand was made on return to Yeovilton with the airbrake, as servo pressure dropped and the servo linkage attempted to change the angle of the swashplate to increase the stroke of the pistons. However, with the pistons seizing, the piston heads were caused to jam against the swashplate track and resist its rotation breaking, the quill drive. At this point the Green system hydraulic pressure fell to zero.

The aircraft appears to have sustained the loss of two hydraulic systems simultaneously, caused by failure of both the Red and the Green system hydraulic pumps. However, it is possible that the design of the Red and Green systems meant the Red system had been in a failed condition in advance of the Green system but manifested itself in each system simultaneously as demands were made. It is not known exactly when either of the systems failed but it is likely that the systems were operating correctly during the flypast when the pilot demonstrated items with high hydraulic demand, such as the landing gear, flaps and arrester hook. The Yellow and Blue hydraulic systems appear to have been unaffected.

## **Conclusion**

The failure mechanisms appeared identical in the Red and Green pumps with the seizure of the pistons caused by a yet unidentified source of contamination or debris in the hydraulic fluid. The presence of microscopic silver particles suggests component wear within the system, but at the time of publication, a source or a component has not been identified. The unexpected activation of a dormant heater circuit within the Red or Green system is of interest as a possible source of contamination. Work will continue to establish the cause of the hydraulic pump piston seizure in this aircraft.

**SERIOUS INCIDENT**

<b>Aircraft Type and Registration:</b>	Let L-410 UVP-E, OK-LAZ	
<b>No &amp; Type of Engines:</b>	2 Walter M601E turboprop engines	
<b>Year of Manufacture:</b>	1990 (Serial no: 902504)	
<b>Date &amp; Time (UTC):</b>	23 February 2017 at 0927 hrs	
<b>Location:</b>	Isle of Man (Ronaldsway) Airport	
<b>Type of Flight:</b>	Commercial Air Transport (Passenger)	
<b>Persons on Board:</b>	Crew - 2	Passengers - 3
<b>Injuries:</b>	Crew - None	Passengers - None
<b>Nature of Damage:</b>	None	
<b>Commander's Licence:</b>	Airline Transport Pilot's Licence	
<b>Commander's Age:</b>	51 years	
<b>Commander's Flying Experience:</b>	7,800 hours (of which 2,200 were on type) Last 90 days - 120 hours Last 28 days - 40 hours	
<b>Information Source:</b>	AAIB Field Investigation	

**Synopsis**

The aircraft departed Isle of Man (Ronaldsway) Airport (IOM) on a commercial flight to Belfast City Airport (BHD), in a region affected by a deep low pressure system with associated strong surface winds. After one unsuccessful attempt to land at BHD in a strong crosswind, the crew diverted back to IOM.

When the aircraft landed at IOM the wind was gusting to 63 kt and creating a maximum crosswind component of 40 kt. After touchdown, nearby witnesses saw the right mainwheel lift off the ground and they estimated the left wingtip rolled to within approximately one metre of the runway surface before the landing was successfully completed.

The relevant maximum demonstrated crosswind component for the Let L-410 is 19.4 kt and this was included in the '*Performance Limitations*' section of the Airplane Flight Manual (AFM) but the aircraft operator did not apply a limiting component of crosswind to its operations. The only wind limit that was applied and used by the crew was 45 kt for ground operation.

Several safety actions have been taken including amendments to the aircraft operator's Operations Manual regarding crosswind operations.

One Safety Recommendation has been made to review the aircraft operator's operational processes, training and operator's guidance.

## History of the flight

The two pilots were based locally in the IOM and they were rostered to report for duty at 0645 hrs to operate a return flight to BHD. The scheduled departure time was 0715 hrs and the return flight from BHD was scheduled to arrive back at IOM at 0850 hrs.

Weather information was downloaded by the pilots from a self-briefing facility in the aircraft operator's crew room at 0632 hrs. Meteorological Airfield Reports (METARs) and Terminal Aerodrome Forecasts (TAFs), along with NOTAM information, was requested for six airports; Belfast International (BFS), BHD, Blackpool, Dublin, IOM and Londonderry. However, weather reports for Blackpool and TAFs for BHD or Londonderry were not available at 0632 hrs<sup>1</sup>. A warning of north-westerly gales, affecting IOM between 0930 and 1300 hrs, had been issued by Ronaldsway Met Office at 0500 hrs and this had been passed to the operator's crew room.

Runway 26 was available at IOM and the 0620 hrs METAR stated the wind was from 230° at 32 kt gusting to (G) 45 kt, creating a maximum crosswind component of 22 kt. The 0455 hrs TAF was for the wind to veer and subside, and to be from 310° at 17 kt during the two hour period ending at 0800 hrs, but that it would then increase to 33 G 46 kt over the next two hours. The only wind limit considered by the crew was a maximum wind velocity of 45 kt for ground operation<sup>2</sup>.

The surface wind at BHD, where Runways 04 and 22 were available, was reported at 0620 hrs to be from 230° at 9 kt but, because they received no TAF for this destination, the pilots reported afterwards that they selected two alternate airports; BFS and IOM. Runway 35 was available at BFS and during the morning the wind was forecast to be from 340° with a probability that it would temporarily increase to a mean speed of 33 kt. The crew created their Operational Flight Plan (OFP) to show IOM as the only alternate. Afterwards, the crew stated they considered BFS to be their first alternate and that IOM was their second, but the OFP only showed the longer of the two potential diversion routes. The ticket-selling company stated afterwards that BFS was its preferred commercial alternate, followed by IOM and then Dublin.

After proceeding to the aircraft, the crew were advised that the wind at IOM had changed and was now from 260° at 39 G 55 kt. Because this exceeded the ground operation limit, they delayed the flight, returned to the crew room and studied weather information that was now available for all six of the airports previously mentioned. This included the 0735 hrs TAF for BHD, which forecast that between 0700 and 1000 hrs the wind would become orientated across the runway at a mean speed of 20 kt.

The 0720 hrs METAR for IOM gave the wind from 250° at 33 G 47 kt but variable between 220° and 290°; with a NOSIG notation (indicating no significant changes) forecast over the next two hours. At 0750 hrs the crew learnt the wind was from 290° at 31 G 40 kt and as both these more recent reports were within the ground operation limit, they decided to

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### Footnote

<sup>1</sup> See *Meteorological information* for synoptic details and relevant METAR and TAF data.

<sup>2</sup> See *Aircraft operator's guidance*.

depart, with 550 kg of fuel on board. The minimum required fuel from the OFP was 453 kg, so they estimated they had sufficient fuel for an extra 20 minutes of flight time in the event of a diversion back to IOM.

Three passengers boarded and the aircraft taxied at 0810 hrs. Shortly afterwards, at the request of BHD ATC, the crew were informed that the wind at BHD was from 320° at 31 G 46 kt, and IOM ATC asked the crew for their intentions because BHD ATC had reported no other known aircraft movements. The crew elected to continue the flight and took off on Runway 26 at 0823 hrs, when the reported wind was from 290° at 21 G 41 kt. The co-pilot was the Pilot Flying (PF) and the commander was Pilot Not Flying (PNF).

No difficulties were encountered en route to BHD, and the PNF listened to the 0827 hrs Automatic Terminal Information Service (ATIS). This stated that Runway 22 was in use and quoted the 0820 hrs METAR<sup>3</sup>, with the wind orientated across the runway at 25 G 40 kt. When the PNF contacted BHD ATC, he was told radar vectoring was available for an ILS approach to Runway 04 and that the wind was now from 320° at 28 G 43 kt. The PNF informed ATC they would make one approach but would go around if the approach was not stable.

The crew reported afterwards that they experienced continuous moderate turbulence during the latter part of the approach. The final wind check, given after they had been cleared to land, was from 320° at 35 kt. They judged that the aircraft operator's stable approach criteria<sup>4</sup> were met until the aircraft passed over the runway threshold, when turbulence de-stabilised the aircraft and they initiated a go-around.

ATC reported that the aircraft went around from approximately 20 ft above the runway at 0858 hrs and climbed straight ahead to 3,000 ft amsl, the standard missed approach procedure. The aircraft continued heading northeast until 0901 hrs when the PNF informed ATC they would not make a second approach and would return to IOM.

Once level at FL070, the PNF listened to the ATIS for the IOM, which stated Runway 26 was in use, it was wet, and detailed the 0850 hrs METAR<sup>5</sup>, which noted that the wind was from 290° at 28 kt. The PF briefed for an approach with the flaps set to 18°, and a target  $V_{REF}$  of 105 kt<sup>6</sup>; with a "SLIGHTLY RIGHT CROSSWIND"<sup>7</sup>. After the brief was completed he commented on the intercom that the wind was "NOT SO CHALLENGING" at IOM but shortly after this ATC provided a special weather observation, timed at 0912 hrs, which stated the wind was now from 310° at 41 kt and gusting between 22 and 53 kt. When asked by ATC if they wished to make an approach, the PNF replied "OF COURSE". There was no recorded discussion between the pilots regarding the change to the wind<sup>8</sup> before the aircraft began descent in preparation for its approach.

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#### Footnote

<sup>3</sup> See *Meteorological information*.

<sup>4</sup> See *Stabilised approach criteria*.

<sup>5</sup> See *Meteorological information*.

<sup>6</sup>  $V_{REF}$  is the landing reference speed, see *Stabilised approach criteria*. Note that a wind of 290° at 28 kt indicated a crosswind component of 14 kt.

<sup>7</sup> See *Recorded information*.

<sup>8</sup> The steady crosswind component was now 31 kt, increasing to 41 kt if the maximum gust was accounted for.

At 0913 hrs, the PNF informed the PF there was about 300 kg of fuel remaining and this was enough "FOR ONE MORE HOUR". Without further discussion, the crew accepted radar vectoring for an ILS approach to Runway 26, with the co-pilot remaining as PF. Before the aircraft was directed towards its final approach, ATC reported the wind was from 310° at 43 kt but gusting between 23 and 63 kt.

At 0924 hrs, after the aircraft had become established on the ILS centreline and glideslope, ATC radioed clearance to land, with a reported wind of 300° at 41 kt but gusting between 31 and 63 kt. While receiving this message, the crew were also presented with an aural "GLIDESLOPE" caution and immediately after this the PF declared "1,000 FT STABILISED". At 0925 hrs, while the PNF was adjusting the propeller rpm, another aural "GLIDESLOPE" caution was annunciated and the PF immediately stated "CORRECTING". At 0926 hrs, following an automatically generated message stating the aircraft was at 500 ft agl, one further "GLIDESLOPE" caution was annunciated and the PF responded saying "CORRECTING, RUNWAY IN SIGHT".

The final wind check provided by ATC, approximately 35 seconds before the aircraft touched down, was from 300° at 48 kt, but gusting between 32 kt and 63 kt<sup>9</sup>. The commander reported afterwards that the runway was in sight at 600 ft.

Given the environmental conditions, ATC was concerned for the safety of the aircraft and its occupants when it landed, so the airfield Rescue and Fire Fighting Service (RFFS) had been placed on alert with two vehicles facing towards the runway, approximately 200 m from the touchdown zone. During the aircraft's approach, ATC discussed the situation with the Isle of Man Civil Aviation Administration because another of the same operator's aircraft had been blown onto its wingtip while taxiing in 2007<sup>10</sup>, in winds greater than 45 kt, and both parties knew 45 kt was now the operator's maximum ground operation limit.

Four RFFS and two ATC witnesses reported that as the aircraft crossed the threshold it seemed unstable and it rolled considerably, causing the tip of the left wing (the downwind wing) to tilt down until it seemed in close proximity to the runway, before the wheels made first contact. The aircraft then bounced and rolled left again before touching down for a second time, on all three wheels.

After travelling along the runway for approximately 20 m, the right mainwheel was seen to lift off the ground and nearby RFFS witnesses estimated the left wingtip rolled to within one metre of the runway surface. The crew seemed aware of this roll because, approximately nine seconds after touchdown, the PF stated "AILERONS...GOOD...TOO MUCH ROLL". The commander stated afterwards that he thought all the wheels remained on the ground and that the aircraft responded to appropriate aileron control; he had no concern that the wingtip or the propeller might have been close to the ground.

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#### Footnote

<sup>9</sup> Taking account of the full gust factor this indicates a crosswind component of 40 kt.

<sup>10</sup> See *Previous incidents*.

After landing the commander took control and the co-pilot commented “TAXI CAREFULLY WITH THE WIND”. ATC then stated the surface wind was from 300° at 47 kt, but gusting between 32 kt and 63 kt and asked if they wished to taxi or to hold on the runway. The crew replied “WE WILL TRY AND TAXI AND IF WE CAN MAKE IT WE WILL VACATE, OTHERWISE WE NEED TO LEAVE THE AIRCRAFT HERE”. The crew then accepted taxi instructions directing them towards the terminal but, 45 seconds later, as the aircraft was leaving the runway, ATC radioed to the crew, “DIRECTION FROM ISLE OF MAN CAA, HOLD POSITION.” The aircraft stopped facing into the wind.

Both ATC and the Isle of Man Civil Aviation Administration later indicated that they were concerned that if the aircraft continued to taxi with the wind gusting to 63 kt an accident could occur. The Isle of Man Civil Aviation Administration therefore issued a directive<sup>11</sup> that the aircraft be held in its current position and it was subsequently shutdown into wind near the junction of Runway 26 and Taxiway C, with 220 kg of remaining fuel being recorded.

RFFS vehicles were positioned around the aircraft, to provide some screening from the wind, and a bus transferred the three uninjured passengers to the terminal building. The aircraft was later tied down until the wind subsided, (Figure 1).

ATC at BHD stated afterwards that no aircraft landed between 0749 and 0944 hrs due to strong crosswinds and associated turbulence. Another aircraft<sup>12</sup> was being vectored towards an approach when OK-LAZ went around but elected to divert to BFS when informed that the preceding aircraft had gone around. ATC at IOM also stated afterwards that six other flights (by other operators) that were scheduled to arrive were cancelled due, as far as was known, to the weather conditions.



**Figure 1**  
Aircraft tied down at IOM

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#### Footnote

<sup>11</sup> See *Isle of Man regulations*.

<sup>12</sup> This aircraft's limiting crosswind component of wind for landing was 32 kt.

## Recorded information

The aircraft was fitted with a 30 minute duration solid state Cockpit Voice Recorder (CVR). This was successfully downloaded at the AAIB and excerpts from the recording are quoted in this report. In addition, a solid state Flight Data Recorder was downloaded with the assistance of the manufacturer. This showed that passing 1,000 ft agl on approach to Runway 26 at IOM<sup>13</sup>, the aircraft's airspeed was stable at approximately 120 KIAS in a steady descent of around 1,000 ft/min. At approximately 850 ft agl, the aircraft stopped descending and the flightpath transitioned to a climb, reaching 950 ft agl, before a descent was re-established. This change in flightpath occurred over a period of 40 seconds and was accompanied by the airspeed fluctuating between 113 KIAS and 146 KIAS.

Passing 500 ft agl, the aircraft's rate of descent had reduced to approximately 440 ft/min with the airspeed decaying towards the lowest speed recorded on the approach of 107 KIAS. The aircraft then levelled at 390 ft agl and a generally increasing trend in airspeed was recorded until the final descent to the runway started. During the final descent, the airspeed fluctuated between 125 KIAS and 148 KIAS.

## Aircraft information

The Let L-410 UPV-E is a high wing, twin-engined turboprop with 19 passenger seats. It has a maximum takeoff weight of 6,400 kg, a wingspan of 19.98 m and a wheel track of 3.65 m. For landing, the flaps can be set to 18° or 42°.

The aircraft is certified in accordance with Certification Specifications (CS) for Commuter Category Aircraft, CS-23. To be approved under CS-23 an aircraft must be demonstrated to be safe for taxiing, takeoff and landing with a 90° '*cross-component of wind velocity*' that is not less than 20% of the stall speed with idle power. CS-23 states that certain normal, abnormal and emergency procedures must be furnished in the AFM and this includes the maximum demonstrated crosswind for takeoff and landing and procedures and information pertinent to operating in crosswinds. Guidance in the Flight Test Guide section of CS-23 relating to crosswinds states:

*'Crosswind. This regulation establishes the minimum value of crosswind that must be demonstrated. Since the minimum required value may be far less than the actual capability of the aeroplane, higher values may be tested at the option of the applicant. The highest 90° crosswind component tested satisfactorily should be put in the AFM as performance information. If the demonstrated crosswind is considered limiting, it should be introduced into Section 2 of the AFM.'*

Section 2 of the AFM for the Let L-410 is titled '*Limitations*' and there is a sub-section titled '*Performance Limitations*' which includes '*Wind Speed and Direction Limitations (Demonstrated Values)*' and states that 19.4 kt is the '*Maximum demonstrated component*'

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### Footnote

<sup>13</sup> The final approach track for Runway 26 at IOM is situated over the sea until shortly before the runway threshold.



## Meteorology - Isle of Man procedures

In the Isle of Man, weather reports and forecasts are produced by the Ronaldsway Met Office, located at IOM, in accordance with the procedures laid down in ICAO Annex 3 'Meteorological Services for International Air Navigation', the UK Civil Air Publication (CAP) 746 'Requirements for Meteorological Observations at Aerodromes' and the UK Aeronautical Information Publication (AIP) Section GEN 3.5 'Meteorological Services'. The AIP states at paragraph 4.7 that:

*'The Aerodrome Forecast (TAF) is the primary method of providing the forecast weather information that pilots require about an airfield in an abbreviated format. The TAF consists of a concise statement of the mean or average meteorological conditions expected at an aerodrome or heliport during the specified period of validity.'*

Paragraph 4.2.9 states:

*'The issue of a new forecast, such as an aerodrome forecast, shall be understood to automatically cancel any forecast of the same type previously issued for the same place and for the same period of validity or part thereof.'*

The AIP advises pilots that:

*'When necessary, the personal advice of a forecaster, or other meteorological information, can be obtained from the appropriate forecast office.'*

There is a duty forecaster available at IOM and a relevant telephone number is listed in the AIP, but he was not consulted by the crew or by the aircraft operator before this flight.

Concerning METARs the AIP states that a TREND is:

*'... a forecast of significant changes in conditions during the two hours after the observation time.'*

Also CAP 746 states:

*'A TREND forecast is a short period forecast, predicting significant weather changes that are likely to occur at the aerodrome in the two hours following the time of the meteorological observation. The TREND forecast may be appended to the METAR either by the forecaster or by the observer at aerodromes where procedures exist for obtaining the TREND message from the meteorological forecasting office.'*

## Meteorology - IOM

The first METAR seen by the crew was produced at 0620 hrs and the wind was from 230° at 32 G 45 kt but BECMG<sup>15</sup> 310° at 17 kt. The available TAF, issued at 0455 hrs, forecast that between 0600 and 1500 hrs, the wind would be from 230° at 28 G 40 kt, BECMG between 0600 and 0800 hrs 310° at 17 kt, then BECMG between 0800 and 1000 hrs 310° at 33 G 46 kt but with a 30% probability that between 0900 and 1200 hrs it would temporarily be from 310° at 38 G 55 kt. The forecast visibility was 10 km or more, with few cloud at 1,500 ft aal, broken cloud at 3,000 ft and temporarily, between 0600 and 1500 hrs, visibility reducing to 7 km in rain and moderate rain showers, with broken cloud at 1,400 ft. There was a 30% probability between 0600 and 1100 hrs of visibility reducing further to 3,000 m with broken cloud at 800 ft. This TAF remained current until replaced at 0800 hrs.

The 0650 hrs METAR included the same trend message as the 0620 hrs report and the forecaster considered this consistent with the BECMG group in the TAF for the period 0600 to 0800 hrs. However, when the 0720 hrs METAR was written, new data indicated there might not be an initial reduction in wind strength when it veered, so the wind was stated as being from 250° at 33 G 47 kt, with its direction varying between 220° and 290° and with NOSIG appended to the METAR, indicating no significant change forecast within the next two hours. This was regarded by the forecaster as broadly consistent with the existing TAF, which had forecast that between 0800 and 1000 hrs the wind would become 310° at 33 G 46 kt and did not negate the forecast possibility of a temporary wind change to 310° at 38 G 55 kt between 0900 and 1200 hrs.

The 0750 hrs METAR stated the wind was from 270° at 30 G 42 kt but did not contain any trend forecast relating to the wind, nor did the subsequent METARs up until the time that the aircraft landed.

A replacement TAF was issued at 0800 hrs and this forecast that from 0900 to 1800 hrs the wind would be from 300° at 30 G 45 kt, with visibility of 10 km or more, scattered cloud at 700 ft, broken cloud at 1,400 ft, but temporarily between 0900 and 1100 hrs the wind would be from 320° at 36 G 55 kt, with visibility of 3,000 m in rain and moderate rain showers, with broken cloud at 700 ft.

The 0850 hrs METAR stated the wind was from 290° at 28 kt, with visibility of 1,800 m in heavy rain, the lowest cloud at 400 ft, temperature 6°C, dew point 5°C and QNH 977 hPa. The 0920 hrs report stated the wind was from 300° at 42 G 56 kt, with visibility of 4,000 m in rain, the lowest cloud at 500 ft, temperature 5°C, dew point 3°C and QNH 979 hPa.

## Meteorology - Belfast City (destination airport)

The 0620 hrs METAR for BHD stated the wind was from 230° at 9 kt and the 0720 hrs report stated it was from 280° at 6 kt. The first TAF for the day was produced at 0717 hrs and this stated that between 0700 and 1000 hrs the wind would veer and increase to be

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### Footnote

<sup>15</sup> BECMG is the meteorological notation used in a TREND forecast which means becoming during the next two hours.

from 320° at 20 G 35 kt. This TAF was updated at 0735 hrs, without any change to the forecast wind, stating that between 0700 and 1200 hrs the visibility was likely to decrease temporarily to 3,000 m in showers of rain and sleet, with broken cloud at 800 ft.

The 0750 hrs METAR stated the wind was from 300° at 25 G 40 kt and the 0820 hrs report stated it was from 320° at 25 G 40 kt, visibility in excess of 10 km, with showers of rain, the lowest cloud at 900 ft, temperature 3°C, dew point 1°C and QNH 981 hPa.

### **Meteorology - other airports**

#### *Belfast International Airport*

At 0559 hrs the TAF for BFS indicated that between 0600 and 0900 hrs the wind would be from 340° at 26 G 36 kt, with a 30% probability of this strengthening temporarily between 0600 and 1200 hrs to 33 G 46 kt.

Before departing IOM, the crew saw the 0720 hrs METAR for BFS which stated the wind was from 320° at 26 G 42 kt, visibility 6 km in rain, scattered cloud at 400 ft, broken cloud at 700 ft and also at 1,200 ft, temperature 6°C, dew point 5°C and QNH 977 hPa.

At 0850 hrs, shortly before the aircraft went around at BHD, the BFS METAR stated the wind was from 320° at 23 G 33 kt, visibility 9 km in rain, broken cloud at 1,100 ft and also at 1,500 ft, temperature 4°C, dew point 3°C and QNH 986 hPa.

#### *Dublin Airport*

The weather data seen by the crew included the 0600 hrs METAR for Dublin (where Runway 28 was available), with the wind from 250° at 42 G 53 kt but the forecast was for a 40% probability of a temporary change between 0600 and 0800 hrs for the wind to be from 270° at 40 G 60 kt. It was then forecast to BECMG, between 0700 and 0900 hrs, from 290° at 30 G 45 kt and between 0900 and 1200 hrs from 300° at 30 G 40 kt.

The 0900 hrs METAR stated the wind was from 290° at 29 G 49 kt, visibility 10 km or more, few cloud at 1,500 ft, broken cloud at 2,600 ft, temperature 6°C, dew point 2°C and QNH 990 hPa.

#### *Glasgow Prestwick Airport*

The crew did not obtain weather information for Glasgow Prestwick Airport which is approximately 67 nm northeast of BHD and where Runway 03 was available. The 0501 hrs TAF stated the wind would be from 040° at 17 kt, visibility 10 km or more, scattered cloud at 3,000 ft, with temporarily between 0600 and 1300 hrs visibility 6 km in rain, broken cloud at 800 ft and a 40% probability of temporarily, between 0600 and 1100 hrs the wind being from 010° at 20 G 30 kt, visibility 1,200 m in heavy sleet with snow and broken cloud at 300 ft.

The 0720 hrs METAR stated the wind was from 020° at 7 kt but the direction variable between 340° and 050°, visibility 10 km or more in rain, few cloud at 800 ft, broken cloud at 2,400 ft, temperature 5°C, dew point 3°C and QNH 977 hPa.

The 0850 hrs METAR stated the wind was from 020° at 10 G 20 kt with the direction variable between 350° and 060°, visibility 10 km or more in light rain, few cloud at 1,000 ft, scattered cloud at 1,900 ft, temperature 3°C, dew point 1°C and QNH 980 hPa.

### Crew information

The commander was a Hungarian national and the co-pilot was a Czech national but, based on the CVR data, they conversed in English.

The commander's total flying experience was 7,800 hours of which 2,200 hours were on type. The co-pilot's total flying experience was 1,052 hours of which 509 hours were on type, including 19 hours in the last 28 days. He also held the post of Deputy Flight Operations Manager for the aircraft operator.

After the flight, the commander reported that following the go-around from BHD he did not ask ATC about the latest conditions at BFS, or whether other aircraft were landing there, because he judged "the same sort of wind was prevailing at both BFS and IOM". When asked if he considered taking over the PF duties for the approach to IOM once the wind increased significantly, he stated there would have been no advantage for him to have been PF, even though he had more flying experience, because as PNF he had oversight of what was taking place.

### Operational information

#### *Wind limits*

The aircraft Operator's Manual (OM) included the information from the AFM relating to the maximum demonstrated component of crosswind. In common with the AFM, this information was presented in the '*Limitations*' section of the OM Part B, rather than the '*Normal procedures*' section, while the '*Performance*' section stated:

*'Maximum crosswind component*

*The maximum crosswind component in which the aeroplane has been demonstrated to satisfactory for takeoff is 20 knots at 90° to the direction of take-off. The demonstrations were made with both engines operating and lateral controllability on the ground was close to being limiting.'*

The OM included no other relevant crosswind limit or guidance and there is no evidence crews were trained to handle the aircraft in crosswinds of more than 19.4 kt.

The only other wind limits included in the OM<sup>16</sup> were the '*Aircraft ground operation wind speed limits*' which instructed a commander with more than 300 hours experience on type to regard 45 kt wind speed from any direction as limiting for ground operation and to calculate this by adding half of the gust factor to the stated steady wind speed. A commander with less than 300 hours on type was to use 40 kt as the limit.

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#### Footnote

<sup>16</sup> Advised in the Operator's 'Safety Bulletin No. 01/16'.

### *Flight planning*

The OFP was produced by the crew once they had selected BFS as their first destination alternate and IOM as their second, but the OFP showed just one diversion route, so only the navigational information and the fuel required for diversion back to IOM from BHD was shown on the OFP. The OM Part A stated that the OFP must show route information for destination '*alternate(s)*'. The distance allowed for a diversion from BHD to IOM was 58 nm<sup>17</sup>. This equates to the direct airway routing from BHD to IOM via the IOM VOR and does not allow any track miles for the missed approach procedure at BHD (involving a climb straight ahead to 3,000 ft amsl), nor for an approach procedure at IOM.

The technical log indicated 550 kg of fuel was on-board at the start of the flight while the minimum required fuel from the OFP was 453 kg. This included 195 kg to taxi-out and for the 30 min flight to BHD, 82 kg for a 16 min diversion back to IOM, 150 kg of final reserve fuel and 25 kg for contingency fuel (1 kg was not accounted for). The OM Part A stated that contingency fuel of not less than 50 kg should be included in fuel calculations<sup>18</sup>.

The OM Part A instructed pilots to select two alternate airfields if no meteorological data for the destination is available before departure, or if the weather reports or forecasts for the destination indicate that, during a period commencing one hour before and ending one hour after the estimated time of arrival, the weather conditions will be below the applicable planning minima. Consideration must be given to the forecast weather conditions for a destination alternate for the time period from one hour before until one hour after the aircraft's likely estimated time of arrival there.

When interpreting meteorological information, the guidance states:

*'For planning purposes an aerodrome shall be considered below minimum if the steady crosswind exceeds the prescribed limitations.'*

The OM guidance on forecasts of deteriorating weather was that meteorological PROB or TEMPO prefixes '*may be considered whenever judged operationally significant*'. It suggested that if a forecast deterioration of this type involved precipitation (rain, snowstorms or thunderstorms), it should be carefully evaluated and the carriage of up to one hour's extra fuel considered, while probable, temporary deterioration due to other forms of weather should be '*fully considered*'.

### *Operational support*

In accordance with the OM Part A, the Operations Control Centre (OCC) was tasked with supporting the crew during flight planning while the Flight Operations Manager (FOM) was to be available for the commander to consult in regard to selection of alternate airfields and when weather creates any '*irregularity in operations*'.

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#### **Footnote**

<sup>17</sup> The comparable distance to Prestwick from BHD is approximately 12 nm further.

<sup>18</sup> Contingency fuel is required to be carried in addition to final reserve fuel.

The decision to operate the flight was taken at 0750 hrs when the 0455 hrs IOM TAF remained valid. The 0800 hrs IOM TAF and the 0750 hrs BHD METAR would have been available to the OCC and the FOM once the crew had returned to the aircraft but before it took off. It was not evident that any discussions took place between the crew and the OCC or the FOM concerning the decision to operate the flight in the prevailing conditions.

#### *Crew resource management*

Standard Operating Procedures (SOPs) were described in Chapter 2 of the OM Part B which stated:

*'...operations are based on the optimum use of Crew Resource Management. The principle of continuous mutual briefing and assistance shall be applied at all times. In normal cockpit work the commander shall endeavour to establish open communication between crew members.'*

The manual continued by stating that clear crew co-ordination is especially important in abnormal situations, so there should be *'clear and precise work distribution'* and crews should operate on the *'closed-loop principle'* where *'each crew member is always informed and kept in the loop'*. There was no guidance given on other aspects of crew resource management (CRM) such as the evaluation and management of threats, problem solving and decision making.

#### *Stabilised approach criteria*

For an approach with flaps set to 18°, the  $V_{REF}$  from the AFM is 89 KIAS, irrespective of the aircraft weight, and the maximum approach speed is 135 KIAS, which is the limiting speed with the landing gear selected down or with flaps set to 18°. The OM advised that the  $V_{REF}$  be increased (up to a maximum of 15 kt) by adding a value equal to half the headwind component in excess of 10 kt plus the full gust value, to give an adjusted  $V_{REF}$ .

The aircraft operator's SOP is for approaches to be stabilised by 1,000 ft aal in Instrument Meteorological Conditions (IMC) and by 500 ft aal in Visual Meteorological Conditions (VMC). To be stabilised the aircraft is to be on the desired flight path in landing configuration with only small changes in heading and pitch required to maintain that path, a maximum *'sink rate'* of 1,000 ft/min and with the airspeed between  $V_{REF}$  and  $V_{REF} + 20$  KIAS, (using the adjusted  $V_{REF}$ ). When the aircraft passes 1,000 ft aal in IMC or 500 ft aal in VMC the PNF is to annunciate this and also to state *'NOT STABILISED'* if the stabilised approach criteria are not met, in which case the PF is to initiate a go-around.

For the aircraft to be considered stabilised when crossing the runway threshold the maximum speed should be the adjusted  $V_{REF} + 10$  KIAS.

#### *Glideslope caution*

During an ILS approach the aircraft's Enhanced Ground Proximity Warning System (EGPWS) produces an aural *'GLIDESLOPE'* caution if the aircraft deviates below the ILS glideslope. The operator's requirement is for the PF to respond by making a correction to

regain the glideslope but if this is not successful, or if the aircraft is below 500 ft aal, the PF is to initiate a go-around. However, the OM also contained the following statement:

*'In VMC conditions and in day with sufficient visual reference, must not take into account the caution.'*

#### *Reporting time*

In accordance with EASA regulations, the OM Part A stated the aircraft operator will:

*'specify reporting times that allow sufficient time for ground duties.'*

and:

*'In general these times will not be less than 30 minutes prior Scheduled OFF Block Time.'*

The OM was approved by the CAA of the Czech Republic.

#### **Regulatory oversight**

This aircraft operator's licences were issued by the CAA of the Czech Republic, which is responsible for oversight of the company in accordance with EASA regulations. However, Part-ARO of Commission Regulation (EU) 965/2012 requires States to cooperate with respect to the safety of operations in the territory of a National Aviation Authority (NAA) which is not the certifying authority.

The Isle of Man is a UK Crown Dependency, but is not an EU Member State and it has its own Civil Aviation Administration that is responsible for the Island's aviation safety. It is an Isle of Man requirement that aircraft registered in a foreign country obtain a Foreign Carrier Permit to operate commercial flights to or from the Island, while the UK has to provide a permit for commercial flights to or from the UK from a non-EU Member State. Consequently, the administration of Foreign Carrier Permits for commercial flights between the UK and the Isle of Man is delivered by the UK CAA in co-ordination with the Isle of Man Civil Aviation Administration. This operator had been issued with such a permit for its operation between the Isle of Man and the UK on behalf of the ticket-selling company.

According to the UK CAA "following a number of operational incidents", the Czech and UK CAAs had participated co-operatively to oversee this aircraft operator in a trial sponsored by the EASA. This trial between selected EASA Member States was initiated in response to the European Plan for Aviation Safety (EPAS 2016-2020 and 2017-2021). It tasked the EASA and Member States to implement cooperative oversight and disseminate best practices on how NAAs can better work together and participate in the oversight of organisations/ persons certified by another Member State.

The EASA stated that:

*‘Co-operative oversight allows the Member State’s competent authority to gain a better understanding of safety risks, related to aviation activities of organisations/persons active in its territory, but certified by the competent authority of another Member State. This extension of the traditional oversight scope has clear advantages in terms of exchange of information between competent authorities, but it also triggered a number of questions regarding the meaning of cooperative oversight, the practical implications for authorities, the necessary tools that need to be in place, the link with the authority’s management system, as well as the link with the existing SACA (Safety Assessment of Community Aircraft) program. The trial project was initiated to address these issues.’*

The UK CAA stated that its joint oversight with the CAA of the Czech Republic identified shortcomings in management structure, operational procedures and in the way the operator’s crew were trained, particularly in threat and error management principles. Although the oversight trial was completed once a programme to address these deficiencies had been agreed, the two NAAs continued to work together to secure further safety and compliance improvements by the operator. To retain its Foreign Carrier Permit the operator had to submit monthly updates and consequently the UK CAA learnt that the newly appointed FOM lacked, in its view, the appropriate experience, knowledge and authority to hold this post, while his deputy also had very little operational experience.

On 22 February 2017, representatives of the UK CAA met their Czech counterparts and requested that inspectors from the two NAAs perform a cooperative audit of the operator at IOM to confirm that safe operations could be guaranteed by the new management structure. The next day this serious incident occurred and, after informing the CAA of the Czech Republic, the UK CAA suspended the Foreign Carrier Permit and issued a Direction under the UK Air Navigation Order, instructing the operator to suspend UK Commercial Air Transport operations indefinitely.

Both NAAs agreed that a crosswind limit of 19.4 kt should have been applied for takeoff and landing. The CAA of the Czech Republic also stated this was the limit that was accounted for when the pilots’ type ratings were issued and it also noted the ground operation limit related to aircraft taxiing and was not a takeoff and landing limit.

#### *Isle of Man regulations*

The Isle of Man aviation regulations are contained in the Air Navigation (Isle of Man) Order 2015. The Isle of Man Civil Aviation Administration stated that Article 13(1) to the Order was applied when directing that the aircraft stop taxiing. This Article empowers the Administration to issue an operator with a directive:

*‘that an operation is prohibited, or must be limited or is subject to specified conditions, in the interests of safe operations.’*

A subsequent paragraph in the Article states, that the reason for issue of the directive, its applicability and duration and the action required by the operator must be given.

Rule 40 of the Rules of the Air Regulations which apply to the Isle of Man states:

*'An aircraft shall not taxi on the apron or the manoeuvring area of an aerodrome without the permission of either -*

*(a) the person in charge of the aerodrome; or*

*(b) the air traffic control unit or aerodrome flight information service unit notified as being on watch at the aerodrome.'*

Several UK CAPs have been adopted by the Isle of Man and this includes CAP 493 '*Manual of Air Traffic Service – Part 1*'. This states:

*'In order to execute his duties, an aerodrome controller has authority over aircraft, vehicles and personnel on the manoeuvring area and aircraft moving on the apron.'*

#### *EU regulations*

Regulation (EU) 216/2008, '*The Basic Regulation*' regarding flight preparation, states at Annex IV, paragraph 2.a.4:

*'Information regarding meteorological conditions for departure, destination and, where applicable, alternate aerodromes, as well as en route conditions, must be available to the flight crew. Special attention must be given to potentially hazardous atmospheric conditions.'*

Regulation (EU) 923/2012, '*The Standardised European Rules of the Air*' (SERA), stipulates certain preflight responsibilities for the pilot in command before a flight. At paragraph SERA.2010 (b) it states:

*'Before beginning a flight, the pilot-in-command of an aircraft shall become familiar with all available information appropriate to the intended operation. Pre-flight action for flights away from the vicinity of an aerodrome, and for all IFR flights, shall include a careful study of available current weather reports and forecasts, taking into consideration fuel requirements and an alternative course of action if the flight cannot be completed as planned.'*

Regulation (EU) 965/2012 on air operations refers to the selection of aerodromes at CAT.OP.MPA 180 and this states that any required, alternate aerodrome(s) are to be specified on the OFP.

The guidance material to CAT.OP.MPA.185 includes a table relating to the application of aerodrome forecasts for flight planning. Where a TAF or TREND indicates a deterioration, from one hour before until one hour after the estimated time of arrival at a destination or

destination alternate, and the change is prefixed BECMG, the mean wind forecast is to be considered relevant and gusts may be disregarded, from the start time of the change. Where a change is forecast as a probable, temporary change it may be disregarded.

### **Aircraft operator's initial report**

The operator carried out an internal investigation and produced an initial report which classified the occurrence as an *'incident'*. It identified a number of causal factors and laid out a corrective action plan. This report was prepared before the UK CAA suspended the Foreign Carrier Permit, causing the operator to cease IOM operations.

In view of the weather situation and especially considering the strong crosswind reported at BHD immediately before takeoff, the report noted that *'the decision to perform the flight could be disputed'*. It stated that the crew's assessment of the available weather data was *'too narrow'* and noted they did not consult *'other operational personnel in charge'*.

The report considered whether more fuel might have been carried, but noted that the operator's guidance to the crew for such circumstances was lacking. Having elected to fly an approach at BHD, the report endorsed the crew's decision to go around but indicated that with a relatively low fuel state, BFS might have been a better airport to divert to. Once en route to IOM, the wind at the surface increased above the operator's ground limit but the crew were committed to continuing due to the fuel state. However, the report acknowledged they could have declared a fuel emergency (an intention to land with less than final reserve fuel) and proceed to another suitable airport, such as Blackpool.

Because the operator's opinion was that the demonstrated crosswind figure was not limiting, the report concluded that the *'operation was legal'*, except for landing in a wind beyond the ground operation limit. It commended the piloting skills that led to a *'safe landing'*.

The corrective actions recommended in the initial report included a reassessment of the operator's wind limits for the aircraft and a review of crew training for IOM operations. Another recommendation was for the responsibilities of ground operations staff to be re-defined so as to better support flight crew preparation, decision making and associated liaison with the ticket-seller. It was also suggested that the operator needed to increase its compliance monitoring activity at IOM.

### **Aircraft operator's final report**

On 30 June 2017 the operator completed an internal investigation and wrote a final report which was passed to the CAA of the Czech Republic. This report recommended that crosswind limits shown in the OM be revised but it supported the crew's decision to operate the flight because *'they found themselves in a complicated situation due to inconsistent weather information'*. It highlighted the 0650 hrs IOM METAR, suggesting this made it reasonable to plan to use IOM as a diversion until 0850 hrs. The report did not mention the aircraft's departure time was 0810 hrs; making it likely the aircraft would arrive back at IOM later than 0850 hrs in the event of a diversion and that forecast weather conditions until one hour after such an arrival time had to be considered.

The final report concluded that the crew's final decision to land at IOM was '*reasonable*' but indicated there were deficiencies in threat and error management which required safety action.

#### *Aircraft operator's further comments*

The aircraft operator believed that the IOM METAR data, when viewed in retrospect, may have misled the crew. The operator noted the 0620 hrs and 0650 hrs reports assessed the wind was BECMG 310° at 17 kt, while the 0720 hrs report stated that the wind was from 250° at 33 G 47 kt but variable between 220° and 290° and with no significant change expected during the following two hours. The last METAR to be available before the aircraft departed was the 0750 hrs and this stated the wind was from 270° at 30 G 42 kt, with no wind-related trend forecast. Because these METARs were prepared after the 0455 hrs TAF, the operator suggested it was reasonable for the crew to rely on them rather than the TAF, for guidance on likely changes to the weather in the near-term. The operator referred to the UK AIP paragraph 4.2.9 (see *Meteorology - Isle of Man procedures*) and suggested this gave the crew authority to disregard the TAF in favour of a METAR issued at a later time.

Commenting on the past shortcomings identified by the CAA of the Czech Republic and UK CAAs in its crew's threat and error management, the operator stated that remedial training had been given to the pilots in December 2016.

The operator supported the crew's decision that led to the co-pilot handling the aircraft for the approach and landing.

#### **Previous occurrences**

##### *OK-UBA, Let L-410, IOM, 18 January 2007*

While taxiing at IOM, with a wind velocity from 260° at 37 G 57 kt, the right wing lifted and the left wingtip struck the ground, causing damage to the wingtip fuel tank. This was investigated by the AAIB and reported in Bulletin 8/2007. The aircraft operator subsequently imposed a maximum wind limit for ground operation<sup>19</sup>.

##### *IOM ATC Report, 30 December 2015*

A Mandatory Occurrence Report (MOR) was submitted to the Isle of Man Civil Aviation Administration after another of the aircraft operator's Let L-410s landed on Runway 21 when the reported wind velocity was from 210° at 45 G 65 kt. After landing the pilot shutdown the aircraft on a taxiway because of the strong wind. ATC filed the MOR knowing (from the AAIB's 2007 report) that a maximum wind limit of 45 kt applied for ground operation and because of concern for the safety of those on-board, while disembarking on an exposed taxiway in 65 kt gusts of wind.

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#### **Footnote**

<sup>19</sup> See *Wind limits*.

## EASA Safety Information Bulletin

In 2014 the EASA published a Safety Information Bulletin (SIB) titled '*Aeroplane Operations in Crosswind Conditions*'<sup>20</sup>. The SIB's objective is:

*'to raise awareness on the risks associated with operations in strong and/or gusty crosswind conditions, with the purpose of adding emphasis to the relevant portions of pilot training and providing flight crews with unambiguous information to support their decision making processes.'*

The SIB highlights a report by the German Federal Bureau of Aircraft Accidents Investigation (BFU) into a crosswind related serious incident<sup>21</sup> and also a study by the National Aerospace Laboratory of the Netherlands (NLR)<sup>22</sup> which associated gusty crosswinds (and also tailwinds) to wingtip strikes, tail strikes, hard landings and runway excursions.

One of the recommendations made by the SIB was:

*'Operators and training organisations should consider publishing operational crosswind limitations which take into account their operational experience and the operating environment (e.g. runway width and state, prevailing weather conditions, etc.). These limits should be based on the AFM maximum demonstrated crosswind value, when more limiting values are not published in the limitation section of the AFM. Operators should also carefully consider including the gust factor in the operating limitations, following the manufacturer's recommendations, if any.'*

## Analysis

The aircraft had diverted to IOM after an attempted landing at BHD, where strong winds and associated turbulence affected the approach, and the crew could have used their first nominated alternate airfield, which was nearby and where the wind was orientated close to the runway axis. After landing at IOM the right mainwheel lifted and RFFS witnesses estimated the left wingtip rolled to within approximately one metre of the runway surface.

### Wind limits

According to CS-23 an aircraft must be demonstrated to be safe for taxiing, takeoff and landing with a 90° '*cross-component of wind velocity*' that is not less than 20% of the stall speed with idle power and '*the highest 90° crosswind component tested satisfactorily should be put in the AFM as performance information. If the demonstrated crosswind is considered limiting, it should be introduced into Section 2 of the AFM.*' For this aircraft, Section 2 of the AFM, the '*Limitations*' section, stated the '*Maximum demonstrated*

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### Footnote

<sup>20</sup> EASA Safety Information Bulletin No 2014-20.

<sup>21</sup> BFU report 5X003-0/08 dated March 2010.

<sup>22</sup> The NLR study of *Near Ground Wind Gust Detection* can be found at <http://www.nlr-atsi.nl/downloads/analysis-of-existing-practices-and-issues-rega.pdf>

*component of crosswind* for *'dry and wet take-off and landing runways with pavement'* is 19.4 kt. The presence of this information in the Section 2 of the AFM and also in the *'Limitations'* section of the aircraft operator's OM implies that during test flying the maximum demonstrated crosswind was considered limiting.

Fifteen minutes before landing the crew were advised the wind was from 310° at a maximum of 53 kt, suggesting a crosswind component of 41 kt. When ATC provided landing clearance the reported wind was from 300° at 41 kt but gusting between 31 and 63 kt, meaning there was a maximum crosswind component for this landing of 40 kt, which is approximately twice the maximum demonstrated value for certification purposes.

The OM included the statement that with a 20 kt crosswind during takeoff *'lateral controllability on the ground was close to being limiting.'* Indeed, the OM contained no other guidance concerning handling the aircraft during crosswind takeoff and landings, nor concerning the value of crosswind gust factor to be taken into account when calculating the crosswind<sup>23</sup>, nor was there any recommendation concerning circumstances in which the maximum demonstrated crosswind might be exceeded. Additionally, the CAA of the Czech Republic stated that the maximum value of crosswind component accounted for when the pilots' type ratings were issued was the maximum demonstrated component (19.4 kt).

The SOP was for the ground operation limit to be applied to determine if an airfield was useable or not, even though this limit should only have applied to taxiing manoeuvres. Moreover, the guidance in the OM that an airfield is to be considered as *'below minimum'* at the planning stage if the steady crosswind exceeds the *'prescribed limitations'*, was not followed. Before takeoff, the IOM forecast, covering the period the aircraft might have had to divert back there, was for the surface wind to be from 310° at 33 G46 kt, meaning the crew should have assumed a crosswind component of 25 kt (disregarding the forecast gusts).

### *Meteorology*

The storm affecting the flight was named *'Storm Doris'* by the Met Office and severe turbulence and very strong winds were forecast at lower levels in the region. Destination and destination alternate airfields ought to have been chosen after study of the anticipated path of the storm and the available runway directions at various airfields. Study of the Met Office's F215 would have provided information concerning en route conditions and may have alerted the crew to certain hazardous atmospheric conditions eg occasional severe turbulence and, behind the frontal system, thunderstorms.

The aircraft operator rostered the crew's reporting time 30 minutes before the scheduled departure time. The crew downloaded the weather data 13 minutes before the reporting time, suggesting that they began their duty approximately 15 minutes before the rostered time, to have sufficient planning time before proceeding to the aircraft. This suggests that the 30 minutes between crew report time and departure that was approved by the CAA of the Czech Republic was insufficient for flight planning.

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### **Footnote**

<sup>23</sup> The EASA SIB 2014-20 recommends the full value of the crosswind gust factor be used.

Only six airfields appear to have been considered by the crew, with significant gaps in the data available from these airfields. No data was obtained for alternative airfields that were within reasonable flying time but further from the expected path of the storm, such as Prestwick.

When the flight was delayed, because the surface wind at IOM exceeded the ground operation limit, the crew had further time available for planning. They obtained updated reports for the same six airfields, but did not consult the FOM or OCC or discuss the situation with the forecaster at Ronaldsway Met Office.

According to the aircraft operator's final report, the crew referred to the IOM METAR's in preference to the valid TAF before finally deciding to operate the flight. However the AIP states that a new forecast cancels '*any forecast of the same type*', so a METAR does not cancel a TAF. Furthermore, the AIP states '*The Aerodrome Forecast (TAF) is the primary method of providing the forecast weather information that pilots require about an airfield*'.

A METAR TREND only forecasts changes that are expected in the two hour period following the observation, therefore the TAF was the only forecast available before departure which was valid for the time period specified in the OM.

The aircraft operator's initial report concluded that it was questionable if the flight should have departed in the forecast conditions, and that the crew made '*too narrow*' an assessment of the available weather data, with insufficient support from the operator. TAFs and METARs appear to have been the only meteorological information the crew considered before the flight.

#### *Flight to BHD*

The aircraft operator's initial report appropriately questioned the decision to continue the flight when it was known there was a crosswind of 31 kt gusting to 46 kt at BHD and that no other aircraft were moving at that airport. Severe turbulence was forecast at low level between IOM and BHD and the crew would have been aware of this had they studied the relevant Met Office chart.

The aircraft took off from IOM with a crosswind component of 20 kt and later made an approach to BHD in a crosswind that was gusting to 43 kt. Continuous moderate turbulence was experienced during the approach and at all times the reported wind significantly exceeded the maximum demonstrated crosswind component by a significant margin. The conditions were such that usually it would be expected that a go-around be initiated earlier than the reported height of approximately 20 ft above the runway.

Although the crew stated afterwards that they considered BFS to be their primary alternate airfield, they did not ask ATC for an update on the BFS weather before heading back towards IOM. This indicates that either they did not fully appreciate the synoptic situation, with the wind at IOM likely to veer and increase above that experienced on departure (as forecast by the TAF), or that they were too focussed on IOM as their preferred alternate airfield.

The commander's statement after the flight that he considered the winds at BFS and IOM to be "similar" indicates that he did not give due consideration to the orientation of the runways. The mean wind forecast at BFS was 33 kt and aligned close to the axis of an available runway, while the mean wind forecast at IOM was of a similar strength but from 50° right of an available runway orientation. Also, BFS was the airfield the crew said was their planned primary alternate, as well as being the ticket-seller's preferred commercial alternate, and the mean wind there was not forecast to exceed the aircraft operator's ground limit.

The crew's focus on returning to IOM indicates they formed a mental or cognitive bias towards returning there after deciding to show it as the only alternate airfield on the OFP.

### *Return to IOM*

During the flight back to IOM the crew learnt that the surface wind was now from 310° at 41 kt and gusting between 22 and 53 kt<sup>24</sup>. The CVR indicates they did not discuss the threats this could pose or consider any alternative courses of action, which suggests that they did not regard this as a significant safety threat. However, the lack of any relevant exchange between the two pilots is at odds with the operator's policy of keeping each other 'in the loop', to ensure a shared mental model, which is essential to achieve good CRM. It also indicates that the threat and error management training given to the crews in response to the concerns of the CAA of the Czech Republic and UK CAA in 2016 may not have been effective.

If the crew had discussed the problem they might have generated some alternative options. With only 300 kg of fuel remaining, their options were limited but, if they had received effective CRM training, they ought to have considered and discussed all possibilities, such as diverting elsewhere, even if this meant declaring a fuel emergency (an intention to land with less than final reserve fuel remaining). The co-pilot stated afterwards that they continued towards a "briefed, challenging crosswind landing" but the CVR did not record them discussing the challenges and they did not talk about the threats posed by the wind when it changed first from 290° at 28 kt to 310° at up to 53 kt or when it increased further and gusted to 63 kt, which was greater than forecast.

No discussion took place between the crew concerning the potential effect that a crosswind of 40 kt or greater might have when the aircraft touched down. The OM states that with 20 kt of crosswind, lateral control is considered 'limiting' during takeoff, so it might have been appropriate to discuss the effects of a strong crosswind between themselves and also to warn ATC of a potential difficulty. In fact ATC was aware that the aircraft was landing with a wind velocity that considerably exceeded the operator's ground limit and took the precaution of having the RFFS on standby for the landing.

### *Approach stabilisation*

The approach was made in IMC until the crew reported becoming visual with the runway at 600 ft aal. The adjusted  $V_{REF}$  used by the crew was 105 KIAS, the maximum speed at

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#### **Footnote**

<sup>24</sup> A wind of 310° at 53 kt for Runway 26 represents a crosswind of 41 kt.

1,000 ft and below for a stabilised approach was therefore 125 KIAS and the target speed to cross the threshold was 115 KIAS. The recorded data shows the airspeed varied between a minimum of 107 KIAS and a maximum of 148 KIAS during the final approach. There were therefore exceedences of the limiting speed of 135 kt for the landing gear and for the flaps set to 18°, as well as exceedence of the 125 KIAS stable approach speed.

On three occasions during the approach the aircraft deviated below the glideslope causing 'GLIDESLOPE' cautions to be annunciated by the EGPWS. The PF responded to these by declaring he was "CORRECTING", an action first taken slightly below 1,000 ft aal, in IMC, which led to the aircraft climbing 100 ft while the airspeed fluctuated by 33 KIAS. To be considered stable the desired approach path has to be maintained using only small adjustments to heading or pitch and the airspeed should be maintained between  $V_{REF}$  and  $V_{REF} + 20$  KIAS. The PNF is required to inform the PF if the approach is not stable and the PF is then to initiate a go-around, but the PNF said nothing in response to the glideslope deviation or the speed fluctuations.

The final 'GLIDESLOPE' caution was annunciated below 500 ft aal, the PF responded with "CORRECTING, RUNWAY IN SIGHT" and the flight data shows a correction to the glideslope was made. This action is consistent with the OM which indicates the caution can be ignored below 500 ft aal by day, with the runway in sight.

#### *Fuel considerations*

At the start of the flight there was 550 kg of fuel on the aircraft and the crew believed they required a minimum of 453 kg, so they were carrying 97 kg of extra fuel. However, if the required contingency fuel of 50 kg had been accounted for, rather than the 25 kg actually accounted for, then the crew would have calculated that they had 72 kg of extra fuel on-board, enough for approximately 14 minutes of flight.

During the flight 330 kg of fuel was burnt and this was 53 kg more than the OFP predicted<sup>25</sup>. It is likely this additional fuel was burnt during the missed approach at BHD and while manoeuvring for the approach to IOM, as neither of these portions of the flight were accounted for in the OFP figures. If this additional 53 kg had been allowed for and the correct contingency fuel included, the OFP would have shown a minimum required fuel for the sector of 531 kg, meaning that there was actually 19 kg of extra fuel on board, and not 97 kg. 19 kg of fuel would be enough for approximately 4 minutes of flight.

The aircraft operator's initial report noted that the OM lacks guidance on the carriage of extra fuel when operating in a region where widespread weather issues are forecast. This crew would have been better placed if they had taken enough fuel to allow a diversion to an airfield beyond the direct path of the storm and, if additional fuel had been carried, they would have had more options available when the wind at IOM increased and veered.

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#### **Footnote**

<sup>25</sup> 550 kg of fuel was on-board and 220 kg was recorded at shutdown, so 330 kg was used. The OFP predicted 195 kg for the taxi out and the flight to BHD and 82 kg for the diversion to IOM;  $330 - 195 - 82 = 53$  kg of additional fuel burnt.

### *Arrival at IOM*

There was credible witness evidence that the aircraft rolled considerably as it approached the runway and that the right mainwheel lifted off the ground after touchdown, causing the left wingtip to roll to within one metre of the runway surface. The crew did not know the wheel lifted or observe the ground clearance of the wingtip but the co-pilot was sufficiently concerned to state 'TOO MUCH ROLL'. It is therefore apparent that lateral control difficulties were experienced while landing due to the very strong, gusting crosswind.

Immediately after landing, the crew began to taxi the aircraft in a wind which exceeded the ground operation limit of 45 kt; the steady wind speed was 47 kt and with the addition of half of the gust factor the total applicable wind was 55 kt. This suggests the crew were not fully aware of the risk that the lightly loaded aircraft might be blown onto its wingtip, even though this had happened to another of the same operator's aircraft at IOM in 2007, in lighter winds. IOM ATC and the IOM Civil Aviation Administration knew about the previous accident and were concerned for the safety of those on board this aircraft.

The aircraft required ATC permission to taxi on the manoeuvring area and this permission was withdrawn when ATC passed on the directive from the IOM Civil Aviation Administration, which brought the aircraft to a halt into wind. The aerodrome controller has authority over an aircraft on the ground and although the directive from the IOM Civil Aviation Administration for the aircraft to cease taxiing may be unusual, it was apparently made with the aim of preventing an accident.

### **Conclusion**

The prime causal factor in this serious incident was the decision to land with a maximum crosswind component of 40 kt<sup>26</sup>, which is approximately twice the maximum demonstrated certification value of 19.4 kt. In the view of the aircraft operator, there was no specific crosswind limit the crew needed to consider when deciding whether to operate the service or not. However, the OM Part A refers to a crosswind limit when it states:

*'For planning purposes an aerodrome shall be considered below minimum if the steady crosswind exceeds the prescribed limitations.'*

and other evidence from the AFM and the OM indicates that the maximum demonstrated crosswind component of 19.4 kt was limiting.

Several contributory factors were also apparent:

- 1) By only studying weather reports for six airfields and without referring to any meteorology charts, the crew had insufficient information to assess the prevailing weather conditions en route and the storm's path.

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### **Footnote**

<sup>26</sup> When ATC provided landing clearance the reported wind was from 300° at 41 kt, but gusting between 31 and 63 kt giving a maximum crosswind component for of 40 kt.

- 2) The aircraft operator believed that a valid TAF could be disregarded upon the subsequent issue of a METAR that included a TREND forecast.
- 3) The aircraft operator did not provide adequate oversight to a flight in airspace affected by this storm. The commander did not refer to the available weather forecast charts and neither the OCC nor the FOM reviewed the situation with him, or suggested he seek guidance from the duty forecaster.
- 4) The fuel figures presented on the OFP did not account for the correct level of contingency fuel and did not allow for a realistic alternate routing. The aircraft had sufficient fuel for the sector, but the crew did not have as much extra fuel on-board as they believed they had, and the OM offered little guidance on the carriage of extra fuel when there was a possibility of widespread, adverse weather conditions.
- 5) The OFP only showed navigational and fuel information for the second of two selected alternates. However, the two Belfast airports are in close proximity so the lack of navigational information for the routing to the first alternate may not have been problematic in this instance.
- 6) The CVR evidence, that evolving threats did not precipitate verbal discussion between the pilots, indicates they had not been effectively trained in respect to CRM, and to threat management in particular. The OM appeared to lack guidance concerning the evaluation and management of threats, problem solving and decision making.
- 7) The approach became unstable before visual flight conditions were achieved, but the crew did not discuss this, and the required SOPs were not followed.
- 8) The limiting airspeed for flight with gear down and for flight with flaps extended was exceeded but no corrective action was taken.
- 9) The crew began taxiing the aircraft in a wind which was stronger than the wind which blew a similar aircraft onto its wingtip at IOM in 2007 and which exceeded the ground operation limit introduced after the 2007 accident.

### **Safety actions and Recommendation**

As a result of this serious incident the CAA of the Czech Republic stated that several safety actions have been completed, including:

1. The aircraft operator has increased the time allocated between crew report and the scheduled departure time to 60 minutes and incorporated this in OM Part A.
2. The aircraft operator has updated the crosswind limits in OM Part B. No details of the changes have been provided except a statement that the OM now offers guidance for taking off and landing in a crosswind, and that the EASA SIB 2014-20 has been taken into account.

3. The CAA of the Czech Republic has also stated that recent audits of the aircraft operator have focussed on hazard identification and safety risk management, with particular focus on operations in hazardous weather conditions.

These safety actions address some of the factors identified in this report but there appear to be a number of issues concerning operational control and supervision which still require attention. While this investigation highlighted certain of the operator's policies and procedures which did not comply with regulatory requirements, it is possible that there are areas outside the scope of this investigation that may also require review. To ensure that the aircraft operator's processes and procedures are effectively compliant with the applicable regulations the following safety recommendation is made:

**Safety Recommendation 2018-005**

It is recommended that the Civil Aviation Authority of the Czech Republic review Van Air's operational processes, training and operator's guidance to ensure that they are effectively compliant with the applicable regulations for commercial air transport operations.

**SERIOUS INCIDENT**

<b>Aircraft Type and Registration:</b>	Saab-Scania SF340B, G-LGNB	
<b>No &amp; Type of Engines:</b>	2 General Electric Co CT7-9B turboprop engines	
<b>Year of Manufacture:</b>	1990 (Serial no: 340B-216)	
<b>Date &amp; Time (UTC):</b>	5 June 2017 at 1415 hrs	
<b>Location:</b>	During climb after departure from Edinburgh Airport	
<b>Type of Flight:</b>	Commercial Air Transport (Passenger)	
<b>Persons on Board:</b>	Crew - 3	Passengers - 33
<b>Injuries:</b>	Crew - None	Passengers - None
<b>Nature of Damage:</b>	None	
<b>Commander's Licence:</b>	Airline Transport Pilot's Licence	
<b>Commander's Age:</b>	34 years	
<b>Commander's Flying Experience:</b>	6,638 hours (of which 6,387 were on type) Last 90 days - 109 hours Last 28 days - 49 hours	
<b>Information Source:</b>	AAIB Field Investigation	

**Synopsis**

During the climb after departure from Edinburgh Airport, the aircraft encountered severe icing and turbulence. During this period the stick shaker activated three times, before the aircraft descended to regain airspeed. After flying clear of the icing conditions and the area of turbulence, the aircraft continued to the destination without further incident.

**History of the flight**

The aircraft took off from Edinburgh Airport at 1402 hrs for a scheduled passenger flight to Sumburgh Airport. The weather forecast showed an occluded front lying to the north of Edinburgh which was moving north-east. There was also an upper level warm front parallel to the occluded front<sup>1</sup>. These fronts brought some rain showers with isolated embedded cumulonimbus clouds in the area around Edinburgh and the initial part of the route north towards Sumburgh.

In the climb out from Edinburgh, the aircraft encountered light turbulence in cloud. With the autopilot engaged the aircraft starting pitching up and down to maintain the selected IAS. Suddenly the turbulence intensified and ice began to form quickly on the aircraft. The stick shaker activated and the autopilot disconnected. The co-pilot, who was pilot

**Footnote**

<sup>1</sup> Figures 3 and 4 show the detail of the weather forecast.

flying (PF), attempted to accelerate the aircraft by reducing the pitch attitude. He then re-engaged the autopilot but, after 13 seconds, the stick shaker activated again and the autopilot disconnected. Shortly afterwards, the stick shaker activated for a third time and the co-pilot began a descent to accelerate the aircraft. The aircraft lost around 500ft during the manoeuvre during which it accelerated and recovered to normal flight. The crew did not select maximum continuous power during the recovery.

### Recorded information

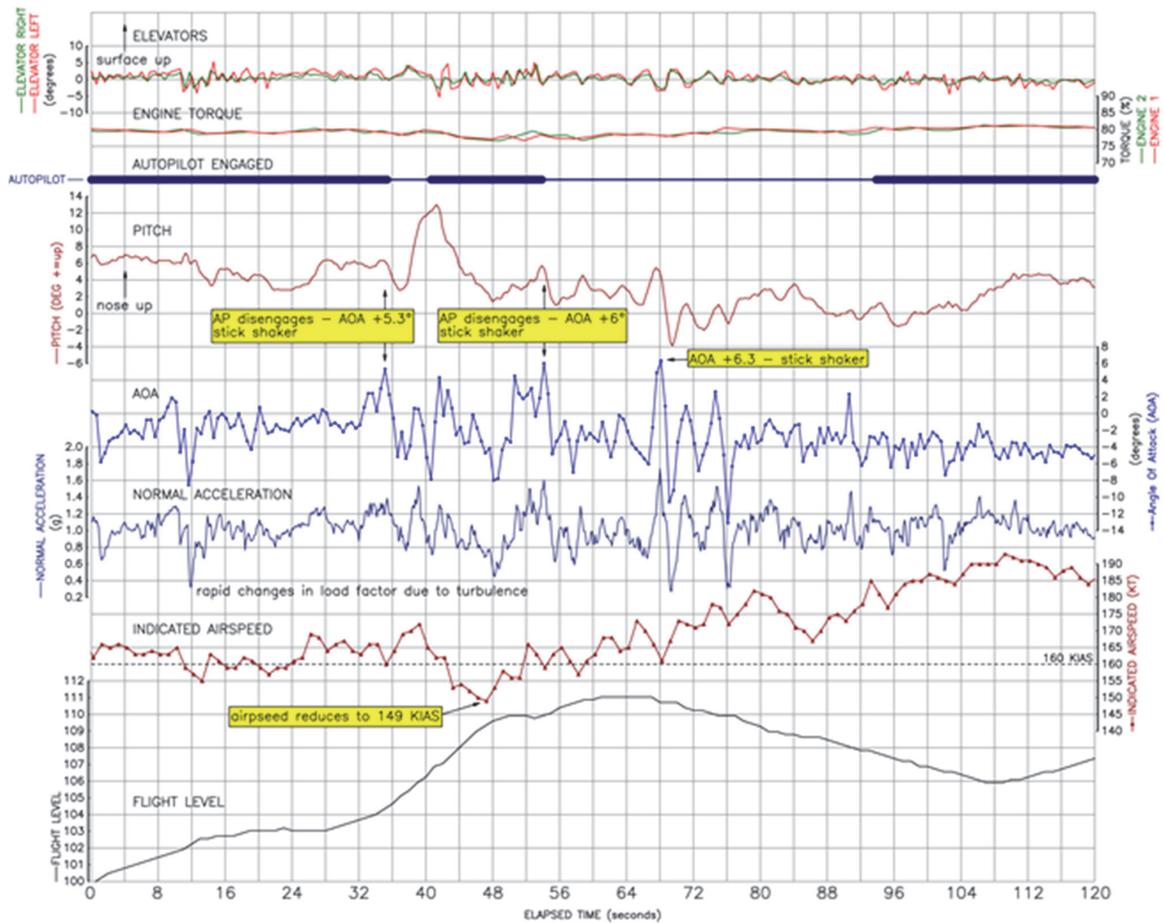
Recorded data for the incident flight was available from the aircraft's FDR. Information from the CVR was not available as it had been overwritten. Salient parameters from the FDR included the engagement status of the autopilot system, angle of attack (AOA), normal acceleration, pitch attitude, and parameters to derive engine power. The AOA parameter is recorded at a rate of twice per second and therefore the peak value may not always be recorded. No parameters are recorded on the FDR regarding the activation of the stall warning system.

Figure 1 shows salient parameters during the period when the aircraft experienced an increase in turbulence during the climb and the autopilot disconnected.

About eight minutes after takeoff, as the aircraft climbed through FL100, perturbations of normal acceleration started to increase, consistent with the aircraft encountering light turbulence. The OAT was  $-5^{\circ}\text{C}$ . The turbulence then continued to increase in intensity, with variations in AOA that closely correlated with changes in load factor, pitch attitude and airspeed; the average airspeed was 162 KIAS at this time. The aircraft then briefly levelled off at FL103, before climbing again. Shortly afterwards, the AOA increased rapidly over one second from just over  $0^{\circ}$  to a recorded value of  $+5.3^{\circ}$ , which coincided with the autopilot disconnecting; the airspeed was 160 KIAS and the pitch attitude was  $6.3^{\circ}$  nose-up. The coincident disconnection of the autopilot meant that the peak AOA value was in excess of the  $5.3^{\circ}$  recorded.

The pitch attitude then reduced quickly to  $2.8^{\circ}$  nose-up, before increasing to  $13^{\circ}$  nose-up in four seconds. During this period, the recorded AOA also varied rapidly, reducing to a minimum of  $-7^{\circ}$ . The autopilot was then re-engaged and the pitch attitude reduced to about  $2^{\circ}$  nose-up. The airspeed reduced to 149 KIAS, after which it started to increase towards 160 KIAS.

Thirteen seconds later the aircraft pitched up quickly to  $5.6^{\circ}$ , the recorded AOA also increased rapidly, reaching a recorded  $6^{\circ}$ , and the autopilot disconnected again; the airspeed was 159 KIAS. The aircraft then briefly levelled off, during which the pitch and AOA both increased rapidly again, with the recorded AOA peaking at  $6.3^{\circ}$ . The aircraft then descended about 500 ft to FL105, during which the airspeed progressively increased to about 190 KIAS. At no time during this period of the flight was engine power increased to the 'maximum continuous' setting. The autopilot was then re-engaged, which coincided with a reduction in turbulence, and the aircraft climbed to its cruise altitude of FL170.



**Figure 1**

FDR data overview of event

#### *Analysis of FDR data by the aircraft manufacturer*

The FDR data was provided to the aircraft manufacturer for analysis. It was concluded that the rapid changes in pitch attitude and AOA were caused by turbulence. The aircraft did not enter an aerodynamic stall at any point, and the activation of the stall warning system was triggered by the AOA threshold being momentarily exceeded.

#### *Flight Data Monitoring (FDM) data review*

The aircraft operator reviewed its FDM data archive for its fleet of Saab-Scania SF340B (Saab340) aircraft. At the request of the AAIB, the data was analysed for occurrences when the autopilot disconnected coincidentally with the recorded value of the AOA being greater than  $5^{\circ}$ . Between June 2015 and June 2017, a total of 23 occurrences were identified. Analysis of these indicated that, on 16 occasions, the autopilot had probably disconnected automatically due to the aircraft entering turbulence that resulted in the AOA exceeding the stall warning system trigger threshold with the anti-ice system selected ON.

The operator introduced a new FDM event which identifies when the autopilot disconnects due to AOA exceedences.

## Aircraft information

The Saab340 is a twin-turboprop aircraft which can seat up to 36 passengers.

### *Ice protection systems*

The Saab340 is fully equipped for all-weather operations. It has wing and stabilizer de-icing<sup>2</sup>, engine and propeller de-icing, and heating for the windshield, outside air temperature probe and AOA sensor. Bleed air is used for the wing and stabilizer boots<sup>3</sup>, and the engine intake. Electrical power is used for the remainder of the ice protection system.

### *Weather Radar*

The Saab340 is equipped with a weather radar which transmits focused microwave pulses which are reflected by any moisture present in clouds in front of the aircraft. The amount the pulses are reflected back to the receiver gives a measure of the amount of moisture present. This information is then presented to the flight crew using different colours to represent the level of moisture.

Weather radars can provide useful information about potentially hazardous flight conditions. The most hazardous flight conditions are mostly concerned with hail and turbulence. Whilst the weather radar can detect wet hail, it cannot detect turbulence that is not associated with moisture (such as clear air turbulence or wind shear). The radar also has limitations in how well it can detect weather beyond areas of heavy rain due to the inability of the microwave pulses to penetrate beyond the rain. This means that more distant targets may appear less intense than they really are or may not appear at all. The weather radar controls include the ability to change its range, tilt and gain. This allows the flight crew to adjust the radar for optimum display of weather that may be on their path.

### *Stall warning system*

The Saab340 is fitted with a dual channel stall warning system which provides the crew with five distinct warnings of an impending stall. The aircraft has a stick shaker channel for each control column which provides a physical warning in the form of vibration, and this is reinforced with an aural warning in the form of a continuous clacker. At the same time as the stick shaker activates, the autopilot disengages. If sufficient action is not taken after the stick shaker and aural warning are triggered, the stick push system provides a forward movement of the control columns to pitch the aircraft to a slightly nose-down attitude. If the stick push activates, visual warnings on the central warning panel and on the instruments panels also illuminate. The stall warning is generated by a combination of AOA, flap position and information from the wing anti-ice system.

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## Footnote

<sup>2</sup> De-icing: Removal of ice accretion by thermal, mechanical or chemical means.

<sup>3</sup> Boots: Flat array of flexible tubes bonded to the leading edge of wings, fins and other aircraft surfaces to break up ice.

### *History of modification*

Due to incidents within the worldwide fleet of the Saab340, in which the aircraft encountered a stall without any prior stall warning, the manufacturer developed a modified stall warning system which incorporated an improved stall warning logic. Fitment was mandated in 2014, with operators given 18 months to complete the fitment of the new stall warning computer.

### *Ice Speed modification*

The modification to the stall warning computer adjusted the logic of the stick shaker and introduced the Ice Speed system. This increased the stall warning speed trigger levels to compensate for possible ice accretion on the wings. The trigger AOA for the stick shaker activation was lowered from 12.1° to 5.9° but the stick push logic remained unchanged. This Ice Speed function is activated by switching on the engine anti-ice system. It remains activated even when the engine anti-ice system is selected off because a separate ICE SPEED switch must be additionally selected OFF. The engine anti-ice system must remain on for five minutes after exiting icing conditions. Any time the Ice Speed system is active, the aircraft speed on approach must be increased in order to maintain the margin over the stick shaker activation AOA.

### *Stick shaker event history*

The Ice Speed system has presented a challenge to operators of the Saab340, especially if operating into performance-limiting runways. The additional 10 kt of airspeed required for the approach, if the Ice Speed system is active, when added to any wind correction can lead to a high approach speed limiting the payload on some shorter runways. This higher approach speed also means the aircraft often makes the approach with a relatively low nose attitude, which is unusual for the flight crew.

Analysis of Saab340 stick shaker events reported to the CAA via the MOR<sup>4</sup> system revealed that, after the introduction of the stall warning modification, the number of reported events increased from an average of 3.8 per year between 2010 and 2014 to 22 in 2015, 42 in 2016 and 35 in 2017 (Figure 2). These events were particularly prevalent in the approach and landing phase of flight.

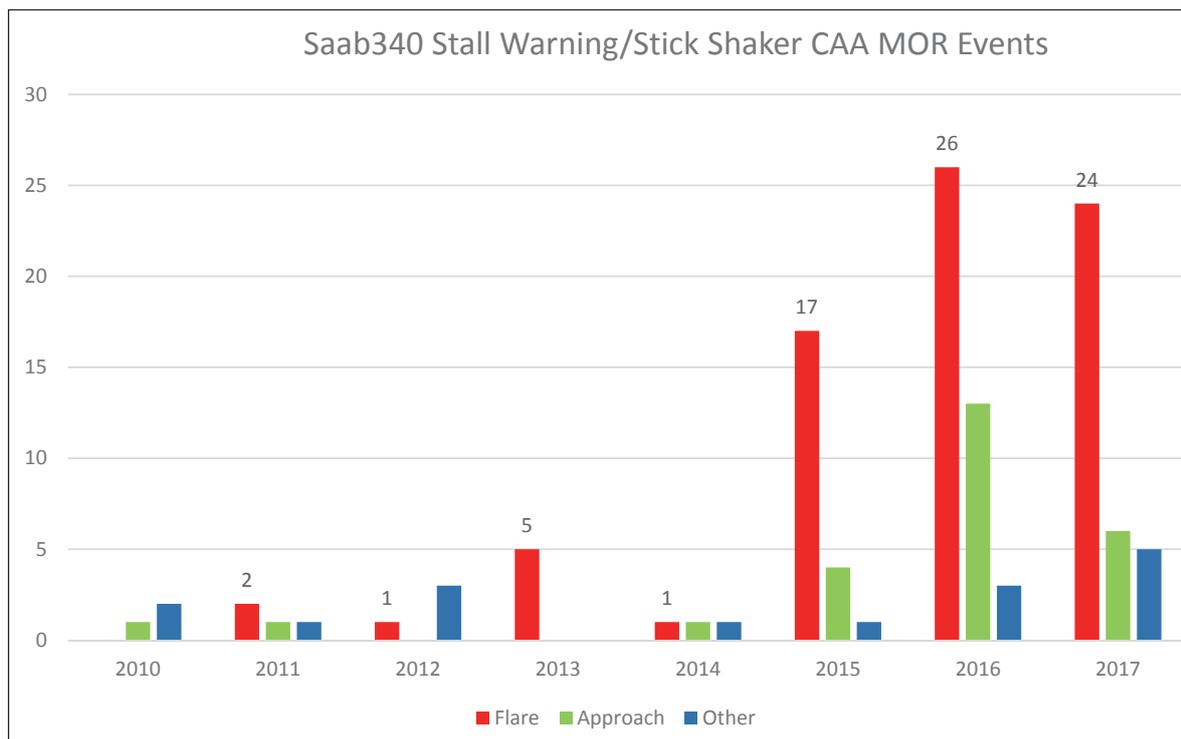
The operator believed that this increase in events was directly related to the requirements of the stall warning computer modification and the trigger AOA being significantly lower than before. If the aircraft is in turbulence, or there is a sudden gust of wind at touchdown, the pitch of the aircraft can alter rapidly, triggering the stick shaker.

EASA requested that the manufacturer review the system architecture and logic to look for any possible adaptation which would address the safety concerns associated with the repeated warnings.

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#### **Footnote**

<sup>4</sup> MOR: Mandatory Occurrence Report, An occurrence means any safety-related event which endangers or which, if not corrected or addressed, could endanger an aircraft, its occupants or any other person



**Figure 2**

Saab340 Stall Warning/Stick Shaker CAA MOR Events 2010 to 2017

## Aircraft performance

### *Autopilot mode*

G-LGNB was climbing in IAS mode in which the flight control computers adjust the pitch attitude of the aircraft in order to maintain the selected IAS. The mode was engaged with an IAS of 163 kt.

### *Event trigger*

The stick shaker was triggered three times by the aircraft AOA reaching 5.9°. The aircraft was in turbulence with the pitch and IAS of the aircraft varying.

## Meteorology

### *Aftercast*

An aftercast, obtained from the Met Office, showed that the weather in both Edinburgh and Sumburgh was affected by the presence of an occluded front lying just to the north of Edinburgh, moving eastwards. There was also a warm front lying parallel to the occlusion. Visibility outside the cloud was good but there were isolated moderate or heavy showers. There were also isolated, embedded cumulonimbus clouds (CBs) with bases from 1,500 to 3,000ft amsl and tops above 10,000ft. Freezing levels were between 4,000 and 5,000ft amsl.

Hi-resolution satellite images taken at 1500 hrs showed a large amount of stratus or fog in the area of the event. Areas of brighter/white cloud on the images indicated the presence of embedded CBs and this was confirmed by both the rainfall radar images and observations in Edinburgh, where large hail stones were recorded at 1220 hrs.

The Met Office assessed that, between 1300 hrs and 1500 hrs, there was a high probability of severe icing on the route, with the risk decreasing during the afternoon to a high probability of light or moderate icing by 1500 hrs.

#### Information available to the crew

The crew received a briefing pack when they reported for duty. This pack included the route, NOTAMS, weather at departure and destination as well as charts of wind, weather and temperature along the intended route. The Met Office chart F215 details the weather in the UK below 10,000ft. The chart for 0800 hrs to 1700 hrs issued on the day of the incident is shown at Figure 3.

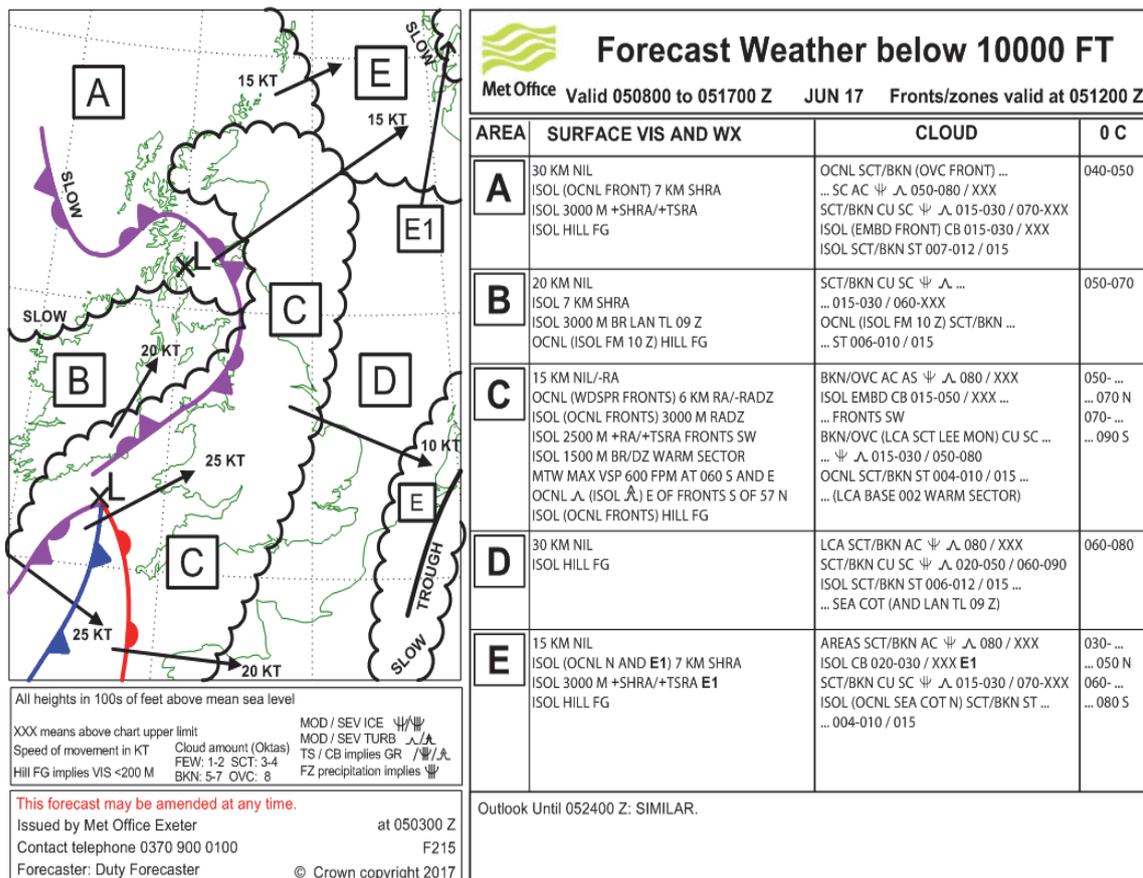


Figure 3

Chart F215 Valid 1200UTC on 5 June 2017 produced by the UK Met Office

The crew received a significant weather chart which was supplied by the operator's flight planning contractor. This chart shows weather which may have affected the aircraft such as icing, turbulence or CB activity from FL100 to FL450. Although the chart the crew had

access to was not produced by the UK Met Office, it was generated from the data supplied by them. Figure 4 shows the Met Office chart for 5 June 2017.

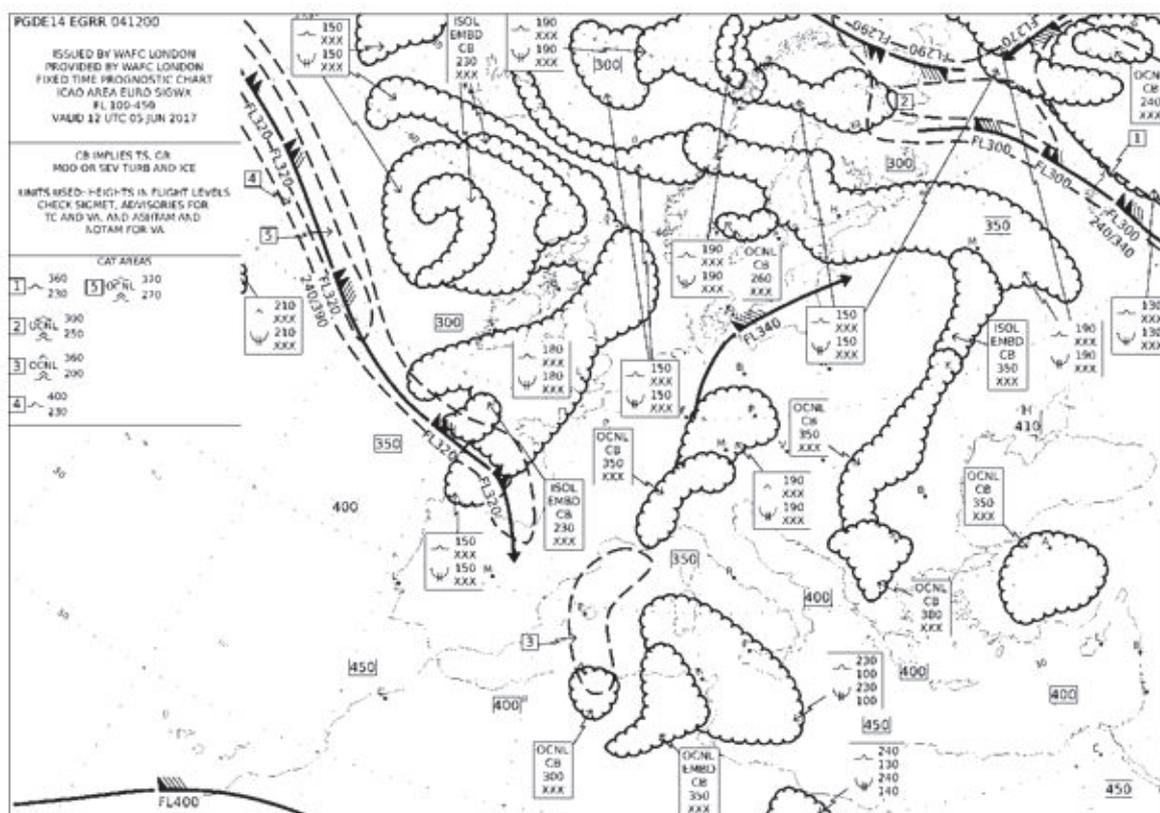


Figure 4

Significant Weather Chart Valid 1200UTC on 5 June 2017 supplied by the UK Met Office

### *Icing conditions definitions*

Aeronautical terms for describing icing intensity are ‘trace’, ‘light’, ‘moderate’ and ‘severe’ yet there are no internationally accepted definitions of these terms. Different aircraft types may experience ice accumulation differently in the same conditions due to their different anti-icing and de-icing equipment as well as their individual propensity to pick up ice on wings and structures.

The UK Aeronautical Information Publication (AIP) gives information for the reporting of icing levels by pilots. It states that ‘moderate’ icing is when:

*‘The rate of accumulation is such that even short encounters become potentially hazardous and the use of de-icing/anti-icing equipment, or diversion, is necessary.’*

For ‘severe’ icing:

*‘The rate of accumulation is such that de-icing/anti-icing equipment fails to reduce or control the hazard. Immediate diversion is necessary.’*

The term 'diversion' in this context implies diverting from intending routing including changing speed, height or heading.

The Met Office does not define icing conditions absolutely but considers the many different factors in preparing forecasts of icing conditions such as type, depth and extent of cloud, temperature and relative humidity. It also appreciates that aircraft have differing levels of susceptibility to icing.

## Procedures

The manufacturer produces an Aircraft Operations Manual (AOM) which contains the technical details of the type, as well as operations procedures for normal, abnormal and emergency situations. The operator has the abnormal and emergency procedures reproduced in booklet form and available in the flight deck for each pilot as an Emergency and Abnormal Checklist (EAC).

The operator produces a suite of Operations Manuals (OM) which contain the information flight crews require. Part A (OMA) is non type-specific and contains policies, instructions and procedures for the operator. Part B (OMB) is type-specific and contains information to supplement the AOM. The AOM is the definitive source of information and the aircraft should be operated in accordance with the AOM unless OMB specifically states otherwise.

### *Flight in icing conditions*

The AOM Section 25, '*Flight Procedures*', has a section on icing conditions. It specifies the use of IAS mode when the engine anti-ice is selected ON with a general rule of a minimum speed of 160 KIAS. It describes specific situations and limitations for when the speed may be reduced below 160 KIAS in order to exit severe icing conditions. These limitations include the selection of maximum power and limiting the bank angle to less than 15° below 160 KIAS.

In OMB the operator sets out the '*Minimum Operating Airspeeds in Icing Conditions*' within the limitations section. This section describes  $V_{CM}$  which is the '*conservative manoeuvring*' speed to be used when climbing above minimum safe altitude. In the clean configuration this speed is 160 KIAS. If there is a significant performance loss, and a slower speed is required to exit icing conditions, then the autopilot must be disengaged and the speed may be reduced to  $V_{CLEAN} + 15$ . Maximum continuous power must be selected until  $V_{CM}$  can be re-established. OMB describes reducing speed below  $V_{CM}$  as a '*Non-standard situation and the risk of this action [must be] assessed.*'

### *Flight in turbulence*

The AOM describes the likelihood of a transient stall warning being generated due to sudden movement of the AOA vane when the Ice Speed system is active and the aircraft is experiencing moderate to severe turbulence. It states that momentary warnings (one second or less) can be disregarded if it is confirmed that the aircraft is at a safe speed and altitude. It suggests that under all circumstances it would be advisable to increase the speed when encountering more than light turbulence but not to a value above the turbulence

penetration speed<sup>5</sup> of 190 KIAS, up to 21,000ft, and V<sub>mo</sub>-30 kt above. This increase in speed means there will be a greater margin over the stick shaker trigger AOA and makes a transient warning less likely.

#### *Response to reducing airspeed and the stick shaker*

In the AOM, Saab makes the following statement:

*'If experiencing severe icing conditions and safe speed and/or climb rate cannot be maintained, do not hesitate to temporarily set TAKEOFF PWR/ MAX CONTINUOUS PWR, if that is required to escape from the situation. Severe icing conditions do not necessarily imply a large amount of ice but ice accumulation causing a large impact on performance making airspeed decrease towards the minimum safe speed in icing conditions.'*

The operator's OMB emphasises not to delay any request to descend when the aircraft is experiencing difficulty maintaining airspeed:

*'Speed can reduce at a rate of 1 knot per second or more in severe icing with cruise power set. If severe icing is encountered it may take less than 20 seconds for airspeed to reduce from 180 knots to 160 knots. Typically it takes around 30 seconds to request and initiate a descent from ATC, if there is no traffic.'*

The recovery procedure from a stall warning or a stall is not listed in the Abnormal or Emergency checklists, it is in the Flight Procedures Training section of the AOM. It states:

*'- CALL: "STALL - MAX POWER"*

*- PITCH: Immediately decrease the pitch by approximately 5 degrees or as commanded by the stick pusher. Do not fight the pusher stroke. Do not hesitate to trade altitude for speed, however, avoid unnecessary dive.*

*- SPEED: Accelerate to minimum  $V_{clean} +5$ , with ice on the wing  $V_{clean} +15$ . After initial recovery, do not pull up with too high rate. Consider the possibility for a secondary stall.*

*- ALTITUDE: When positive climb rate is indicated, select gear up and recover altitude loss. Climb to safe altitude with  $V_{clean} +5$ , with ice on the wing  $V_{clean} +15$*

*- FLAPS: If flaps are down, leave them where they are. However, if in landing configuration, after the initial recovery and in climb, select flaps (7/20 as for go-around).'*

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#### Footnote

<sup>5</sup> Turbulence penetration speed: maximum speed at which a gust will not overly stress the aircraft.

### *Training*

Both flight crew received training in stall identification and recovery during their conversion to type. The commander had also received refresher training as part of the operator's recurrent training programme where stalling featured as one of the abnormal/emergency scenarios. The co-pilot had very recently completed his conversion to type and had yet to undergo any recurrent simulator training. His training was therefore only that which he received on his conversion.

### *Crew comments*

The crew said that stick shaker activation is a reasonably regular occurrence on the Saab340 with the operator of G-LGNB. This is because of a combination of the frequency with which the engine anti-ice is used on the approach and the relatively short length of some of the runways into which the aircraft operate. Pilots often discuss the possibility even if they have yet to encounter it themselves.

The incident crew commented that they were fully aware of the stall procedures. However, the lack of the trigger call "Stall – Max Power" from either pilot in response to the stall warning meant neither recognised the situation as one which required the actions listed above. They also noted how quickly the ice built up on the aircraft. The commander had encountered the stick shaker on previous flights.

## **Analysis**

### *Icing condition encounter*

The aircraft encountered icing on departure from Edinburgh Airport. The severity and extent of ice accumulation on the upper wing surface led to a significant performance loss, which meant the aircraft was unable to maintain the selected airspeed at the aircraft altitude and a descent was necessary to regain lost airspeed. This level of icing would match the UK AIP pilot reporting definition of severe icing and this, combined with the information available from the Met Office, suggested that the crew probably encountered a CB on their route. Whilst these CBs were forecast, it is possible they did not show on the aircraft's weather radar, which would have made it less likely that the crew would become aware of their presence before encountering them.

The severe icing and turbulence they encountered caused the AOA to increase beyond the 5.9° trigger for the stick shaker on three occasions due to short duration transient variations. On two occasions this caused the autopilot to disconnect (during the third activation the autopilot was not engaged). Re-engaging the autopilot without fully reducing the pitch attitude of the aircraft, meant that the stick shaker was triggered for the second time after 10 seconds. The subsequent descent saw the aircraft clear both the icing and turbulent conditions whilst increasing the airspeed.

### *Procedures*

Procedures in the AOM and the OMB gave the crew clear guidance on the actions to be taken on entering areas of turbulence and icing. The AOM advised increasing the airspeed when encountering turbulence to give a wider margin over the stick shaker trigger, and both the AOM and OMB listed actions to be taken when the speed decays in icing condition.

Once the stick shaker triggered, the AOM listed the actions to be taken which included decreasing the pitch of the aircraft, setting maximum power and accelerating. However, these procedures relied on the flight crew recognising the situation and responding accordingly. In this case, the situation was not recognised and the trigger call of “Stall – Max Power” was not verbalised by either crew member. Consequently, maximum power was not set and the other trained responses were not carried out.

The third stick shaker did trigger the crew to descend the aircraft and regain the required airspeed but at no point was maximum continuous power set. Increasing the airspeed when the aircraft encountered turbulence, as recommended in the AOM, might have avoided this event because it would have increased the AOA margin over the stick shaker.

### *Human factors*

The modification to the stall warning computer has had the unintended consequence of increasing stick shaker activation for the operator’s Saab340 aircraft on which it has become a regular occurrence. Therefore, it is possible that pilots no longer take the activation as seriously as they did previously as they may interpret it as a nuisance and not react. The AOM specifically allows the crew to disregard transient (less than 1 second) warnings as long as the aircraft is at a safe speed and height. In this case, for two of the stick shaker activations the speed was below  $V_{CM}$ , and the stick shaker could not be disregarded. Whilst there is no suggestion that the crew on G-LGNB deliberately ignored the warning, or considered it a nuisance, it is human nature to give less regard to a warning known to be triggered regularly even when it is not required.

### **Safety Action**

EASA, the operator and the manufacturer considered making deactivation of the ICE SPEED logic independent of the requirement to maintain the engine anti-ice system on for five minutes after leaving icing conditions. This change, considered feasible by the manufacturer, would address the concerns about repeated activation of the stick shaker in the latter stages of an approach and in the flare.

EASA expected to mandate the implementation of this improvement to address the safety concern.

## Conclusion

After encountering severe icing, probably associated with a CB, the Saab340 stall warning system functioned as it was designed to by alerting the crew, through the stick shaker, of an AOA in excess of 5.9°. The crew actions did not initially address the problem sufficiently and the stick shaker occurred again. Following the third activation of the stick shaker the crew descended the aircraft to regain a safe airspeed. Although maximum power was not set, the aircraft did accelerate and the crew were able to clear the icing and turbulent conditions before continuing their flight without further incident.

## ACCIDENT

<b>Aircraft Type and Registration:</b>	Airbus Helicopters AS355F1 Ecureuil II, G-OHCP	
<b>No &amp; Type of Engines:</b>	2 Allison 250-C20F turboshaft engines	
<b>Year of Manufacture:</b>	1982 (Serial no: 5249)	
<b>Date &amp; Time (UTC):</b>	29 March 2017 at 1155 hrs	
<b>Location:</b>	Summit of Rhinog Fawr, Snowdonia	
<b>Type of Flight:</b>	Private	
<b>Persons on Board:</b>	Crew - 1	Passengers - 4
<b>Injuries:</b>	Crew - 1 (Fatal)	Passengers - 4 (Fatal)
<b>Nature of Damage:</b>	Aircraft destroyed	
<b>Commander's Licence:</b>	Private Pilot's Licence	
<b>Commander's Age:</b>	56 years	
<b>Commander's Flying Experience:</b>	3,650 <sup>1</sup> hours (of which 102 were on type) Last 90 days - 9.0 hours Last 28 days - 1.5 hours	
<b>Information Source:</b>	AAIB Field Investigation	

## Synopsis

The helicopter was flying on a Visual Flight Rules (VFR) flight plan from its operating base near Cranfield Airport on a direct track to a private site near Dublin. The weather on departure was suitable for VFR flight but, as forecast, deteriorated markedly in the area of Snowdonia with low cloud and rain. The helicopter flew over a witness 4.3 nm southeast of the accident site before disappearing into the cloud. Shortly afterwards it struck the east side of Rhinog Fawr Mountain, fatally injuring the five occupants.

## History of the flight

The pilot and four family members had planned to fly from the helicopter's operating base adjacent to Junction 13 of the M1 motorway, to a private site close to Dublin Airport before returning later that evening. The pilot had used two commercially available flight planning applications on his iPad, both for flight planning and during parts of the flight but it is not known what information he used.

The maintenance organisation was contacted by the pilot on the evening before the flight and requested that the helicopter be ready for departure at 1000 hrs with full fuel. The

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### Footnote

<sup>1</sup> The pilot's log book available to the investigation covered only the early part of his flying career and was incomplete. The total hours were identified from his aircrew medical renewal form and the total on type and last 90/28 days from the available technical log sheets.

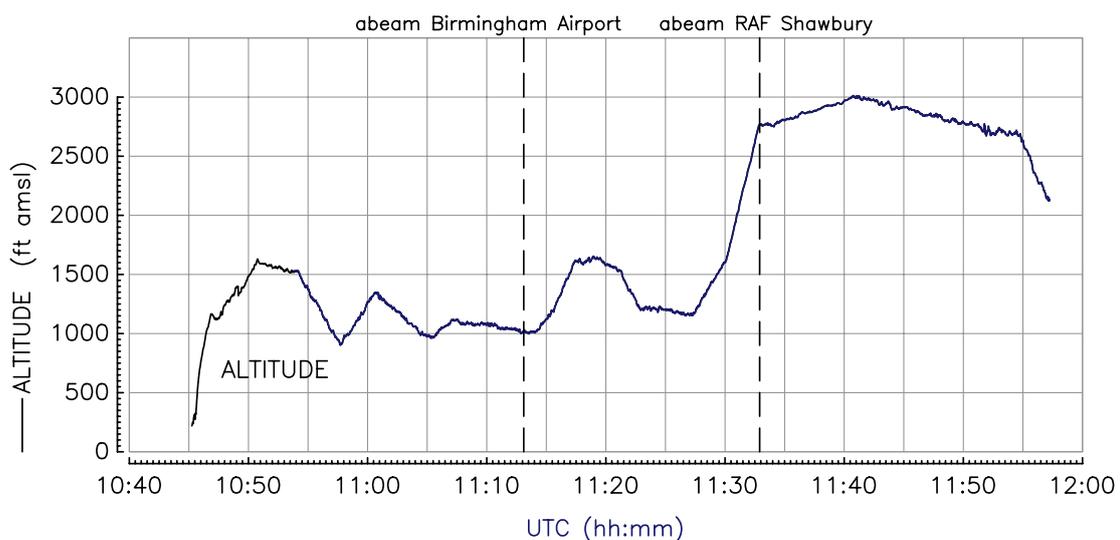
next morning, the engineer moved the helicopter from the hangar to a parking spot and then refuelled the helicopter to tanks full. One family member arrived shortly afterwards, followed by two other passengers, and all three occupied the rear seats. The engineer had moved off to refuel another helicopter and did not see which seat each passenger occupied. Another passenger arrived and sat in the front left seat and the pilot occupied the front right seat. The engineer did not see the pilot arrive but noticed that the passengers had no luggage other than carrier bags. The helicopter was heard to start up and departed at about 1045 hrs.

The GPS derived ground track and vertical profile of the flight are shown in Figure 1 and Figure 2.



**Figure 1**

Planned route (blue) and actual track (red)



**Figure 2**

GPS derived vertical profile of the accident flight

The helicopter was flown along the direct track from the departure point towards the destination achieving a maximum altitude of 3,000 ft at about 1142 hrs. The heights flown appeared to approximate to remaining below the main cloud base in order to maintain Visual Meteorological Conditions (VMC).

A full description of the weather is included in the Meteorology section of the report, but in order to consider the weather encountered during the transit, the METAR cloud base for the airfields shown at the nearest time were:

- Luton Airport at 1050 hrs, cloud overcast at 1,200 ft,
- Birmingham Airport at 1120 hrs, cloud broken at 1,500 ft,
- Shawbury at 1120 hrs, cloud scattered at 1,400, broken at 3,000 ft,
- Valley at 1150 hrs, cloud broken at 600 ft.

At what he estimated was between 1130 and 1150 hrs, a witness was located in Coed Brenin Forest, 4.3 nm southeast of the accident site. He saw a helicopter pass overhead and watched it for some 5 - 10 seconds before it went into the cloud cover. He reported the elevation of his position as 120 m (400 ft) at which time the helicopter was at 2,500 ft. A replay of the NATS radar tape for the appropriate time, showed only G-OHCP in the area and flying on its track with no other aircraft in the vicinity.

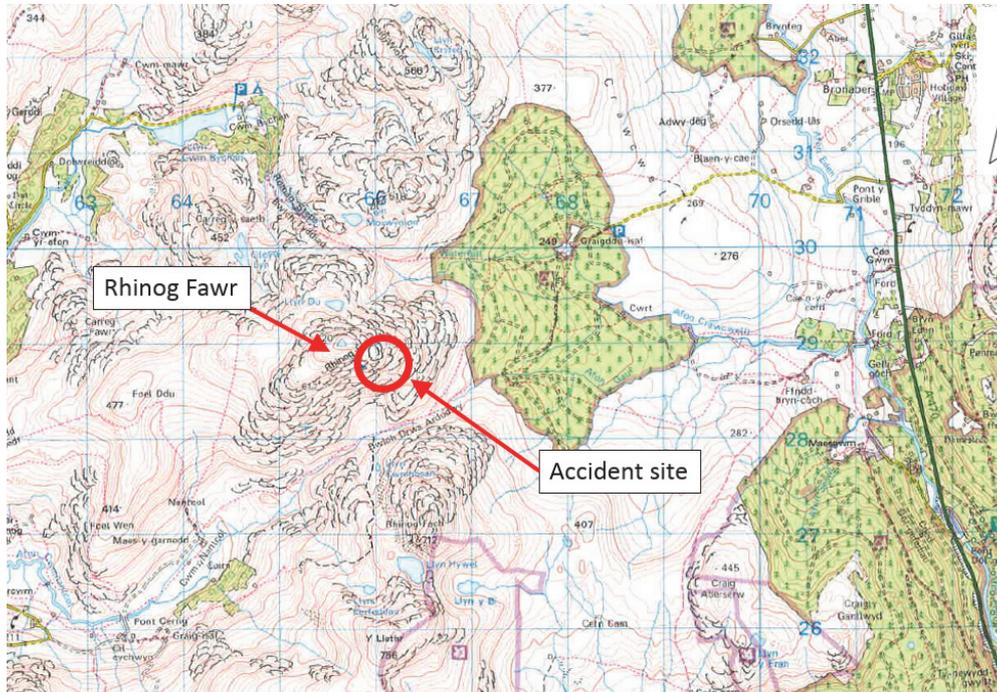
The helicopter had been in a gentle descent from its maximum height to 2,500 ft before descending to 2,060 ft when it struck the east side of Rhinog Fawr Mountain, at about 1157 hrs. At the moment of impact, the auto pilot was engaged with the heading (HDG), turn coordinator (T/C) and vertical speed (V/S) modes active. This was consistent with a pilot-managed, autopilot-flown descent.

### **Accident site**

The accident site was located on the south-east face of Rhinog Fawr in southern Snowdonia, at an elevation of 2,060 ft amsl, approximately 300 ft below the summit shown in Figure 3. The helicopter had struck a rock outcrop (Figure 4), completely destroying the cabin section and depositing wreckage along a trail 150 m in length, oriented on a heading of 280°M. The helicopter's main rotor, gearbox and engines had separated from the fuselage and continued over the rock outcrop, coming to rest 140 m from the initial impact. The degree of disintegration of the cabin indicated that the helicopter had been flying at cruising speed immediately prior to impact. Witness marks made by the cabin, right skid and right horizontal stabiliser on the rock outcrop showed that the helicopter was in an approximately level pitch and roll attitude at impact.

All major parts of the helicopter were identified at the accident site. A number of wreckage parts were burned and a small part of the impact area also exhibited evidence of burning, indicating that an intense, short-duration fuel fire had occurred after impact. There was a strong smell of unburned aviation fuel at the base of the rock outcrop, immediately below the impact area.

One of the main rotor blades was heavily impact-damaged, indicating that the main rotor had been rotating at impact. Both tail rotor blades were damaged, consistent with rotation under power at impact and rotational scoring marks on the tail rotor drive shaft were further evidence of tail rotor rotation at impact.



**Figure 3**

Location of the accident site



**Figure 4**

Section of the accident site wreckage trail

## Aircraft description

G-OHCP was an AS355F1, a twin-engine light helicopter configured to carry a pilot and five passengers. The AS355F1 is powered by two Rolls-Royce (Allison) model 250-C20F gas turbine engines which drive a three-bladed main rotor system through the main gearbox (MGB). Each engine drive input in the MGB is fitted with a freewheel unit that is designed to allow normal operation in the event of an engine failure.

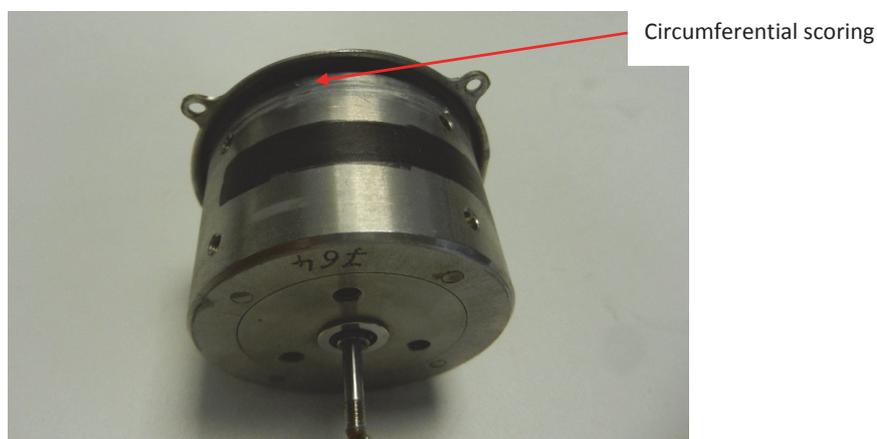
The AS355F1 is equipped with two independent hydraulic systems and is controlled by hydraulically-assisted flying controls. The pilot's control inputs are transmitted through a series of control rods, bell cranks and mixing units to three hydraulic actuators attached to the MGB and a single tail rotor actuator which change the pitch of the main and tail rotor blades respectively. The hydraulic system is powered by two pumps mounted on the MGB. In the event of a hydraulic system failure, the helicopter can continue to fly in response to the pilot's control inputs.

G-OHCP was fitted with analogue flight instruments and a panel-mounted Garmin GNS430 GPS display unit. In addition, the helicopter was fitted with an SFIM 85T31 three axis autopilot, capable of controlling the helicopter's desired flight path by inputs from electro-mechanical actuators mounted in series to each of the pitch, roll and yaw flight control linkages. The autopilot was controlled by an autopilot mode control panel, mounted on the centre instrument console.

## Detailed examination

### *Flight instrumentation*

All the helicopter's flight instruments had been severely damaged during the impact sequence. The pilot's artificial horizon and the standby artificial horizon were disassembled and examined in detail. Both units had suffered from significant internal damage. Circumferential scoring was identified on the gyroscope of the pilot's artificial horizon and rotational damage was observed on the cooling fins of the standby artificial horizon gyroscope wheel (Figure 5), indicating they were both operational at the time of impact.



**Figure 5**

Pilot's artificial horizon gyroscope exhibiting circumferential scoring

### GPS system

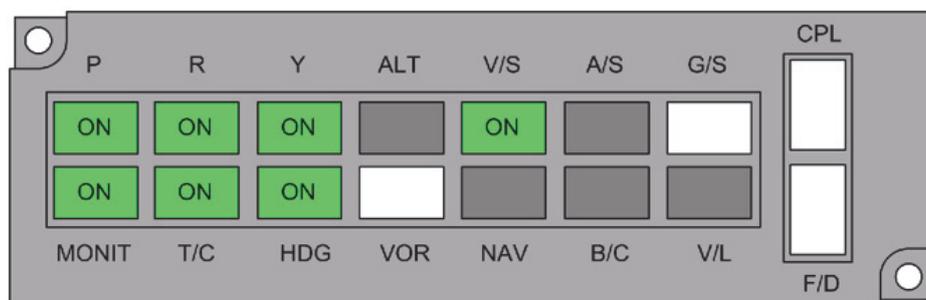
The Garmin GNS430 fitted to the helicopter was recovered and examined in detail. No information about the accident flight or any preceding flights were recovered from the unit. A modification is available for the GNS430 that introduces a terrain warning function. Examination of the internal components of the unit indicated that this modification had not been embodied and therefore, the unit would not have provided the pilot with any warning of the approaching high terrain.

### Autopilot system

The autopilot mode control panel of the type fitted to G-OHCP features 16 push-button latching switches that illuminate when pressed; each button is illuminated by two incandescent filament light bulbs.

An additional autopilot monitoring panel is mounted centrally on the upper section of the pilot's instrument panel, with coloured captions further indicating whether the autopilot is engaged and which modes are selected. Each caption is illuminated by a single incandescent filament light bulb.

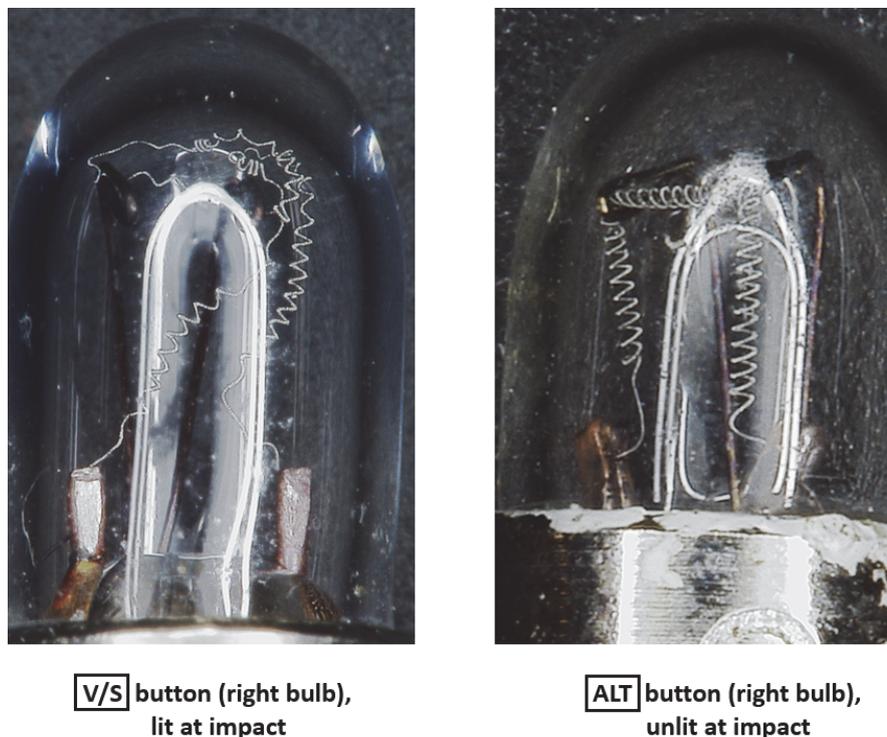
The autopilot mode control panel (Figure 6) was recovered from the wreckage trail. The control panel was substantially intact apart from the 'VOR', 'G/S', 'CPL' and 'F/D' buttons, which had separated during the accident and were not located.



**Figure 6**

Autopilot mode control panel recovered from the accident site (top), and assessment of the control panel buttons illuminated at impact by light bulb filament analysis (bottom)

The push-button switches were disassembled and their lightbulbs removed for visual examination by microscope. This examination showed that a number of bulbs' filaments were stretched, with the double-helix coils elongated, consistent with bulb illumination at impact. By contrast, the remaining bulbs examined did not exhibit any evidence of filament hot-stretching, indicating that those bulbs were unlit at impact (Figure 7).



**Figure 7**

Example of *filament hot-stretching*, left and an unlit bulb, right, from the autopilot mode control panel buttons

The lightbulb filament analysis indicated that the autopilot was switched ON, and was engaged at impact. The pitch ('P' button), roll ('R') and yaw ('Y') channels were available and engaged, the pitch and roll monitor<sup>2</sup> ('MONIT') was engaged and the turn coordination mode<sup>3</sup> ('T/C') was ON. The analysis also showed that the heading hold ('HDG') and vertical speed ('V/S') modes were also engaged.

The autopilot logic dictates that for any vertical or lateral mode to be available, the coupler ('CPL') button and/or the flight director<sup>4</sup> ('F/D') push-button must be pressed. Due to

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#### Footnote

<sup>2</sup> The pitch and roll monitor is automatically engaged as soon as one (or both) of the pitch or roll channels is engaged. The MONIT push-button is therefore used to switch off the pitch and roll monitor, if the need arises. The monitor disengages automatically, and the button is then unlit, in case of the loss of a valid signal from the pilot's attitude directional indicator (ADI), such as would be caused by a failure of the ADI.

<sup>3</sup> The turn coordination mode uses the yaw control actuator to minimise side-slipping during turning manoeuvres at airspeeds greater than 50 kt.

<sup>4</sup> The flight director consists of pitch and roll command bars that are displayed on the pilot's ADI display, showing the pilot the attitude required to follow a certain flight trajectory.

the absence of both buttons it was not possible to determine which button, if either, was illuminated. However since the vertical speed and heading hold modes were engaged, one or both of these buttons were most probably lit at impact.

The pilot can select a target vertical speed using a bug on the vertical speed indicator (VSI), mounted in the instrument panel. Similarly the pilot can select the desired heading using a heading bug on the horizontal situation indicator (HSI). It was not possible to reliably determine the pre-impact positions of the vertical speed or heading bugs due to accident damage to the VSI and HSI.

The autopilot monitoring panel was recovered from the wreckage but its condition prevented a comprehensive examination. All light bulbs on the panel, apart from one, were broken and the filaments dispersed. The single intact light bulb was from the vertical speed ('VS') caption; examination of this bulb filament by microscope showed that it had been illuminated at impact, confirming the analysis of the autopilot mode control panel.

### *Flying controls*

All the damage observed in the mechanical elements of the flying controls was consistent with accident forces.

The main rotor and tail rotor hydraulic actuators were functionally tested with the assistance of their respective manufacturers. All four actuators functioned as expected in response to control inputs, and no significant anomalies were noted in their performance.

### *Main rotor gearbox and transmission*

There was no evidence of a failure within the main gearbox. Both the left and right engine freewheel units operated correctly and the main rotor head turned when drive was applied to either of the engine input shafts.

### *Engines*

Examination of the right engine confirmed that it had been subject to significant force during the impact sequence. The compressor and turbine sections of the engine had partially separated from the gearbox. The left engine, although damaged, had remained intact. Both engines were disassembled at an approved overhaul facility in the presence of the AAIB and representatives from the engine manufacturer.

### *Left engine*

Tests of the Fuel Flow Governor (FFG) and the Fuel Control Unit (FCU) identified several minor defects; these would not have prevented the engine from operating normally.

The turbine casing had been distorted during the impact sequence, which prevented the power turbine from rotating freely. All the blades and nozzle guide vanes were present with no evidence of impact damage. The combustion chamber showed no evidence of abnormal operation and when tested, the fuel spray nozzle operated normally.

During the removal of the compressor from the gearbox, it was found that the retaining feature of the impeller drive coupling shaft had failed, allowing the shaft to be released. Examination of the remains of the shaft showed evidence of bearing impact marks on the shaft consistent with forces experienced during the impact sequence. Disassembly of the compressor and impeller module revealed that all the compressor vanes and stators were present. However there was clear evidence of rotational damage to the forward stages of the axial compressor (Figure 8), with associated loss of the compressor abraidable liner. There was also evidence of rotational contact between the impeller and the impeller shroud.



**Figure 8**

Left engine axial compressor and impeller assembly

### *Right engine*

The right engine was severely damaged during the impact sequence. There was evidence that it hit the ground several times before coming to rest. Both the compressor and turbine modules had separated partially from the gearbox module. Impact damage prevented testing of the engine's FFG and FCU.

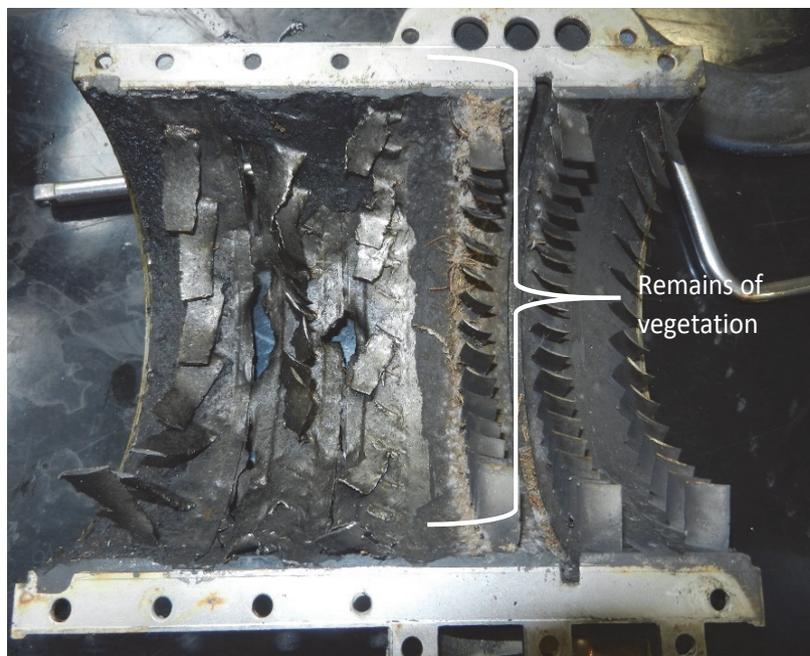
The compressor case exhibited multiple penetrations (Figure 9) typical of significant axial compressor blade release.



**Figure 9**

Right engine compressor case showing case penetration

Disassembly of the compressor assembly revealed significant damage to all the stator vanes in the first three stages of the axial compressor, and the remains of vegetation was observed on the fourth stage stator vanes (Figure 10).



**Figure 10**

Damage to the right engine axial compressor stator vanes

The compressor spool was heavily damaged, all the first three stages of compressor blades had been released, and the blades on the fourth stage exhibited significant impact damage (Figure 11). The impeller and impeller shroud also showed signs of rubbing. Small particles of vegetation were also found within the impeller.

Disassembly of the turbine confirmed that all the blades and nozzle guide vanes were present with no evidence of impact damage. The combustion chamber showed no evidence of abnormal operation and when tested the fuel spray nozzle operated normally.

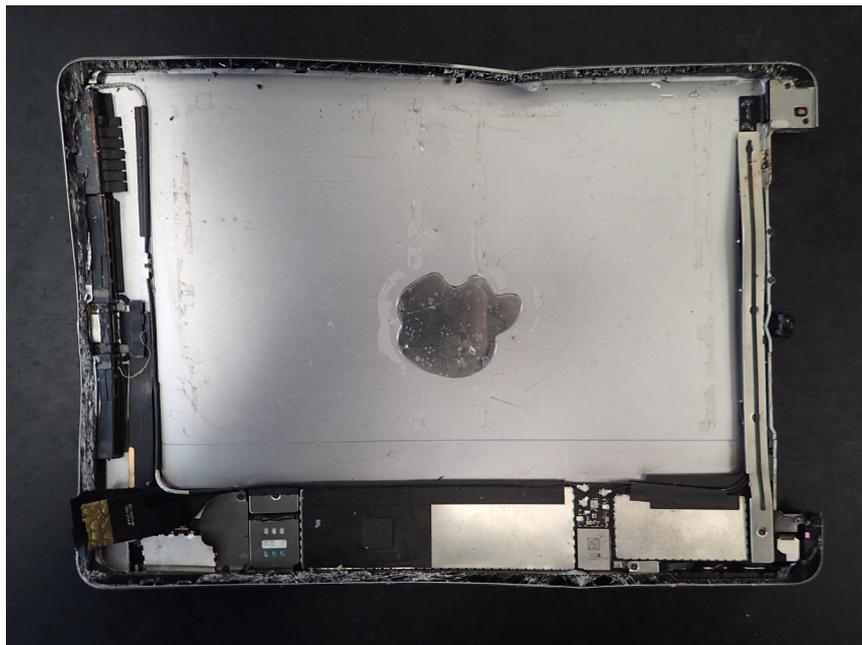


**Figure 11**  
Right engine axial compressor

## Recorded information

An iPad mini with the screen and matrix missing was recovered from the accident site and taken to the AAIB for the memory to be downloaded and analysed.

The logic board (containing the memory) and battery were still attached to the base of the iPad, which was slightly bent and dented (Figure 12). The logic board was removed from the iPad base and slaved into a similar iPad mini whose own logic board had been removed. The memory was downloaded using a commercially available data extraction and analysis software tool.



**Figure 12**

Base of iPad mini containing logic board (battery has been removed)

On initial power up, before the memory was downloaded, it was established that four apps were on or running in the background at the time of the accident, as well as the order in which they had last been selected. In order of recency these were: (1) RunwayHD; (2) SkyDemon; (3) Met Office website, and (4) a flight guide showing information for Tunisia (and therefore not related to the accident flight). Figure 13 to 15 show the stored screenshots for the relevant apps.

Both of the screenshots for RunwayHD (Figure 13) and SkyDemon (Figure 14) show the position of the helicopter as 8 nm east of Welshpool Airport (33 nm from the accident site, at 2,280 ft amsl with 112 kt groundspeed), implying that SkyDemon had been selected prior to this point (no information available as to how long for) and that RunwayHD was then selected and remained selected until the accident<sup>5</sup>.

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### Footnote

<sup>5</sup> Had another app been selected after this point then the RunwayHD screenshot would have shown the helicopter at a different location.

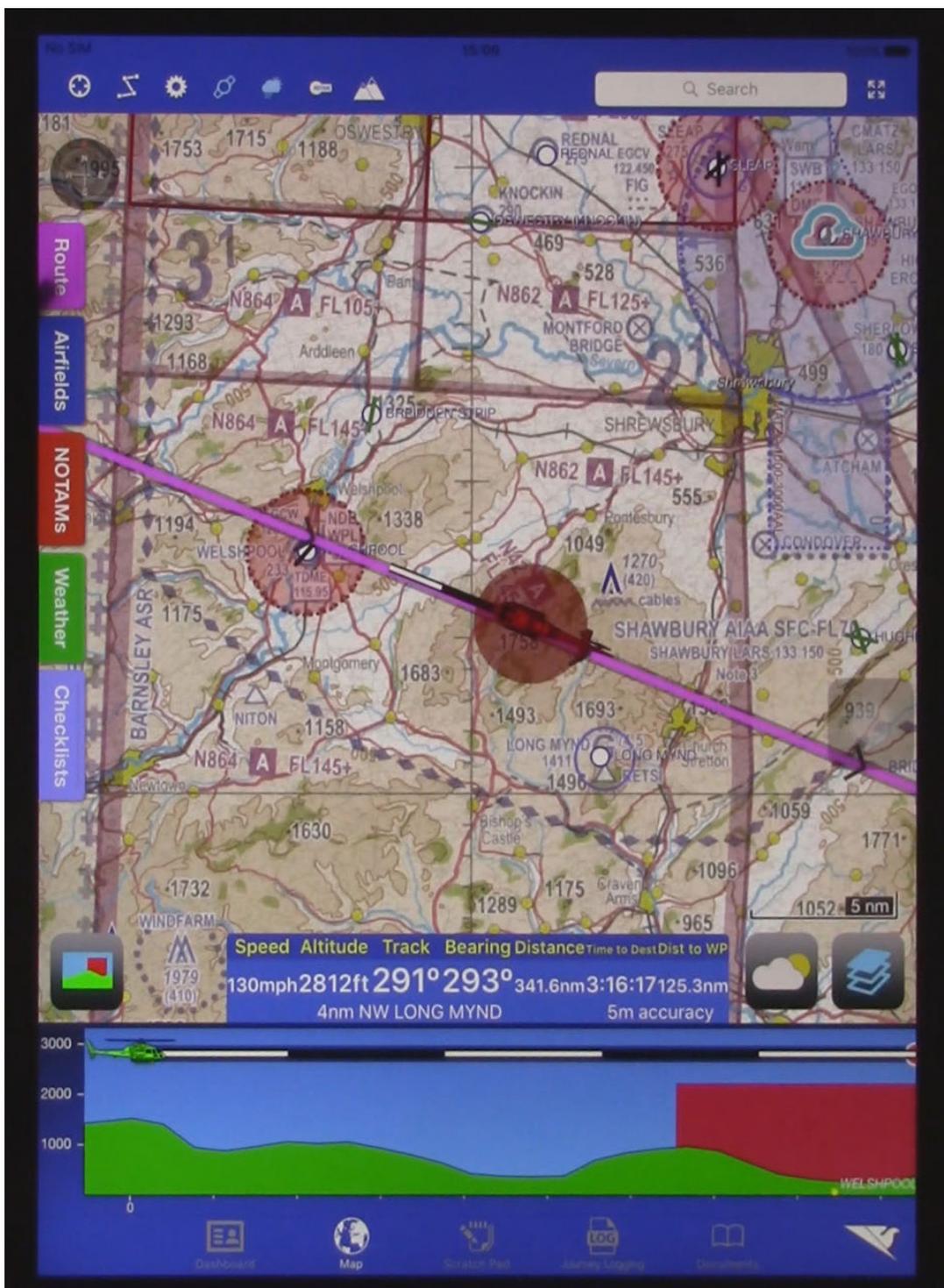


Figure 13

Stored screenshot of the selected app (Runway HD) running at the time of the accident

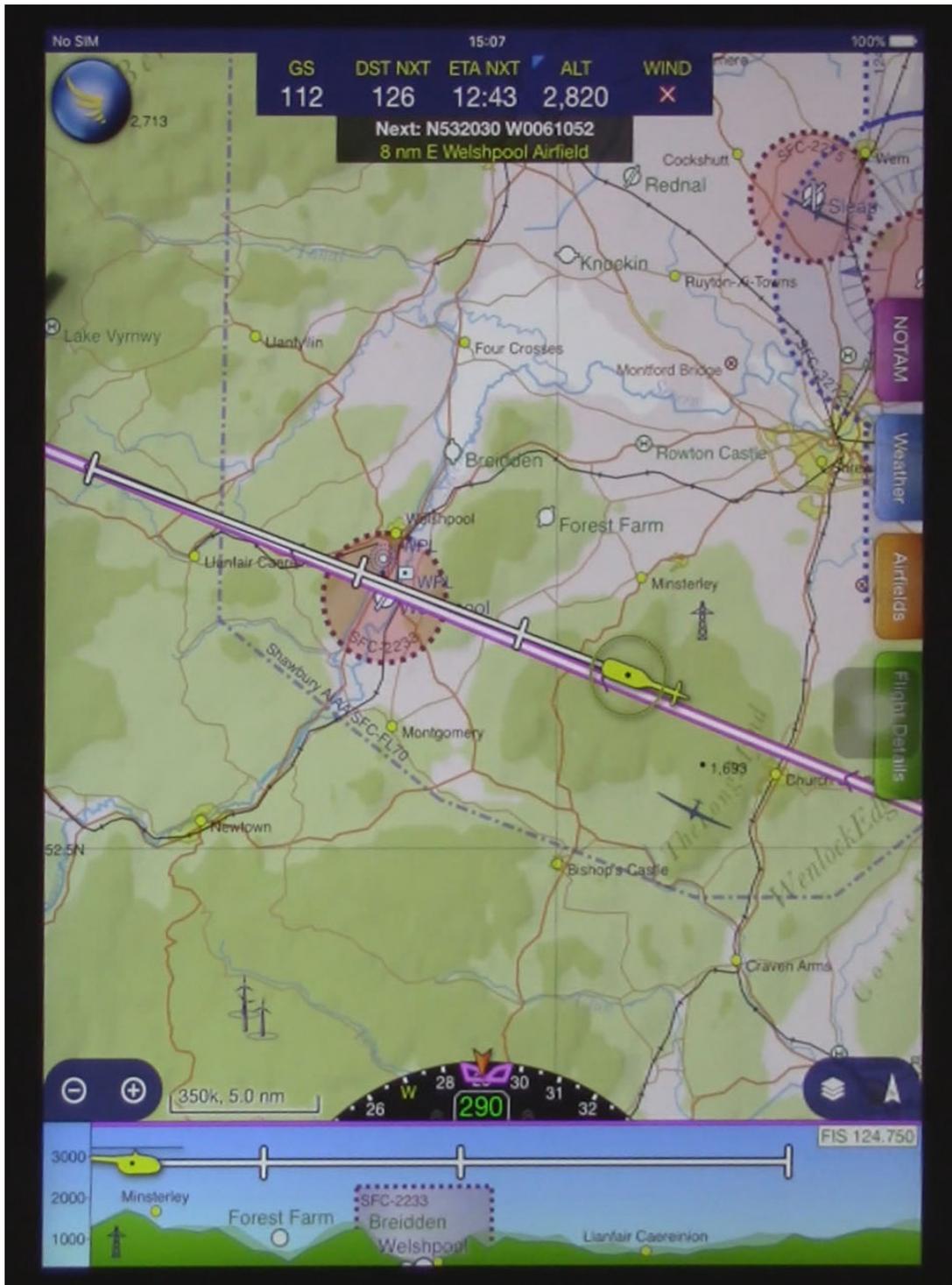


Figure 14

Stored screenshot of app (SkyDemon) running in the background at the time of the accident

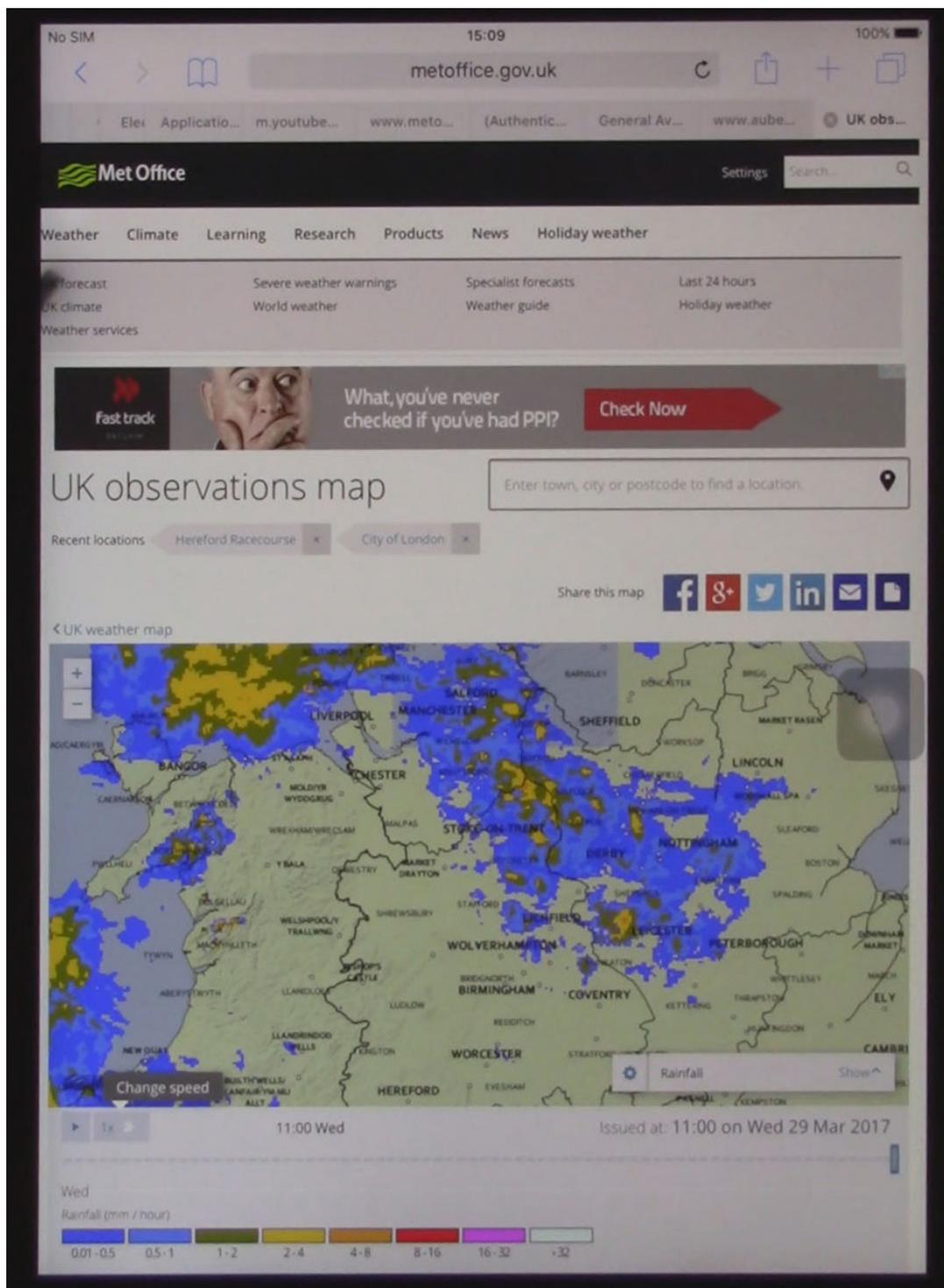


Figure 15

Stored screenshot of app running in the background at the time of the accident

### *Planned route and actual track*

Recorded data from both RunwayHD and SkyDemon contained the planned route from Brook Farm, south of the Cranfield ATZ, direct to a point 216 nm further west, at the mouth of the River Liffey east of Dublin, continuing around Baldonnell aerodrome to Weston Airport. This track is shown as a pink line on the app screenshots<sup>6</sup> in Figure 13 and 14. The altitude for the route was 3,000 ft in RunwayHD and 4,000 ft in SkyDemon.

The planned route and actual track flown is illustrated in Figure 1, and the altitude and groundspeed profile for the flight in Figure 16 with other GPS derived and transponder information. The helicopter lifted around 1045 hrs; the last point, approximately 0.5 nm from the accident site, was recorded shortly after 1157 hrs. Figure 1 shows the helicopter flew close to the planned route, the maximum deviation being 0.7 nm in the early stages of the flight. The altitude profile in Figure 16 indicates that the first part of the route was flown between 1,000 and 1,500 ft amsl before climbing to 2,750 ft abeam RAF Shawbury at around 1133 hrs. Eight minutes later it climbed to a maximum of 3,000 ft before descending at approximately 25 ft/min to 2,700 ft. Shortly before 1155 hrs, the descent rate increased to 185 ft/min, after which radar contact was lost. The altitude of the last recorded point on the RunwayHD and SkyDemon apps was 2,125 ft. The calculated groundspeed for the flight varied between 100 and 120 kt.

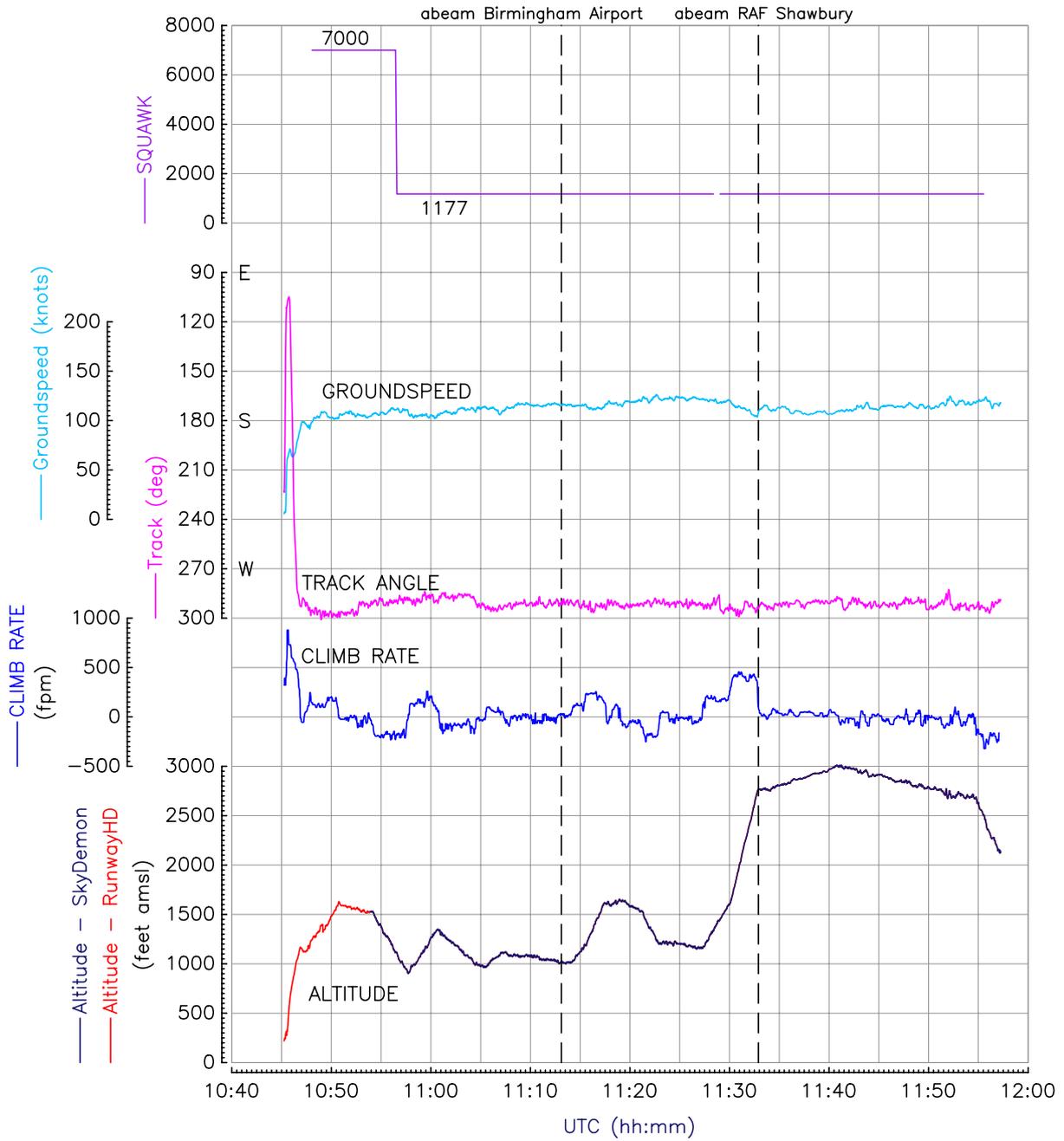
### *Met Office webpage*

A related web browsing history indicates that the Met Office UK observations rainfall map webpage was selected several times between 1008 hrs and 1133 hrs on the day of the accident, and for 10 minutes on the previous evening. The screenshot of the Met Office webpage (Figure 15), corresponding to the final selection of the website at 1133 hrs, shows the rainfall for Mid and North Wales issued at 1100 hrs, indicating a band of rain in the vicinity of the accident site.

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### **Footnote**

<sup>6</sup> The stored RunwayHD route started at Weston Airport and ended at Brook Farm – the reverse of the actual flight – so the displayed route has arrows pointing back to Brook Farm.



**Figure 16**

Recorded data from RunwayHD and SkyDemon with radar Mode A squawk

## Weight and balance

The All Up Weight (AUW) of the helicopter at takeoff was approximately 2,555 kg, assuming full fuel and estimated weights for the passengers and the small amount of luggage. The Maximum Permitted All Up Weight (MPAUW) was 2,400 kg. Consequently the helicopter was approximately 155 kg over MPAUW on departure, though some fuel would have been consumed during start and prior to takeoff. With an approximate fuel consumption of 180 kg per hour, the AUW at the time of the accident would have been 2,375 kg.

The Centre of Gravity (CG) envelope at MPAUW was 3.25 to 3.475m aft of the CG datum at 2,400 kg. The CG of the helicopter at departure was approximately 3.31 m and at the time of the accident was approximately 3.3 m. At the time of the accident, the helicopter weight and CG were within the promulgated permitted weight and CG operating envelope.

## Meteorology

The Met Office provided an aftercast for the flight.

### *General situation*

The meteorological synoptic chart showed a series of fronts approaching the south and west of the UK, and a moderate to strong gradient wind from the southwest. On the 0600 hrs analysis a warm front was positioned through Cardigan Bay and ran across the north midlands and then down through Norwich. At 1200 hrs a wave had developed along the front and had pushed north. A cold front was positioned north-south through Bangor, North Wales, to Swansea. A warm sector covered the area of Wales east of that front and England, and another cold front was positioned north-south through Ireland.

### *Chart F215*

Met office Chart F215, depicts the forecast weather below 10,000 ft. The relevant chart covering the time of the accident is at Figure 17.

The route of the flight would have passed from Zone E into Zone D in the Kidderminster area. Zone E had the lowest cloud base, scattered or broken stratus with a base between 600 and 1,000 ft amsl with tops to 1,500 ft merging with the main cloud base which was scattered to broken at 1,500-3,000 ft amsl. Visibility and weather in Zone E were noted as prevailing 20 km with no weather, and isolated areas of 7km visibility associated with light rain and drizzle or light rain.

Zone D was the area encompassing the frontal zones. The fronts on the chart are drawn as occlusions however they are in very similar positions to those on the 1200 hrs UTC analysis chart. Cloud bases were occasionally broken ST 500-800 ft amsl with tops up to 1,500 ft. This stratus was widespread along the fronts and on windward coasts where it was locally deteriorating to the surface to 200 ft. Above this was a layer of broken to overcast Cumulus and Stratocumulus with bases from 1,500 to 2,500 ft; this cloud was expected to have moderate icing and turbulence. Locally in the lee of the mountains

(that part of the flight over the Welsh border areas) there may have been breaks as the cloud cover reduced to scattered. Visibility and weather in Zone D was also worse than in Zone E. Prevailing visibility was 15 km in nil weather, occasionally (widespread along the fronts) deteriorating to 7 km in light rain and drizzle or moderate rain. Isolated further deteriorations to 2,000 metres in mist and moderate drizzle, this increased to occasional for sea areas, windward coasts and upslopes. In sea areas and windward coasts fog bringing visibility to 200 metres was expected and occasional fog inland.

Another effect of note on this chart was the mountain wave activity expected in the west of Zone D. It was expected to bring maximum vertical wind speeds of 600 feet per minute at 7,000 ft.

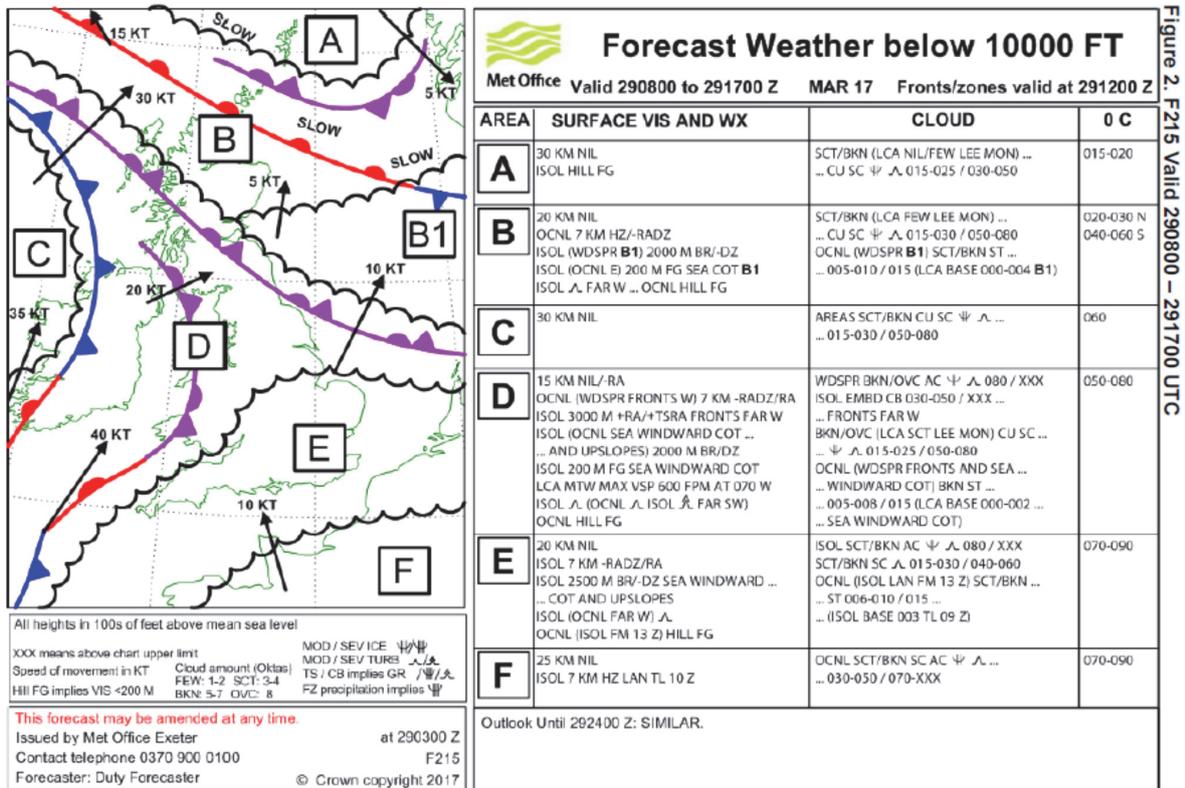


Figure 2. F215 Valid 290800 – 291700 UTC

Figure 17

Met Office Chart 215 for the period including the accident flight

*TAFs and METARs*<sup>7</sup>

## Luton (EGGW)

TAF EGGW 290502Z 2906/3006 21011KT 9999 BKN010 TEMPO 2906/2913  
 8000-SHRA TEMPO 2906/2910 BKN009 BECMG 2907/2910 FEW015 SCT025  
 TEMPO 2910/2913 BKN014 PROB30 TEMPO 3004/3006 9000 -SHRA=  
 METAR EGGW 291050Z AUTO 21011KT 9999 OVC012 13/10 Q1022=  
 METAR EGGW 291120Z AUTO 20110KT 170V240 9999 OVC011 13/11 Q1022=

## Birmingham (EGBB)

TAF EGBB 290501Z 2906/3006 20009KT 9999 FEW010 SCT025 TEMPO  
 2906/2910 9000 -RA BKN010 PROB40 TEMPO 2906/2910 4000 RADZ  
 BKN006 PROB30 TEMPO 2910/3006 9000 -RA BKN013=  
 TAF EGBB 291058Z 2912/3012 20009KT 9999 FEW010 SCT025 TEMPO  
 2912/2921 9000 -RA BKN013 BECMG 2921/2924 BKN010 PROB30 TEMPO  
 3000/3008 8000 -RA BKN008 BECMG 3009/3012 SCT015=  
 METAR EGBB 291120Z 19008KT 9999 BKN015 13/11 Q1020=  
 METAR EGBB 291050Z 19008KT 9999 BKN012 13/11 Q1020=  
 METAR EGBB 291020Z 19009KT 9999 BKN012 13/11 Q1019=  
 METAR EGBB 290950Z 20009KT 170V230 9999 BKN011 13/11 Q1019=

## Shawbury (EGOS)

TAF EGOS 290755Z 2909/2918 21010KT 9999 FEW020 SCT035 BECMG  
 2909/2911 21012G20KT TEMPO 2909/2918 BKN020 PROB30 TEMPO  
 2909/2918 7000 -RADZ SCT012=  
 TAF EGOS 291039Z 2912/2918 19012G22KT 9999 FEW020 SCT035 TEMPO  
 2912/2918 BKN020 PROB30 TEMPO 2912/2918 7000 -RADZ SCT012=  
 METAR EGOS 290950Z 21017KT 9999 FEW012 SCT018 BKN120 13/10  
 Q1018 WHT NOSIG=  
 METAR EGOS 2911050Z 19018KT 9999 FEW014 SCT018 BKN100 13/10  
 Q1018 WHT NOSIG=  
 SPECI EGOS 291120Z 16012KT 9999 SCT014 BKN030 BKN120 13/11 Q1018  
 GRN TEMPO 18012G22KT SCT015 WHT=  
 METAR EGOS 291150Z 17014KT 9999 SCT014 BKN030 BKN120 13/10  
 Q1018 GRN TEMPO SCT015 WHT=

**Footnote**

<sup>7</sup> A summary of meteorological information appears at the end of this section. Resources for decoding TAFs and METARs are available on the Met Office web site: <https://www.metoffice.gov.uk/aviation/ga>

## Valley (EGOV)

TAF EGOV 290747Z 2909/2918 18020KT 8000 BR OVC006 BECMG 2909/2911  
OVC007 TEMPO 2909/2918 3000 RADZ BKN003=

TAF EGOV 291034Z 2912/2919 17025KT 8000 BR OVC007 TEMPO 2912/2919  
3000 RADZ BKN004=

SPECI EGOV 290921Z 17019KT 7000 RA OVC006 11/10 Q1015 BLACKYLO1  
TEMPO 3000 RADZ BKN003 YLO2=

METAR COR EGOV 290950Z 16019KT 8000 BR OVC007 11/10 Q1015  
BLACKGRN TEMPO 3000 RADZ BKN003 YLO2=

SPECI EGOV 291038Z 16020KT 3000 -DZ OVC004 11/10 Q1015 BLACKYLO2  
BECMG 8000 BKN007 GRN=

METAR EGOV 291050Z 15019KT 8000 6000N -RA FEW004 OVC006 11/10  
Q1015=

METAR EGOV 291052Z 15019KT 8000 6000N -RA FEW004 BKN006 11/10  
Q1015 BLACKYLO1 BECMG BKN007 GRN=

SPECI EGOV 291107Z 16018KT 9999 -RA FEW004 BKN013 11/11 Q1014  
BLACKGRN TEMPO 3000 DZ BKN004 YLO2=

METAR EGOV 291150Z 16017KT 9999 BKN006 11/10 Q1015 BLACKYLO1  
TEMPO 4000 -RADZ BKN004 YLO2=

## Dublin (EIDW)

TAF EIDW 290500Z 2906/3006 15007KT 9999 SCT010 BKN022 TEMPO  
2906/2910 5000 -RADZ BKN012 BECMG 2907/2909 18010KT BECMG  
2909/2912 19015KT TEMPO 2911/2915 19016G26KT TEMPO 2920/3001  
5000 -RA BKN012 BECMG 3000/3003 22010KT BECMG 3003/3006 17007KT  
TEMPO 3004/3006 5000 -RA BKN012=

METAR EIDW 290930Z 10010KT 9000 FEW004 BKN021 BKN200 13/10  
Q1012 NOSIG=

METAR EIDW 291000Z 15004KT 110V200 9000 FEW004 BKN020 BKN050  
13/10 Q1012 NOSIG=

METAR EIDW 291030Z 12011KT 9000 FEW004 BKN020 BKN050 14/10  
Q1012 NOSIG=

METAR EIDW 291100Z 12009KT 100V160 9000 FEW004 BKN020 BKN050  
14/10 Q1012 NOSIG=

METAR EIDW 291130Z 21013KT 9999 FEW004 BKN022 BKN050 14/10  
Q1012 NOSIG=

METAR EIDW 291200Z 19012KT 150V210 9999 FEW004 SCT022 BKN050  
15/11 Q1012 NOSIG=

METAR EIDW 291230Z 21012KT 9999 FEW004 BKN022 BKN050 15/10  
Q1012 NOSIG=

METAR EIDW 291300Z 21010KT 9999 FEW005 BKN024 BKN250 15/10  
Q1012 NOSIG=

### *Summary of meteorological information*

A flight departing Brook Farm at about 1056 hrs and flying a direct track to the destination would have experienced a light south-westerly wind and cloud bases 1,000 ft amsl as far as Snowdonia. Underneath this cloud, visibility would have been around 20 km, probably with no rain or drizzle. Before entering Snowdonia it is likely there were isolated patches of hill fog on upslopes but the main cloud base would have been clear of the tops of the terrain. As the flight progressed north-west the front would have moved east and conditions would have deteriorated. The western parts of Snowdonia and the Welsh coastal areas would have had extensive hill fog, cloud bases being between 200 and 400 ft amsl. As well as the poor cloud bases and visibility, moderate turbulence may have been experienced due to convection embedded along the frontal zone. Once over the Irish Sea and further away from the cold front the turbulence would have eased although cloud bases and visibility would have remained poor, between 200 and 400 ft and 2,000 to 5,000 metres respectively. On crossing the Irish coast en route to the destination, shelter from the Wicklow Mountains would have led to a significant improvement in conditions.

### **Personnel**

The pilot was an experienced private helicopter pilot and had renewed his Licence Proficiency Check (LPC) on 17 August 2016. He held a PPL(H) with an AS355 type rating, a night rating and a current class two medical certificate. He did not hold any instrument flying qualification. As part of the renewal process, the pilot was required to demonstrate level turns to the left and right on instruments, and maintaining altitude, whilst wearing 'Foggles'<sup>8</sup>. This was intended to demonstrate that, should an inadvertent entry be made into cloud, the pilot would be able to reverse the aircraft's track and return to an area clear of the cloud.

### **Medical and pathological information**

A post-mortem examination of the pilot included toxicological analysis involving tests for alcohol and other substances. A small amount of alcohol was detected that may have been produced post-mortem. Other substances were detected but their effect if any on the performance of the pilot could not be determined due to the severe trauma he sustained.

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### **Footnote**

<sup>8</sup> Foggles are spectacles worn by the pilot under test which permit visibility of the flight instruments but obscure the external references in order that the pilot flies by sole reference to his flight instruments.

## Flight in Class G airspace

The helicopter was being operated in Class G airspace and was required to be flown under the VFR in VMC. According to Section 5 of the Standardised European Rules of the Air, as set out in the following excerpt from the UK Integrated Aeronautical Information Package, the helicopter was required to be clear of cloud and in sight of the surface, with a minimum inflight visibility of 1,500 m.

VFR flights shall be conducted so that the aircraft is flown in conditions of visibility and distance from clouds equal to or greater than those specified in Table 1.

Table 1 (See Paragraph 1.1)			
Altitude Band (Note 1)	Airspace Class	Flight Visibility	Distance from Cloud
At and above 3050 m (10000 ft) amsl	A B C D E F G (Note 2)	8 km	1500 m horizontally 300 m (1000 ft) vertically
Below 3050 m (10000 ft) amsl and above 900 m (3000 ft) amsl, or above 300 m (1000 ft) above terrain, whichever is the higher.	A B C D E F G (Note 2)	5 km	1500 m horizontally 300 m (1000 ft) vertically
At and below 900 m (3000 ft) amsl, or 300 m (1000 ft) above terrain, whichever is the higher	A B C D E (Note 2)	5 km	1500 m horizontally 300 m (1000 ft) vertically
	F G	5 km (Note 3)	Clear of cloud and with the surface in sight

**Note 1:** Or if, any aircraft which is not a helicopter, at 3000 ft amsl or below and flying by day only at 140 KIAS or less:  
Clear of Cloud and with the surface in sight in a Flight Visibility of at least 5 km.

**Note 2:** Or if a Helicopter and flying by day at 3000 ft amsl or below:  
Clear of Cloud and with the surface in sight in a Flight Visibility of at least 1500 m.

**Note 3:** Flight visibilities reduced to not less than 1500 m are permitted for flights operating:  
(a) at speeds of 140 KIAS or less to give adequate opportunity to observe other traffic or any obstacles in time to avoid collision;  
or  
(b) in circumstances in which the probability of encounters with other traffic would normally be low, e.g. in areas of low volume traffic and for aerial work at low levels.

## Maximum Elevation Figures (MEF)

Figure 18 shows part of an aeronautical chart including the area in which the accident occurred. MEF are located in quadrangles bounded by graticule lines for every half degree of latitude and longitude. MEFs are represented in thousands and hundreds of feet above mean sea level. Each MEF is based on information available concerning the highest known feature in each quadrangle, including terrain and obstacles and allowing for unknown features. A note printed on the complete chart states that this is not a safety altitude. The MEF provides an instant figure on which to base the Minimum Safe Altitude (MSA) for a given area. MSA is based on the MEF plus 1,000 feet, below 5,000 feet. Thus, the MSA in the quadrangle containing the accident mountain would have been MEF 3,300 ft plus 1,000 ft terrain clearance giving an MSA of 4,300 ft. MSA is applied on IFR flights but is not required for VFR flights.



Figure 18

1:500,000 Chart with Maximum Elevation Figures shown

### Other information

*Use of a tablet device to provide information in flight*

The pilot had an iPad fixed on the centre of the instrument panel with a dedicated power supply and equipped with a Runway HD and SkyDemon flight planning tool. The engineer who refuelled the helicopter noticed that it was fitted before the accident flight with the power ON and displaying an aviation chart with a track.

The Runway HD app automatically updates weather and NOTAMS every six hours, and the pilot's subscription provided for 1:500,000 and 1:250,000 aviation charts, and 1:50,000 Ordnance Survey (OS) maps. Spot heights are shown in feet on the aviation charts and metres on the OS maps. The system has airspace alerts but no terrain alerts, however a terrain overlay feature can be selected which colour codes the terrain getting

redder the higher it goes. A vertical terrain profile is available which shows the ground five minutes ahead on the helicopter's track. It is not known if these facilities were selected and in use.

### *Decision making*

On 15 January 2017 a Piper PA-30 Twin Comanche, G-ATMT collided with terrain in Instrument Meteorological Conditions (IMC), fatally injuring the sole occupant. The AAIB report of its investigation into this accident<sup>9</sup> considered decision making by pilots faced with a transition from VMC to IMC, and concluded:

*'a. When under stress, people tend to place a greater emphasis on positive outcomes when making decisions.*

*b. When conditions deteriorate gradually, cues suggesting that a course of action be abandoned often fail to change that course.*

*This indicates that, if intending to remain in VMC, it is better to anticipate the need to avoid the boundary between VMC and IMC than to fly towards it and, perhaps inadvertently, across it.'*

## **Analysis**

### *Engineering*

The investigation did not identify any defect that would have prevented the helicopter from responding normally to the pilot's control inputs.

The helicopter's records showed that the helicopter had been maintained in accordance with its approved maintenance program and that it was compliant with all the mandatory requirements in force at the time of the accident.

The evidence found at the accident site showed that the helicopter struck a rock outcrop in a relatively level pitch attitude at high speed. There was no evidence of a failure of the main rotor drive system and the damage to the main rotor blades and the evidence of rotational scoring to the tail rotor drive shaft indicated that the rotor system was operating under power at impact.

Examination of the flight instrumentation showed that both the pilot's and the standby artificial horizon were operating at impact. The evidence provided by the autopilot mode control panel indicated that the autopilot had been engaged and the modes selected were those associated with normal, descending flight. The GARMIN GNS430 fitted had not been equipped with the modification that would have provided a terrain warning function.

There was no evidence to indicate the presence of a restriction or a pre-existing defect in the flying control circuits, and the main and tail rotor hydraulic actuators operated normally when tested.

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### **Footnote**

<sup>9</sup> Published in AAIB Bulletin 10/2017.

The damage observed to both the left and the right engines was consistent with both engines operating normally immediately prior to the impact. There was no evidence of a pre-existing defect in either engine which would have prevented them responding normally to control inputs.

### *Operations*

The pilot was licensed to fly the helicopter in VMC by day or night and held a valid Class 2 medical certificate. He did not hold any instrument flying qualification and none was required for flight in VMC.

The weather was a significant factor in the accident and from the iPad download, weather information was available to the pilot prior to and during the flight. The pilot would have been flying towards the deteriorating weather in the area of the West Coast of Wales and the Mountains. If unable to maintain VMC the pilot had the option to turn back, divert or land. If he continued, the poor visibility and low cloud forecast for and reported at Valley, combined with low cloud in the Dublin area, would have meant a low level crossing of the Irish Sea in marginal weather conditions.

The helicopter was seen to enter cloud when at an altitude of approximately 2,500 feet heading towards the high ground at Rhinog Fawr, which has a summit of 2,360 ft. The helicopter, which was descending, continued on its track, increasing its rate of descent at about the time it entered the cloud. Having entered cloud, there appears to have been no attempt to turn back.

The pilot had recently demonstrated his ability to perform a 180° turn on instruments during his LPC. It is possible that his last visual observation of the surface was at about 2,000 ft agl, whilst over low ground. It is therefore possible that having entered the cloud, his mental picture was that he had adequate height to descend and regain VMC. However, if he did check the terrain ahead from his chart or iPad he may have then been aware of the rising ground. Given that the cloud would have meant the pilot was now flying in IMC and as the helicopter's GNS430 was not fitted with the terrain warning modification, there was no other means of warning the pilot of the rising ground.

The helicopter was being flown using the autopilot system with the HDG and V/S modes engaged. On entering IMC, it would have been possible to maintain the current height by selecting the ALT mode of the autopilot or setting the VSI command bug to zero. Selecting the heading bug to the reciprocal heading would have initiated a left or right 180° turn which, if completed before impact, should have allowed the pilot to regain VMC and surface contact.

There was no apparent attempt to avoid the high ground, resulting in impact with the mountain at approximately cruise speed whilst in IMC.

## Conclusion

The accident occurred after the helicopter entered cloud while descending. The pilot did not carry out a 180° turn away from the rising ground and probably did not regain VMC before impact with the side of the mountain.

CAA Safety Sense Leaflet 1e – *Good Airmanship*, Leaflet 5e – *VFR Navigation*, and Leaflet 23 – *Pilots – It's Your Decision*, provide guidance for pilots operating VFR in the lower levels of Class G airspace and in poor weather.

The CAA has published CAP 1535 – *The Skyway Code*, intended to provide General Aviation pilots involved in non-commercial and flight training operations with practical guidance on the operational, safety and regulatory issues relevant to their flying, such as flight planning, meteorology and decision making.

## ACCIDENT

<b>Aircraft Type and Registration:</b>	Kolb FireFly, G-CEPN	
<b>No &amp; Type of Engines:</b>	1 Fuji Robin 330 piston engine	
<b>Year of Manufacture:</b>	2007 (Serial no: FF05.4.00048)	
<b>Date &amp; Time (UTC):</b>	20 June 2017 at 0920 hrs	
<b>Location:</b>	Near Newell Lane, Luffenhall, Hertfordshire	
<b>Type of Flight:</b>	Private	
<b>Persons on Board:</b>	Crew - 1	Passengers - None
<b>Injuries:</b>	Crew - 1 (Fatal)	Passengers - N/A
<b>Nature of Damage:</b>	Aircraft destroyed	
<b>Commander's Licence:</b>	Private Pilot's Licence	
<b>Commander's Age:</b>	71 years	
<b>Commander's Flying Experience:</b>	5,215 hours (of which 342 were on type) Last 90 days - 0 hours Last 28 days - 0 hours	
<b>Information Source:</b>	AAIB Field Investigation	

## Synopsis

Shortly after takeoff, approximately one mile from the runway, the aircraft was seen to enter a steep descending left turn from which it did not recover before striking the ground vertically. Analysis of CCTV footage confirmed that, immediately before the final manoeuvre, the aircraft's speed was above the predicted stall speed. The investigation was unable to identify any defect which would have prevented the aircraft from responding normally to the pilot's control inputs.

## History of the flight

The pilot drove to Cottered Airfield with the aircraft on a trailer on the morning of the accident flight. There were no witnesses to his arrival at the airfield, to rigging the aircraft or taking off from the airfield. The aircraft took off from Runway 25 and after flying for less than a mile, was seen by local witnesses and on CCTV to enter a steep descending left turn and impact the ground vertically. The pilot was fatally injured.

## Accident site

Police body camera footage confirmed that, when the Police arrived at the accident site, the aircraft was in a steep nose-down attitude. The emergency services had rotated the aircraft onto its landing gear prior to the arrival of the AAIB.

## Recorded information

The final 4 seconds of the accident flight had been captured by a CCTV system installed on a house approximately 400 m from the accident site. The imagery showed the aircraft entering the camera's field of view for 1.5 seconds in straight and level flight.

The aircraft was then observed to roll sharply to the left and enter a steep dive from which it did not recover before striking the ground. Based on known measurements it was possible to calculate that, immediately before the initiation of the left roll, the aircraft was flying at a height of approximately 120 ft agl with a groundspeed of between 38 and 46 mph.

## Aircraft details

The Kolb FireFly is a high-wing 'unregulated' ultralight/microlight aircraft. The aircraft is an American design with an open cockpit and was intended for amateur construction. The forward fuselage is mainly constructed of steel tubing, which is mated to an aluminium tail boom. The structure of the wings, horizontal stabiliser and tail fin are of aluminium tubing, covered with fabric. The wings are quick-folding for ease of storage and transportation. The FireFly is fitted with a single engine mounted between the wings which powers a pusher propeller through a belt-driven reduction gear system. The aircraft design was intended to meet the limited requirements of the 'FAR Part 103' federal regulations in the USA for 'Ultralight Aircraft', which would mean the aircraft would not need to be registered and the pilot would not require a licence.



**Figure 1**  
Kolb FireFly

Around 2007, the CAA developed regulations, 'Single Seat De-Regulated (SSDR)', which were similar to those in the United States, allowing aircraft such as G-CEPN to operate without requiring a certificate of airworthiness or permit-to-fly. A pilot is still required to hold a licence for the class and the aircraft is registered. In 2013 this category was extended, to include all single-seat microlights within certain weight restrictions.

Since the aircraft are sold in kit form for construction by amateurs, there are no flight instruction manuals produced by the kit manufacturer. Each aircraft will perform differently due to the individual nature of the build. G-CEPN was the first FireFly imported into the UK and was test flown for a magazine article. This article listed the stall speed for the aircraft at the time of the test flight as 27 mph. This speed would be in agreement with the information published by the manufacturer which states:

*'It is very responsive and light on the controls, yet is not twitchy or sensitive. The FireFly also has gentle stall characteristics. Upon entering a stall from straight and level flight, there is some sink which precedes the stall. Continuing into the stall, there will be a gentle break at about 30 mph and the nose will drop. The aircraft gains speed and resumes flying with a reduction of stick back pressure.'*

### **Maintenance history**

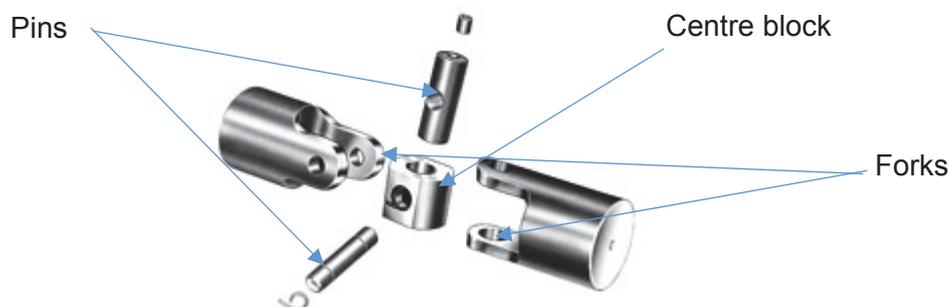
The aircraft had been built in 2007 and had been fitted with a Hirth F33 engine. In November 2011, after 48 flying hours, the engine had been replaced with a Fuji Robin 330. The last entry in the aircraft's log book was made in July 2013, at 199 flying hours, when the aircraft suffered an in-flight loss of the propeller and the reduction-gear system, reported in AAIB Bulletin 1/2014.

In addition to the log book, the pilot recorded aircraft maintenance activity in a note book. The last dated entry in the note book was 11 March 2017, maintenance notes continued after this entry but were not annotated with dates. The notes suggested that the pilot monitored engine and airframe performance and carried out routine maintenance tasks. A review of the pilot's log books suggests that the aircraft had accumulated approximately 370 flying hours at the time of this event.

### **Aircraft examination**

Examination of the aircraft showed that both wings exhibited leading edge compression, the main mounting structure for the left wing had fractured during the impact and the left wing spar had fractured approximately 1 m from the wing root. The rear section of the engine mounting structure had failed and both propeller blades had shattered at approximately 30% of the blade span; the internal metal spar of one of the blades was exposed and had been bent in a direction opposite to the direction of propeller rotation. The fuel tank, which had been removed by the emergency services, was approximately 25% full of fuel. The damage to the wing mounting structure prevented confirmation of aileron control continuity on site but the continuity of the rudder and elevator controls was confirmed. It was also confirmed that all the pins and bolts used to secure the wings to the fuselage were in place and secure.

It was not possible to carry out any investigation of the aircraft's instrumentation due to impact damage. Examination of the aileron control circuit confirmed that it had been correctly rigged but the universal joint within the control circuit had fractured and the centre block was missing, Figure 2.



**Figure 2**

Example of a universal joint

Evidence of mechanical damage and deformation of the joint forks and pin locating holes was observed on the remaining sections of the joint, showing that the centre block was in place at the time of the impact with the ground.

Examination of the left wing spar failure and the fuselage wing and engine mounting structure confirmed that all the failures were as a result of structural overload. The engine was disassembled and no evidence of a defect or failure was identified. Inspection of the carburettors confirmed that fuel was present in the carburettor bowls and there was no evidence of a defect which would have prevented normal operation.

### **Meteorology**

Luton Airport lies 13 nm south west of Cottered Airfield, and Stansted Airport lies 13 nm south east. Both were reporting light easterly winds, with no cloud, good visibility and a temperature of 24°C.

### **Airfield information**

Cottered Airfield is a 500 m grass strip on a farm. The pilot was familiar with the airfield and the local area. He stored his aircraft at home, rigging and de-rigging each time at the airfield.

### **Pilot information**

The pilot had been flying microlight aircraft for many years and had extensive experience on a number of different types. Up to the flight of 20 June 2017 he had not flown for some months, due to technical issues with the aircraft as well as personal reasons. As his class rating for microlights had been issued prior to 1 February 2008, he was not required to have any flights with an instructor to renew his rating by experience. There was no record of him having flown any dual flights since he received his licence in 1990.

A post-mortem examination was carried out on the pilot by a pathologist. It reported no evidence of underlying disease and concluded that the pilot had died from multiple injuries. Toxicology tests revealed no evidence of any substance that could have contributed to the event.

### **Analysis**

With no witnesses to the arrival of the pilot at the airfield, his rigging or takeoff, it was not possible to establish the pilot's intentions for this flight. He appears not to have flown for over six months, so he was out of recent flying practice, but it is not known whether this was a factor in the event.

There was no evidence of a pre-impact failure of the aircraft's structure and there was no evidence of a defect within the engine which would have prevented its normal operation. The damage to the propeller blades was consistent with them hitting the ground whilst rotating under power.

The damage observed to the universal joint within the aileron control circuit was consistent with the joint being correctly connected at impact. No defects were observed within the aircraft's controls which would have prevented the aircraft responding to the pilot's control inputs and there was no evidence of an in-flight structural failure.

### **Conclusion**

The investigation did not find any evidence of a defect with the aircraft which would have prevented the aircraft responding to control inputs. The pathology did not indicate that the pilot had suffered an incapacitation and although he had not flown recently it is not known if this lack of recent experience was a factor in this event.

Analysis of the CCTV imagery showed that, immediately before the final manoeuvre, the aircraft was flying at an airspeed greater than its predicted stalling speed. It is highly unlikely, therefore, that a stall or spin entry was a factor in this event.

It is therefore not known why the aircraft departed from what appeared, from the CCTV imagery, to be level and controlled flight.

## ACCIDENT

<b>Aircraft Type and Registration:</b>	SZD-55-1, G-CKLR	
<b>No &amp; Type of Engines:</b>	None	
<b>Year of Manufacture:</b>	1993 (Serial no: 551193056)	
<b>Date &amp; Time (UTC):</b>	8 April 2017 at 1045 hrs	
<b>Location:</b>	Currock Hill Airfield, Northumbria	
<b>Type of Flight:</b>	Private	
<b>Persons on Board:</b>	Crew - 1	Passengers - None
<b>Injuries:</b>	Crew - 1 (Fatal)	Passengers - N/A
<b>Nature of Damage:</b>	Extensive	
<b>Commander's Licence:</b>	Private Pilot's Licence	
<b>Commander's Age:</b>	62	
<b>Commander's Flying Experience:</b>	18,800 hours (of which 39 were on type) Last 90 days - 1 hour Last 28 days - 0 hours	
<b>Information Source:</b>	AAIB Field Investigation	

## Synopsis

During a towed launch, the glider was seen to climb rapidly. After disconnecting from the tow rope with a very high pitch angle, the glider rolled to the right and descended before hitting the ground in a nose-down attitude. The pilot was fatally injured.

The investigation determined that the elevator control connection had not been correctly made when the glider was rigged and this condition was not detected prior to the flight. Consequently, during the launch, the glider would have had no effective elevator control and the pilot would have been unable to control the pitch of the glider.

It was found that an historic and unapproved modification to the glider significantly increased the opportunity for mis-rigging. As a result, the European Aviation Safety Agency have taken safety action to mandate an inspection of similar gliders. In addition, one Safety Recommendation is made.

## History of the flight

In the two months prior to the accident, the pilot had been conducting some work on the glider to fit some new avionics, including a transponder. This was his first flight after completing the work. He arrived at the airfield at around 0830 hrs in order to prepare and rig the glider for flight.

He engaged the help of some club members, who were on their way to the launch point, to help him with rigging the wings of the glider. Once that was done, he drove them, in his car, to the launch point, before returning to complete the rigging of the glider. There were no witnesses to the rest of the rigging, nor to any checks which may have been carried out upon completion. Other club members reported that it was usual for the pilot to complete the rigging of the tailplane himself, and then tow the glider up to the launch point using his car.

Once at the launch point, the pilot was joined by the other owner of the glider. It was normal practice for both owners to fly the glider in turn. The pilot positioned the glider for launch at the end of the north-easterly runway, strapped in and completed the pre-launch checks, including a check for full-and-free movement of the controls with the help of the other owner. The tow line was attached to the front hook, also known as the aero-tow hook, and the launch commenced in accordance with the club procedures.

As the tug accelerated towards takeoff speed, the tug pilot became aware that there was a problem with the launch. When he looked behind, he noticed the glider was climbing rapidly above him. He then felt the tow release and the tug continued its takeoff.

Witnesses on the ground saw the glider become airborne and adopt a steep angle before they heard the crack of the tow rope releasing. The glider reached an estimated height of 100 ft, then appeared to drop its right wing and descend nose-first into the ground, coming to rest at the right of the grass strip, facing back towards the launch point. The pilot sustained fatal injuries.

### **Meteorology**

The weather recorded at Newcastle Airport, which lies 8 nm to the north-east of the gliding site, was a light variable wind, CAVOK and a temperature of 11°C. Witnesses at the gliding club reported the same conditions with a light easterly wind.

### **The pilot**

The pilot was an experienced former airline captain. He also had extensive flying experience in hanggliders, microlights, and fixed wing aircraft. He had started gliding in 2014 and, after completing his gliding course, the pilot flew a Sport Vega glider before purchasing G-CKLR. He had completed 85 launches, all of which were at Currock Hill with 52 of those launches being in G-CKLR. He had flown for 38 hours and 44 minutes in G-CKLR before the accident flight. The pilot had not flown for the two months prior to the accident as he was completing the work on the glider.

The pilot had recently retired from commercial flying due to medical issues which meant he could no longer hold a Class One medical. One of these issues was some loss of strength and feeling in his right arm and shoulder.

## Airfield information

Currock Hill has a grass strip orientated 06/24 which is 600 m long. It is operated by a gliding club. The gliders are towed into the air using a light aircraft and a tow rope. The airfield and the accident site are shown in Figure 1.



*Google Earth imagery date 17/7/17 - accessed 5 December 2017*

**Figure 1**

Currock Hill Airfield and accident site

## On-site examination

The glider had struck the ground in a steep nose-down attitude, to the right of Runway 06 and facing approximately opposite to the takeoff direction. The nose of the glider and cockpit area were severely disrupted. The seat was intact but had separated from its structural mounts. However, the harness and its attachment points were intact.

The left wing leading edge struck the ground, as indicated by a 3 m long ground mark and the right wing had detached at the root. The impact severed the fuselage structure aft of the wings, causing the base of the tail fin to strike the ground. The rudder surface did not move freely, having been forced off its pivots during the impact. The elevator appeared to be jammed in the fully-up position, having been forced upwards by the impact and maintained in that position due to the elevator control rod having been bent at the location of the fuselage break. The elevator released when the control rod was cut to facilitate removal of the wreckage; however, once released, it did not exhibit a full range of movement.

## Survivability

The glider descended with a high rate of descent and hit the ground nose-first, crushing the front of the structure completely. The pilot was wearing a parachute, however the glider did not reach a height at which this could have been used successfully. The accident was not survivable.

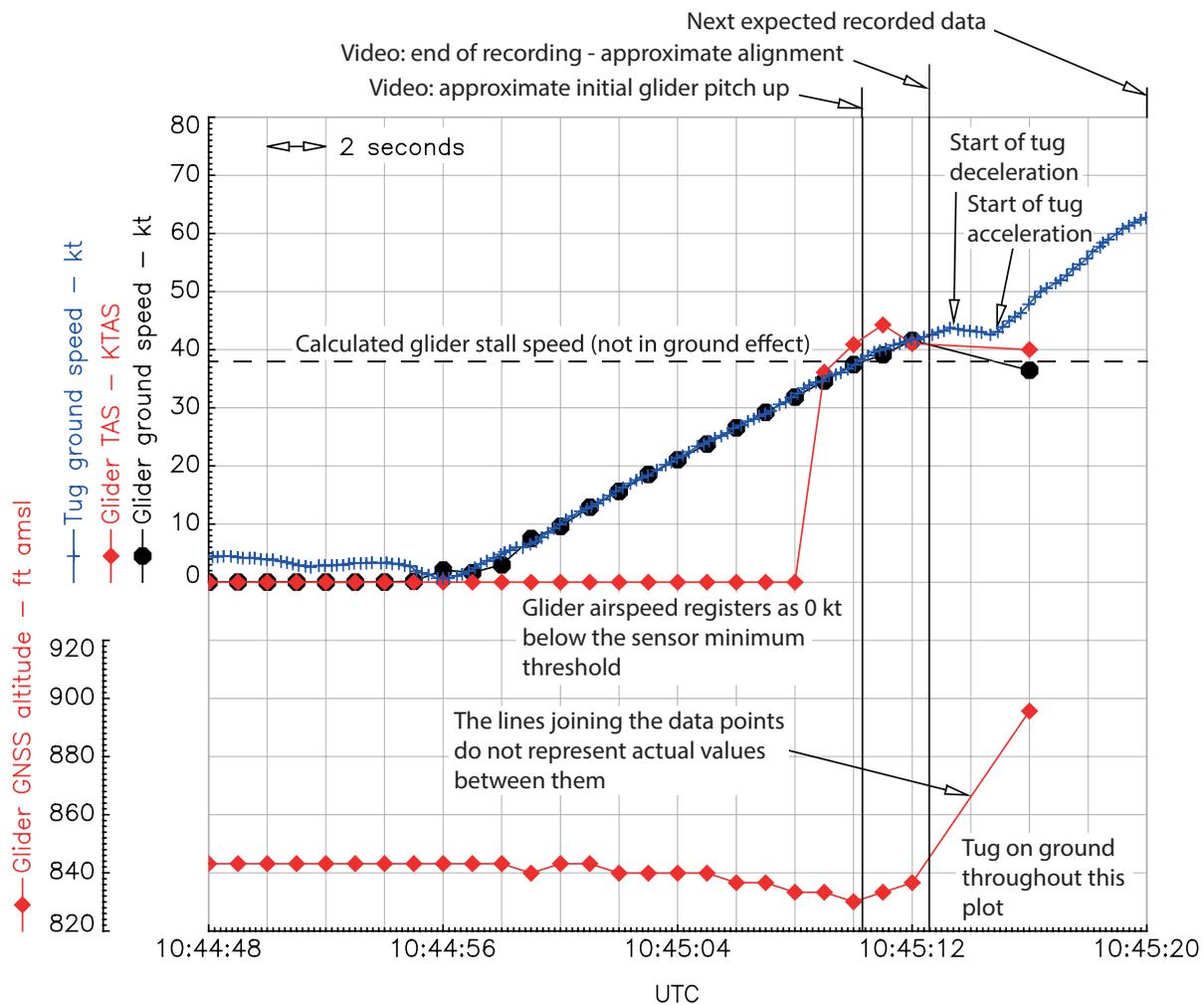
## Recorded data

A video of the initial takeoff roll was made available to the investigation. The video commences with a right rear view of the stationary tug. The glider was not in view but was to the left of and behind the camera. The tug started its takeoff and the glider came into view on the left of the frame. The glider continued forward into the distance and pitched up. In the final video frame, the glider was approximately 15 ft above the ground with approximately 5° of right roll and 15° of nose-up pitch. The tug did not appear to have left the ground by the end of the video.

During the glider's takeoff roll, use of ailerons, rudder and airbrake were evident. When first visible in the video, the elevator is in a slight trailing edge-up position. The image resolution, thin profile of the elevator and poor contrast does not support accurate measurements of elevator deflection. No large elevator deflections were identified in the video but, as the distance between the camera and glider increased, even large deflections would have been increasingly difficult to detect.

A number of electronic items were recovered from the accident site, including an LX8080 unit which recorded data during the accident flight. It recorded a set of parameters once per second during the takeoff roll and then switched to recording once every four seconds once it met its takeoff detection criteria. The data is shown in Figure 2. The peak TAS recorded was 44 kt (82 km/h). At the last recorded data point, the GNSS (Global Navigation Satellite System) and pressure-derived altitudes indicate that the glider had a height of approximately 60 ft agl. The low sampling rate at that time makes it unlikely that the last data point coincided with the peak height reached. In addition, both the sources of altitude data could be subject to increased errors during dynamic manoeuvres.

Data recovered from the tug (Figure 2) indicates that in the four second period between the glider's last two data points, the tug, which was still on its takeoff ground roll, experienced a short period of deceleration. Thereafter the tug's acceleration was higher than that evident earlier in the takeoff roll.



**Figure 2**

Recorded data from the glider and tug

## Description of the glider

### General

The SZD 55-1, a single-seat standard class sailplane with an empty mass of 215 kg, was designed and manufactured by Szybowcowy Zakład Doswiadczalny (SZD) Bielsko in Poland in the 1990s. The type certificate is currently held by Allstar PZL.

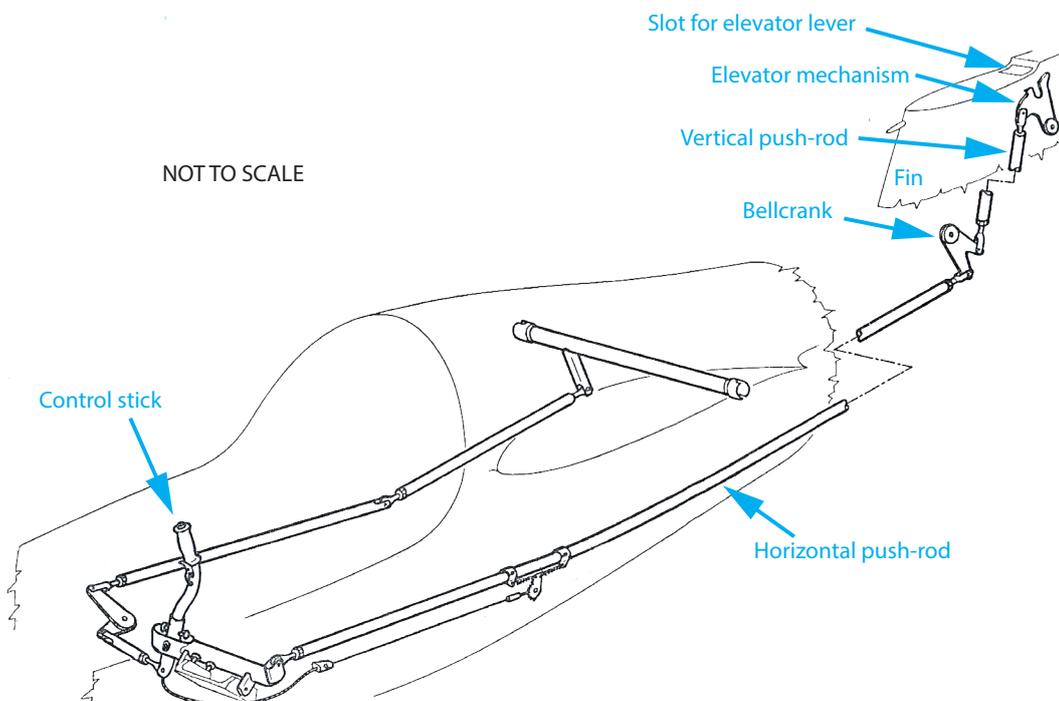
The SZD-55-1 is of predominantly fibreglass construction with an elliptical wing planform. It has a retractable main undercarriage wheel and a fixed tailwheel. G-CKLR was equipped with two towing hooks, a Tost G-type hook on the undercarriage fork, used for winch launching and a Tost E-type hook under the nose of the glider, used for aero-tow launches.

The flight control systems for the aileron, airbrake and elevator are of the push-rod type, and designed to be automatically-connecting during the rigging process. The rudder, towing hooks and wheel brake control systems are operated by cables.

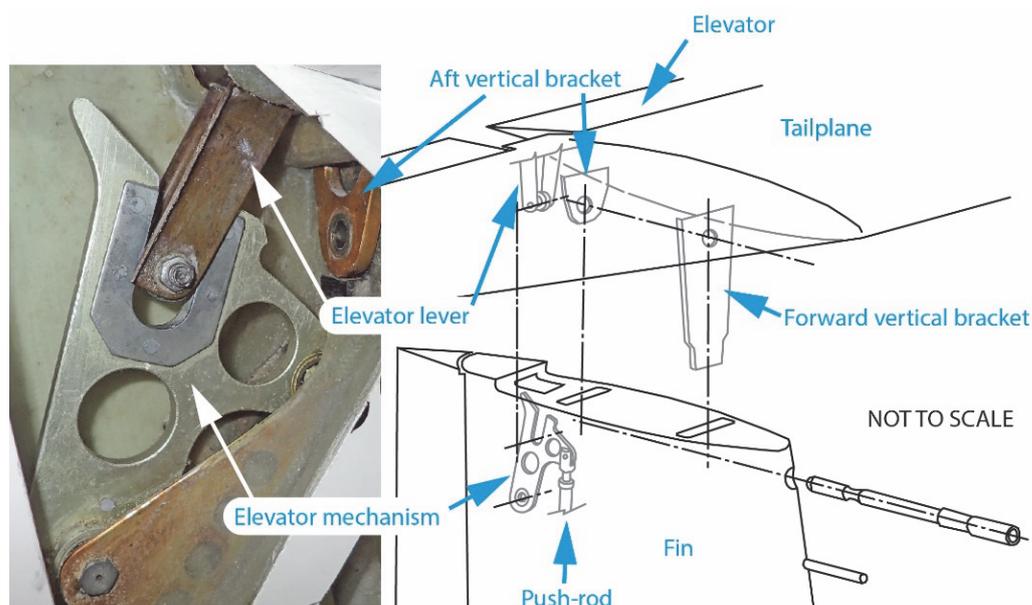
### *Elevator control system*

The elevator control system on the SZD-55-1 (Figure 3) comprises a horizontal push-rod which runs from the control stick quadrant, throughout the length of the fuselage to the base of the tail fin, where it is connected via a bellcrank to another push-rod, which runs vertically up through the fin. At the top of the vertical push-rod, a pivoting guide mechanism, known as the elevator mechanism, couples with the elevator control hinge (elevator lever), when the tailplane is attached to the fin. A roller on the end of the elevator lever facilitates alignment by ensuring the lever engages in the U-shaped channel of the mechanism. Figure 4 shows a detailed view of the elevator lever and elevator mechanism.

The elevator control system includes a spring-trimming lever on the control stick. Pressing the lever disconnects the spring from the control system; when the lever is released the spring engages and helps to retain the control stick in the selected position.



**Figure 3**  
SZD-55-1 elevator control system



**Figure 4**

Normal connection of elevator lever and elevator mechanism on SZD-55-1

### **SZD-55-1 tailplane rigging philosophy**

Gliders are generally stored in a trailer and therefore, before the first flight of each day, the glider must be rigged. Assembly of the wings normally requires two or three people and rigging of the tailplane requires one or two people.

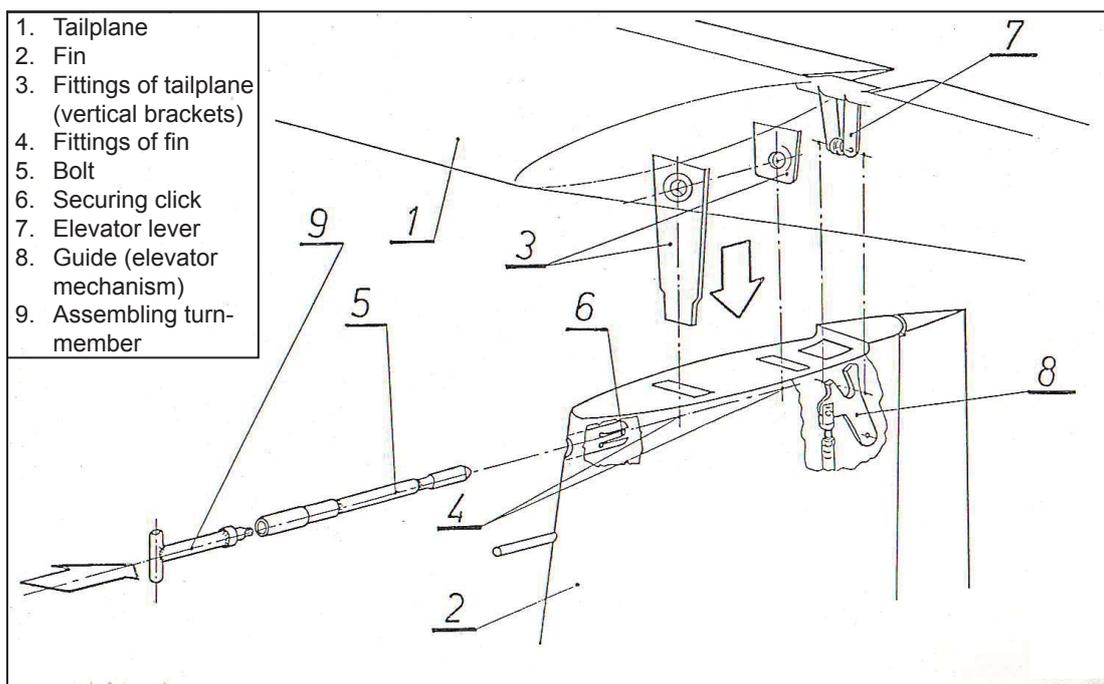
Section 4.13 of the SZD-55-1 Flight Manual describes the assembly procedure and indicates that the wings should be assembled first and then the tailplane. It states that three people are necessary to rig the glider or, if wing supports are available, it may be accomplished by two people.

Two vertical metal brackets, on the underside of the tailplane, provide the structural connection between the tailplane and the airframe. When the tailplane is offered up to the fin, these brackets fit through two slots on the upper surface of the horizontal rib of the fin. The elevator lever, mounted at the trailing edge of the tailplane, fits through a third slot to engage with the elevator mechanism (Figures 3 and 4). The tailplane is secured in place by a long bolt, which is inserted through the leading edge of the fin.

The geometry of the tail fin and the dimensions of the slots on the upper surface of the tail fin are intended to ensure correct alignment of the structural and flight control connections, and to prevent improper connection of the elevator lever.

With respect to rigging the tailplane, the following instructions are given in the Flight Manual. The numbers in parenthesis refer to the items labelled in Figure 5:

- *Put the [control] stick in the neutral position using the trimming device.*
- *Fit the tailplane (1) on the fin. Move the stick, if necessary, to insert the lever (7) into the guide (8).*
- *Connect the tailplane (3) and fin (4) fittings by means of bolt (5) with the assembling turn-member (9) screwed in*
- *Screw-off the assembling turn-member and check at the final phase of screwing-off (2 threads) the efficient securing [of] the bolt against shifting out.*
- *.....*
- *Hold the elevator and ailerons and check the operation of the control systems under the loading.*
- *.....'*



**Figure 5**

Amended extract from SZD-55-1 Flight Manual showing tailplane and elevator rigging

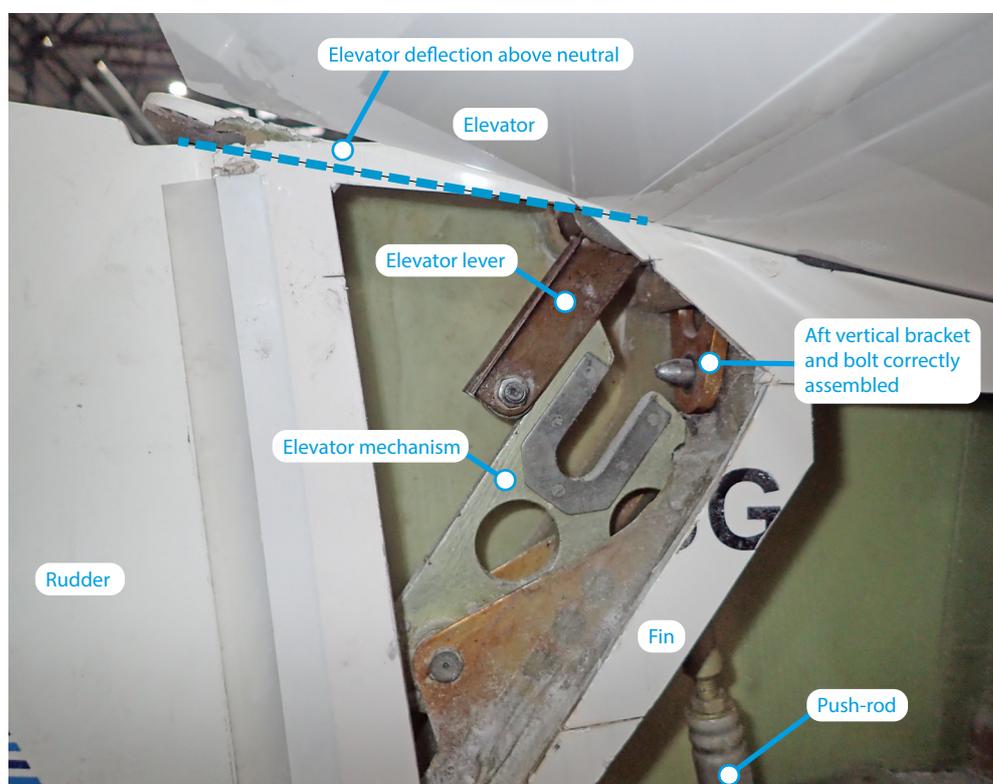
## Information from the manufacturer

The manufacturer of the glider was not aware of any previous SZD-55-1 accidents relating to elevator mis-rigging. Following this accident, it performed a trial tailplane rigging on an SZD-55-1 to identify if there was any potential for a mis-rigging condition. The manufacturer determined that if the elevator lever was not properly engaged in the elevator mechanism, it was not possible to fully rig the tailplane, even if excessive force was used. The manufacturer advised the investigation that the design features of the tail fin and tailplane, namely the shape and dimensions of the slots in the horizontal rib of the fin, the design of the elevator mechanism and the presence of the wooden stop block, prevented the possibility of a mis-rig. If the elevator lever and mechanism were not fully connected, the tailplane would not fit properly to the vertical fin, a gap would be visible and it would not be possible to insert the rigging pin.

The manufacturer advised that the trimming spring would not hold the control stick rigidly in place and would allow some movement of the mechanism to achieve alignment.

## Detailed aircraft examination

The tailplane was correctly seated on top of the tail fin with no obvious gap between the tailplane and the fin. Access panels were cut in the tail fin to inspect the elevator control connection. It was observed that the tailplane structural connections were correctly made, and the securing bolt correctly inserted. However, the elevator lever was not engaged in the elevator mechanism, but was instead sitting aft of the mechanism (Figure 6).



**Figure 6**

Position of elevator lever as found on G-CKLR  
(Note: elevator lever not engaged in elevator mechanism)

Disruption to the elevator control system, caused by the impact, meant that the control stick was no longer connected to the elevator control mechanism, and the position of the mechanism was therefore not restrained. Consequently, as shown in Figure 6, the elevator mechanism, under its own weight, is resting against a small wooden block, which forms the forward stop of the elevator control system. This corresponds to a position slightly forward of full forward control stick. In normal circumstances, control stops on a bracket at the base of the control stick limit its range of movement and, when the control stick is in the fully forward position, there should be a 0.5 mm gap between the elevator mechanism and the wooden block.

During examination of the wreckage, the horizontal elevator push-rod was moved forward and aft to simulate movement of the control stick. It was demonstrated that in this mis-rigged condition, the elevator surface could be driven upwards by moving the control stick (push-rod) aft. Forward movement of the control stick (push-rod) resulted in the elevator surface moving downwards under gravity, but only to a position above neutral and not into the normal downwards range of elevator deflection. The available range of elevator deflection in the mis-rigged condition was measured as 5° UP to 30° UP; the normal range of elevator deflection is 20° DOWN to 30° UP.

The rigging pin was removed from the fin and it came out smoothly, with no resistance. When the tailplane was removed, it was evident from examination of the horizontal rib of the tail fin, that the elevator lever slot was substantially larger than the original design dimensions. The appearance of the edge of the slot was rough and unfinished and was of uneven thickness. The manufacturer considered that the finish did not correspond to original production standard.

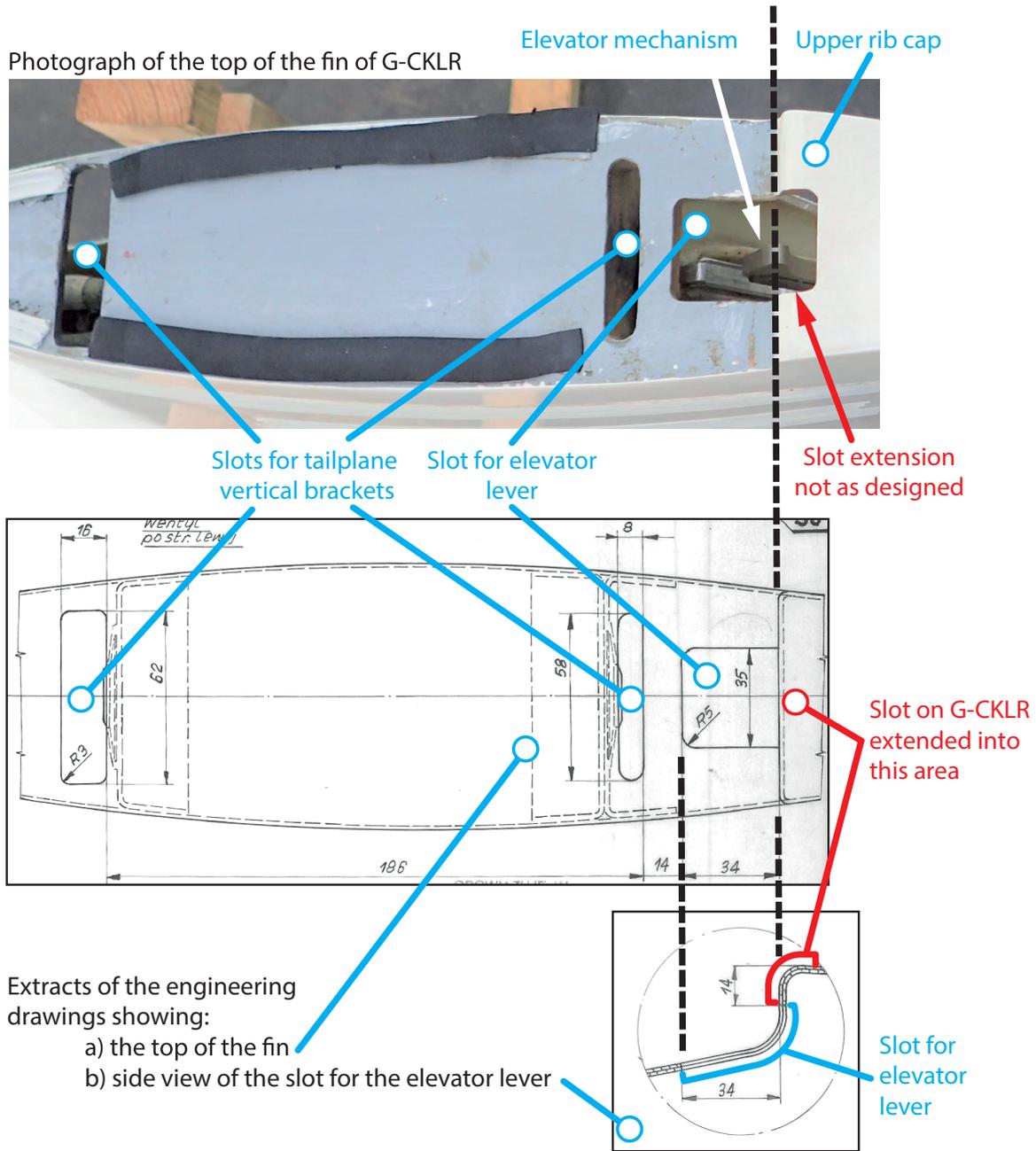
Figure 7 shows a plan view of the horizontal rib from the tail fin of G-CKLR compared with extracts from an engineering drawing provided by the manufacturer.

The design dimensions of the elevator slot in the horizontal rib of the tail fin should be 34 mm x 35 mm. The horizontal rib exhibits an approximately vertical step-change in profile towards its aft end. The design drawings indicate that the elevator lever slot should extend only partially up this vertical step, to a position which is approximately indicated by the dashed line in Figure 8. However, on G-CKLR this slot extends up the entirety of the vertical step and onto the upper rib cap.

#### *De-rigging and re-rigging tests*

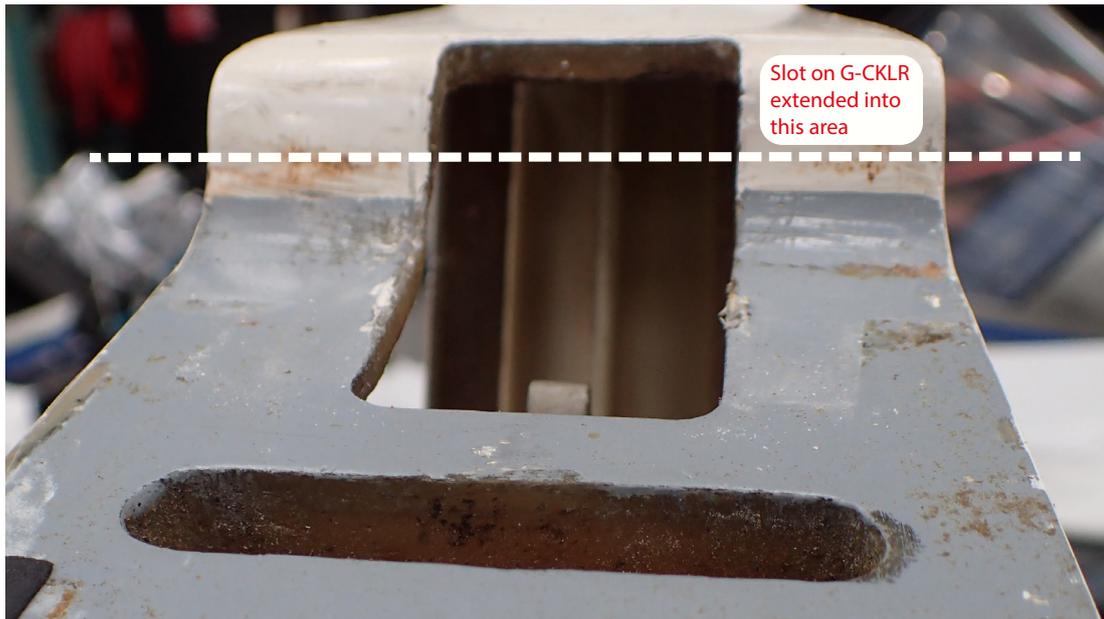
A number of trial tailplane riggings were conducted, in various configurations, to understand how the presence of the enlarged slot on G-CKLR may have affected the rigging process.

It was noted that when the tailplane was held in a way that did not involve touching the elevator, the elevator surface would droop under its own weight and the elevator lever would hang vertically downwards. This put the elevator in the best orientation to align with the elevator mechanism. When offered up to the fin in this manner, even with the elevator mechanism in the fully forward position, it was possible to rig the elevator controls correctly.



**Figure 7**

G-CKLR tail fin horizontal rib comparison with extracts from engineering drawing showing design dimensions



**Figure 8**

Rearwards view of elevator slot in G-CKLR's tail fin

If the tailplane was offered up to the fin with the elevator surface in the fully-up position, such as might occur if those rigging it held on to the elevator trailing edge, the shallow angle of the elevator lever caused it to foul against the aft edge of the slot, preventing it from entering the slot.

However, with the elevator mechanism in the fully forward position, if the elevator was held in a range of intermediate positions, the angle of the elevator lever was such that it could very easily and with no resistance enter the empty space behind the mechanism, creating the mis-rigging condition observed following the accident.

It was noted that when attempting to rig the tailplane single-handedly, it was difficult to do so without touching the elevator surface, and it was more convenient to position the tailplane with one's palms under the tailplane and one's thumbs resting under the elevator. This slight upward force would place the elevator in an intermediate position.

When the tailplane was rigged with the mechanism held in a position corresponding to a neutral control stick position, it was not possible to mis-rig the elevator controls because the position of the mechanism prevented the lever entering the empty space behind the mechanism.

In summary, these tests demonstrated that with the enlarged slot, a mis-rigging condition could occur when the elevator mechanism was in a forward position and the tailplane was held such that the elevator was in a slightly up position during rigging.

## Pilot rigging experience

All the pilot's gliding in G-CKLR took place from Currock Hill. Based on logs from the gliding club, the pilot had flown a total of 52 flights in G-CKLR on 41 separate days. The glider was stored in a trailer and was rigged prior to each day's flying. Therefore the pilot would have been involved in the rigging of G-CKLR a minimum of 41 times prior to the day of the accident; the most recent being on 04 February 2017, and, prior to that, on 10 December 2016.

## British Gliding Association (BGA) publications

The BGA is the governing body for the sport of gliding in the UK and, among other things, is responsible for managing training standards and ongoing airworthiness of the UK glider fleet.

The BGA publishes a Safety Briefing Leaflet '*Is your glider fit for flight?*' which aims to highlight the importance of preparing gliders correctly for flight, offer guidance on how to do so and indicate some of the glider types and mechanisms that are vulnerable to rigging errors. The leaflet states:

*'Rigging errors, and other errors and omission in preparing a glider for flight, are frequently caused by interruption, distraction, forgetfulness, and making unwarranted assumptions.'*

Further, it states that, for a glider without automatic control connections, it is essential for positive control checks to be carried out every time it is rigged, because this can reveal connections that have only partially been engaged. It describes the positive control check as follows:

*'Taking care not to apply excessive force, each control surface should be restrained while an attempt is made to move the control, and the direction of motion checked. It only takes a couple of minutes for a helper to advise the rigger whether movement of the cockpit controls generates the correct responses at the control surface.'*

The leaflet describes a number of incidents where gliders have launched with elevators unconnected or incorrectly connected and identifies some glider types that are vulnerable to mis-rigging; the SZD-55-1 is not one of the types listed.

The BGA require that all gliders operating under its remit are subject to a Daily Inspection (DI) prior to flight. Typically, the DI is recorded in a DI book, which the pilot signs to indicate it has been completed. The tasks required to be completed during a DI are described in BGA publication '*Generic Maintenance Programme*', Issue 1 revision 2 19/02/2013, Section 2, page 2-2. Item 5 of the DI includes the requirement to:

*'Check flying controls for operation and sense. Perform positive control check.'*

## **Other SZD-55-1 glider examinations**

The AAIB examined one other UK-registered SZD-55-1 in order to inspect the geometry of the slots on the horizontal rib of the tail fin. The slot for the elevator lever appeared to have been marginally enlarged, but not to the same extent as that on G-CKLR. The forward slot also appeared to have been enlarged. The owners of the glider had not been aware of this.

At the AAIB's request, the BGA inspected a second UK-registered SZD-55-1; the elevator slot appeared to have been marginally enlarged, but not to the same extent as that on G-CKLR.

## **G-CKLR maintenance history**

### *Previous maintenance history*

The previous owners, a two-person syndicate, purchased the glider in September 2005 from a sales agent who had acquired it in France, and did the necessary work to transition it to the UK register. They first flew the glider in February 2006 and sold it to the accident pilot in March 2015.

The lead owner in the syndicate confirmed to the investigation that no work had been carried out on the elevator control system or fin during the period in which he owned the glider; nor was he aware of any previous modifications performed in these areas. This situation was reflected in maintenance records. In addition, he stated that he had never encountered any difficulties rigging the tailplane or possible mis-rigging conditions.

In April 2006, not long after it was purchased by the previous owners, the glider was damaged while landing-out in a field and was sent to a facility in Poland for repair and replacement of the right wing. In a photograph taken in July 2006 while this repair was being carried out, the enlarged elevator lever slot in the horizontal rib of the tail fin is clearly visible, indicating that it had been modified prior to this point.

Prior to being brought to the UK, the glider had been owned and operated since new by a gliding club in France. A review of the maintenance records from this period did not reveal any reference to enlargement of the elevator lever slot in the horizontal rib of the tail fin. In 2003, G-CKLR was the SZD-55-1 fleet leader in terms of flight hours and, approaching the original design life of 3,000 flight hours, a life extension inspection was carried out in France by the original designers of the SZD-55-1. A review of records from that inspection did not reveal any remarks about observed deviations from the original design.

### *Recent maintenance history*

The accident pilot purchased the glider in March 2015. Between January and April 2016, the glider had undergone repairs after it sustained damage when its trailer was blown over in a storm. The last annual inspection was carried out on 5 April 2016, and the next was due on 25 May 2017.

At the time of the accident the glider had accumulated 3,634 flying hours over 1,449 launches. Prior to the accident flight, the glider had last been flown during a 32-minute flight in February 2017. Between then and the date of the accident, the pilot had taken the glider to his home where he had carried out extensive work on it, including fitting a new transponder and radio together with the associated wiring and replacing some other wiring.

On 2 March 2017, a BGA Inspector who had agreed with the pilot to perform the upcoming annual inspection in May 2017, visited the pilot at his home to familiarise himself with the glider and carry out part of the annual inspection while it was disassembled. During that visit he took a number of photographs of the glider which show that the seat and upper instrument panel had been removed. The new transponder had been fitted but neither the transponder antenna nor the new radio had been fitted. The pilot asked the Inspector to look at the installation of the transponder. The cockpit trim and floor had also been removed such that the base of the control stick and its connections to the aileron and elevator control runs were exposed. The Inspector also collected the glider log book and technical manuals from the pilot, in preparation for doing the annual inspection.

A number of weeks later, while at the gliding club, the pilot mentioned to the BGA Inspector that when installing the LX8080 in G-CKLR he had incorrectly connected the power leads and damaged the unit. In the week leading up to the accident, the pilot had had to cancel a planned week's gliding at another airfield as he was still waiting for the replacement LX8080 to arrive.

A member of the gliding club reported a conversation with the pilot on 2 April 2017, in which the pilot mentioned that he was doing some work on the control surfaces and linkages. The club member asked him if he was a BGA Inspector, because his own understanding was that any work done on the flight controls must be supervised by a BGA Inspector, and be subject to a duplicate inspection. The pilot's response suggested that he was not concerned by this aspect as it was only he and the other co-owner who flew the glider. He did not specifically mention what controls he was working on but the club member advised him that he should get someone to supervise the work or to do it for him.

The pilot brought the glider in its trailer to the gliding club on the evening of 5 April, in preparation for flying during the coming weekend. A friend indicated that, during a phone conversation on 6 April 2017, the pilot said he was still waiting for some parts for the glider to arrive.

Following the accident it was noted that none of the recent work performed on the glider by the pilot, nor any elements of the inspection performed by the Inspector had been documented in the glider's log book, so it was not possible to determine exactly what work was carried out. The co-owner of the glider was not aware of any work having been done on the flight controls by the pilot. No current DI book was found for G-CKLR.

## Pilot-owner maintenance

BGA Airworthiness and Maintenance Procedures (AMP 2-1) '*Pilot Owner Maintenance*', Version 1.2, effective date 1st October 2016, describes pilot-owner maintenance tasks which are permitted to be carried out under the UK ANO and EU Regulation 1056/2008 (Part M) and states that any such work should be documented via log book entries.

*'The pilot-owner may carry out simple visual inspections or operations to check for general condition and obvious damage and normal operation of the airframe, engines and components.*

*Maintenance tasks shall not be carried out by the pilot-owner when the task:*

- i. is critically safety related, whose incorrect performance will drastically affect the airworthiness of the aircraft or is a flight safety sensitive maintenance task and/or;*
- ii. requires the removal of major components or major assembly unless otherwise specified in the flight manual as a pilot task and/or;*

*.....'*

With respect to some of the maintenance which was recently performed on G-CKLR, AMP 2-1 describes the following permitted glider pilot-owner maintenance tasks:

*'Communication devices:*

*Remove and replace self-contained front instrument panel mount communication devices with quick disconnect connectors.*

*Navigation devices:*

*Removal and replacement of self-contained, front instrument panel mount navigation devices with quick disconnect connectors.....excluding transponders ....*

*Wiring:*

*Installation of simple wiring connections to the existing wiring for additional equipment such as variometers, flight computers but excluding communication and navigation systems.'*

With regard to flight controls, AMP 2-1 describes the following permitted glider pilot-owner maintenance tasks:

*'Flight controls:*

*Measurement of free play in the flight control systems including minor adjustment by simple means.*

*Measurement of the control system travel without removing the control surfaces:*

*Control stick removal and reinstallation where provision for quick disconnect is made by design.'*

## Analysis

### *Introduction*

From the examination of the aircraft, it is evident that when the glider was rigged prior to the accident flight, the elevator lever did not correctly engage in the elevator mechanism but instead entered the empty space behind the mechanism. The mis-rig was not identified prior to flight.

In this condition, while the glider was on the ground prior to flight, the elevator surface would have moved upwards when the control stick was moved aft. Forward movement of the control stick would have resulted in the elevator surface moving downwards under gravity, but only to a position above neutral.

During the takeoff, airflow across the elevator's surfaces would have caused it to move upwards and this movement would have been entirely independent of control stick position. Consequently, during the launch, the pilot would have had no effective elevator control in either direction and therefore would have been unable to control the pitch of the glider.

### *Design of the elevator control connection*

The SZD-55-1 was designed with automatically-connecting flight controls. The design geometry of the elevator slot on the horizontal rib of the fin was specifically intended to limit the angle at which the elevator lever could be inserted, in order to facilitate correct and automatic alignment with the elevator mechanism and to prevent the possibility of a mis-rig. In order to place the elevator mechanism in the ideal position to receive the elevator lever, the rigging instructions in the SZD-55-1 Flight Manual required the control stick to be in the neutral position. However, the manufacturer did not consider the control stick position to be critical to the success of the rigging procedure because the profile of the mechanism and the presence of the roller on the end of the elevator lever, would ensure that any minor mis-alignment would be rectified by the roller rolling down the face of the mechanism and into the U-shaped channel. In addition, as per design intent, if the elevator lever and mechanism were not fully connected, the tailplane would not sit properly on the vertical fin and it would not be possible to insert the rigging pin.

### *Effect of the enlarged elevator slot*

The enlargement of the elevator slot on G-CKLR removed one of the designed-in protections against mis-rigging and allowed a situation where the elevator lever could be inserted into the slot in a range of possible angles, effectively making the control stick position much more critical to the success of the rigging. Testing showed that the presence of the enlarged slot, when combined with a forward control stick position and a minor upwards deflection of the elevator surface during rigging, created a situation where the elevator lever could easily, and without resistance, enter the void behind the mechanism rather than correctly engaging with the mechanism. Furthermore, in this condition, the tailplane would have seated correctly on the top of the tail fin, with no obvious gap, and the rigging pin would have been easy to insert. This condition would not have been visually evident to the pilot. In normal circumstances, without an enlarged elevator slot, the first indication

of any potential elevator control mis-rig would be that the tailplane did not properly seat on the fin and it would not be possible to insert the rigging pin.

#### *Tailplane rigging on the day of the accident*

While the presence of the enlarged elevator slot significantly increased the potential for an elevator mis-rig to occur, the investigation determined that the enlarged slot had been present since at least July 2006. The owners of G-CKLR before the accident pilot were not aware that the slot had been enlarged, and therefore there is no reason to believe that the accident pilot or co-owner could have been aware either. However, the glider had been rigged successfully many times since 2006, both by the previous owners and on at least 41 occasions by the accident pilot / co-owner, without a mis-rig occurring. It is important therefore to explore what might have been different on the day of the accident.

The accident occurred on the first flight following extensive maintenance being carried out on the glider by the pilot. It was not possible to determine the full extent of the work performed by the pilot as it was not documented in the technical log, but it is known that the work included the installation of a new transponder, radio, associated wiring and the replacement of some other avionics units. Photographs taken during the work showed that significant disassembly of the cockpit was required to carry out this work. The co-owner was not aware of any intent by the pilot to conduct work on the flight controls, however one witness recalled a conversation with the pilot in which the witness believed he clearly expressed his intent to do so. Examination of the wreckage did not reveal any obvious indications that work had been carried out on the elevator control run, but the possibility that the pilot had adjusted the elevator control run or control stick in some way which subtly changed the position of the elevator mechanism during rigging, could not be ruled out. However, this in isolation would not have caused the mis-rig but could explain why the outcome of the rigging on the day of the accident was different from previous occasions.

The pilot was keen to get airborne and test the new equipment he had fitted to the glider. He arrived at the gliding site in good time to rig his glider and prepare for the launch. During the rigging, the pilot left the glider to perform another task before returning to conclude the process. The BGA Safety Briefing Leaflet '*Is your glider fit for flight?*' highlights that interruption, distraction and forgetfulness are key factors in rigging errors. The pilot interrupted his rigging process with the best of intentions yet, in doing so, the risk of not completing the process, or introducing errors, increased. However, it is not possible to determine whether this was a factor in this accident.

There were no witnesses to the final part of the rigging process and, although other members of the club suggested that it was the pilot's normal practice to complete this task alone, the presence or help of another party could not be ruled out. Rigging and de-rigging tests conducted on G-CKLR during the investigation showed that, with the control stick in a forward position the elevator lever could easily enter the empty space behind the elevator mechanism if there was a small amount of upwards deflection on the elevator when the tailplane was placed on the fin. It was demonstrated that this situation could occur if those rigging the tailplane placed a hand on the elevator while positioning it on the

fin. Furthermore, when single-handedly rigging the tailplane, the manner in which a person holds and positions the tailplane to align it with the fin, may increase the likelihood that there would be some upward force on the elevator, for example, if their thumb was resting on the underside of the elevator.

Having only flown the glider once in the preceding four months, it is possible that the pilot was less practised in the rigging process. This may explain why the control stick was not in the neutral position at the time of rigging. Furthermore the pilot's medical condition which resulted in a loss of strength to his right arm and shoulder may have affected the manner in which he was able to hold and position the tailplane, if doing so alone.

#### *Opportunities to detect the mis-rig*

The elevator lever and mechanism are not visible once the tailplane has been fitted. Therefore, the only opportunities to detect the mis-rig condition once the rigging was complete, would have been during a positive control check, during a full-and-free check of the controls prior to flight, or identifying a problem with the elevator feel during the takeoff roll.

The SZD-55-1 Flight Manual rigging procedure required that, upon completion of rigging, the elevator and ailerons were held to '*check the operation of the control systems under loading*', which is, in effect, equivalent to a positive control check. The absence of any witnesses to the rigging of the tailplane, or to any checks which the pilot may have carried out upon completion, meant it was not possible to establish if, or how, a positive control check was performed by the pilot. However a number of gliding club members, including the co-owner, stated that the pilot was normally very careful about checking the glider. A pilot alone may not be able to determine, by moving the control stick, whether or not the elevator is properly connected. An effective positive control check would have required two people: one to move the control stick forward and aft, and the other to physically resist the movement of the control surface, in this case the elevator. A correctly executed positive control check should have identified, prior to the accident flight, that the elevator controls were not properly connected.

While conducting the full-and-free check of the flight controls at the launch point, the pilot would not have felt any unusual resistance to the movement of the control stick, however he would not have achieved a full range of aft control stick movement. Having flown the glider only once in the preceding four months, the reduced range of control stick movement may not have been immediately obvious to the pilot. In this case, identifying the mis-rig would have relied upon an observation that the range of movement of the elevator surface was incorrect, rather than that the surface did not move at all. The mis-rig was insidious in that the elevator would have seemed to move with the control column in the correct sense, yet it would not have deflected down past the neutral position as the control column was pushed forward. Casually observed by someone at the launch point, the elevator movement might have seemed normal.

During the takeoff roll the pilot would have been concentrating on keeping the glider straight and level, then retracting the speed brakes once adequate aileron control was

felt. The problem would probably not have been noticeable until the airspeed of the glider reached the point at which the elevator would normally become effective. The mis-rig resulted in an increasing pitch attitude over which the pilot had no control, even with full forward control stick. It would have taken some time to realise that his control inputs were having no effect, and another period to try and work out why. The cognitive recognition that there was an issue, and the mental processing time to diagnose the situation and release the tow rope, would have exceeded the time available before the glider was in an irrecoverable situation.

#### *Recorded data*

During the tug's takeoff roll it had a brief period of deceleration. This was followed by the tug accelerating faster than it had during the initial part of the takeoff roll. The tug maintained power throughout the takeoff, therefore this would be consistent with significant drag being generated by the glider pitching up until the tow rope was detached, leaving the tug with a nett reduction in drag.

#### *Pilot-owner maintenance*

The work performed by the pilot to install the transponder and associated wiring did not come under the permitted tasks for pilot-owner maintenance and would have required inspection and release to service by a BGA Inspector prior to flight. However, this did not have any bearing on the accident.

Had any work been undertaken on the flight controls, other than that listed in BGA publication AMP 2-1 '*Pilot Owner Maintenance*', it would have required inspection and release to service by a BGA Inspector prior to flight.

#### *Enlargement of the elevator slot*

It was not possible to determine exactly when, or why, the elevator slot was modified as there was no record of this in the glider's technical records. There is no manufacturer-approved modification or repair scheme for the elevator slot, as its geometry is considered critical to the successful rigging of the elevator controls. The enlargement of the slot on G-CKLR can therefore be considered as an unapproved modification.

Photographic evidence showed that the slot enlargement had taken place at some point before July 2006. The most recent previous owners were unaware of any such modification, and there is no evidence to suggest that this work was performed during their ownership. In 2003 the glider was inspected in France by a team from the original designer, for the purposes of extending the design life of the glider. The manufacturer reviewed the records from that inspection and advised the investigation that they did not contain any reference to modification of the elevator slot, or any other deviations from the original design, but it is not clear whether this area would have been specifically inspected during the life extension inspection.

During repeated rigging and de-rigging the edges of the slot can become damaged by the elevator lever resulting in scratches, dents and paint removal. It is therefore possible that

the slot may have been enlarged to remove such damage. However, such a repair is likely to have resulted in minimal removal of material. Given the extent of the enlargement on G-CKLR, it is more reasonable to conclude that the reason for enlarging the slot was to make the tailplane rigging process easier.

The potential for mis-rigging the elevator would have existed since the elevator slot was enlarged. But, as the immediately-previous owners and the accident pilot/ co-owner were unaware that the slot had been modified, they would have assumed that the G-CKLR continued to benefit from the original design features which were intended to assure automatic connection of the elevator controls and prevent a mis-rig situation. The unapproved modification to the elevator slot remained a latent condition until this accident. One other SZD-55-1 glider in the UK fleet inspected by the AAIB, also appeared to have a marginally enlarged elevator slot, of which the owners were unaware. These findings indicate the possibility that such modifications may have historically been considered acceptable among glider owners.

#### *Safety action to be taken*

Given the criticality of the geometry of the elevator slot in assuring automatic connection of the elevator controls in the SZD-55-1, the European Aviation Safety Agency (EASA) has indicated its intent to issue an Airworthiness Directive to mandate a fleet inspection of the SZD-55-1 glider, and other types, where applicable. The AD is intended to verify that the dimensions of the slots in the horizontal rib of the tail fin are within design dimensions.

#### *BGA rigging guidance*

The BGA Safety Briefing Leaflet '*Is your glider fit for flight?*' describes the actions required to carry out a positive control check, however it indicates that such checks are only required for gliders which do not have automatically-connecting controls. Separately, the BGA require a DI to be carried out prior to flight for all gliders, which includes the requirement to perform a positive control check. The SZD-55-1 was designed with automatically-connecting controls, however the enlargement of the slot in G-CKLR's tail fin horizontal rib removed one of the key design features intended to assure automatic connection of the elevator controls and prevent the possibility of mis-rigging.

It was not established if, or how, a positive control check was performed by the pilot of G-CKLR after completion of its rigging. However, the guidance in the BGA Safety Briefing Leaflet could be interpreted to mean that these checks are not required for gliders with automatically-connecting controls. The following Safety Recommendation is therefore made:

#### **Safety Recommendation 2018-004**

It is recommended that the British Gliding Association review its policy on the need for positive control checks on gliders with automatically-connecting controls and, where appropriate, amend its relevant publications including the Safety Briefing Leaflet entitled '*Is your glider fit for flight?*'.

## Conclusion

The SZD-55-1 glider was designed with automatically-connecting elevator controls, and the design includes features intended to prevent the possibility of a mis-rigging condition. An historic modification which enlarged the elevator slot on the tail fin of G-CKLR, degraded the protections of these design features and created a situation whereby the elevator connection could potentially be mis-rigged without any visible means of detecting it. On the day of the accident, the elevator connection was mis-rigged and this condition was not detected before flight. Consequently, during the accident flight, the pilot had no effective elevator control and was therefore unable to control the pitch of the glider.

The EASA intend to issue an Airworthiness Directive to mandate an inspection of the SZD-55-1 glider, and other types, where applicable, to verify that the dimensions of the slots in the horizontal rib of the tail fin are within design dimensions.

A positive control check could have identified the mis-rigged condition. Guidance material published by the BGA suggests that positive control checks, which are intended to detect control mis-rigging, are not required to be performed on gliders with automatically-connecting controls. Therefore, one Safety Recommendation has been made to review and, if appropriate, amend this guidance.



## **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.



**ACCIDENT**

<b>Aircraft Type and Registration:</b>	Airbus A319-111, G-EZFP
<b>No &amp; Type of Engines:</b>	2 CFM56-5B5/3 turbofan engines
<b>Year of Manufacture:</b>	2009 (Serial no: 4087)
<b>Date &amp; Time (UTC):</b>	1 December 2017 at 1500 hrs
<b>Location:</b>	Stand 13, Jersey Airport
<b>Type of Flight:</b>	Commercial Air Transport (Passenger)
<b>Persons on Board:</b>	Crew - 6                      Passengers - 138
<b>Injuries:</b>	Crew - None                      Passengers - 1 (Serious)
<b>Nature of Damage:</b>	None
<b>Commander's Licence:</b>	Airline Transport Pilot's Licence
<b>Commander's Age:</b>	42 years
<b>Commander's Flying Experience:</b>	8,800 hours (of which 6,750 were on type) Last 90 days - 185 hours Last 28 days - 46 hours
<b>Information Source:</b>	Aircraft Accident Report Form submitted by the pilot

G-EZFP parked on Stand 13 at Jersey Airport following an uneventful flight from Liverpool. A jetty was positioned at door 1L and steps at door 2L. A 74-year-old passenger, carrying a trolley suitcase, was the first person to disembark from the rear steps. When 6 or 7 steps from the bottom she tripped and fell forward, suffering serious head injuries. She was initially attended by a passenger, who was a nurse, and then by airport paramedics before being taken to hospital. Other passengers were redirected to the forward door.

After the accident, the commander found a broken shoe heel on the steps which he believed came from the passenger's shoe.

It was daylight and weather conditions were reported as dry with light winds.

The subsequent investigation by the ground handling agent found the steps were fully serviceable, correctly positioned and free from any contamination.

The accident probably occurred because the passenger's shoe broke whilst she was descending the steps. Carrying a suitcase may have impaired her ability to hold the handrail.

The operator already makes a PA before passengers disembark reminding them to take care on the steps and to hold the handrail.

**SERIOUS INCIDENT**

<b>Aircraft Type and Registration:</b>	Beech 200C Super King Air, G-NIAB
<b>No &amp; Type of Engines:</b>	2 Pratt & Whitney Canada PT6A-41 turboprop engines
<b>Year of Manufacture:</b>	1980 (Serial no: BL-16)
<b>Date &amp; Time (UTC):</b>	29 August 2017 at 0955 hrs
<b>Location:</b>	10 nm south of Belfast International Airport
<b>Type of Flight:</b>	Commercial Air Transport (Passenger)
<b>Persons on Board:</b>	Crew - 1                      Passengers - 2
<b>Injuries:</b>	Crew - None                  Passengers - None
<b>Nature of Damage:</b>	Burnt out flap control motor
<b>Commander's Licence:</b>	Commercial Pilot's Licence
<b>Commander's Age:</b>	47 years
<b>Commander's Flying Experience:</b>	1,866 hours (of which 894 were on type) Last 90 days - 113 hours Last 28 days - 34 hours
<b>Information Source:</b>	Aircraft Accident Report Form submitted by the pilot

After departure from Belfast International Airport, the pilot and passengers became aware of an unusual smell in the cabin, reminiscent to that of a solvent. As a precaution, the pilot donned his oxygen mask, declared a PAN and prepared to return to Belfast.

When configuring the aircraft to land, the pilot found that the flaps would not deploy when selected. He performed a successful flapless landing, taxied to the apron and shut down the aircraft.

Subsequent examination of the aircraft identified that the flap motor circuit breaker had tripped and the flap motor had burnt out. The failure of the flap motor was likely to have caused the unusual smell. The cause was not established; however, the maintenance organisation commented that flap motor failure is not uncommon on this type of aircraft.

**SERIOUS INCIDENT**

<b>Aircraft Type and Registration:</b>	Boeing 757-28A, G-OOBC
<b>No &amp; Type of Engines:</b>	2 Rolls-Royce RB211-535E4-37 turbofan engines
<b>Year of Manufacture:</b>	2003 (Serial no: 33098)
<b>Date &amp; Time (UTC):</b>	8 July 2017 at 0600 hrs
<b>Location:</b>	En route from Manchester to Girona Airport, Spain
<b>Type of Flight:</b>	Commercial Air Transport (Passenger)
<b>Persons on Board:</b>	Crew - 7                      Passengers - 204
<b>Injuries:</b>	Crew - 3 (Minor)          Passengers - None
<b>Nature of Damage:</b>	None
<b>Commander's Licence:</b>	Airline Transport Pilot's Licence
<b>Commander's Age:</b>	55 years
<b>Commander's Flying Experience:</b>	21,230 hours (of which 9,650 were on type) Last 90 days - 240 hours Last 28 days - 90 hours
<b>Information Source:</b>	Aircraft Accident Report Form submitted by the pilot and investigation by the operator

**Synopsis**

During a passenger flight to Spain, extensive smoke emitted from the forward galley ovens which, despite cabin crew actions, did not dissipate. The aircraft subsequently diverted to London Gatwick. An investigation by the operator determined that the ovens had been cleaned with a degreasing fluid which was not designed to be used in aircraft ovens.

**History of the flight**

Approximately 15 minutes after takeoff a member of the cabin crew switched the forward galley ovens on prior to starting the in-flight drinks service. When the cabin crew member returned to the galley a few minutes later, smoke was emanating from both ovens. The cabin crew member pulled the circuit breakers for the ovens and requested assistance from other crew members in the rear galley. A BCF extinguisher was discharged into both ovens and the commander was informed of the situation and that the fire drill actions had been completed. The smoke did not dissipate or reduce, so the cabin crew discharged a second BCF extinguisher which, once again, had no noticeable effect. The cabin crew updated the commander of the situation and the decision was made to divert to London Gatwick. After landing, the aircraft taxied onto a stand where AFRS personnel confirmed that there was no further fire hazard. Ground staff assisted with passenger

disembarkation while three cabin crew members received medical assistance on board before being taken to hospital for checks.

### **Investigation**

Examination of the forward galley ovens confirmed that a fluid was present in the interior of both ovens. The ovens were removed from the aircraft for cleaning and testing. Inspection of the ovens in the rear galley showed that they were contaminated with a similar fluid. The rear galley ovens were cleaned and the ovens operated to ensure that they did not produce smoke. The fluid in both the forward and rear galley ovens was found to be a degreasing fluid, commonly used for removing chewing gum from carpets, and not the approved oven cleaning fluid.

The aircraft ovens had been 'deep cleaned' 48 hours prior to the incident flight and the incident flight was the first time the aircraft had operated since the 'deep clean'. The aircraft operator and the contracted aircraft cleaning company reviewed the approved oven cleaning instructions and confirmed that they were unambiguous and make reference to the use of the correct cleaning fluid. An investigation carried out by the cleaning company appeared to confirm that the 'deep clean' had been completed in accordance with the approved cleaning instructions, that the correct fluid had been used and that it was not possible to identify when or how the ovens became contaminated with the degreasing fluid.

**SERIOUS INCIDENT**

<b>Aircraft Type and Registration:</b>	Boeing 767-300, D-ABUK	
<b>No &amp; Type of Engines:</b>	2 GE CF6-80C2B6F turbofan engines	
<b>Year of Manufacture:</b>	1999 (Serial no: 30009)	
<b>Date &amp; Time (UTC):</b>	21 July 2017 at 0200 hrs	
<b>Location:</b>	En route from Kangerlussuaq, Greenland to Frankfurt, Germany	
<b>Type of Flight:</b>	Commercial Air Transport (Non-Revenue)	
<b>Persons on Board:</b>	Crew - 4	Passengers - 4
<b>Injuries:</b>	Crew - None	Passengers - None
<b>Nature of Damage:</b>	Window 1R, burnt terminal block and terminal lug and cable loom damaged	
<b>Commander's Licence:</b>	Airline Transport Pilot's Licence	
<b>Commander's Age:</b>	31 years	
<b>Commander's Flying Experience:</b>	5,200 hours (of which 5,200 were on type) Last 90 days - 120 hours Last 28 days - 70 hours	
<b>Information Source:</b>	Aircraft Accident Report Form submitted by the pilot	

**Synopsis**

The aircraft was in the cruise on a positioning flight when the flight crew noticed an unusual smell, followed by smoke from the vicinity of the right windscreen. A MAYDAY was declared and the aircraft was diverted to Newcastle Airport where it landed without further incident. Investigation by the operator identified an anomaly with an electrical connection to the right windscreen heater. The operator has taken safety actions intended to prevent recurrence.

**History of the flight**

The aircraft had previously diverted to Kangerlussuaq Airport, Greenland due to a smell in the cockpit. After extensive inspection the smell was attributed to a heavily contaminated oven in the forward galley and the aircraft was released back to service. The Danish Accident Investigation Board reported on the incident; file number HCLJ510-2017-336 refers.

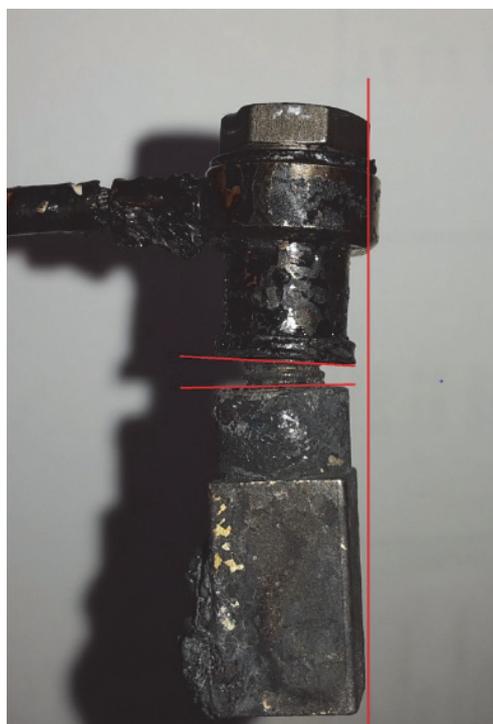
The subsequent flight was a positioning flight to Frankfurt, Germany, with only crew and staff members onboard. During the climb the flight crew noticed an unusual smell, but as it had dissipated by the time the aircraft reached its cruising altitude, they decided to continue the flight as planned. Approximately one-and-a-half hours later, the smell reappeared and remained at a constant level. Whilst the crew were discussing the situation

and their options, the first officer noticed smoke emanating from around Window 1R (the right windscreen). The crew donned oxygen masks, declared a MAYDAY and initiated a diversion to Newcastle Airport. After a few minutes the smoke started to dissipate and the aircraft landed without further incident.

### Aircraft examination

Troubleshooting by the operator revealed that the right windscreen was damaged, its terminal block J5 and terminal lug were burnt and the cable loom was damaged. The aircraft was then ferried to Frankfurt, with the window heat isolated, so the damaged components could be replaced.

Following removal, the operator initiated a more detailed examination of the affected parts. It identified that the terminal lug was not parallel to the terminal block; this could allow the mounting screw to become loose, creating a high resistance connection with the potential for overheating, Figure 1. No reason for the incorrect alignment was identified.



**Figure 1**

J5 Terminal block and terminal lug showing misalignment and heat damage  
(Image courtesy of the operator)

The affected parts were returned to the manufacturer for further examination and any adverse findings will be dealt with by normal continued airworthiness processes.

## Safety actions

Following its investigation the operator took the following safety actions:

- Adopted a double inspection requirement for electrical terminal installation following windscreen replacement;
- Reduced the repeat inspection threshold for windscreen electrical terminals from 500 flight hours to 100 flight hours;
- Introduced an additional engineering condition inspection for all windscreens entering stores;
- Conducted a fleet check to ensure correct installation of windscreen terminal connections;
- Clarified Aircraft Maintenance Manual (AMM) task 56-11-01-404-017, No 1 Window Installation, so that the resistance test of the window heater element is performed before installation to prevent the J5 terminal block connection being made twice;
- Added advice to AMM task 30-41-00-765-046 to use a torque wrench when connecting the wiring to the window terminals;
- Evaluating a coordinated replacement of windscreens not using the later design pin and socket connections.

**SERIOUS INCIDENT**

<b>Aircraft Type and Registration:</b>	Saab 2000, G-LGNS	
<b>No &amp; Type of Engines:</b>	2 Rolls-Royce AE 2100A turboprop engines	
<b>Year of Manufacture:</b>	1995 (Serial no: 2000-041)	
<b>Date &amp; Time (UTC):</b>	27 October 2017 at 1820 hrs	
<b>Location:</b>	Sumburgh Airport	
<b>Type of Flight:</b>	Commercial Air Transport (Passenger)	
<b>Persons on Board:</b>	Crew - 4	Passengers - 18
<b>Injuries:</b>	Crew - None	Passengers - None
<b>Nature of Damage:</b>	None	
<b>Commander's Licence:</b>	Airline Transport Pilot's Licence	
<b>Commander's Age:</b>	31 years	
<b>Commander's Flying Experience:</b>	4,302 hours (of which 1,821 were on type) Last 90 days - 106 hours Last 28 days - 52 hours	
<b>Information Source:</b>	Aircraft Accident Report Form submitted by the pilot	

**Synopsis**

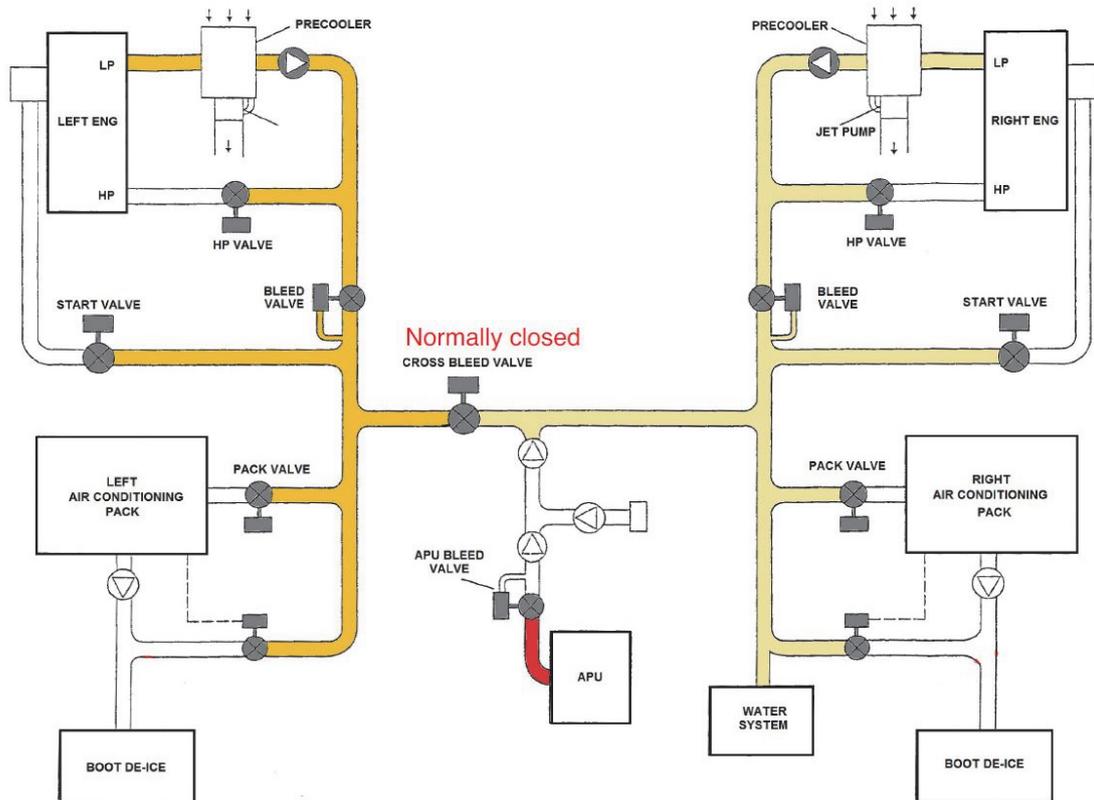
Following an uneventful landing, and as the aircraft taxied onto the stand, the cabin crew reported smoke in the cabin. The aircraft stopped on the stand and the passengers were disembarked through the forward main door. The cause of the smoke was contaminated air from the APU entering the right air conditioning pack.

**History of the flight**

The commander reported that following an uneventful landing at Sumburgh Airport, and just as the aircraft was taxiing onto the stand, Cabin Crew 1 positioned at the rear of the aircraft made an emergency call to the flight crew informing them that there was smoke at the rear of the cabin. As the aircraft was entering the stand, and the wind was in excess of 40 kt, the commander decided to continue onto the stand and park the aircraft into wind. A second emergency call was then received from Cabin Crew 2 who reported smoke in the centre of the cabin. Both cabin crew members reported that the smoke was first visible after the aircraft landed and the cabin lights were switched on. The flight crew shut the engines down and the commander opened the flight deck door to assess the smoke. The decision was then made to disembark the passengers through the main door at the front of the aircraft, which the commander reported took approximately 30 seconds. At the same time, the co-pilot contacted the airport fire service by radio and they arrived promptly at the aircraft. On the advice of the fire crew, the rear door of the aircraft was opened to vent the smoke and the aircraft batteries were disconnected. The fire crew could identify no hot spots in the cabin.

## Description of the aircraft air system

The aircraft is equipped with two air conditioning packs, which can be provided with compressed air from either of the engines or the APU (Figure 1). Except for engine start, the cross-bleed valve normally remains closed and the APU, which is normally only operated on the ground, supplies compressed air to the right air conditioning pack. The commander reported that the report of smoke in the cabin coincided with the starting of the APU after landing.



**Figure 1**

Schematic of the aircraft air system

## Operator's engineering investigation

The operator's engineers operated both air conditioning packs on the ground and identified a strong smell of oil from the right pack. Blue acid smoke was also evident in the cockpit area and the right-hand heat exchanger was found to be very dirty. The cause of the smoke was subsequently identified as oil contamination of the air bleed from the APU. The APU and right-hand heat exchanger were replaced and there have been no further reports of smoke in the cabin or cockpit.

**SERIOUS INCIDENT**

<b>Aircraft Type and Registration:</b>	Airbus Helicopters EC120B Colibri, G-SWNG	
<b>No &amp; Type of Engines:</b>	1 Turbomeca ARRIUS 2F turboshaft engine	
<b>Year of Manufacture:</b>	2008 (Serial no: 1532)	
<b>Date &amp; Time (UTC):</b>	17 August 2017 at 11:30 hrs	
<b>Location:</b>	Wellesbourne, Warwickshire	
<b>Type of Flight:</b>	Private	
<b>Persons on Board:</b>	Crew - 1	Passengers - None
<b>Injuries:</b>	Crew - None	Passengers - N/A
<b>Nature of Damage:</b>	Right engine cowling and main rotor blades damaged	
<b>Commander's Licence:</b>	Private Pilot's Licence	
<b>Commander's Age:</b>	71 years	
<b>Commander's Flying Experience:</b>	341 hours (of which 195 were on type) Last 90 days - 26 hours Last 28 days - 12 hours	
<b>Information Source:</b>	Aircraft Accident Report Form submitted by the pilot	

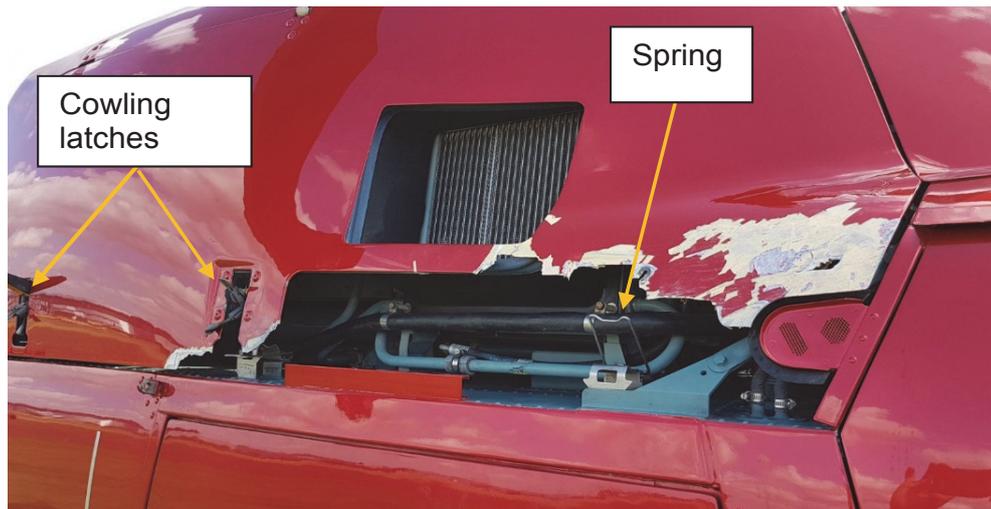
**Synopsis**

The right engine cowling opened and struck the main rotor blades as the helicopter flared to land. The incident was caused by the three cowling latches remaining unlocked after maintenance completed prior to the flight. The pilot did not complete a walkaround inspection, prior to the flight, which should have identified the unlocked latches.

**History of the flight**

Prior to the flight the pilot carried out routine maintenance which included a compressor wash and an 'A' check. After completing the maintenance, the pilot left the helicopter for a short period of time. The pilot stated that when he returned to the helicopter, contrary to his normal practice, he forgot to complete a walkaround inspection of the helicopter before commencing the flight.

After flying for approximately one hour the pilot returned to land. During the flare he became aware of an unusual noise and landed immediately. Examination of the helicopter showed that the lower forward edge of the right engine cowling was damaged, the forward cowl latch assembly was missing and the centre latch had been damaged (Figure 1). Damage was also observed on the inboard sections of all the main rotor blades.

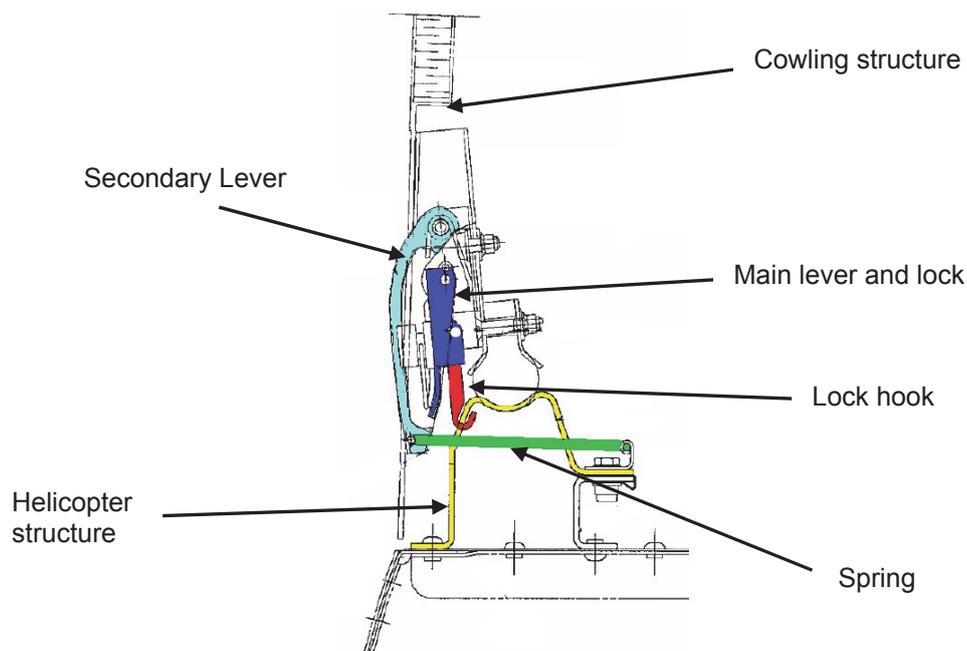


**Figure 1**

G-SWNG right engine cowling

### EC120 engine cowl latches

The engine cowlings on the EC120B are hinged to open upwards. Each cowling is held in the closed position by three hooked latches which engage with fixings on the helicopter structure (Figure 2). Closing the main lever of each latch places the latch hook under tension, securing the cowling to the structure and locks the main lever in the closed position. The secondary lever will not close if the main lever is not in the locked position, providing a positive indication of an unlocked latch. When the secondary lever is closed a spring can then be moved over the tip of the secondary lever to prevent it from opening.



**Figure 2**

Engine cowling latch diagram (courtesy of Airbus Helicopters)

## **Aircraft examination**

Examination of the helicopter by the authorised maintenance organisation confirmed that the damage to the main rotor blades had been caused by contact with the right engine cowling. Inspection of the remaining two cowling latches confirmed that there was no evidence of unusual wear or damage to the latch hooks or the parts of helicopter structure where the hooks engage. There was no evidence of distortion or adverse wear to any of the springs used to retain the secondary latch levers.

## **Previous events and safety action taken**

As a result of a number of previous in-flight cowl opening events Eurocopter (now Airbus Helicopters) published Safety Information Notice No 2339-S-53 in June 2016. This highlighted the need to inspect the condition and function of the cowl latches during the Daily Inspection. In addition, the notice also advised that, for helicopters with a predominantly red colour scheme, the inside faces of the lock levers should be painted in a contrasting colour to the helicopter's colour scheme, to provide an increased visual cue of an unlocked cowl latch. The inner faces of G-SWNG's engine cowling lock levers had been painted in this manner.

## **Analysis and conclusions**

The damage to the right engine cowling and main rotor blades was caused as a result of the cowling opening during the final stages of the helicopter's landing. The lack of damage and distortion to the remaining cowl latches, the helicopter structure onto which the latch hooks engaged and the latch springs confirmed that the latches had been unlocked prior to the flight.

In view of the maintenance activity immediately before the flight it is reasonable to conclude that the right engine cowling latches had not been correctly locked when the 'A' check was completed. Given that the inner faces of the latches had been painted in a contrasting colour to the helicopters paint scheme it is probable that this condition would have been observed by the pilot during a pre-flight walkaround inspection. The fact that the pilot left the helicopter for a short period of time before takeoff, coupled with the recent completion of routine maintenance, probably introduced sufficient interruption and distraction to the pilot's normal pre-flight routine to cause him to forget to carry out a pre-flight walkaround inspection.

**ACCIDENT**

<b>Aircraft Type and Registration:</b>	Bulldog Series 120 Model 1210, G-BHXB	
<b>No &amp; Type of Engines:</b>	1 Lycoming IO-360-A1B6 piston engine	
<b>Year of Manufacture:</b>	1980 (Serial no: BH120/408)	
<b>Date &amp; Time (UTC):</b>	24 September 2017 at 1550 hrs	
<b>Location:</b>	Embelton, Northumberland	
<b>Type of Flight:</b>	Private	
<b>Persons on Board:</b>	Crew - 1	Passengers - None
<b>Injuries:</b>	Crew - None	Passengers - N/A
<b>Nature of Damage:</b>	Damage to propeller, engine, nose landing gear, engine cowling and fuselage.	
<b>Commander's Licence:</b>	Airline Transport Pilot's Licence	
<b>Commander's Age:</b>	55 years	
<b>Commander's Flying Experience:</b>	18,758 hours (of which 6 were on type) Last 90 days - 198 hours Last 28 days - 68 hours	
<b>Information Source:</b>	Aircraft Accident Report Form submitted by the pilot and additional enquiries made by the AAIB	

Prior to his departure from Eshott, Northumberland on a test flight, following a prolonged period of engine maintenance, the pilot visually confirmed that he had sufficient fuel for 2 hours and 45 minutes. However, at 2,500 ft amsl, having been airborne for approximately 1 hour and 35 minutes, the engine lost power and, despite repeated attempts, could not be restarted. During this time, the pilot confirmed that all engine controls, fuel and ignition selections were correct and noted that each fuel tank had indicated 1/3 full.

The pilot, wearing a full harness, was uninjured during the subsequent forced landing, but the aircraft sustained damage to the nose landing gear, engine and propeller.

The pilot reported that the engineering organisation, who attended the accident site to recover the aircraft, confirmed that the fuel tanks had run dry. He considered that, as the flight involved running in the engine at various power settings and durations, the fuel depleted more quickly than he had calculated. The aircraft was not fitted with a fuel flow meter.

**Safety message**

The UK CAA's publication CAP1535, *The Skyway Code*, published in September 2017 details the importance of having a good working knowledge of your aircraft's fuel burn at different power settings, as well as warning that the fuel gauges in most types of General Aviation aircraft are not very accurate and should not be considered a reliable indicator of fuel level.

**ACCIDENT**

<b>Aircraft Type and Registration:</b>	1) DH82A Tiger Moth, G-BMPY 2) Reims Cessna F152, G-LAMS
<b>No &amp; Type of Engines:</b>	1) 1 De Havilland GIPSY MAJOR 1C piston engine 2) 1 Lycoming O-235-L2C piston engine
<b>Year of Manufacture:</b>	1) 1941 (Serial no: 82619) 2) 1978 (Serial no: 1431)
<b>Date &amp; Time (UTC):</b>	23 September 2017 at 1315 hrs
<b>Location:</b>	Sleap Aerodrome, Shropshire
<b>Type of Flight:</b>	1) Private 2) Training
<b>Persons on Board:</b>	1) Crew - 1                      Passengers - None 2) Crew - 1                      Passengers - 1
<b>Injuries:</b>	1) Crew - None                  Passengers - None 2) Crew - None                  Passengers - None
<b>Nature of Damage:</b>	1) Right wingtips 2) Propeller and possible engine shock-loaded
<b>Commander's Licence:</b>	1) Light Aircraft Pilot Licence 2) N/K
<b>Commander's Age:</b>	1) 77 years 2) N/K
<b>Commander's Flying Experience:</b>	1) 1,231 hours (of which 1,104 were on type) Last 90 days - 12 hours Last 28 days - 7 hours  2) N/K Last 90 days - n/k Last 28 days - n/k
<b>Information Source:</b>	Aircraft Accident Report Form submitted by the pilot

Whilst taxiing from the grass apron towards the runway, the pilot of a DH82A Tiger Moth (G-BMPY) made a left turn to avoid parked aircraft, including a Cessna 152 (G-LAMS) which was stationary but had its engine running. The pilot of G-BMPY stated that he misjudged the turn, which resulted in the right wingtips of G-BMPY passing through the propeller arc of G-LAMS. Neither the pilot of G-BMPY nor the occupants of G-LAMS were injured in the collision.

**SERIOUS INCIDENT**

<b>Aircraft Type and Registration:</b>	Liberty XL-2, N518XL
<b>No &amp; Type of Engines:</b>	1 Continental IOF-240-B piston engine
<b>Year of Manufacture:</b>	2006
<b>Date &amp; Time (UTC):</b>	10 January 2018 at 1528 hrs
<b>Location:</b>	5 miles west of London Biggin Hill Airport
<b>Type of Flight:</b>	Private
<b>Persons on Board:</b>	Crew - 1                      Passengers - None
<b>Injuries:</b>	Crew - None                      Passengers - N/A
<b>Nature of Damage:</b>	Door damaged after opening in flight
<b>Commander's Licence:</b>	Private Pilot's Licence
<b>Commander's Age:</b>	66 years
<b>Commander's Flying Experience:</b>	625 hours (of which 345 were on type) Last 90 days - 12 hours Last 28 days - 1 hour
<b>Information Source:</b>	Aircraft Accident Report Form submitted by the pilot

As the pilot levelled off after climbing to his cruise altitude, he became aware of a vibration which was getting louder. The left door then opened suddenly and his headset and glasses were torn off by the slipstream. He donned his spare glasses quickly and tried to reach his spare headset and handheld transceiver, but was unable to. He realised that flying the aircraft was the greatest priority and concentrated on this. He selected 7700 on the transponder and returned to land back at Biggin Hill.

Examination showed that a section of the door had detached after the door opened. The remains of the door were subsequently recovered, with no reports of any injuries or damage to property.

The pilot was behind schedule but did not feel rushed. He was unable to say categorically that he had checked the security of the left door prior to takeoff and considered that it had not been fully latched.

This occurrence highlights the importance of ensuring that spare glasses are within reach and concentrating on flying the aircraft following an unexpected event.

## ACCIDENT

<b>Aircraft Type and Registration:</b>	Piper J3C-65 Cub, G-AJAD	
<b>No &amp; Type of Engines:</b>	1 Continental Motors Corp C90-12 piston engine	
<b>Year of Manufacture:</b>	1943 (Serial no: 11700)	
<b>Date &amp; Time (UTC):</b>	20 September 2017 at 1630 hrs	
<b>Location:</b>	Private airstrip, Saltford, Bath	
<b>Type of Flight:</b>	Private	
<b>Persons on Board:</b>	Crew - 1	Passengers - None
<b>Injuries:</b>	Crew - None	Passengers - N/A
<b>Nature of Damage:</b>	Damage to wing strut, upper cockpit airframe and propeller	
<b>Commander's Licence:</b>	Commercial Pilot's Licence	
<b>Commander's Age:</b>	49 years	
<b>Commander's Flying Experience:</b>	1,627 hours (of which 1,000 were on type) Last 90 days - 32 hours Last 28 days - 21 hours	
<b>Information Source:</b>	Aircraft Accident Report Form submitted by the pilot	

## Synopsis

Following a short flight to a privately owned grass airstrip, the pilot completed a crosswind landing and proceeded to taxi the aircraft, a classic 'taildragger' type, toward the hangar situated to the north of the runway. Still on the runway, the aircraft veered to the left and the left wing strut hit a fence post. The strut, upper cockpit frame and propeller were damaged in the collision. The pilot was uninjured.

## History of the flight

Following a short flight, the pilot had landed G-AJAD, a classic 'taildragger' type, at a privately owned grass airstrip with a runway on a heading of 270°. The local weather conditions were dry with surface winds of 190° at 7 kt, across the runway. This runway has a nominal width of approximately 30 m between wire stock fencing. After touchdown the pilot had slowed the aircraft to taxi speed and was proceeding to a hangar situated to the north of the runway. During this manoeuvre, whilst still on the runway, the aircraft veered rapidly to the left and hit a fence post which formed part of the southerly boundary of the airstrip. This caused the wing to drop, further damaging the upper cockpit frame and propeller against the fence. The pilot was uninjured.

**Discussion**

In the pilot's opinion, the cause of the accident was a "mismanagement of rudder, brakes and throttle" during the taxi.

**ACCIDENT**

<b>Aircraft Type and Registration:</b>	Piper PA-32R-301 Saratoga SP, G-BJCW	
<b>No &amp; Type of Engines:</b>	1 Lycoming IO-540-K1G5D piston engine	
<b>Year of Manufacture:</b>	1981 (Serial no: 32R-8113094)	
<b>Date &amp; Time (UTC):</b>	4 August 2017 at 1404 hrs	
<b>Location:</b>	Bembridge Airport, Isle of Wight	
<b>Type of Flight:</b>	Private	
<b>Persons on Board:</b>	Crew - 1	Passengers - 1
<b>Injuries:</b>	Crew - None	Passengers - None
<b>Nature of Damage:</b>	Propeller, underside skin damage and flaps bent	
<b>Commander's Licence:</b>	Private Pilot's Licence	
<b>Commander's Age:</b>	50 years	
<b>Commander's Flying Experience:</b>	217 hours (of which 5 were on type) Last 90 days - 9 hours Last 28 days - 2 hours	
<b>Information Source:</b>	Aircraft Accident Report Form submitted by the pilot	

The pilot landed the aircraft without having selected the gear down. He stated that the approach did not include a full circuit during which he would usually have conducted the appropriate checks, and he did not hear an audible gear warning. He also advised that the aircraft he had flown previously had a fixed undercarriage.

An audible warning should be triggered if the gear is not down and a switch on the throttle quadrant indicates a low power setting of less than approximately 14 inches of manifold pressure. Either the warning trigger conditions were not met, the warning was triggered but not noticed by the pilot, or the warning failed to trigger as intended. The serviceability of the audible warning system at the time of the accident was not known at the time of publishing.

**ACCIDENT**

<b>Aircraft Type and Registration:</b>	Socata TB20, N20TB	
<b>No &amp; Type of Engines:</b>	1 Lycoming IO-540 piston engine	
<b>Year of Manufacture:</b>	2000	
<b>Date &amp; Time (UTC):</b>	27 September 2017 at 1350 hrs	
<b>Location:</b>	Blackbushe Airport, Hampshire	
<b>Type of Flight:</b>	Private	
<b>Persons on Board:</b>	Crew - 1	Passengers - 1
<b>Injuries:</b>	Crew - None	Passengers - None
<b>Nature of Damage:</b>	Damage to propeller, fuselage, landing gear, engine mounts and cowling	
<b>Commander's Licence:</b>	Private Pilot's Licence	
<b>Commander's Age:</b>	74 years	
<b>Commander's Flying Experience:</b>	294 hours (of which 23 were on type) Last 90 days - 8 hours Last 28 days - 2 hours	
<b>Information Source:</b>	Aircraft Accident Report Form submitted by the pilot	

The pilot had intended to fly to Sandown, but on checking the weather he decided that it was unsuitable for VFR flight. As it was his passenger's first flight in an aircraft, to avoid disappointment, the pilot planned to fly a couple of circuits.

He took off, climbed to the circuit height of 800 ft and performed one circuit, which ended in a wheels-up landing.

The pilot stated that he was normally rigorous in performing his checks on finals and could not understand why he had omitted them on this occasion. He suggested that a contributory factor to the accident may have been that he was wearing a recently purchased noise-cancelling headset, which may have made the sound of the landing gear warning chimes less apparent to him.

**SERIOUS INCIDENT**

<b>Aircraft Type and Registration:</b>	Sky 220-24 hot air balloon, G-SPEL	
<b>No &amp; Type of Engines:</b>	None	
<b>Year of Manufacture:</b>	1996 (Serial no: 45)	
<b>Date &amp; Time (UTC):</b>	14 June 2017 at 1945 hrs	
<b>Location:</b>	Bashall Eaves, Lancashire	
<b>Type of Flight:</b>	Commercial Air Transport (Passenger)	
<b>Persons on Board:</b>	Crew - 2	Passengers - 6
<b>Injuries:</b>	Crew - None	Passengers - 1 (Serious)
<b>Nature of Damage:</b>	Passenger's portable electronic device	
<b>Commander's Licence:</b>	Commercial Pilot's Licence (Balloon)	
<b>Commander's Age:</b>	63 years	
<b>Commander's Flying Experience:</b>	1,975 hours (of which 500 were on type) Last 90 days - 11 hours Last 28 days - 9 hours	
<b>Information Source:</b>	Aircraft Accident Report Form submitted by the pilot and further enquires by the AAIB	

**Synopsis**

The balloon was on commercial passenger flight with six passengers. After an uneventful flight the balloon landed firmly, at a horizontal speed relative to the ground of about 9 kt, and the basket tipped over onto its side, during which one passenger fell out. The passenger was seriously injured.

The operator is considering safety actions regarding how it conducts the passenger safety briefings.

**History of the flight**

The balloon was on a commercial flight with six passengers, a pilot and a crew member. Prior to takeoff the pilot briefed the passengers about the posture and positions they should assume during the landing. This included instructions to bend their knees enough so that their shoulders were below the top of the basket, grip the rope handles inside the basket and brace themselves with their backs facing the direction of travel. Several passengers stated this was explained at least twice, with the pilot adding that the landing could be bumpy, and it was not unusual for the basket to tip over during the landing. Several friends and relatives of the passengers were in the vicinity during the briefings.

The interior of the rectangular basket was divided by a 'T-shaped' partition into three compartments. Prior to takeoff the pilot and the crew member occupied the compartment

at the top of the T, while three passengers occupied each of the compartments either side of the stem of the T. Each passenger compartment had rope handles on both long sides, to provide hand holds for landings in either direction (Figure 1).

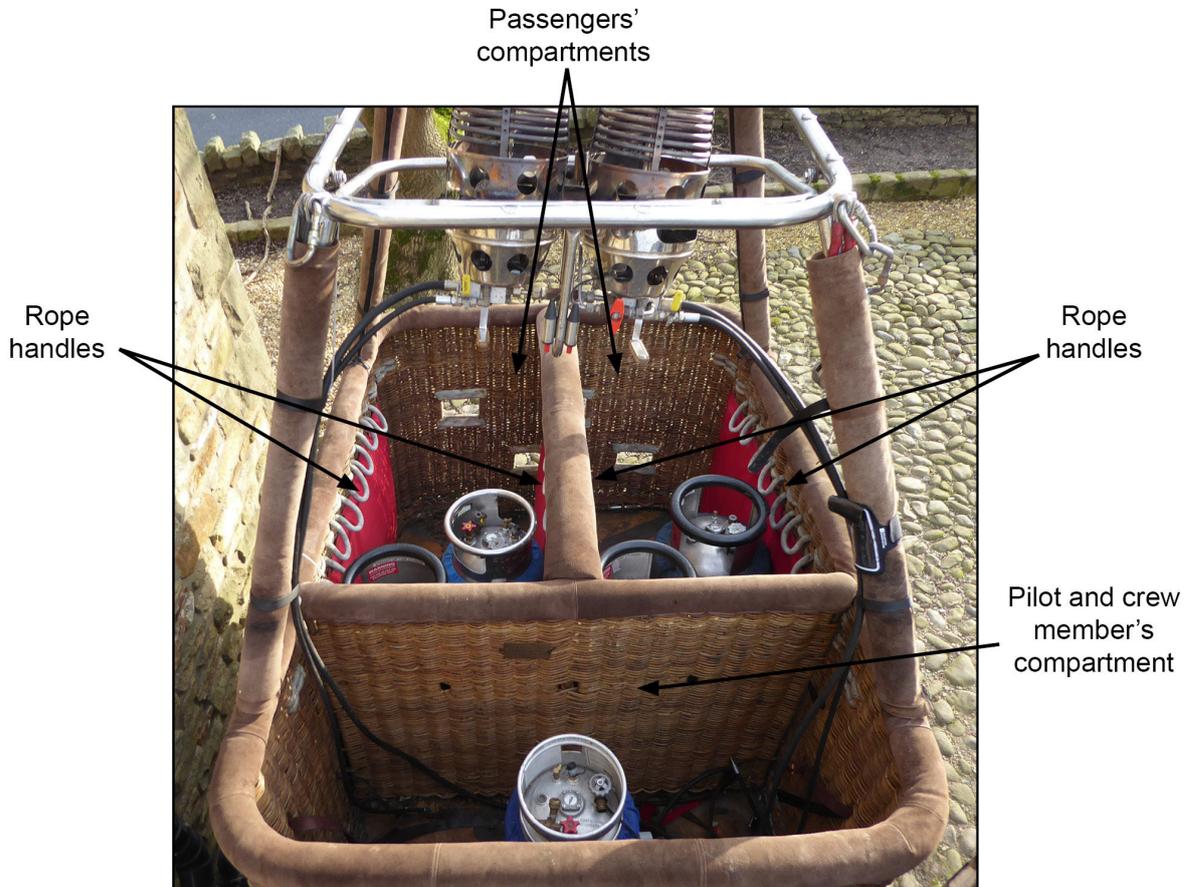


Figure 1  
Interior view of the basket.  
(Gas bottles would not be in the passenger compartments during flight)

The takeoff from a field near Samlesbury, Lancashire, was uneventful, and the balloon climbed to about 1,000 ft agl and flew in a north-easterly direction towards Longridge Fell, Lancashire. The weather was fine with a wind predominately from the south-west at cruising altitude. During the cruise the crew member was seen to use the gas burners on several occasions, under the guidance of the pilot, and to assist with the navigation with the aid of a hand-held GPS. The crew member stated that the GPS indicated a wind speed of 7 to 8 kt during the cruise but it reduced to about 4 kt in the lee of Longridge Fell.

On the leeward side of the fell, the balloon descended to low level and the pilot started looking for a landing field, noting that the wind speed had increased to about 9 kt. Once a field had been identified he informed the passengers that it was going to be a steep and hard landing, as the wind had increased, and instructed them to get into their landing positions, bend their knees and to hold on tight.

After flying over a tree, at the near end of the selected field, the balloon descended towards the ground, landing firmly on an edge of the basket, and tipped over onto its side. As it did so a passenger in the higher of the two passenger compartments fell between passengers in the lower compartment and out of the basket. One other passenger in the upper compartment found themselves hanging over the partition into the lower compartment and was prevented from falling further by a passenger in the lower compartment. The balloon was then dragged by the wind for about 30 m before coming to rest.

As soon as the balloon stopped the crew member went to assist the fallen passenger who was visibly shaken and was reassured by the crew member. They were then joined by the pilot and the other passengers. The fallen passenger was asked by the pilot if she would like an ambulance called, but this was declined. After a few minutes the fallen passenger sat up and drank some water. A portable electronic device, that was in her handbag was then found to have been damaged.

Once the balloon operator's support vehicle had arrived all the passengers were taken to a local hostelry where the fallen passenger was collected by a relative. On their way home the relative took her to hospital where she was found to have suffered several injuries and showed signs of psychological trauma. The following day the hospital contacted her to advise her that following re-examination of her x-rays she had suffered a fracture in her groin<sup>1</sup>.

### **Passengers' comments**

As part of the investigation all the passengers were contacted by the AAIB.

#### *Fallen and hanging passengers' comments*

The fallen and hanging passengers stated the pilot did not mention that passengers' shoulders should be below the top of the basket, and that the description of the recommended landing position was repeated. They also did not recall the pilot mentioning during the safety briefing that the landing could be bumpy or that it was not unusual for the basket to tip over.

They added that the crew member was at the controls of the balloon throughout the flight including the takeoff, descent and landing. Additionally, the fallen passenger stated that due to the force of the impact, during the landing, everyone let go of the rope handles. Both these passengers believed the accident could have been prevented had the pilot been at the controls throughout the flight.

#### *Other passengers' comments*

The crew member stated that the fallen passenger seemed to be distracted during the safety briefings, given by the pilot, prior to takeoff. This resulted in the pilot asking her to pay attention.

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#### **Footnote**

<sup>1</sup> The fact that it was later discovered that the fallen passenger had suffered a fracture means her injuries are classified as serious.

Four passengers stated that while the crew member did assist the pilot during the cruise portion of the flight she did not handle the controls during the takeoff, approach or landing.

Four passengers stated that they held onto the rope handles during the landing. The passenger who prevented the hanging passenger from falling further added that he let go with one hand to do so, but maintained a grip on the handle with the other.

### **Pilot's comments**

The pilot stated that while the crew member did operate the balloon's controls at times during straight and level flight, above 1,000 ft agl and under his instruction, she played no part in the landing itself.

### **Analysis**

The investigation could not determine who was controlling the balloon during the landing. The fact that the crew member was at the controls at some point during the cruise appears to have had no bearing on the accident.

The crew member stated that the fallen passenger seemed to be distracted during the safety briefing. If this was the case, she may have missed some of the important information mentioned by the pilot.

It could not be determined why the passenger fell out. However, it is probable she was not holding on to the rope handles firmly enough.

This accident highlights the importance of listening to and understanding the safety briefings and pilot's instructions given before and during flights in any type of aircraft.

### **Safety actions**

The operator stated that it is considering conducting the safety briefings before takeoff with only the passengers present, to avoid them being distracted. He will also give more emphasis on the need to hold onto the rope handles tight 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](http://www.aaib.gov.uk)).



**BULLETIN CORRECTION**

<b>Aircraft Type and Registration:</b>	Eurofox 912(IS), G-ODGC
<b>Date &amp; Time (UTC):</b>	28 May 2017 at 0900 hrs
<b>Location:</b>	Near Puddletown, Wareham, Dorset
<b>Information Source:</b>	Aircraft Accident Report Form submitted by the pilot

**AAIB Bulletin No 2/2018, page 61 refers**

There was a typographical error in the Commander's Flying Experience on page 61 of the Bulletin. The text should read:

'Last 90 days – **10** hours.'

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

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

- |  |   |
|--|---|
| 2/2011 Aerospatiale (Eurocopter) AS332 L2 Super Puma, G-REDL<br>11 nm NE of Peterhead, Scotland on 1 April 2009.<br>Published November 2011.   | 2/2015 Boeing B787-8, ET-AOP<br>London Heathrow Airport on 12 July 2013.<br>Published August 2015.                                  |
| 1/2014 Airbus A330-343, G-VSXY<br>at London Gatwick Airport on 16 April 2012.<br>Published February 2014.  | 3/2015 Eurocopter (Deutschland) EC135 T2+, G-SPAO<br>Glasgow City Centre, Scotland on 29 November 2013.<br>Published October 2015.  |
| 2/2014 Eurocopter EC225 LP Super Puma G-REDW, 34 nm east of Aberdeen, Scotland on 10 May 2012<br>and<br>G-CHCN, 32 nm south-west of Sumburgh, Shetland Islands on 22 October 2012.<br>Published June 2014. | 1/2016 AS332 L2 Super Puma, G-WNSB<br>on approach to Sumburgh Airport on 23 August 2013.<br>Published March 2016.                   |
| 3/2014 Agusta A109E, G-CRST<br>Near Vauxhall Bridge, Central London on 16 January 2013.<br>Published September 2014.   | 2/2016 Saab 2000, G-LGNO<br>approximately 7 nm east of Sumburgh Airport, Shetland on 15 December 2014.<br>Published September 2016. |
| 1/2015 Airbus A319-131, G-EUOE<br>London Heathrow Airport on 24 May 2013.<br>Published July 2015.  | 1/2017 Hawker Hunter T7, G-BXFI<br>near Shoreham Airport on 22 August 2015.<br>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>

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## GLOSSARY OF ABBREVIATIONS

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

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