AAIB
Air Accidents Investigation Branch

# AAIB Bulletin 12/2019

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## CONTENTS

### SPECIAL BULLETINS / INTERIM REPORTS



### SUMMARIES OF AIRCRAFT ACCIDENT ('FORMAL') REPORTS



### AAIB FIELD INVESTIGATIONS



### AAIB CORRESPONDENCE INVESTIGATIONS

## CONTENTS Cont

## AAIB CORRESPONDENCE INVESTIGATIONS Cont

### SPORT AVIATION / BALLOONS



### UNMANNED AIRCRAFT SYSTEMS



## RECORD-ONLY INVESTIGATIONS



## MISCELLANEOUS

### ADDENDA and CORRECTIONS



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

## AAIB Field Investigation Reports

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

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

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

**SERIOUS INCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Boeing 737-8AS, EI-GJT |
| **No & Type of Engines:** | 2 CFM56-7B26E turbofan engines |
| **Year of Manufacture:** | 2018 (Serial no: 44837) |
| **Date & Time (UTC):** | 9 October 2018 at 2205 hrs |
| **Location:** | En route from Porto Airport, Portugal to Edinburgh Airport |
| **Type of Flight:** | Commercial Air Transport (Passenger) |
| **Persons on Board:** | Crew - 6 Passengers - 177 |
| **Injuries:** | Crew - None Passengers - None |
| **Nature of Damage:** | None reported |
| **Commander's Licence:** | Air Transport Pilot's Licence |
| **Commander's Age:** | 61 years |
| **Commander's Flying Experience:** | 19,500 hours (of which 350 were on type)<br>Last 90 days - 170 hours<br>Last 28 days - 60 hours |
| **Information Source:** | AAIB Field Investigation |

## Synopsis

Shortly after reaching cruise at FL360 the commander's attitude indicator malfunctioned affecting numerous aircraft systems, and the aircraft climbed 600 ft. After a significant time delay an IRS caution was displayed. The Quick Reference Handbook (QRH) was followed by the crew and the left Air Data Inertial Reference Unit (ADIRU) was put into ATT mode. The left Primary Flight Display (PFD) continued to display erroneous attitude information to the pilot, and other systems were also affected. The aircraft was flown manually to Edinburgh where it landed safely.

The left Inertial Reference System (IRS) suffered a transient fault in one of its accelerometers which led to an erroneous calculation of position. False position information led to the incorrect attitude information on the commander's PFD, and the autopilot (AP) responded by initiating a slow climb.

One Safety Recommendation is made concerning the Boeing 737 QRH.

## History of the flight

The flight was scheduled from Porto, Portugal, to Edinburgh with 6 crew and 177 passengers. The crew had operated the sector into Porto and there had been no technical issues with the aircraft prior to departure for Edinburgh. The crew conducted turnaround procedures for the IRS in accordance with the operator's procedures. The aircraft left the stand at 1953 hrs and took off at 2000 hrs. The departure and climb were uneventful and the aircraft established in cruise flight at FL360.

Shortly after crossing into the Brest Flight Information Region (FIR), the aircraft began a slow and un-commanded pitch up. The aircraft left its planned cruise altitude and climbed to approximately FL366. As the speed decayed below the minimum manoeuvring speed, the autothrottle minimum speed protection activated increasing the $N_1$ (thrust) to approximately 95% (although the co-pilot also recalled increasing power). The commander's PFD initially indicated a pitch attitude of around 10° nose-up, though the crew's perception was that the actual aircraft attitude was lower than this. The altitude warning sounded indicating a deviation from the selected flight level. The commander deselected the AP and autothrottle (AT), and the aircraft was recovered to level flight manually using standby instruments.

The initial pitch indication on the commander's PFD was followed by a slow 'topple' in roll with the attitude indicator (AI) showing around 60° left angle of bank. The yellow pitch, roll and flight path vector (FPV) comparator annunciations appeared on both crew PFDs[1]. It appeared that the co-pilot's flight instruments were serviceable, however.

During the recovery, the aircraft descended to FL357 and then returned to its assigned cruise altitude of FL360. The crew discussed the failed attitude indication and the comparator annunciations. They consulted the QRH for a checklist related to these indications but found no guidance. They also consulted the Flight Crew Operating Manual (FCOM) but again found nothing of value to assist in resolving the issue. They then engaged the AP on the co-pilot's side.

There are checklists in the QRH for '*Display Failure*', but the symptoms covered by these are significantly different from those encountered by the crew. They tried to select the AP lateral navigation mode (LNAV) but while the AP would engage in this mode it did not operate correctly, so the crew engaged the heading select mode (HDG SEL). Due to the thrust changes made by the AT during the event, the cause of which the crew felt was unresolved, the crew elected to continue using manual thrust.

After approximately 10 minutes, AP B disconnected and the Master Caution System illuminated with an IRS caution. This drew the crew's attention to a left IRS FAULT indication on the IRS Mode Select Unit (MSU). The MSU is in the overhead avionics panel and, as it is out of direct crew view, caution lights in the system trigger the Master Caution System. The commander took control of the aircraft and directed the co-pilot to action the QRH checklist. The crew then completed the '*IRS Fault'* checklist as directed by the QRH. The checklist has several steps and decision points which the crew discussed and completed. The IRS had been correctly set to NAV for the flight, but the checklist now called for the crew to select ATT on the MSU, which they did.

**Footnote**

[1] Pitch and Roll comparator annunciations appear on the pilots' PFDs when the associated parameter differs between their instruments by more than 5º. The indications flash for 10 seconds then remain steady.

The objective of selecting ATT is to recover limited ADIRU operation following an inflight power loss or certain ADIRU fault conditions. Selecting ATT mode resets the local vertical reference. Navigation data (position, groundspeed, track and wind information) is not available in ATT and is removed from the ARINC 429 data bus. The decision point which follows this action in the checklist is based solely on whether the fault light clears: if it does, the QRH checklist ends with the advice to not select either AP. In this case, on selecting ATT the fault light cleared but the IRS continued to provide erroneous attitude data to the pilot's PFD due to a faulty accelerometer. The crew continued in manual flight, sharing the flying task. They considered diverting to an alternate airport but, given the aircraft was controllable, elected to continue to the planned destination of Edinburgh. During the later stages of the cruise, the co-pilot noticed some unexpected handling characteristics in roll.

For the arrival into Edinburgh the weather was a moderate south-westerly wind, gusting to 30 kt, with good visibility and no cloud below 3,000 ft. As the aircraft neared Edinburgh, the crew declared a PAN to Scottish ATC and informed them that there were issues with the aircraft's APs. During their preparations for the approach, the crew considered that the failed IRS would influence other systems and they prepared for this during their approach brief. There was a failure of a single channel of the speed trim system, and the possibility of stick shaker activation was of particular concern. During the approach, they encountered erroneous airspeed and windshear warnings, and the autobrake system would not arm. The roll issues noted by the co-pilot were more evident, but the crew were able to control them satisfactorily and made an ILS approach in good weather conditions. The landing was uneventful, using manual braking, after which the aircraft taxied to the stand where the passengers disembarked.

### Recorded information

The aircraft's flight data recorder (FDR) and cockpit voice recorder (CVR) were removed from the aircraft and downloaded at the AAIB where their recorded information was analysed. The duration of the CVR was two hours and included the event. The FDR recorded just over 107 hours of data.

Figure 1 is a plot of the aircraft's latitude and longitude, recorded from the Flight Management Computer (FMC) and the left IRS, together with the groundspeed indicated on the commander's PFD. The figure shows that at 2039 hrs the latitude and longitude in the left IRS began to drift with a corresponding 250 kt jump in the indicated groundspeed.

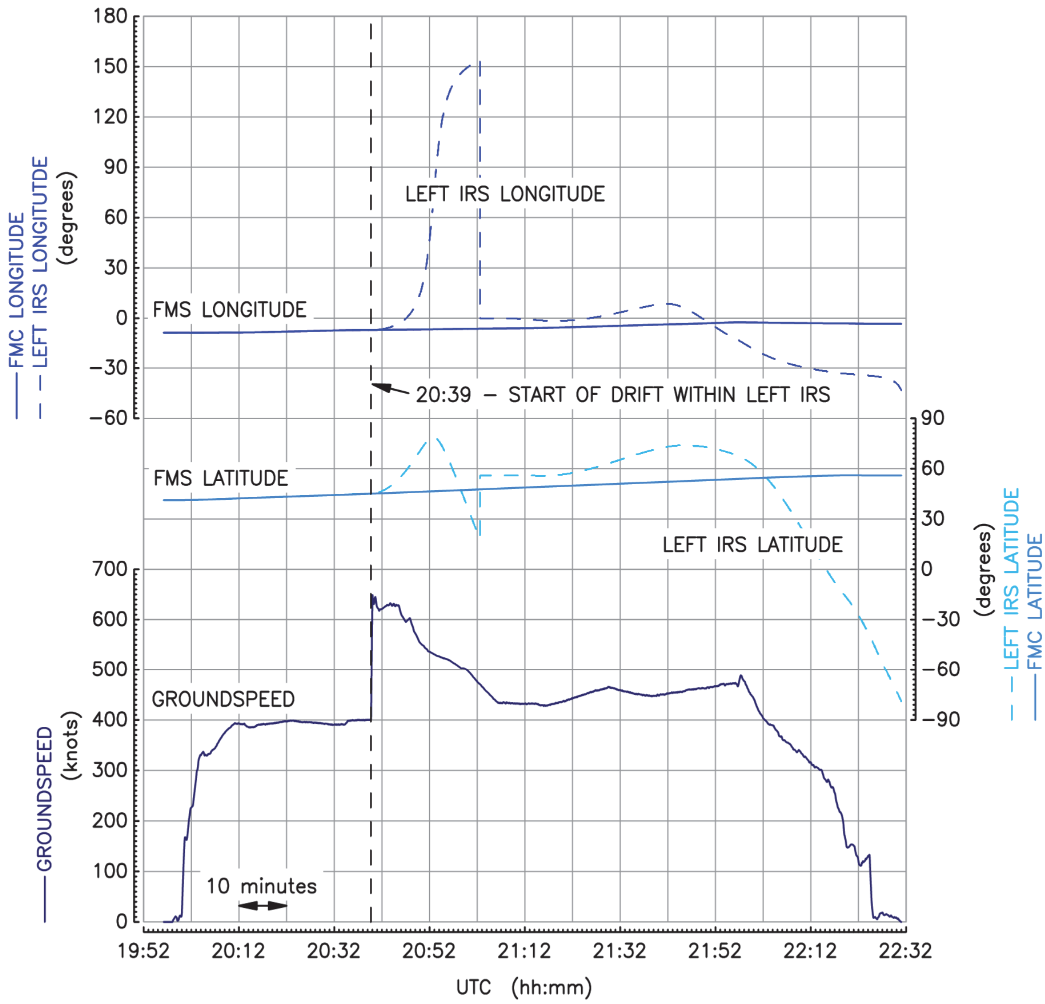



**Figure 1**

Left IRS latitude and longitude drift during the flight

Figure 2 is a closeup of salient parameters recorded on the FDR from when the left IRS started to drift until just after the failed attitude indication was given. Highlighted in the figure shortly after the drift started are the climb to FL367 from FL360, the increase in $N_1$ to 95%, the pitch up, and the decrease in airspeed from about 250 kt to below 232 kt when a minimum airspeed warning was triggered. The erroneous attitude, heading and groundspeed information presented to the commander are also plotted and show the pitch attitude increasing to 90° and the heading changing by nearly 180° over a period of about 20 minutes, after which the aircraft issued an indication of invalid attitude information.

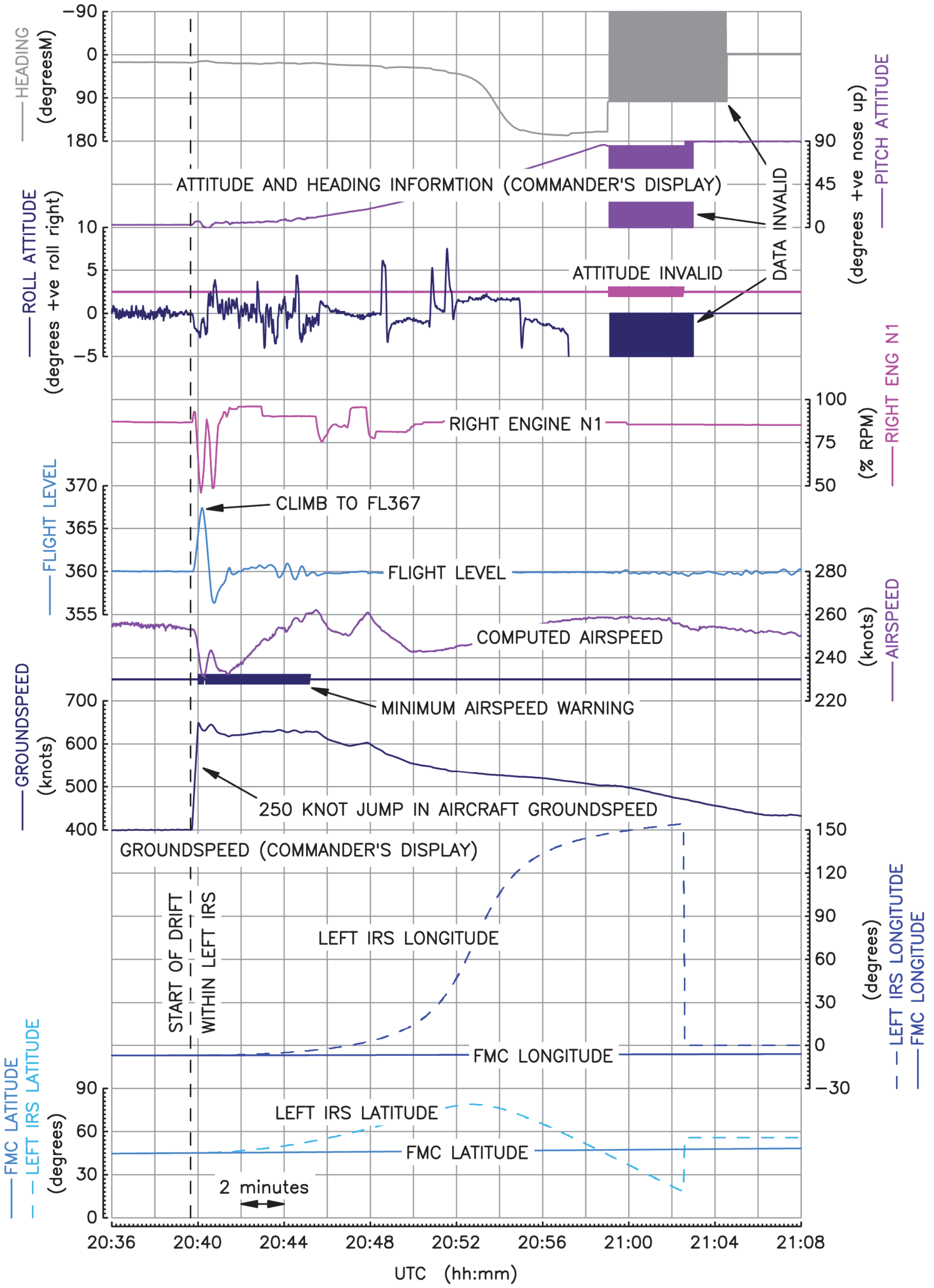



**Figure 2**

Salient FDR data during left IRS drift event

Although only the latitude and longitude from the left IRS were recorded, it was possible to derive the track and groundspeed it would have been generating, as well as an estimate of the aircraft's heading and, hence, the drift the left IRS was experiencing. These derived parameters are reproduced in Figure 3 and show that the drift in latitude and longitude was initially driven by an along-track acceleration of about 1.6 g. The figure also shows that when the aircraft issued an indication that the attitude information was invalid, the left IRS drift had just reached 60°.

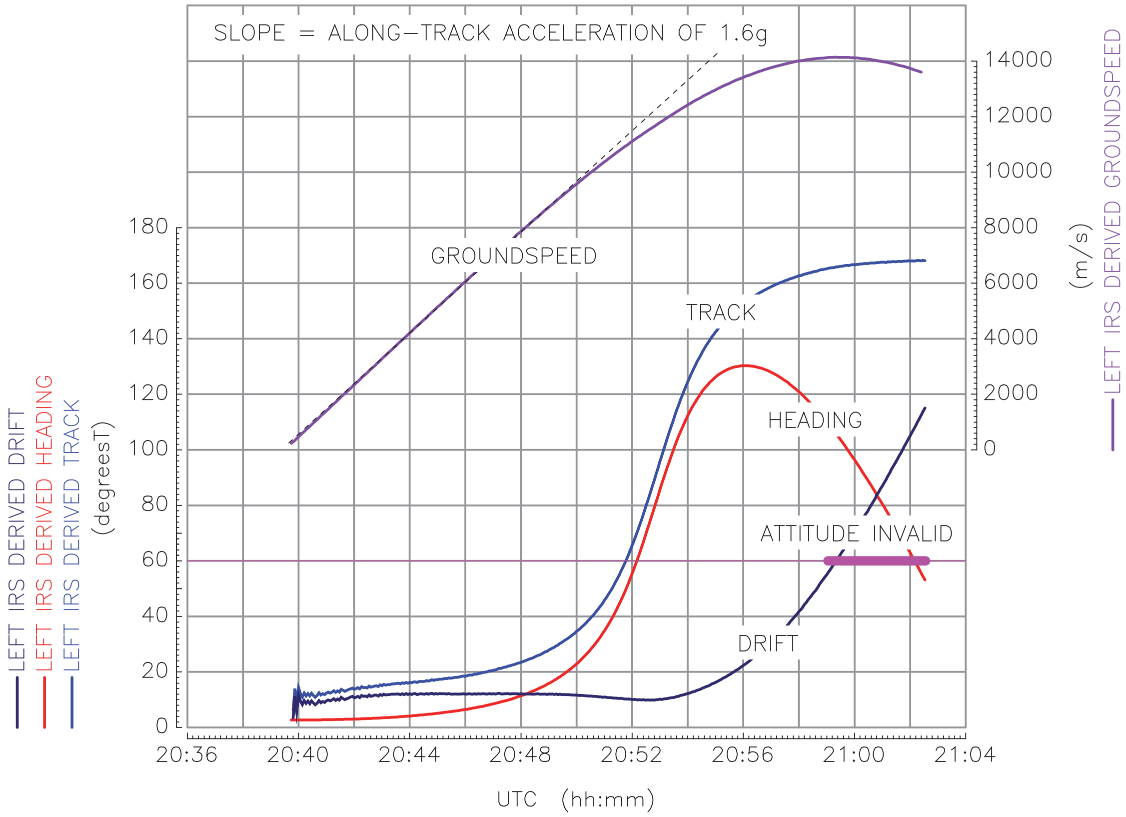



**Figure 3**

Left IRS derived data based on its recorded latitude and longitude

## Aircraft description

EI-GJT is a Boeing 737-800 which was manufactured and entered service with its current operator in 2018, and which had accrued 1,705 flight hours and 890 cycles. Flight information is presented to the crew on the pilot's flight and navigation displays and the engine indication caution advisory system (EICAS) multifunction displays (MFDs).

The aircraft is fitted with two (left and right) ADIRUs which are powered from the AC electrical busses. Each ADIRU includes an IRS and an air data computer which receives information from separate pitot static sources. The air data part of the ADIRU provides airspeed, Mach number, angle of attack (AOA), barometric altitude and temperature data. The IRS part of the ADIRU uses solid state ring laser gyros and X, Y and Z axis accelerometers to provide information to attitude, FPV and positional data systems. Data is fed by the ADIRUs to the AP, AT, engine control, yaw damper and stall protection systems. Primary flight and navigation data from the ADIRUs are displayed on the PFDs, and the IRS status is shown on the IRS MSU.

The ADIRU NAV mode uses position data entered during the align mode as its initial present position. It then updates the present position based only on inertial data while it remains in the NAV mode, which is the normal operational mode. This inertially-generated positional data in relation to the Earth is used to generate the attitude indication on the PFD.

Data from the IRS and GPS and radio navigational information is integrated within the FMC. The FMC uses GPS position as its priority for position updates. If GPS is not available, FMC position is biased in a ratio of approximately 80:20 toward radio position and IRS position. The FMC also contains a software comparison logic designed to dismiss erroneous data. In this case, the FDR recorded that the FMC position data remained valid throughout the flight.

### Engineering investigation

During the flight the crew were presented with several unusual aircraft reactions, display information and configuration data. These included a slow topple of the commander's attitude indication on his PFD with unreliability thereafter, and a slow pitch up with the AP engaged along with a gradual speed loss. As the incident developed the crew also came to distrust the standby instruments and AT. During the approach the crew had to correct an aircraft roll caused by a secondary flying control effect from the rudder due to the yaw damper reacting to spurious inputs from the ADIRU.

Once on stand, the crew debriefed the operator's engineering staff and recorded the symptoms of the failure in the aircraft Technical Log. The engineers downloaded the Quick Access Recorder (QAR) and Built-in Test Equipment (BITE) data and diagnosed a failure of the left ADIRU. The left ADIRU is a line replaceable unit (LRU) and a replacement was fitted. System functional tests were then satisfactorily carried out in accordance with the Aircraft Maintenance Manual (AMM) and the aircraft was released to service. The manufacturer carried out a review of the QAR data and the BITE fault codes and concurred with the fault diagnosis and rectification action[2]. The right ADIRU produced no faults codes and was working normally throughout the incident. There were no previous events in this aircraft with the left or right ADIRU.

The data downloaded from the left ADIRU showed the unit experienced a drift angle test fault whilst in inertial reference navigation mode. The QAR data showed that this was caused by a longitudinal acceleration offset, which manifested itself as a 1.6 g acceleration in the along-track sense. This, and the resultant groundspeed error, induced an ADIRU positional error along the aircraft track, which led to a left IRS position that passed east of the north pole (Figure 4). As the flight progressed, the positional error increased leading to the spurious attitude indication on the PFD experienced by the crew.

**Footnote**

[2] The operator's engineering staff based at Edinburgh carried out fault rectification without delay as expected and required by the operator. Thus, the diagnosis and rectification work was completed prior to the AAIB deployment. In some circumstances this may not have been ideal. However, in this case there was a detailed audit trial in the aircraft Technical Log of the actions taken and the results, and of the aircraft manufacture's support advice.

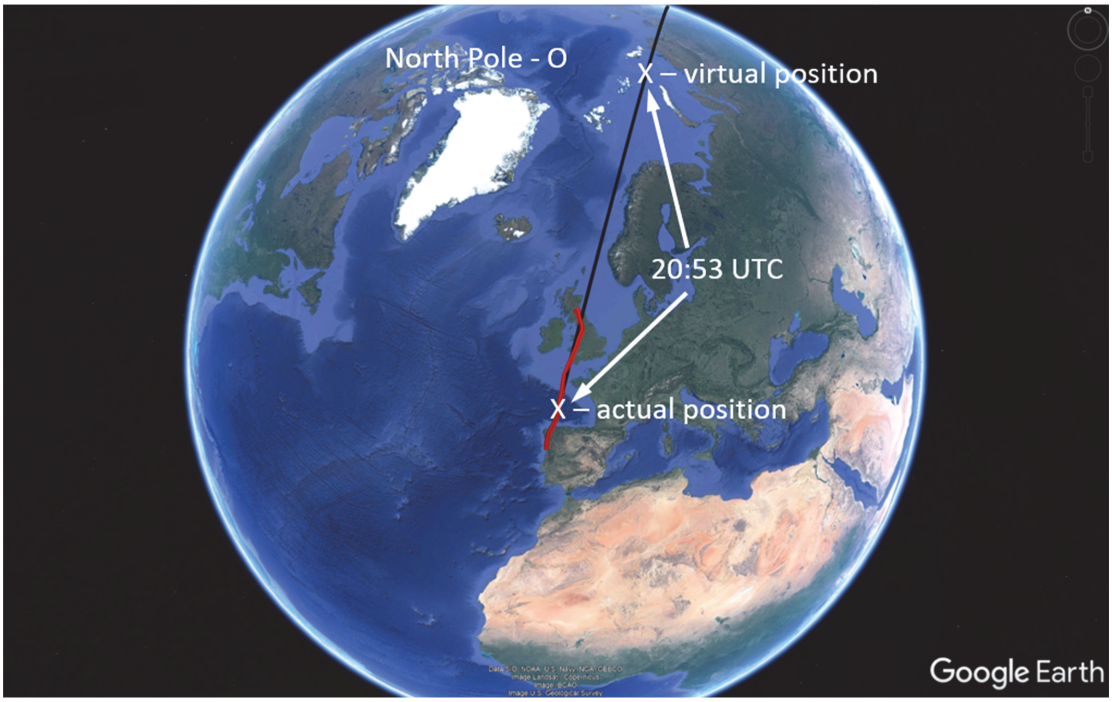



**Figure 4**

FMC ground track (red) and left IRS ground track (black)

**Left ADIRU testing by the manufacturer**

*Component testing*

The left ADIRU was returned to the Original Equipment Manufacturer (OEM) for further investigation. An examination revealed no visual indication of wiring defects, water ingress or physical damage. It was bench-tested and passed the navigation, acceleration, electrical and calibration test in accordance with the acceptance test schedule.

As there were no obvious indications of fault or failure, the manufacturer carried out a programme of follow-on testing. The unit was subjected to thermal testing between -40°C and +75°C over a period of more than 240 hours during 880 power cycles. Throughout this process, no failures were recorded.

Testing was carried out to simulate 1.6 g on the longitudinal axis by injecting an input to the Y axis accelerometer. After approximately 23 minutes this produced a drift angle test fault and created similar conditions to those which resulted in the positional error.

Disassembly, testing and examination of sub-components was also carried out, but no significant faults or defects were found. The simulation results suggested there was an anomaly with the Y axis accelerometer, which was removed for further testing. However, it was found to perform to acceptable test limits and close to the production testing carried out when the component was produced in March 2018.

*Manufacturer's findings*

Testing by the ADIRU manufacturer validated the QAR data analysis regarding the 1.6 g longitudinal offset. However, the manufacturer was not able to reproduce the drift angle test fault other than by a simulated input to the Y axis accelerometer. It was therefore concluded, based on the available data and testing, that a transient anomaly in the Y axis accelerometer was the most probable source of the longitudinal offset, although no specific fault or failure could be identified or confirmed.

**Crew response to the situation**

In the initial stages of the event, the crew were presented with several unusual indications and warnings. The attitude information displayed on the commander's PFD was erroneous and faulty data was supplied to AP A which was engaged. The AP responded to the faulty data and the aircraft's flightpath was disturbed. After the crew disengaged the AP and recovered the aircraft to manual flight at the allocated flight level, yellow comparator annunciations appeared on each pilot's PFD. Aware there were no QRH memory items for PFD comparator annunciations, the crew consulted the aircraft QRH for related checklists; there were none. The crew considered the possibility of using other checklists but discounted this because their training discouraged the use of QRH checklists except in response to relevant associated warnings. The QRH states in CI.2.2:

> *'While every attempt is made to supply needed non-normal checklists, it is not possible to develop checklists for all conceivable situations. … In some multiple failure situations, the flight crew may need to combine the elements of more than one checklist. In all situations the captain must assess the situation and use good judgement to determine the safest course of action. It should be noted that, in determining the safest course of action, troubleshooting ie, taking steps beyond published non-normal checklist steps, may cause further loss of system function or system failure. Troubleshooting should only be considered when completion of the published non-normal checklist results in an unacceptable situation.'*

When the crew completed the '*IRS Fault'* checklist, they were aware that they had not recovered the system. However, they had the aircraft under control and were able to maintain its flight path adequately using the co-pilot's PFD and the commander's Integrated Standby Flight Display (ISFD). If the IRS FAULT light clears, the QRH checklist reaches an endpoint. They felt that the QRH discouraged any other actions and that this philosophy was also emphasised by the operator's training department.

The '*IRS Fault'* checklist directs selection of ATT mode on the failed system. Once this has been done the QRH directs that neither AP should be engaged, so the crew flew the aircraft manually. Due to the lack of an AP the aircraft was no longer compliant with Reduced Vertical Separation Minima (RVSM) regulations and the crew was required to declare this to ATC. Given the unusual nature of the failure and their confusion over the QRH checklist outcome, the crew did not do so. Nevertheless, after the initial upset the aircraft remained within the RVSM performance limits for the remainder of the flight.

### Organisational information

The operator's expectation was that crews would only conduct QRH checklist actions as memory items or in response to non-memory items specifically covered in the QRH. This philosophy was strongly emphasised throughout initial and recurrent training, although the operator incorporated some of their own amendments to the Boeing QRH under the terms of No Technical Objection[3] from Boeing. The objective of the amendments was to provide as much clear guidance as realistically possible while still discouraging actions that could lead to further system failures.

### Tests and research

A Boeing 737 simulator was provided by the operator to examine this event, but the simulator was unable to replicate the fault that occurred in the aircraft. If the IRS FAULT light is triggered in the simulator, QRH actions cause the IRS to enter the reversionary mode and recover the PFD. Should the IRS FAULT light remain illuminated after selection of ATT mode (not what happened in this event), the QRH directs use of the IRS Transfer Switch to switch relevant systems to the operative IRS. This action (in the simulator) gave both pilots an operative PFD with only minor capability degradation. The QRH still requires there to be no AP use in this configuration.

The aircraft is fitted with a display source selector which is routinely left in AUTO but which can be used to supply both pilot's displays from either the left or right Display Electronics Unit (DEU). Using this switch following an IRS failure restores PFD indications with only minor degradations.

### Other information G-FDZF

The day following the EI-GJT incident, another Boeing 737-800 encountered a similar problem while operating a ferry flight from Manchester to Palma, Mallorca. In this event, the co-pilot was the pilot flying (PF). Shortly after reaching the cruise flight level, AP B disconnected, attitude comparator annunciations appeared on the PFDs, both Electronic Engine Controls (EEC) changed to alternate mode, TCAS FAIL appeared on the Navigation Display (ND) and a HDG fail flag appeared on the standby compass. Neither AP could be re-engaged, so the crew continued in manual flight. On checking the Master Caution recall a MACH TRIM caption was present indicating a single lane failure in the Mach Trim system.

The crew completed the QRH actions for the EEC ALTN caution. Their interpretation was that there was a technical issue with the right IRS, but they did not conduct any IRS or Flight Instrument non-normal checklist (NNC) as the QRH contained no relevant information. They decided to return to Manchester, and during preparations for the approach it became apparent that the autobrake would not arm, further evidence of an IRS issue.

**Footnote**

[3] A letter of No Technical Objection from Boeing indicates acceptance of the amendment proposed by the operator for inclusion in the QRH used by the operator. This information is not promulgated to other Boeing customers.

During the ILS approach to Manchester, the Master Caution System activated an IRS caution, and the IRS FAULT light appeared on the MSU in the overhead panel. The aircraft was close to touch down and rather than initiate a go-around to complete the '*IRS Fault'* QRH checklist the commander elected to land. The aircraft landed safely and the ADIRU was removed for technical examination and found to have been contaminated by water ingress.

## Analysis

*EI-GJT*

Analysis of the flight data showed that a longitudinal acceleration offset was induced in the left IRS. The resultant velocity error induced an IRS position error, initially along the track of the aircraft. As the flight progressed, the computed track remained constant, passing east of the north pole, while the computed heading changed. The angular difference between track and computed heading (ie the drift) increased until, after a period of approximately 20 minutes, it reached a value of 60° and triggered an IRS FAULT caution.

As the position error increased, the commander's flight instruments began to react in relation to a false position over the surface of the Earth, and he was presented with incorrect attitude information on his PFD. The erroneous attitude information caused the AP to climb the aircraft away from its assigned flight level. Pitch and roll comparator annunciations appeared on both PFDs. By comparing the information on the co-pilot's PFD and the ISFD the crew were able to satisfy themselves that the faulty information was being displayed on the commander's PFD. The AP and AT were disconnected, and the aircraft was recovered to level flight using standby instruments, cross-referenced against the co-pilot's PFD.

During the event the crew believed that the AT may have malfunctioned because they observed the $N_1$ reaching 95%. However, the flight data indicated that during the uncommanded climb the airspeed fell below minimum manoeuvre speed and the AT minimum speed protection activated.

The crew consulted the Boeing QRH for information and actions related to the pitch and roll comparator annunciations, but it includes no such actions. They also searched the FCOM, which explains the purpose of the comparator annunciations but offers no advice on restoring instrument capability. This caused some confusion in the crew, but they were reluctant to take any other action because their training discouraged them from doing so. As a result, although a solution to restore attitude information on the PFD was available – selecting a different data source for the PFD – the actions required were not taken because they were not directed to be taken by the QRH. Consequently, the commander's PFD displayed erroneous information for the rest of the flight, and the comparator annunciator indications remained on both PFDs. These displays are the pilots' primary attitude reference and the information on them is crucial for safe flight. Both pilots were faced with significant distractions on these primary instruments for the remainder of the flight.

When the IRS FAULT light illuminated, the crew selected ATT mode as directed by the QRH. The fault light cleared but the commander's PFD continued to provide erroneous information. This was because the ATT mode uses the same ring laser gyros and accelerometers as the NAV mode and so the system remained affected by accelerometer anomalies.

Following this incident, Boeing decided to amend the QRH checklist for IRS FAULT. The reference to ATT mode would be removed and the checklist would direct crews to use the IRS Transfer Switch to supply relevant systems from the serviceable side.

The crew's consideration of the fault allowed them to predict and prepare for the influence of the faulty attitude information on other systems. Accordingly, they were prepared for a number of erroneous indications which arose during the rest of the flight. The crew felt that there was some degradation of the aircraft's handling in manual flight, particularly in roll. The failed left ADIRU continued to supply information to the yaw damper computer for the remainder of the flight. As the yaw damper was periodically deflecting the rudder to the maximum extent allowed by the system, the roll issue felt by the crew was a secondary effect of the erroneous yaw damper action.

*G-FDZF*

The crew of G-FDZF faced similar problems to those experienced by the crew of EI-EGT: erroneous attitude information and failure of several systems. They recognised that the problem lay with the IRS but, like the crew of EI-EGT, they did not carry out any corrective action as there was no relevant guidance in the QRH.

*QRH guidance*

In both cases discussed in this report there was a significant period between the first symptoms of faulty attitude information and the appearance of the IRS FAULT indication. Shortly after the attitude information failed, pitch and roll comparator annunciations appeared on both PFDs. While these flags indicate a failure, they do not decisively indicate where it lies. Pilots must use standby instruments to determine where the failure is and, if necessary, recover to the correct attitude through manual flight. Selecting a different source for the faulty PFD would remove the flags and restore valid attitude information on both pilots' PFDs, although it would lead to a reduction in redundancy because all PFD attitude information would be from a single source. Information is available in the FCOM to aid crew understanding, but because of the expressed philosophy in the QRH discouraging troubleshooting, and the training discouraging the use of QRH checklists except in response to relevant associated warnings, it is unlikely crews will act unless specifically directed to do so by the QRH checklist.

In these events, the failure occurred in VMC and straight and level flight and the outcome was benign. However, the PFD is a primary instrument which dominates a pilot's display panel, and a failed attitude display presents a powerful disorientating stimulus to the relevant pilot. The comparator annunciation appears simultaneously in both PFDs and, if no action is taken, can remain as a significant distraction for the remainder of the flight. In manoeuvring flight it could be unclear where the failure lay, and the presence of the failed display would continue to constitute a disorientating factor.

Boeing decided to amend the QRH checklist for IRS FAULT but this would not address the situation where there was faulty attitude information but no IRS caution message. Therefore, the following Safety Recommendation is made:

**Safety Recommendation 2019-012:**

It is recommended that Boeing Commercial Aircraft amend the Boeing 737 Quick Reference Handbook to include a non-normal checklist for situations when pitch and roll comparator annunciations appear on the attitude display.

## Conclusion

On EI-GJT, the IRS of the left ADIRU suffered a fault which led to an erroneous calculation of position. On G-FDZF, the ADIRU was contaminated by fluid ingress. In both cases, this resulted in the display of faulty attitude information on the commander's PFD, and the supply of erroneous information to several aircraft systems. The problems were contained through manual flight and the use of standby instrumentation. Although action could have been taken to restore reliable attitude information to the commander's PFD, such action was not directed from within the QRH. The training given to the crews discouraged them from acting unless directed by the QRH, so this lack of relevant information in the QRH contributed to the situation.

## Safety action

Following this incident, Boeing decided to amend the QRH checklist for IRS FAULT. The reference to ATT mode would be removed and the checklist would direct crews to use the IRS Transfer Switch to supply relevant aircraft systems from the serviceable side.

*Published: 31 October 2019.*

**SERIOUS INCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | DHC-8-402 Dash 8 Q400, G-JECR |
| **No & Type of Engines:** | 2 Pratt & Whitney Canada PW150A turboprop engines |
| **Year of Manufacture:** | 2006 (Serial no: 4139) |
| **Date & Time (UTC):** | 15 November 2018 at 0807 hrs |
| **Location:** | Exeter Airport |
| **Type of Flight:** | Commercial Air Transport (Passenger) |
| **Persons on Board:** | Crew - 4 Passengers - 35 |
| **Injuries:** | Crew - None Passengers - None |
| **Nature of Damage:** | None |
| **Commander's Licence:** | Airline Transport Pilot's Licence |
| **Commander's Age:** | 39 years |
| **Commander's Flying Experience:** | 7,200 hours (of which 5,800 were on type)<br>Last 90 days - 156 hours<br>Last 28 days - 49 hours |
| **Information Source:** | AAIB Field Investigation |

## Synopsis

Whilst climbing to FL190 en-route to Charles De Gaulle Airport, Paris the pilots received an ALT MISMATCH message and they elected to return to Exeter Airport. Following an inspection after landing, a small white crystalline deposit was found covering three of the four static pressure holes on the left primary pitot static probe. It is probable that the use of a non-approved product, to improve the seal between a test adaptor and the pitot static probe during maintenance immediately prior to this flight, may have resulted in the blockage of the static holes and led to the ALT MISMATCH message. Two Safety Recommendations have been made; one to the air data accessory kit manufacturer and one to the aircraft manufacturer to improve the instructions for the use of testing kits when carrying out leak tests of the pitot/static system and to only use approved lubricants. The maintenance organisation has taken Safety Action to introduce tighter controls on the test kit equipment.

## History of the flight

Prior to the incident flight, the aircraft had been undergoing a standard maintenance check at the operator's maintenance facility at Exeter Airport. This activity included cleaning and leak checks of the pitot static system. The aircraft was released for service on the morning of 15 November 2018.

The first flight, on that morning, was planned from Exeter to Charles de Gaulle Airport, Paris. The weather conditions were benign with a temperature of approximately 9°C. The commander completed a pre-flight walkaround of the aircraft and did not observe anything unusual. The aircraft pushed back from the stand at 0706 hrs. The pushback, engine start, and taxi were all normal. The pitot heat was selected ON as the aircraft entered the runway in accordance with the operator's standard procedures. The takeoff roll was uneventful and the 80 kt airspeed cross check did not reveal any discrepancy.

At approximately 500 ft aal, an ALT MISMATCH message briefly appeared on the primary flight display. The flight crew reduced the rate of climb whilst they discussed the message. The mismatch message reappeared intermittently throughout the climb. The aircraft levelled off at FL190, where the flight crew recall the commander's altimeter showed 18,860 ft, the co-pilot's altimeter showed 19,000 ft and the standby altimeter showed 18,920 ft. The airspeed was consistent with the aircraft's pitch and power setting but, the two primary airspeed indications showed a 3 to 4 kt difference.

The ALT MISMATCH message continued to appear intermittently at FL190. The flight crew actioned the appropriate QRH drill and decided, in consultation with the operator, to return to Exeter Airport. The subsequent descent, approach and landing were uneventful.

**Recorded information**

The aircraft was equipped with a two-hour CVR, a 25-hour FDR and a wireless Quick Access Recorder (QAR) system. The QAR recorded the same data as the FDR. Significant parameters recorded by the FDR included the altitude and airspeed parameters from Air Data Unit 1 (ADU1) and Air Data Unit 2 (ADU2). Information from the standby altitude and standby airspeed indicator was not recorded.

The FDR and QAR provided a complete recording of the incident flight. However, by the time the operator became aware that the CVR was required by the AAIB, the incident flight had been overwritten. The CVR recording provided some useful information on the post incident ground inspections to diagnose the fault.

Analysis of flight data for the incident flight indicated that shortly after takeoff the altitude from ADU1 under-read the altitude from ADU2 by about 50 to 60 ft, but as the aircraft climbed the altitude difference varied between 20 and 70 ft. During this same period the airspeed from the ADU1 under-read the airspeed from the ADU2 by about 3 kt.

When the aircraft levelled off at FL190, the altitude from ADU1 under-read the altitude from ADU2 by about 140 ft, and the difference between the ADU1 and ADU2 airspeeds remained at approximately 3 kt. The cruise airspeed was then reduced from about 230 to 190 kt, at which point the ADU1 and ADU2 altitude difference reduced to about 100 ft.

As the aircraft descended for the approach, the altitude difference between ADU1 and ADU2 reduced to about 20 ft and the airspeed difference increased briefly to 5 kt.

A review of previous flights of G-JECR, and data from other aircraft of the same type, indicated that during the climb it was normal to see a difference in altitude between ADU1 and ADU2 of 20 to 30 ft. This then reduced to less than a few feet in the cruise and to an average of about 5 ft during the approach. The difference between ADU1 and ADU2 airspeed during the climb and cruise was about 1 kt and during the approach, this could increase to about 3 kt.

The FDR also provided a recording of the post incident ground tests. This showed that when the altitude was set to about 10,000 ft, ADU1 overread ADU2 by 40 ft, at about 20,000 ft, the difference increased to 100 ft, and at about 30,000 ft the difference was 120 ft.

## Aircraft information

The De Havilland Aircraft of Canada Ltd Dash 8 Q400 is a high wing regional airliner powered by two turboprop Pratt & Whitney Canada PW150A engines.

*Pitot static system*

The two functionally independent ADUs use inputs from a variety of sources to calculate parameters such as altitude, indicated and true airspeed, and temperature. Two such inputs are static and total pressure which are sensed by the pitot static probes installed on the front of the aircraft. There are two primary pitot static probes located on the left and right side of the nose fuselage, linked to ADU1 and ADU2 respectively, and a third pitot static probe on the right side of the nose fuselage linked to the standby instruments (Figure 1).

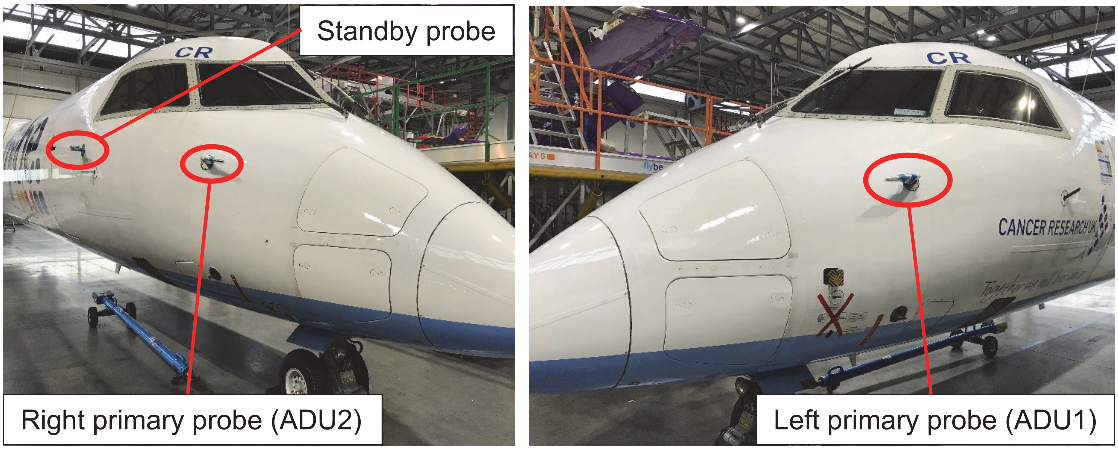



**Figure 1**
Pitot static probe locations

Pitot, or total pressure, is measured by the forward-facing hole, and static pressure by four 1.5 mm diameter holes on the side of the probe (Figure 2).

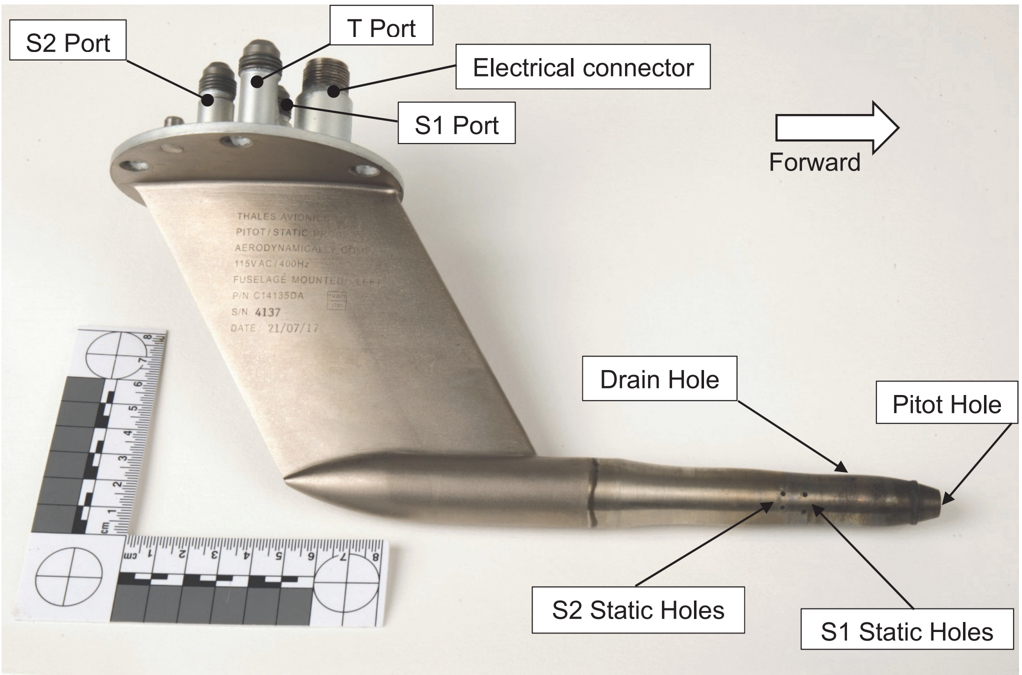



**Figure 2**
Left primary pitot static probe

The two primary pitot pressures (T1 and T2) are fed directly to the respective ADU, whereas the static pressures from the two static holes from each primary probe are averaged (S1 and S2) and fed to each ADU to minimise any sideslip effect (Figure 3).

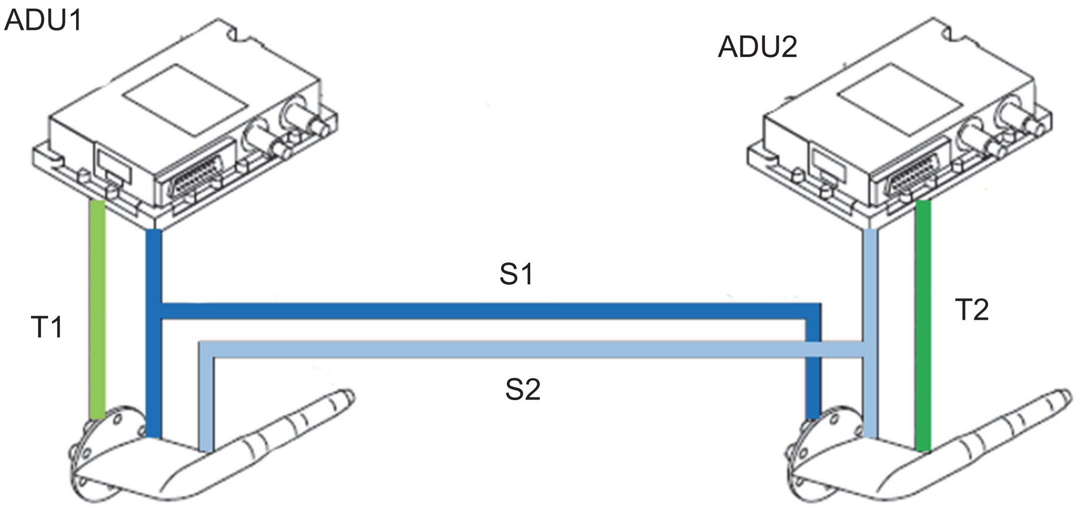



**Figure 3**
Pitot static system

In normal operation all three altimeters should read similar values. The aircraft manufacturer defined the tolerances for the difference between the two primary altimeters as 60 ft on the ground, increasing to 180 ft at 27,000 ft (FL270) and is 140 ft at 19,000 ft (FL190). When there is a difference greater than these values between the ADU altitudes for more than one second, the ALT MISMATCH message appears on the PFDs.

**Aircraft examination**

*Post flight troubleshooting*

Following the incident flight, the aircraft was inspected on the ground and white '*crystallised deposits*' were reported to be covering three of the four static pressure holes on the left primary pitot static probe (Figure 4). The deposits were lightly adhered to the surface and were removed by a technician but were not retained for further analysis. The right primary and standby pitot static probes were clear of deposits, and the pressure pipes from the probes to the ADUs were cleaned in accordance with the Aircraft Maintenance Manual (AMM) with nothing significant found. Functional and leak checks were also performed with satisfactory results in accordance with the AMM after the deposit had been removed.

*Left pitot static probe*

The left pitot static probe was removed from the aircraft and inspected under laboratory conditions to characterise any remaining residue. Samples of a range of products available in the maintenance facility were selected as potential candidate materials to aid identification of any residue found (Table 1).

| Product | Description | Comments |
|---|---|---|
| Lubricating fluid LF5050 | Liquid, equal mix of glycol and water. Does not contain fluorine or silicon. | Supplied in the Air Data Accessory kit. |
| DC4 compound | Semi-solid material, silicone containing grease. SEM-EDX confirms silicon present. | Mentioned during interviews. |
| Petroleum jelly | Semi-solid material, mix of hydrocarbons. Does not contain silicon or fluorine. | Reported at the time of event notification. |
| Swagelok Snoop | Liquid, predominantly water with a surfactant[1]. Does not contain silicon or fluorine. | Found in the air data accessory kit. |

**Table 1**

Samples of available materials for analysis

**Footnote**

1 A surfactant is a compound that lowers surface tension and in this case acts as a foaming agent.

*Examination*

Under microscopic examination trace amounts of a white residue was visible around the two aft and the inboard forward static holes (Figure 4). Inside the outboard rear static hole enough residue remained to allow for a sample to be taken for chemical analysis. No holes were fully blocked. A videoscope was inserted into all the probe holes and no blockages were observed, with only trace amounts of environmental debris found.

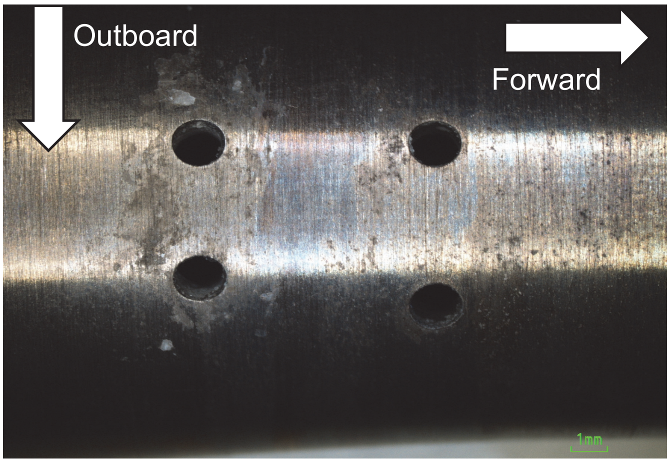



**Figure 4**
Left pitot static probe – note white residue inside static holes

Fourier Transform Infra-Red (FT-IR) spectroscopy and Scanning Electron Microscopy with semi quantitative Energy Dispersive X-ray (SEM-EDX) spectroscopy were used to chemically characterise the recovered samples and the candidate materials. The SEM-EDX analysis of the residue samples showed elevated levels of silicone and fluorine along with other lower levels of inorganic elements which could be associated with a lubricating product such as a grease. The presence of lower levels of inorganic elements suggest environmental material had collected over a period of time.

**Air data accessory kit**

*Description*

To perform functional and operation checks of the pitot static system, including a leak test, it is required to connect the pitot static probes to an air data test kit. The air data test kit enables air pressures to be applied to the static and pitot holes of the probe to simulate various altitudes in flight. They are used on several aircraft types.

The air data accessory kit includes all the aircraft type specific items required to make the connection to the air data test kit and is supplied by a specialist company. The air data accessory kit comprises three pitot static probe adaptors (left primary, right primary and standby), pneumatic hoses, three pre-test probes and lubricating fluid LF5050 (Figure 5).

**Figure 5**

Air data accessory kit

The primary pitot static probe adaptor is a machined aluminium tube which is slid onto the pitot static probe and has three hose connectors; one for pitot pressure [13], and one each for static pressure S1 and S2 [14] (Figure 6). Internally, there are seals [4, 8, 9 & 10] to enable the separate parts of the system to be tested and a knurled locking sleeve [2] to compress the seals onto the probe. A glycol and water-based lubricant (LF5050) is also supplied to aid installation.

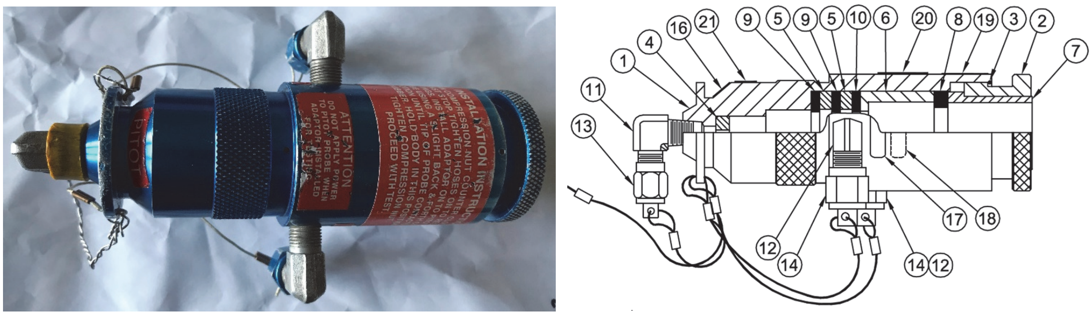



**Figure 6**

Primary pitot static probe adaptor

*Examination*

The air data test kit used during the preceding maintenance period was checked and verified to be within calibration limits. The air data accessory kit used on the incident aircraft during maintenance prior to the incident flight was subjected to a visual and microscopic inspection which revealed the probe adaptors seals to be in good condition with no significant amounts of residue inside. However, a trace amount of material was recovered from the first seal of each adaptor and the FT-IR results showed that it was a type of petroleum product, with the SEM-EX results showing elevated levels of silicone that were not consistent throughout the sample. There was evidence of damage to the knurled finish on the locking sleeves of all the adaptors.

*In service use*

To understand how the air data accessory kit is utilised in the maintenance organisation the 'varieties of human work' concept, as described by Shorrock (2016)[2], was used. The concept breaks down human work in to four varieties: work as imagined, work as prescribed, work as disclosed and work as done. This concept provides a framework to analyse a maintenance task, and the differences between the four varieties are often indicative of missing or incomplete safety barriers.

'*Work as imagined*' is the prediction by the manufacturer of the air data accessory kit of how a maintenance organisation will connect and use the equipment. It will be based upon their previous knowledge of working practices and will be written in general terms as it will be used in many different organisations.

The technical information guide supplied with the air data accessory kit contains a description of all the individual components and a brief explanation of when each one should be used. No detailed instructions for use are included as it is the expectation of the kit manufacturer that this should be documented in the AMM. It does however include a recommendation to apply a small amount of LF5050 to lubricate the seals of the adaptor and thereby '*insuring a smooth installation*' onto the pitot static probe.

The kit manufacturer also recommends that hand tightening the knurled locking sleeve is sufficient to enable a good seal, however this information is not included in the guide. They also stated that they have never received any feedback from operators on issues using the air data accessory kit.

'*Work as prescribed*' is the formalisation of a task or piece of work (in this case a work order). It is often written by those not involved in the accomplishment of the task and it is often viewed as the right or safe way to complete the task.

During the maintenance check prior to the incident flight, a work order was raised to clean the aircraft pitot static pipes. The work order stated to perform a leak test of the main system in accordance with Aircraft Maintenance Manual (AMM) task 34-11-00-790-801 and then to repeat the leak test after the cleaning has been completed. The AMM task details the procedure to follow for the leak testing of the system including precautions, set up, required tools and the test procedure.

**Footnote**

[2] https://humanisticsystems.com/2016/12/05/the-varieties-of-human-work/ - Accessed July 2019.

To connect the air data accessory kit to the pitot static probes the following instructions are given:

*(1) Connect the air data test set to the pitot/static probes. Refer to (Figure 7)*

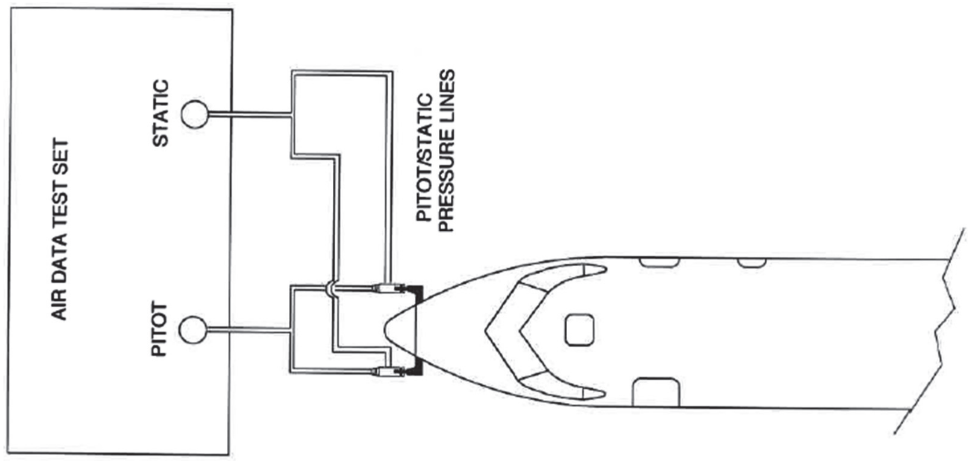



**Figure 7**

AMM diagram showing pitot static connections for testing

No further instructions are given, for example detailed instructions for connecting the air data accessory kit to the pitot static probes. To remove the kit, part (7) applies:

*(7) Set the test set to off.*

*(a) Disconnect the test set from the pitot/static probes.*

Following the incident flight, a further work order was raised to define the tasks required by the avionics technicians to troubleshoot the altitude mismatch on the aircraft. In addition to the leak checks, functional and operational checks were required. Both were done in accordance with AMM task 34-11-00-720-801 and 34-11-00-710-801 respectively. These AMM tasks describe the procedure to connect and disconnect the air data test kit in the same way as in the leak check task.

*'Work as disclosed*' is how work done is described by those who perform the task. How people describe their work can be influenced by several factors such as the audience, the context of the conversation and the potential outcome of the conversation.

The AAIB interviewed 10 avionics technicians from the maintenance organisation to understand how the air data accessory kits were used, if there were any issues or problems associated with them and whether they were aware of any non-standard practices. Two themes were disclosed which may have had an influence on the incident flight.

Although not a problem for all users, the avionics technicians noted that occasionally it can be difficult to establish a good seal between the pitot static probe and the adaptor resulting in incorrect air pressures being applied to the ADUs. Various remedial actions were described: repeatedly removing and reinstalling the adaptors until a seal was achieved, using a set of adaptors from a different accessory kit, applying various products to achieve a seal or replacing with new seals. There was no consensus on a single solution which was successful every time and several products were mentioned, other than the approved lubricant, to achieve a seal but no evidence could be provided of specific occasions when they were used.

The air data accessory kits contain many items and the maintenance organisation have multiple kits available which are taken from a controlled tool store when required. The kits are regularly audited during which they are visually examined, leak checks are performed on the hoses and the adaptors and the kit contents are assured. The kit used on the incident aircraft was last audited in July 2018 but at the time of the investigation it was missing the recommended lubricant and the instruction manual, some of the hoses were from another kit (identification label mismatch) and there was a bottle of 'Snoop' in the kit. Snoop is a commonly used water-based leak detection solution. It was stated during several interviews with avionics technicians that occasionally the approved lubricant was not available in the kit.

## Analysis

*Altitude mismatch*

During the incident flight the altitude difference between the commander's and co-pilot's instruments was 140 ft which equates to a pressure differential of 2.8 mb under ISA conditions. There was good evidence from the post-flight troubleshooting that three of the four holes on the left primary pitot static probe were blocked; this would have affected the pressure balancing between the left and right side of the aircraft. The S1 static pressure system had one hole open in the left probe and two holes on the right probe which resulted in the higher pressure (lower altitude) whereas the S2 system had only two holes open in the right probe and gave a lower system pressure (higher altitude).

It is possible that the difference of 2.8 mb between these two dissimilar system configurations could have been caused by a slight sideslip to the right which would increase the pressure on the right side of the aircraft and would not have been averaged due to the blockage of the left side S2 holes. Although on this occasion the altitude and airspeed errors were small and resulted in a successful return to the departure airport, a blocked pitot static system has the potential to cause a large error in altitude and airspeed information displayed to the pilots. Unreliable primary flight data has previously been a contributory factor in several accidents and serious incidents.

*Work as done - blocked static holes*

'*Work as done*' according to the Shorrock concept is the actual activity taken to complete the task and may occur in an environment that is subject to a variety of constraints, challenges and demands that are not 'imagined' or 'disclosed'. The work done may be the product of adaptations to overcome these which, although intended to achieve the objective, may result in unintended consequences.

From interviews with the avionics technicians it is known that it can be difficult to achieve an effective seal between the test adaptors and the probe, and they indicated that several different methods have been employed to achieve a seal. Analysis of residue found on and inside the pitot static probe, as well as on the seals on the probe adaptor, strongly suggests that substances other than the recommended lubricant had been used during maintenance activity. There was also some evidence of damage to the knurling on the probe adaptor, and it is probable that hand tools had been used to tighten the locking sleeve, despite the air data accessory kit manufacturer stating that hand tight is sufficient.

*Instructions for use of air data accessory kits*

The kit manufacturer stated that the instructions for use of the air data accessory kit should be described in the relevant section of the AMM. The work orders issued by the maintenance organisation state that to accomplish a task it is to be done in accordance with the specific AMM task. However, the AMM does not provide any details on how to install the adaptors, which products should be used, or any additional information to aid the technicians to achieve a good seal between the probe and the adaptor.

Therefore, to improve the information with the air data accessory kits, which are used on several different aircraft types, the following Safety Recommendation is made:

**Safety Recommendation 2019-010**

It is recommended that Nav-Aids Ltd amend the manual supplied with air data accessory kits to include more specific installation instructions, and to include warnings against using non-approved materials to aid sealing.

To improve the information in the AMM for the De Havilland Aircraft of Canada Ltd DHC-8-402 the following Safety Recommendation is made:

**Safety Recommendation 2019-011**

It is recommended that De Havilland Aircraft of Canada Ltd amend the instructions in the Aircraft Maintenance Manual for the DHC-8-402 for testing pitot static probes to include more specific installation instructions, and to include warnings against using non-approved materials to aid sealing.

*Lubricating fluid*

The air data accessory kit manufacturer recommends the use of LF5050 to aid installation and the avionics technicians stated that it is often missing from the kit box due to kit control issues. It is possible therefore that to ‘get the job done’ the technicians may resort to other more easily available products with the unintended consequence, in this case, of residual grease blocking some of the static holes. As a result of this investigation the following safety action has been taken:

The maintenance organisation has purchased new air data accessory kits and implemented tighter tool control of the kits to ensure all the components are always available.

## Conclusion

Following scheduled maintenance of the incident aircraft, a small quantity of a silicone-based grease was blocking three of the four static pressure holes of the left primary pitot static probe. The inadvertent blockage of the static pressure holes resulted in an altitude mismatch of 140 ft between the commander's and co-pilot's altimeter. This may have been caused by using a non-approved grease to aid sealing the test adaptor to the pitot static probe, a task which can sometimes be problematic. The kit manufacturer's recommended lubricant is sometimes missing from the kits and the AMM and the kits instructions do not include any details on installation or sealing.

## Safety actions/Recommendations

The following two Safety Recommendation have been made:

> **Safety Recommendation 2019-010:** It is recommended that Nav-Aids Ltd amend the manual supplied with air data accessory kits to include more specific installation instructions, and to include warnings against using non-approved materials to aid sealing.

> **Safety Recommendation 2019-011:** It is recommended that De Havilland Aircraft of Canada Ltd amend the instructions in the Aircraft Maintenance Manual for the DHC-8-402 for testing pitot static probes to include more specific installation instructions, and to include warnings against using non-approved materials to aid sealing.

The following safety action has been taken:

> Safety action has been taken by the maintenance organisation to purchase new air data accessory kits and implement tighter tool control of the kits to ensure all the components are always available.

*Published: 31 October 2019.*

**SERIOUS INCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | EC135 P2+, G-POLA |
| **No & Type of Engines:** | 2 Pratt & Whitney Canada PW206B2 turboshaft engines |
| **Year of Manufacture:** | 2010 (Serial no: 0877) |
| **Date & Time (UTC):** | 5 April 2018 at 1040 hrs |
| **Location:** | Morpeth, Northumberland |
| **Type of Flight:** | Flight test |
| **Persons on Board:** | Crew - 1 Passengers - 1 |
| **Injuries:** | Crew - None Passengers - None |
| **Nature of Damage:** | None |
| **Commander's Licence:** | Commercial Pilot's Licence |
| **Commander's Age:** | 49 years |
| **Commander's Flying Experience:** | 6,200 hours (of which 2,400 were on type)<br>Last 90 days - 16 hours<br>Last 28 days - 7 hours |
| **Information Source:** | AAIB Field Investigation |

## Synopsis

During a maintenance flight to adjust engine speed, main rotor rpm varied between its maximum and minimum continuous limits. A mechanical stop within the adjusting potentiometer had failed in such a way that main rotor speed could not be controlled accurately, putting the helicopter at a significant risk. The pilot had not been specially trained to carry out the flight test but his actions in flight prevented rotor speed exceeding its limits and a more serious outcome. The manufacturer and operator have taken safety action regarding the conduct of airborne engine speed adjustments.

## History of the flight

In November 2017, after an engine change, a deferred defect log (DDL) entry restricted the helicopter to 4,500 ft density altitude[1] (DA). To remove this restriction the helicopter required an $N_2$ adjustment flight at 9,500 ft DA. The pilot indicated that because the DDL had been present for some time, he planned to use the opportunity of good weather at his base of Newcastle Airport to perform the flight test with appropriate engineering support.

**Footnote**

[1] Density Altitude – Pressure altitude corrected for non-standard temperature variations.

The pilot arranged for the helicopter to be left with the appropriate fuel onboard. He and the engineer reviewed the relevant procedure in the Aircraft Maintenance Manual (AMM)[2]. The pilot then calculated the DAs, because the helicopter would be required to climb from below 4,000 ft DA to at least 9,500 ft DA. This process also established the expected engine torque at the pitch stop.

The pilot started both engines, carrying out a five-minute drying out run after the cold rinse, followed by a hover check. The helicopter then departed the airfield. The pilot initiated a climb in accordance with the AMM procedure and called out the heights and temperatures for the engineer to record. They determined a pitch stop torque value at 9,500 ft DA of 67%, with an associated $N_2$ of 103.2%. This was slightly lower than the required 103.8% $N_2$. The pilot asked the engineer to make an adjustment on the $N_2$ adjuster, which he did. Initially there was no increase. However, after further adjustment, the $N_2$ slowly increased at a constant rate.

As the $N_2$ reached 103.8% the pilot advised the engineer to stop the adjustment, and he did so. However, the $N_2$ continued to increase through 104% and the $N_R$ began to increase at the same time. The pilot arrested the rising $N_R$ at 106% (the maximum continuous power-on $N_R$ allowable) by raising the collective lever to full travel with a torque of 69%. At this point the $N_R$ overspeed warning light illuminated and the associated aural alert sounded. To contain the now increasing airspeed and resulting airframe vibration, the pilot adjusted the helicopter attitude and initiated a moderate climb. The pilot asked the engineer to reverse the adjustment as soon as possible, which he did, but with no effect.

The helicopter had climbed approximately 1,000 ft and the pilot advised the engineer that he would have to manually retard the engines if the $N_2$ could not be reversed using the adjuster. The pilot stated that he was reluctant to do this because he considered it would result in either a double manual throttle approach[3], or a double manual throttle transit to a double engine shutdown and associated auto rotation forced landing at the airport. However, as the engineer continued adjusting, the $N_2$ started to reduce. The pilot advised the engineer to stop the adjustment as the $N_2$ reduced towards the target figure. Despite this, the $N_2$ continued to reduce past the target figure down to 98% which had a "dramatic effect" on the $N_R$. The pilot then lowered the collective to 20% torque and the $N_R$ stabilised at 97%, the minimum continuous $N_R$, power-on allowable.

The helicopter was now in a moderate descent with an increasing airspeed, so the pilot adjusted the pitch the attitude and lowered the collective lever to increase the $N_R$. At this point the torque reduced to around 10% and the FADEC 1 & 2 FAIL (Full Authority Digital Engine Control) caution indications illuminated. By lifting the collective lever, the pilot increased the torque to 25% and the captions went out. In an attempt to recover $N_R$, the engineer made additional $N_2$ adjustments.

**Footnote**

2 AMM Section 05-60-00, 6-4 *'Ground Check Run and Functional Check Flight – EC135 P2 / P2+ Ground Check Run and Functional Check Flight'*, section F10 *'Adjust / check N2 in or above 9500 ft density altitude (only to be performed if the helicopter is operated above 4500 ft density altitude'*.

3 Whereby the pilot, not the FADEC, regulates engine speed.

The pilot began to revert to manual throttle but had difficulty lifting the associated catches until he removed one of his flying gloves. Just as he lifted one of the catches, the $N_2$ rose to 105% and eventually, with further adjustments, the engineer stabilised the $N_2$ at 101%. No further attempts were made to adjust the $N_2$ setting.

The pilot started a gentle descent. Aware that both engines were in an “under-trimmed” $N_2$ state, he performed power checks and a simulated approach to the hover at 2,000 ft agl. whilst maintaining a stabilised $N_R$ of 101%. Therefore, the pilot elected to fly a normal approach to his base helicopter landing site at Newcastle, using a shallow descent profile to the hover. The pilot stated that he had been prepared to engage manual throttle on the No 1 engine and increase power, or commit the aircraft to a running landing[4], should the $N_R$ decay dangerously on the approach.

After confirming that the $N_R$ was sufficient, the pilot hover taxied the helicopter to the parking area and landed. As he fully lowered the collective lever, the pilot observed the $N_R$ to rapidly drop to below 96%. The helicopter was then shutdown normally.

## Weather

The pilot reported the weather on the ground as CAVOK, with a wind of 14 kt from 280° and air temperature of 6°C.

## Personnel

The pilot was a “line”[5] pilot for the operator. He reported that of his 6,200 hours flight experience, 2,400 hours were on the EC135; mostly on the T2 variant. He had previous experience as a military “air-test” pilot.

The engineer was an experienced B1 licenced engineer who had carried out similar flight tests on previous occasions.

## Aircraft description

### *General*

The EC135 P2+ is a twin-engine, lightweight utility helicopter fitted with a four-blade rigid rotor. Yaw and anti-torque control is provided by a Fenestron[6]. It is fitted with two Pratt and Whitney Canada PW206B2 free turbine, turboshaft engines[7] with FADEC[8]. Input from the engines into the main rotor gearbox is via two main drive shafts with freewheel units. Inputs from sensors within the engines, main rotor gearbox and airframe are converted to digital control outputs from the FADECs into the engine fuel control units to control fuel to the

**Footnote**

[4] Running landing – Helicopter landing made into wind with groundspeed and/or translational lift at touchdown.
[5] Line pilot – common term for those of the front-line pilot workforce, who have no additional management or training functions within an organisation.
[6] A ducted fan system providing yaw control in the manner of a tail rotor.
[7] EC135 helicopters fitted with Pratt and Whitney engines are designated as EC135 P variants and those fitted with Turbomeca engines are designated as EC135 T variants.
[8] Full authority digital engine control.

combustion chambers. Power output is varied automatically to maintain the rotor $N_R$ within its design limits throughout the flight envelope. The FADECs are linked, known as 'cross-talk', to automatically match each engine as collective demands are made by the pilot.

*$N_2$ description*

After installation of a replacement engine or FADEC unit the $N_2$ speed is set by adjustments made to the $N_2$ ADJUST control installed in the lower part of the overhead panel.

On the earlier P1 variants of the EC135 there was no cross-talk between the engines which therefore required an individual adjuster for each engine. In the P2 variants of the EC135 the cross-talk facility means that it is possible for one adjuster to set $N_2$ in both engines simultaneously. When a replacement engine is fitted, the cross-talk facility automatically matches both engines. Normally the remaining, and already correctly set, engine would cross-talk to the replacement engine and $N_2$ would be correct. However, occasionally adjustments are required to ensure that when the engine start switch is in the FLIGHT position, the $N_2$ speed is maintained at 100% in normal flight conditions. This also ensures that the $N_2$ speed is automatically increased to between 100% and 104% when DA is between 4,000 ft and 9,000 ft.

*$N_2$ adjuster*

The $N_2$ adjuster is a small rotary switch set into the overhead panel (Figure 1) alongside the ENG I and ENG II MODE and VENT selection switches just behind the rotor brake lever. To operate the adjuster, a small flat-bladed screwdriver must be inserted which then enables it to be turned clockwise or anticlockwise. Within the switch there are a series of radially spaced contacts which are brought into alignment in various combinations as the spindle is rotated. In the switch casing there are 12 detent slots which engage a spring-loaded plunger held in the spindle designed to assist in the accurate alignment of the contacts. The detents give the switch a distinctive but light 'click' as the switch is rotated. There is also a fixed limit stop within the switch casing. However, in this application, it is required to work in a similar way to a three-position switch that can be rotated left or right 45° either side of the neutral setting. This range of movement is set by a stop ring fitted around the spindle of the rotary switch. The stop ring has a tang which protrudes through the switch casing into the path of a moulded lug, thus restricting spindle rotation to between the lug and limit stop. Figure 1 shows the $N_2$ adjuster location within the overhead switch panel of an example EC135. Safety lacquer (highlighted in Figure 1) is applied after adjustment in accordance with the AMM.

If the adjuster is turned anticlockwise against its stop the $N_2$ will gradually decrease until the adjuster is returned by the operator to its neutral position. Similarly, if rotated clockwise against the stop it will gradually increase until returned to the neutral position. The $N_2$ figure is shown as a percentage on the Vehicle and Engine Monitoring Display when the FADEC status page is selected. The gradual rate of response of $N_2$ allows accurate adjustments to be made.


**Figure 1**

Pratt and Whitney engine EC135 $N_2$ adjuster location

## Maintenance history

The helicopter was maintained in accordance with the AMM and had recently undergone an engine change, which was not relevant to this occurrence other than it required the flight test to adjust and set the $N_2$.

## Flight test procedure

The procedure in AMM Section 76-10-00, 5-5 - *'Setting N2 Speed',* describes how the $N_2$ adjustment is carried out and how to use both types of adjuster in the P2 and T2 series EC135 helicopters.

The flight test schedule for this task is set out in AMM Section 05-60-00, 6-4 *'Ground Check Run and Functional Check Flight…'*, as item F10 *'Adjust / check N2 in* [sic] *or above 9500 ft density altitude…'*. This describes how the helicopter should be flown and the altitudes at which this adjustment should be made to achieve the correct $N_2$ setting. It is laid out such that the pilot and engineer can record the readings at each stage of the step by step process.

In its internal report into the serious incident, the manufacturer stated that the correct procedure had been followed.

The operator indicated that, at the time of the occurrence, line pilots were permitted to perform the $N_2$ adjustment flight. The manufacturer stated that it is for an operator to decide which of its pilots qualify for maintenance activities. However, the manufacturer indicated that this flight test should be restricted to specially trained pilots, commenting that its own pilots undertake in-house training and would not carry out this flight test until they had seen it performed by another pilot. The manufacturer highlighted the importance of briefing what might happen on such a flight test, a process known as Threat Error Management (TEM)[9].

**Footnote**

[9] TEM – To plan, direct and control an operation or situation.

As an immediate response to this serious incident, the operator restricted the $N_2$ adjustment flight test to its maintenance test pilot only. It subsequently sought advice from the manufacturer and categorised all flight tests according to which of its pilots should perform them. Level 1 tests may be performed by line pilots without specific training; Level 2 tests require pilots to undertake a briefing; and Level 3 tests may only be conducted by specially trained type rating instructors and examiner pilots[10]. The $N_2$ adjustment flight test was categorised as Level 3, and the required training was modelled on that provided by the manufacturer to its pilots.

## Investigation by the manufacturer and operator

*$N_2$ adjuster*

During the subsequent investigation by the operator and the helicopter manufacturer, the adjuster was found to be faulty. The adjuster spindle rotated freely through approximately 330° so was only being restricted by its fixed internal stop.

Pictures supplied by the manufacturer of the faulty switch showed no outward evidence of damage. However, the small screwdriver slot at the end of the spindle showed some evidence of wear marks left by screwdriver blades in the past (Figure 2).

The metal stop ring tab engages in the plastic components within the switch. The helicopter manufacturer issued a Technical Information Notice in 2010 drawing attention to the delicacy of the $N_2$ adjuster in the P2 variants of the EC135 helicopters. It also described the differences between the adjusters and how they operate to adjust the $N_2$.

*Actions by the engineer*

Prior to the flight, the engineer and pilot briefed the AMM procedure. During the flight, when the helicopter had been correctly configured for the first adjustment, the pilot noted the first $N_2$ figure and asked the engineer to increase it. This meant turning the adjuster clockwise, which he did. At first there was no reaction, so the engineer turned it a little further. The $N_2$ then continued to rise past the desired figure and so the engineer stopped adjusting. Then, as requested by the pilot, he turned it back anticlockwise and again, after a delay, the $N_2$ reacted, this time reducing. After his first adjustments he no longer knew the orientation of the $N_2$ adjuster relative to its neutral datum. The engineer was now "very concerned" about this and felt that he had completely lost control of the $N_2$.

Although the engineer was expecting the stops to limit his adjustments, he was not aware of them having done so. He did, however, observe evidence of a previous application of safety lacquer.

*Investigations by the manufacturer*

The adjuster was removed from the helicopter and was returned to the helicopter manufacturer for further investigation. After removal of the adjuster the stop ring could not be found. Tests carried out on the adjuster using a spare stop ring showed that the adjuster worked correctly, with the stop ring and fixed stop restricting rotation either side of its neutral position.

**Footnote**

[10] Pilots with a formal training function.

Additional tests were carried out on another adjuster and stop ring combination. During this test the adjuster was forcibly over-driven using a screwdriver in the spindle slot. This had two effects: the screwdriver slot became misshapen and burred on the slot faces; and the lug on the plastic rotating part of the adjuster, which limits its travel against the stop ring tang, was damaged with a distinctive ‘cut’ through the lug.

These effects were compared to the original adjuster removed from G-POLA. The screwdriver slot showed superficial wear and the lug on the rotating part of the adjuster was undamaged (Figure 2).

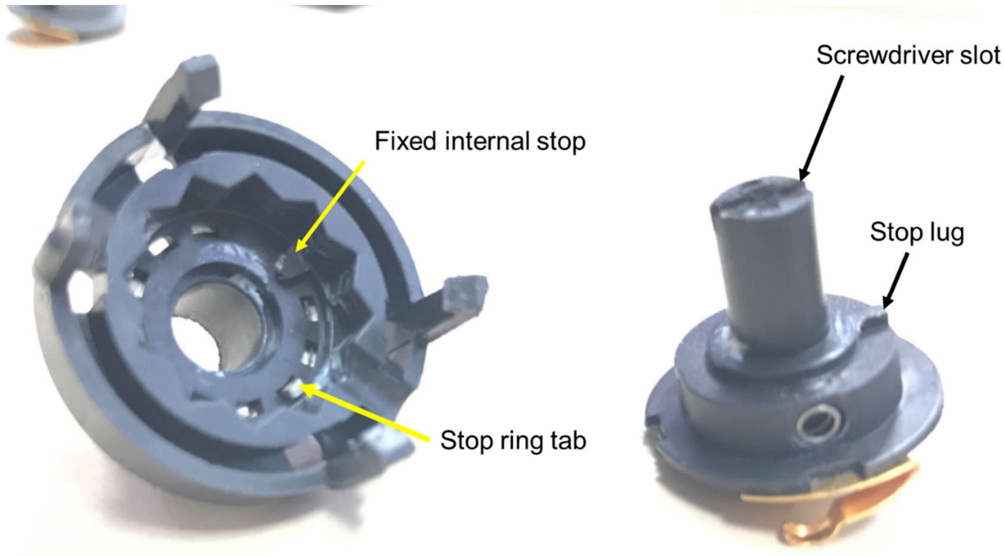



**Figure 2**

$N_2$ adjuster fixed casing and spindle.
Note the stop ring tab, fitted to show how it controls the range of spindle rotation

As a result of this serious incident the manufacturer released a Safety Information Notice (SIN), which stated:

> *‘During an engine power turbine speed ($N_2$) adjustment flight of an EC135, P2+, the $N_2$ had been unintentionally adjusted up to 106% $N_R$. In the subsequent attempt to reduce $N_2$ speed again, $N_2$ reduced to 98% with a corresponding effect on the rotor speed $N_R$. For safety reasons, the pilot then aborted the flight and landed.*
>
> *Therefore, Airbus Helicopters Deutschland (AHD) wants to highlight that – depending on the engine variant – there are different procedures for adjusting the power turbine speed ($N_2$). These are described in AMM 76-10-00-5-5 (setting – $N_2$ speed). Additional information can be found in TIL EC135 033-2010.*
>
> *Applying the wrong adjustment procedure could result in an incorrectly adjusted $N_2$’.*

The SIN did not refer to the faulty adjuster or offer advice on how pilots should prepare for carrying out the flight test.

## Comments by pilot

The pilot and engineer found the occurrence disconcerting because they were faced with several emergencies in a short space of time.

The pilot believed he had been assisted by his previous military training, during which he encountered similar malfunctions to those in the incident flight in a full motion simulator.

Most of the pilot's EC135 experience had been on the T series. In his opinion, manual throttle control on the P series is more difficult because it is more "sensitive" and the pilot's inputs control[11] the engine directly. He stated that he had not had the opportunity to practice a double manual throttle emergency on either series but had previously developed a plan for dealing with one, which he believed was crucial in his handling of this emergency. He stated that he had "meticulously planned" the logistics of the incident sortie, but that he had not specifically briefed the "what if's" of the flight.

The pilot wore thick gloves because he had calculated the OAT during the flight test would drop to around -15°C. However, these impeded his ability to lift the manual throttle catches, which he reflected could have been problematic had it happened close to the ground.

The pilot suggested that an $N_2$ adjustment flight should be performed by specially trained pilots and conducted in smooth air conditions. Pilots should be prepared for uncommanded changes in $N_2$ and a double FADEC failure.

## Additional information from the operator

The operator stated that at the time of the serious incident it was in the process of introducing simulator training for its pilots. This training began in September 2018, after this serious incident. The operator has incorporated what it considers "high risk" scenarios in the simulator syllabus and intends to mimic the occurrence as closely as possible in training.

## Analysis

The helicopter had been correctly prepared and configured to carry out the flight test. The engine change was not related to the occurrence other than to have created the requirement to undertake an airborne test to adjust and set up the $N_2$.

*Actions by the pilot and engineer*

At the time of this serious incident, the operator had not prohibited line pilots without specific training from performing the $N_2$ adjustment flight test. The pilot chose to perform the flight test in order to clear the associated DDL. The pilot and engineer did not specifically brief the possible hazards of performing it.

**Footnote**

[11] The pilot explained that the T series' manual throttle mode retains an element of FADEC control.

During the flight, the engineer was unable to control $N_2$ and the pilot made large control inputs to control $N_R$. High and low $N_R$ values had the potential to have a catastrophic effect on the helicopter in flight but by working together and using the effects of the helicopter dynamics, the pilot and engineer were able to stabilise the $N_R$, albeit lower than normal, and recover the helicopter to land safely.

*Effect of the faulty $N_2$ adjuster*

$N_R$ variation was consistent with $N_2$ changes made using the faulty adjuster. In the absence of the stop ring there was no means to ensure correct alignment of the contact combinations within the rotary switch. This meant the switch did not have a reliable effect on $N_2$. The engineer making the adjustments could not determine which contacts were made and was no longer confident in the neutral position. The gradual $N_2$ change rate also made it difficult to establish what was happening with the adjuster, which appeared to be having an unexpected effect. Despite the residual safety lacquer on the adjuster, the engineer was not able to establish a neutral position or judge its extremes of range, so was therefore quite correct in his feeling that he had completely lost control of the adjuster.

*$N_2$ adjuster*

The manufacturer found the adjuster to be undamaged and, when combined with a spare stop ring, it worked correctly. The description of the action of the adjuster by the engineer during the flight test indicated that there was no restriction, apart from the detent clicks, in the rotation of the adjuster. The feel of an adjuster that has been forced is distinctive and was not present on the adjuster removed from G-POLA. Discussions with the manufacturer indicated that despite the delicate construction of the switch, considerable force would be required to overcome the stop ring. This verifies the finding that after removal of the adjuster the stop ring could not be found and therefore it was not present during the test flight.

From the description of the event by the engineer it appears that the initial adjustment would have been a clockwise rotation to increase the $N_2$. Without the stop restricting movement there is a risk of rotating the adjuster too far.

However, it is possible that on previous occasions the detent ‘clicks’ were enough to have prevented over- or under adjustment by other engineers.

Once the $N_2$ is set, in normal circumstances the $N_2$ adjuster does not have a dynamic effect on the helicopter in flight. However, it is only when it is adjusted in flight that it becomes apparent whether it is working correctly. Unlike the $N_2$ adjuster in the T series EC135, which is of a different design and is a more traditional potentiometer, it is possible to establish the integrity of the stops of the adjuster in the P series helicopters on the ground with power-off before a flight test is carried out.

*Training and preparation*

Although operators decide which pilots may perform the $N_2$ adjustment flight test, the manufacturer indicated that it should be restricted to specially trained pilots. The operator now intends that only nominated and trained pilots should perform it, and intends to incorporate the event in to its simulator training.

SIN 3254-S-76, released by the manufacturer after this serious incident, only focussed on the differences between the two types of $N_2$ adjusters. The AAIB discussed with Airbus Helicopters Deutschland the possibility of it informing all EC135 operators of the circumstances of the occurrence to G-POLA, advising them to use appropriately trained pilots to conduct $N_2$ adjustment flight tests, and explaining the importance of conducting a threat and error management briefing before performing it. Airbus Helicopters Deutschland has undertaken to action those suggestions, which it intends to extend to all AMM post maintenance tasks for all of its helicopter types, reminding operators of the importance of the specific pilot skills required by post maintenance flying activities.

It is likely that the hazards related to post maintenance flying highlighted by this event are relevant to helicopters from other manufacturers.

## Conclusion

The loss of control of $N_{2,}$ and therefore of $N_R$, was caused by the absence of the stop ring mechanism within the P2 series EC135 $N_2$ adjuster, which risked a loss of control of the helicopter. The pilot had not been trained to carry out the procedure but his actions in flight prevented a more serious outcome.

Several safety actions have been taken by the manufacturer and the operator in relation to the related AMM procedure, pilot suitability for conducting post maintenance flying tasks, and pilot training.

## Safety action

The manufacturer has:

- Issued an AMM amendment regarding the $N_2$ adjuster installation procedure (76-11-00,8-4), a caution to install the stop ring correctly / take care that the ring is not forgotten.
- Issued an AMM amendment regarding $N_2$ adjustment maintenance flights (05-60-00, 6-4), to check, prior to flight while on ground without power, that the $N_2$ adjustment switch works properly (only three switch positions are possible - decrease, neutral, increase). After successful check the switch must be turned into the neutral position.
- Issued Safety Information Notice AH 3254-S-76: *'Engine Controls – Engine Power Turbine Speed ($N_2$)'* to draw attention to this occurrence, remind operators of the procedure, and to highlight the difference in $N_2$ adjustment procedures between the P2 and T2 Series EC135 helicopters.

- Has undertaken to inform operators of all its helicopter types of the circumstances of the occurrence to G-POLA, reminding them of the importance of the specific pilot skills required by all AMM post maintenance flying tasks.

The operator:

- Has categorised its flight test activities according to which of its pilots should perform them. It has restricted the $N_2$ adjustment flight procedure to the remit of specially trained type rating instructor and examiner pilots.
- Intends to incorporate the incident scenario in to its newly established simulator training package.

*Published: 24 October 2019.*

## ACCIDENT

| | |
|---|---|
| **Aircraft Type and Registration:** | Rolladen-Schneider LS7, G-CFMY |
| **No & Type of Engines:** | None |
| **Year of Manufacture:** | 1988 (Serial no: 7004) |
| **Date & Time (UTC):** | 4 May 2019 at 1416 hrs |
| **Location:** | Near Blaenau Ffestiniog, Gwynedd |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - None |
| **Injuries:** | Crew - 1 (Fatal) Passengers - N/A |
| **Nature of Damage:** | Destroyed |
| **Commander's Licence:** | British Gliding Association Gliding Certificate |
| **Commander's Age:** | 64 years |
| **Commander's Flying Experience:** | 3,349 hours<br>Last 90 days - 30 hours<br>Last 28 days - 17 hours |
| **Information Source:** | AAIB Field Investigation |

### Synopsis

The pilot was flying his glider on a cross-country flight from Talgarth Airfield in South Wales towards Snowdonia National Park. When the pilot did not return a search was launched. The glider and deceased pilot were found in a field 3 nm south of Blaenau Ffestiniog. A post-mortem examination of the pilot found he had suffered a heart attack in flight which would have either rendered him unconscious or been fatal.

### History of the flight

The pilot was participating in a week-long gliding trip to Talgarth Airfield with his local club. On 28 April 2019 he had passed a local check flight at Talgarth and had then flown four times during the week. He had brought G-CFMY, which he co-owned in a syndicate, to Talgarth. Throughout the week the weather forecast for the Saturday had looked favourable for a cross-county flight to North Wales. He had planned, with another glider pilot, to fly north from Talgarth towards Long Mynd and Oswestry then to Lleweni (Denbigh) and then on to Snowdonia.

On 4 May 2019, the pilot attended the group briefing at 0900 hrs. The airfield records showed that he launched in G-CFMY at 1013 hrs with an aerotow and was released at 1,100 ft agl (2,000 ft amsl). A friend who helped with the launch reported that the pilot was well rested and well briefed before launch. He watched the glider take off, then climb in the local area before seeing it depart to the north-east.

The other glider pilot flying the same route launched 10 minutes later, they had agreed a frequency on which to communicate with each other if necessary, but they didn't make contact during the flight. He described the conditions as "challenging" with a "good 20 kt wind" aloft with wave influence near Oswestry. He landed in a field near Ruffin at approximately 1500 hrs. He tried to call the pilot of G-CFMY before he landed but didn't get an answer. He recalled that the conditions had flattened out with sea air degrading the thermals. He recalled the cloud base in North Wales was approximately 4,000 ft amsl.

G-CFMY's pilot spoke to his wife on his mobile phone twice during the flight. He initially tried to call her at 1248 hrs and 1251 hrs; but did not get an answer. She called back at 1257 hrs and they spoke for 1 minute 31 seconds. She called him again at 1349 hrs and they spoke for 33 seconds. She recalled that during this second conversation he said he was 9-10 miles from Snowdon. She asked him what the conditions were like and she recalled he said something like "not good, cloud ahead, might turn back".

The pilot took several photographs during the flight using his mobile phone. The last photograph was taken at 1401 hrs.

When the pilot did not return to Talgarth the alarm was raised. The Distress and Diversion cell (D&D) were informed at 1717 hrs. The local police were able to track the pilot's mobile phone and determine its approximate position. The coastguard helicopter launched at 1828 hrs, located the glider at 1846 hrs and landed on site at 1849 hrs. The glider was within 300 m of the location provided by the police. The helicopter crew found the deceased pilot still strapped into the glider.

**Recorded information**

*Sources of recorded information*

Data was successfully recovered from a memory card that had been fitted to the pilot's portable tablet computer[1]. The card had been ejected from the tablet computer during the impact. The tablet computer was installed with a flight navigation software application[2] that recorded a GPS track log of the accident flight, with position, track, altitude and groundspeed recorded at a rate of once every four seconds.

*Accident flight*

GPS-derived data salient to the accident flight are presented in Figures 1, 2 and 3. The recorded altitudes have been reduced by 181 ft in order that the altitude of G-CFMY aligned with the elevation amsl of Talgarth during the takeoff roll. Altitudes are referenced to amsl unless stated and all times are UTC (local time was +1 hour).

The recording started at 1011 hrs when G-CFMY was positioned on Runway 33 at Talgarth. A few minutes later the glider was towed to an altitude of about 2,000 ft amsl. It then proceeded on a northerly course towards the town of Denbigh, Wales, which it

**Footnote**

1 Hewlett Packard Travel Companion.
2 Naviter SeeYou Mobile software application.

reached at 1307:30 hrs. Having passed almost overhead Lleweni Parc Airfield (located near to Denbigh) at 1323 hrs, the pilot altered course, initially to the west, and then to the south-west, towards the southern area of Snowdonia National Park.

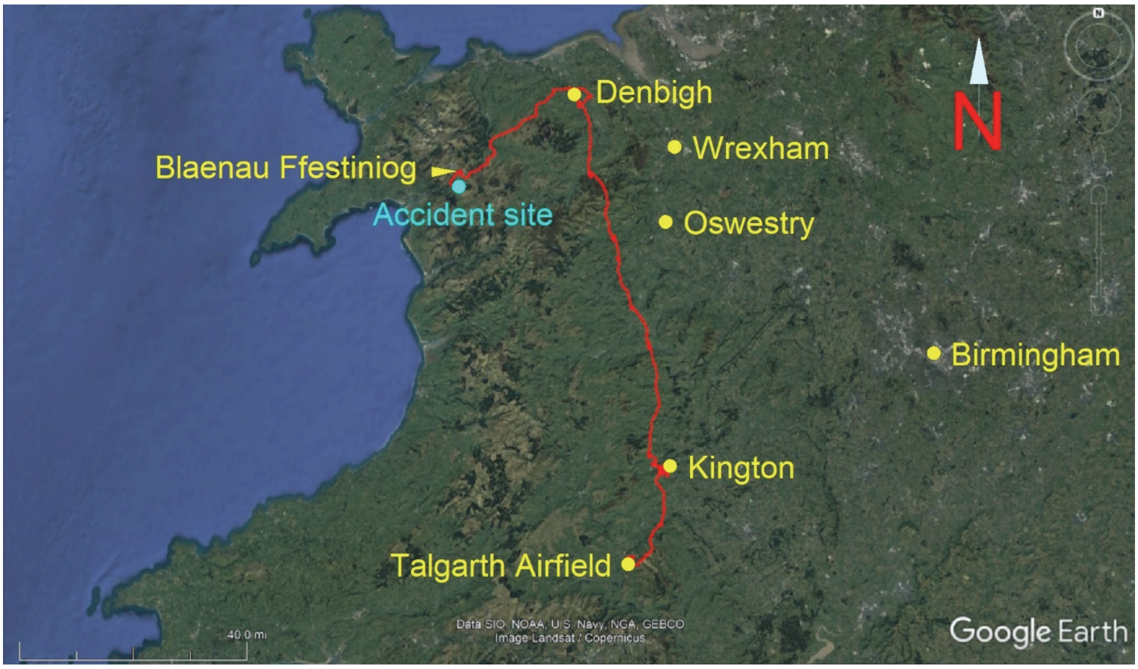



**Figure 1**

GPS track of G-CFMY

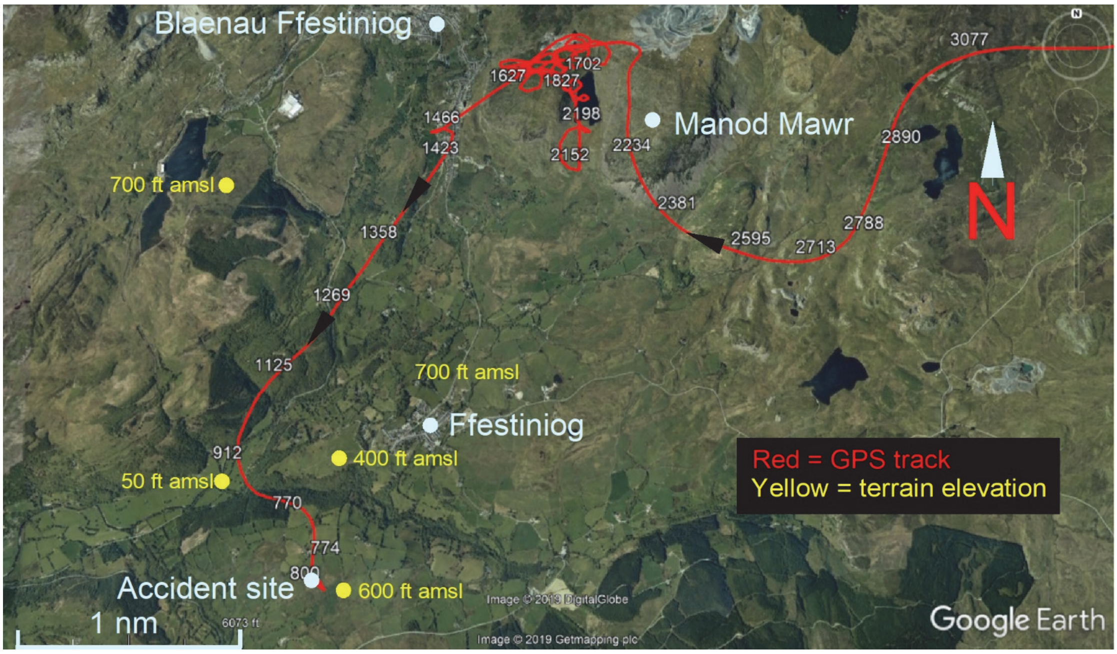



**Figure 2**

GPS track of final 15 minutes of flight
(values presented are aircraft altitude amsl and terrain elevation)

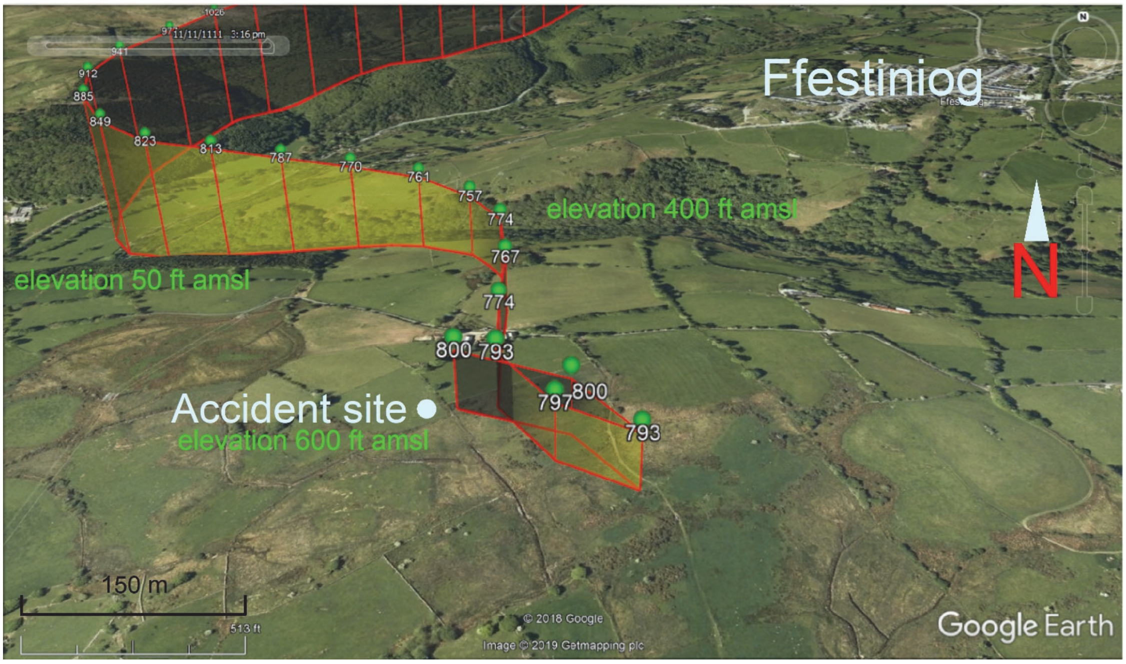



**Figure 3**

GPS track of final 15 minutes of flight
(values presented are aircraft altitude amsl and terrain elevation)

At 1359 hrs, the glider was positioned about 6 nm north-east of the village of Ffestiniog. After several minutes of soaring it climbed to an altitude of about 3,500 ft before resuming a course towards the south-west. Several minutes later, having descended to an altitude of about 2,700 ft, the glider turned northwards towards Manod Mawr mountain, where it then proceeded to soar in an area just west of the summit above a quarry on the south facing slope. The glider soared in this area for about eight minutes, during which its altitude varied from between about 2,200 ft and 1,700 ft. At 1412:30 hrs the glider was at an altitude of 1,630 ft when it headed towards the south-west.

About 30 seconds later, the glider made a single right-hand orbit at an altitude of about 1,400 ft amsl (a height of approximately 700 ft agl) before turning onto a course of about 215°. The glider's ground speed was about 60 kt and it was descending at an average rate of 280 ft/min. Due to the sloping terrain elevation, G-CFMY maintained a relatively constant height above the ground as it descended. When the glider was 0.8 nm west of Ffestiniog its altitude was about 900 ft (a height of about 850 ft agl). At this point it was overhead the valley floor that extended towards the coastline which was approximately 8 nm to the south-west.

The glider then started a left turn towards the east, which was almost immediately followed by a right turn onto a southerly course that took the glider towards rising terrain. The final data points were recorded shortly after, which indicated that the glider had made a left turn. The final data point was recorded at 1416:01 hrs with the glider almost overhead the accident site at a height of about 200 ft agl and on a recorded track of 273°.

It was not possible to ascertain why the recorded data stopped prior to the end of the flight, but possible reasons included the glider striking the ground prior to the next data point being recorded or buffering of the data within the portable tablet computer prior to it being written to the memory card.

## Accident site

The accident site was in a field that was used for grazing cattle. The nearest buildings, which were adjacent to a road, were approximately 150 m away but none were inhabited. Assessment of the ground impact marks indicated that the glider had struck the ground in a slightly nose-down attitude and with a slight left bank of approximately 10°. It was structurally complete before the accident with the landing gear extended.

Both wings were found to be still attached to the fuselage, but the left wing was broken because of forces imparted during the accident. The glider had bounced in a counter-clockwise direction when viewed from above before coming to rest (Figure 4). The right wing was largely undamaged with the airbrake slightly deployed. The tail boom was broken, and the horizontal stabiliser and elevators had detached. Broken remnants of the canopy acrylic were found throughout the accident site. The furthest forward item was part of the canopy frame and was found approximately 16 m forward of the glider.

The glider was taken to AAIB Headquarters for detailed examination.

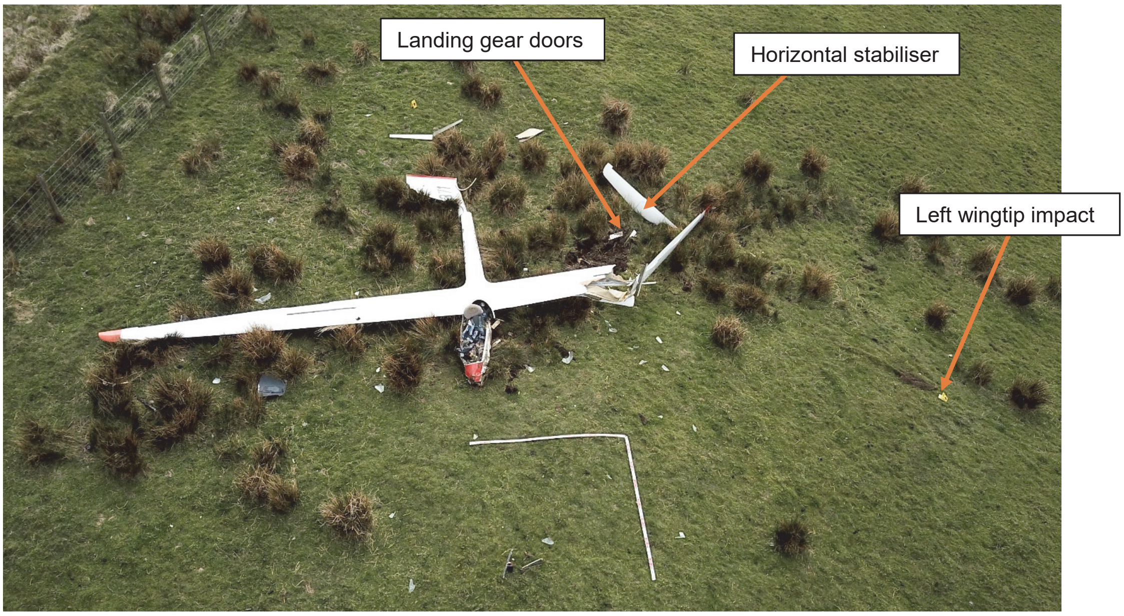



**Figure 4**

Aerial view of the accident site

**Aircraft information**

The Rolladen-Schneider LS7 is a single-seat glider with a wingspan of 15 m. It is constructed predominantly of fibreglass.

G-CFMY was manufactured in 1988 and had a valid Certificate of Airworthiness and Airworthiness Review Certificate. Maintenance records showed that an annual inspection had been carried out in March 2019, at 2,197 airframe flying hours.

**Aircraft examination**

The landing gear selector lever was found in the DOWN position and the landing gear was extended. The airbrake selector lever has a 'gate' at the forward position to prevent inadvertent airbrake extension. The lever was found out of the gate and slightly aft such that the airbrakes were partially deployed.

Examination of the flying controls concluded that all the damage was consistent with forces imparted during the accident.

**Meteorology**

Three other glider pilots who were flying in the same region at a similar time that the accident occurred were interviewed. They described the weather as northerly wind at approximately 20 kt with cloud base around 4,000 ft amsl. The cloud base was higher further south. They described challenging gliding conditions with significant turbulence particularly in the lee of the hills. The photographs in Figure 5 give an indication of the cloud cover in the area at the time of the accident. The left picture was taken by a glider pilot flying to the west of Mount Snowdon approximately one hour before the accident. The right picture was taken from the ground near Rhyd Ddu (9 nm north-west of the accident site) looking west.

**Figure 5**

Photographs showing the weather near the accident location

An aftercast provided by the Met Office confirmed the weather on the day of the accident was dominated by high pressure centred to the north-west of the UK. Surface winds were generally moderate north or north-easterly at around 15 kt. Winds at altitude were northerly at around 20 to 25 kt across Snowdonia. This would be sufficient to generate some lee wave activity but, any activity was relatively weak with maximum descent rates of around 100 ft/min. There were no large convective clouds within the area to introduce additional downdraughts. Maximum ascent rates of around 200 to 300 ft/min were very localised over Snowdon itself, and do not appear to have propagated downwind.

**Pilot information**

The pilot held a British Gliding Association Gliding Certificate and was a senior instructor at his local gliding club. He qualified as a glider pilot in 1982. His logbook recorded that he had accumulated 3,349 hrs of glider flying.

He did not hold, nor was he required to hold, an EASA flying licence.

He had completed 30 hours gliding in the last 90 days and 17 hours in the last 28 days. He had flown solo from Talgarth four times in the week preceding the accident with flights ranging from 2 hours 5 minutes to 3 hours 25 minutes duration. On each occasion he landed back at Talgarth.

*Medical*

The pilot had completed a medical declaration, signed by his General Practitioner, on 20 February 2015 which confirmed he met the Driver and Vehicle Licensing Agency (DVLA) Group 2 standard[3]. The declaration was valid until 20 February 2020.

The pilot's medical records did not show any pre-existing conditions which may have contributed to the accident. His family confirmed that he did not have any on-going or prolonged health issues.

The friend who helped the pilot launch the glider reported that he appeared to be in good health prior to the flight.

*Post-mortem*

The post-mortem (PM) found '*a significant coronary artery atheroma and what appeared to be occlusive acute thrombus within the left anterior descending artery*'. The pathologist considered this occurred before the ground impact and would have caused sudden death or rendered the pilot unconscious. The PM also found multiple fractures which were not survivable. There was a lack of blood loss at the fracture sites indicating that the pilot may have been deceased prior to the glider impacting the ground. However, it is also possible that the pilot was only unconscious at the time of the impact and the multiple injuries he sustained in the impact may have contributed to his death.

**Footnote**

[3] DVLA Group 2 standard for professional driving allows the pilot to fly with passengers.

## Analysis

The investigation did not find any defect with the glider prior to the accident. The landing gear was extended before the accident and the airbrake lever was found out of the gate and slightly aft. The left wing was badly damaged in the accident, but the right wing was in good condition. The airbrake on the right wing was found to be partially extended and, whilst it is possible that this happened during the accident, it is considered more likely that the airbrakes were deployed slightly before the accident.

The post-mortem found that the pilot had suffered a blockage to a coronary artery. This occurred before the ground impact and would have either rendered the pilot unconscious or been fatal.

The post-mortem could not determine at what point prior to the accident the heart attack occurred. However, the pilot spoke to his wife approximately 30 minutes prior to the accident and did not mention feeling unwell. He took a photograph with his mobile phone approximately 15 minutes prior to the accident. After this the glider continued south-west soaring to about 3,500 ft then flying further south-west towards a quarry near Manod Mawr. The glider attempted to soar in an area above the quarry but did not gain height. The glider was clearly still being actively piloted at this stage. The lack of climb could be an indication that the pilot was starting to feel unwell or simply that there were no thermals in this area.

Having been unable to climb and now at quite low altitude a pilot would normally start positioning to land in a suitable field. However, after initially flying south-west the glider turned to the east and then south and flew towards high ground. It seems unlikely that an experienced pilot would intentionally do this, which suggests he was impaired at this stage.

The glider made several sharp turns at low altitude prior to impacting the ground. It is unlikely that an experienced pilot would intentionally manoeuvre the aircraft in this way which suggests he was significantly impaired at this stage. The landing gear had been selected down and it is likely that the airbrakes were partially extended which implies that the pilot was trying to land.

## Conclusion

The post-mortem found that the pilot had suffered a heart attack prior to the ground impact which would have either rendered the pilot unconscious or been fatal.

It could not be determined at what point prior to the accident the pilot became impaired, but it appeared that the glider was being actively piloted until a few minutes before the accident.

*Published: 7 November 2019.*

## ACCIDENT

| | |
|---|---|
| **Aircraft Type and Registration:** | Snowbird Mk IV, G-MVOJ |
| **No & Type of Engines:** | 1 Rotax 582/48-2V piston engine |
| **Year of Manufacture:** | 1989 (Serial no: SB-019) |
| **Date & Time (UTC):** | 22 June 2019 at 0925 hrs |
| **Location:** | Bedlands Gate, Newby, Cumbria |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - None |
| **Injuries:** | Crew - 1 (Serious) Passengers - N/A |
| **Nature of Damage:** | Nose structure and engine displaced, right wing leading edge misshapen and front spar bent |
| **Commander's Licence:** | National Private Pilot's Licence |
| **Commander's Age:** | 87 years |
| **Commander's Flying Experience:** | 363 hours (of which 289 were on type)<br>Last 90 days - 0 hours<br>Last 28 days - 0 hours |
| **Information Source:** | AAIB Field Investigation |

### Synopsis

Following a period of maintenance during which the aircraft fabric covering had been replaced, the pilot was carrying out a ground run and taxi test. During taxi the pilot heard a rattle and decided to try to identify its source and so taxied the aircraft at higher speed. To his surprise, the aircraft became airborne but right wing low. Despite his attempts, he could not prevent the aircraft from flying a continuous turn to the right. The aircraft hit a tree and then struck the ground, still right wing low, before 'pole vaulting' over a dry-stone wall. The aircraft came to rest approximately where it had started the taxi. The pilot suffered serious injuries but has since recovered. The tendency for the aircraft to continuously roll right was probably caused by a slight change in the angle of attack of the outer section of the left wing due to a pair of flying wires being overly tight. The lift created by this condition was greater than the left roll control spoiler could counteract.

### History of the flight

The pilot had just completed some restoration work on the aircraft which included replacing the aircraft skin and repainting it. He intended to run the aircraft engine and then to complete some taxi testing.

Having run the aircraft engine without issue, the pilot taxied the aircraft onto the airfield. As he taxied around the airfield, he could hear what he described as a "little rattle". He decided that he would need to taxi the aircraft at a higher speed down the runway in order to try and isolate the source of the noise.

The pilot taxied onto the runway and began to accelerate for his high-speed run. He was surprised when he felt the aircraft become airborne at around 45 kt which he thought was significantly below the normal speed for lift off. As it lifted off, the pilot heard a sound which he described as a "ping" and the aircraft immediately began to roll right. The pilot was concerned that the right wingtip would hit the ground so, whilst he applied opposite stick to the roll, he decided to leave the power set, hoping that the aircraft would climb. He felt that even the application of full opposite stick did not alter the angle of bank to the right. Witnesses describe the aircraft lifting off and immediately banking to the right. The aircraft was then seen to climb, still turning to the right. It flew a continuous right turn through approximately 270° to the west of the airfield before it struck the top of a group of trees. The estimated flight path from witness statements is shown in Figure 1.

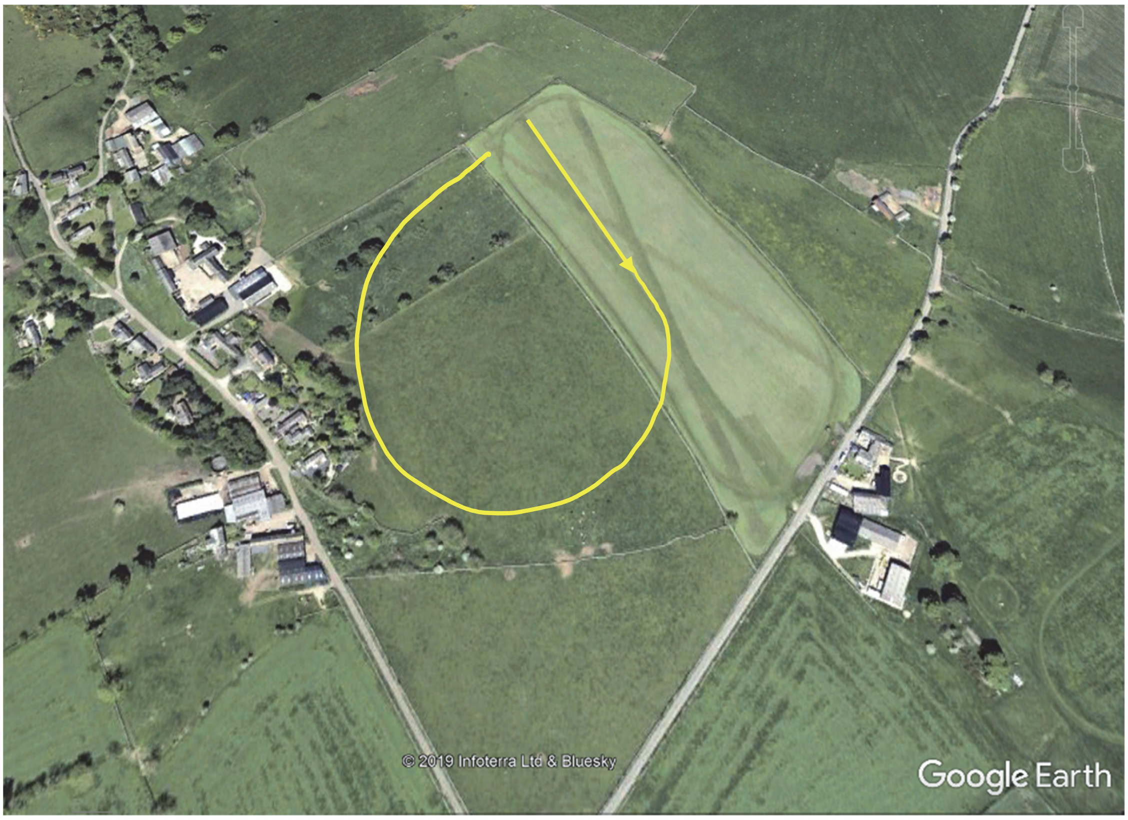



**Figure 1**
Estimated flight path of G-MVOJ

The aircraft then descended, striking the ground and a dry-stone wall next to the airfield. The aircraft came to rest, on the airfield side of the wall (Figure 2). The pilot was seriously injured.

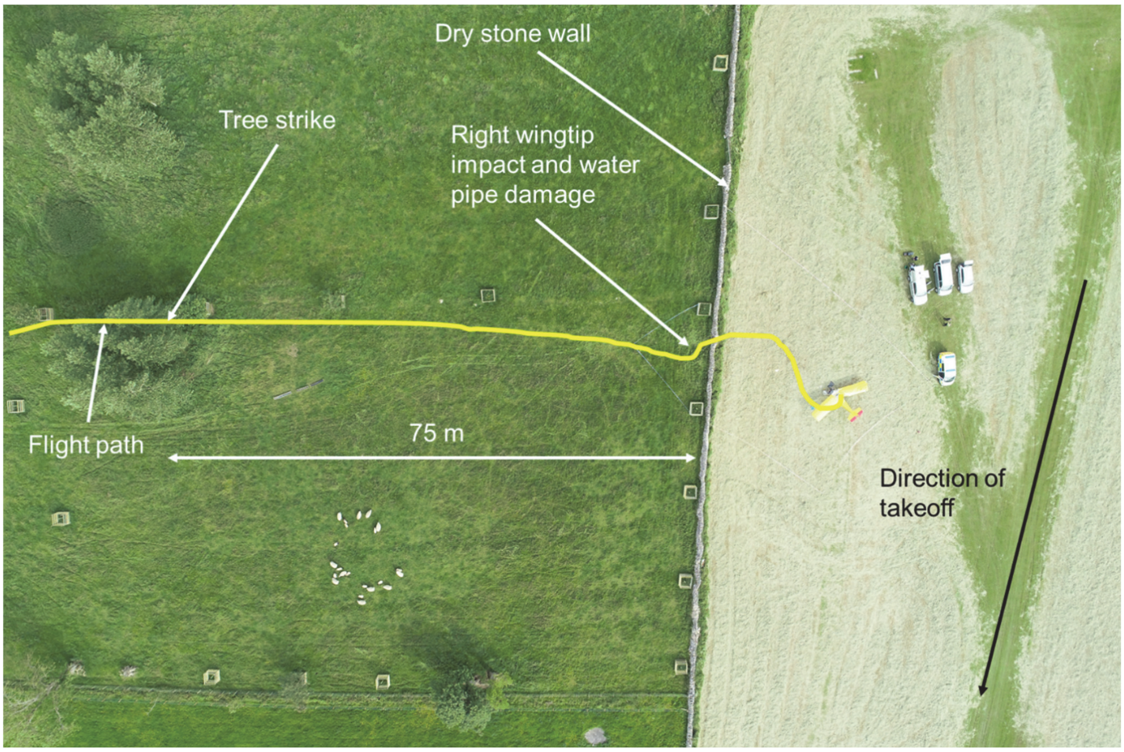



**Figure 2**

Final aircraft flight path and impact points[1]

## Weather information

Weather information was gathered from witnesses, the pilot and a limited recording capability at the airfield. The wind was from 170° at around 10 kt, there was little if any cloud and the temperature was 17°C. The QNH was 1020 hPa.

## Accident site

The aircraft had flown a large right arc and was heading back towards the airfield on a track perpendicular to the runway. Whilst airborne and outside the airfield boundary the aircraft hit the top of a poplar tree at a height of approximately 30 ft. A 6 ft long branch was found at the base of the tree, and leaves and twigs had been caught between the aircraft radiator and its fairing.

The aircraft continued to descend, and its right wingtip contacted the ground just in front of the dry-stone wall which forms the airfield boundary. By chance, as the wingtip dug into the soil, part of the tubular wingtip frame broke away and passed through a one-inch diameter polypropylene water pipe buried in the ground alongside the base of the wall. The wingtip digging in caused the aircraft to 'pole-vault' over the wall during which it became entangled

**Footnote**

[1] At the time that the aircraft took off, the prepared grass runway strip was more clearly defined. Hay making operations were underway and the grass cuttings had been spread for drying. The runway conditions had no bearing on the accident and the AAIB gave permission for hay baling to continue outside of a small cordon placed around the aircraft.

in a single strand barbed wire fence, dragging it and its posts over the wall. Marks on the leading edge of the right wing and stones that dislodged as it hit the wall, suggest that the aircraft was at a 45° angle of right bank.

Now within the airfield boundary, the aircraft hit the ground on the right side of its nose which displaced the engine and caused significant distortion to the right side of the cockpit. The aircraft bounced, rotated about its nose and came to rest upright facing the direction from which it came. Both propeller blades had broken off from their roots and there was a loss of coolant. The right wing, although still attached, had been bent rearwards during the impact sequence. There was no fuel or oil spillage. Figure 3 shows the aircraft at the accident site.

**Figure 3**
Aircraft accident site

Apart from the distortion to the front and right of the cockpit and instrument panel, the rest of the cockpit and space to the rear were remarkably intact although the lightly-constructed cabin doors had detached. The pilot had been sitting in the left seat and was wearing a four-point harness. The lap strap was undone during the rescue operation, but the narrow shoulder straps had failed.

## Aircraft description

The aircraft is a high-wing three-axis two seat microlight aircraft. It has an aluminium box section framework with a synthetic fabric covering with transparencies around the rear of the cockpit. The aircraft is powered by a Rotax 582 two-stroke piston engine driving a twin-blade fixed-pitch propeller. The wing structure consists of fabricated aluminium alloy front and rear spars with ribs attached by dry-riveted joints.

The wings are fitted to the fuselage structure using bolts through the front and rear spars. The spars are braced by tubular struts bolted to the lower edge of the fuselage under the wing. There are also two wire cables, known as flying wires, attached to the lower end of each strut. They extend outwards to where they are attached to eye plates, fixed to the rear spar, a third and two thirds the way along on the underside of the wing. Figure 4 shows the flying wires and the bracing strut under the left wing.


**Figure 4**

Flying wires and the bracing strut under the left wing
(The blue rope was attached after the accident to stabilise the aircraft)

The aircraft is fitted with conventional rudder and elevator controls and the elevator has an electrically-operated trim tab. There is a small trim tab position indicator in the cockpit alongside the pitch trim switch.

Roll is controlled by a spoiler on the upper surface of each wing. The spoilers are connected to the control stick by rods, levers and cables. When the stick is moved to the left or right to roll the aircraft, the relevant spoiler extends up from the wing surface against spring pressure provided by an elastic bungee. If a left roll is required, the left spoiler extends, lift on the left wing is reduced and the aircraft rolls to the left. When the stick is relaxed and brought back to the mid position the spoiler is closed by the bungee. The right spoiler operates in the same manner for a roll to the right. The design of the system is such that when one of the spoilers extends, the cable to the opposite spoiler slackens and that spoiler is held closed solely by tension in the elastic bungee.

The seats consist of simple crossbars supporting a fabric 'hammock' which creates the seat squab and back. The aircraft is fitted with safety straps which consist of a lap strap and two narrow shoulder straps. The shoulder straps are formed by a loop of material passing through rectangular slot plates mounted on a cross frame at the rear of the cockpit above and behind the pilot and passenger's seat. The shoulder straps equal length either side of the slotted plate is maintained by stitches across both parts of the strap. The shoulder strap lower ends are attached to the left and right parts of the lap strap and are tightened by a sliding buckle assembly on each side.

**Aircraft maintenance history**

The owner did all the maintenance on the aircraft with appropriate oversight by a British Microlight Aircraft Association (BMAA) inspector. The owner had recently replaced the fabric covering on the aircraft. During this work the pilot described that he had put a "loop" or a "knot" with a whipping[2] in one of the spoiler bungees but cannot recall how or whether it was the left or right. He was content with the work he had carried out and therefore was not expecting any problems or issues and explained that he had ground ran and taxied the aircraft to ensure "everything was right". He had pre-arranged for the BMAA inspector to visit later that day to carry out the final sign off inspection.

**Engineering investigation**

The aircraft was dismantled at the accident site and recovered to the AAIB facility in Farnborough for further examination. The aircraft structure and components, from the seats rearwards, were mostly intact except for minor scuffs, tears and abrasions. Notwithstanding the impact damage at the front of the aircraft and the right wing, the fabric covering was tight and in excellent overall condition.

The elevator control system had continuity from the stick to the elevator and had a full and free range of movement. The elevator was fitted with a trim tab on the trailing edge of the right side of the elevator. Although its hinge was slightly loose, it was attached correctly to its electric actuator and was set at an angle 13° downwards. The rudder bar was jammed due to distortion of the cockpit floor, but the cables were intact and, when disconnected from the rudder bar, also gave a full and free range of movement.

On first examination, the stick could not be moved laterally and appeared to be jammed. Closer inspection found that, during the impact sequence, a bell crank inside the fuselage adjacent to the right wing root, had rotated over-centre and become geometrically locked. Once released, the spoilers operated in the correct sense and had a full and free range of movement up to their restrainer cable stop limit. The bungee spring system on each spoiler was examined and both left and right bungees were attached to their respective hooks and eyes. In both cases, a single piece of bungee cord was used but the left bungee was knotted at its ends (thus forming a continuous loop) whereas, for the right bungee, each end had been folded back and whipped to make a small loop around a hook and its ends were covered. Both bungee cords appeared to be of the same material. Figures 5 and 6 show the left and right bungees under the spoilers.

**Footnote**

2 Twine wrapped tightly around rope ends to splice them together or to prevent rope ends from fraying.

**Figure 5**
Left spoiler looped bungee cord

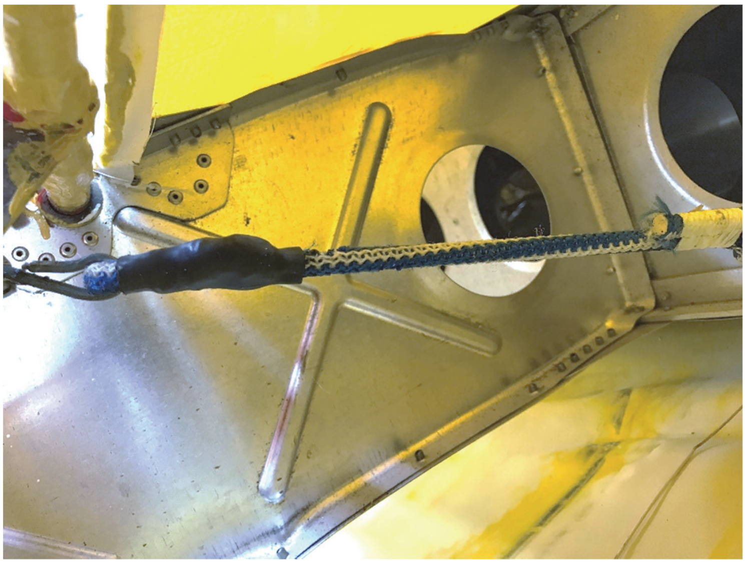


**Figure 6**
Right spoiler whipped bungee cord

As the methods of installation were different, pull-off checks were carried out on each spoiler by extending them to 250 mm between the spoiler trailing edge and the wing surface. The right spoiler required a 1,325 g force to extend and the left spoiler only required a 675 g force. Similar differences were also found when an operating force was applied to the cables linked to the spoilers within the wings.

At the accident site, both wing struts had been disconnected from the fuselage by removing the attachment bolt, along with the smaller strut braces, and allowed to settle down against the wing for transport. It was noted that the left lower bracing strut joint bolt was more difficult to remove than expected, considering the lightness in construction of the aircraft.

Subsequent examination of the left strut also found that it had a slight permanent curvature along its length whilst the right strut was straight.

The flying wires were not disconnected from the struts or their spar attachments at the accident site. On later examination, it was noted that the right wing flying wires, in their relaxed state, were slack and in good condition. However, the two left wing flying wires were very different in their relaxed condition. They both had multiple tight loop twists and kinks indicating that they had been 'wound up' at some point during assembly. In the absence of tension, the wind-up had released and, because they are restrained at each end, twist loops were formed. The eye plates on which the cables were fitted had not been undone and were still attached correctly. It was also noted that the left pair of cables were made from galvanised steel and the right pair of cables were made from stainless steel. Figures 7 and 8 shows the wind-up twisting and kinks on the left flying wires, compared the right flying wires shown in Figure 9.

**Figure 7**

Left wing flying wire distortion

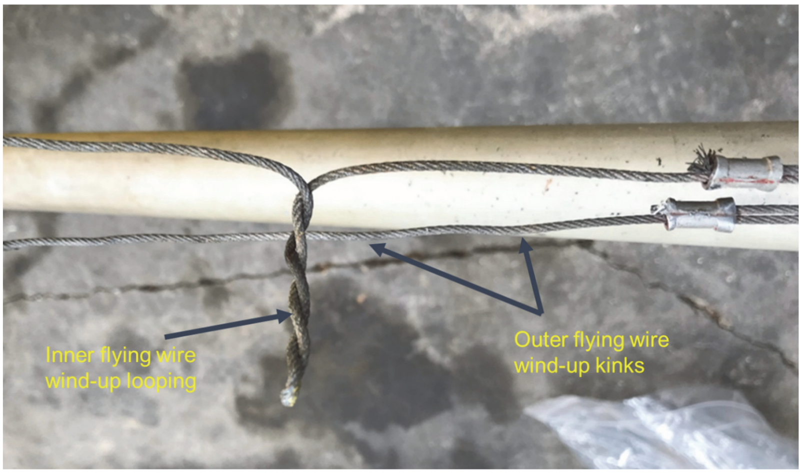



**Figure 8**

Close up of the distortion to the left inner and outer flying wires.
In addition to the kinks, the outer wire also showed identical wind-up looping further along the cable (out of shot)

**Figure 9**
Right wing flying wires

Damage to both propeller blades indicated the engine was producing power when the aircraft hit the ground. Subsequent examination of the engine's fuel, ignition and lubrication systems revealed no anomalies. Although the throttle cable was damaged and had been distorted in the accident, it was correctly attached to the carburettors and had a full and free range of movement.

Some of the instruments had been displaced from the instrument panel but were otherwise intact and, when tested, worked correctly; the barometric altimeter was set to 990 hPa (QFE). Apart from a personal camera, which contained nothing relevant to the accident, there were no recording devices on the aircraft.

The seats were undamaged, but the left safety harness shoulder strap had parted. The straps were made from a synthetic canvas-like material and were approximately 25 mm wide. The tapered nature of the strap parting suggests a tensile overload failure. The stitching near the slotted plate had parted. Tapering at the point of failure suggests a severe pull to the right whilst in the slotted plate and the strap failing as it was pulled tight against the edge and corner of its slot. The right pull is consistent with the forces exerted on the pilot during the accident sequence. The lap strap and buckle were undamaged.

### Discussions with the pilot

Despite the severity of his injuries, the pilot made a good recovery and was able to describe the events leading up to the accident and up until the point that the aircraft hit "the big tree next to the airfield". He was somewhat surprised when he was informed of his actual trajectory and of which tree he had eventually hit. He described how his aircraft "just hopped off the ground at 40 to 45 kt, much slower than the normal 50 kt" and then of his fear that the right wingtip would touch the ground and cartwheel the aircraft. He also described that he had to pull the stick all the way over to the left and, even with full stick and rudder, could not stop the aircraft turning to the right.

The aircraft was fitted with an electric pitch trim tab and the pilot stated that the trim setting was not adjusted prior to the taxi. He also advised that he very rarely altered the trim because where it was set was suitable for all conditions of flight.

Regarding the work he had done to the aircraft, as well as describing the new fabric coverings and the need to tighten the spoiler bungee, he also mentioned that he had put twists into the flying wires to "keep everything nice and taut".

## Additional information

There are very few of this aircraft type still in flying condition and few light aircraft types use upper wing surface spoilers for roll control. There is a rudimentary maintenance manual for the Snowbird Mk IV which includes a list of inspections to be carried out on the control systems. There are some details of the inspection requirements for the spoilers, but there is no mention of the bungee or spring tension required nor of any inspection of the bungees for condition or correct assembly.

The pilot described the aircraft as usually very stable in flight. The pilot's operating handbook (POH) gives the Snowbird Mk IV stall speed at Maximum All Up Weight as 38 mph (33.7 kt) and a lift off speed of 42 mph (37.3 kt). These figures correlate well with the records of G-MVOJ's flight test that was conducted in September 2018.

Anecdotal evidence suggests that the Snowbird is sensitive to alterations in its lateral centre of gravity, ie when flown by a single pilot. If there is only one occupant sitting in the left seat, the lateral imbalance must be countered using a small amount of constantly applied left spoiler. This has two disadvantages; the roll range is reduced, and asymmetric drag is increased, leading to aircraft yaw which must be corrected with the rudder. To alleviate this, owners have often tightened the flying wires which changes the wing form and slightly increases the lift produced by the left wing.

Anecdotal evidence also suggests that this is done by twisting the flying wires in the same direction as the lay (twist) of the strands, this increases the pitch of the helix created by the lay of strands, thus shortening the wires to increase their tension. This method is used in the absence of turnbuckle assemblies. However, this is not an ideal practice and may compromise any factor of safety inherent in a multi-strand wire by introducing bends or kinks as seen in Figures 7 and 8.

Again, the aircraft maintenance manual makes no mention of the tension required to be pre-set in the flying wires.

## Analysis

The pilot described a "ping" coincident with the aircraft becoming airborne. The examination of the aircraft found nothing that was broken or had been damaged prior to the accident. All the damage to the aircraft could be attributed to the various stages of the accident sequence and there was no evidence of a problem with the power output and controllability of the engine.

At the accident site it could be seen that the left side of the fuselage bracing strut and wing spar mounts were undamaged. However, it was noted that the flying wires seemed particularly tight and this manifested itself in the difficulty experienced extracting the bracing strut lower bolt. After the left wing was removed, the phenomenon of the flying wires twisting up in their relaxed state shows that they were under additional tension as the pilot had described.

*Unintentional takeoff*

The pilot was surprised at what he thought was the lower than normal speed at which the aircraft became airborne, stating that it was at 40 to 45 kt, as indicated on the airspeed indicator. However, when the figures given by the POH are taken into consideration, taking off at that speed with one person onboard was reasonably normal.

From the description by the pilot and witnesses, the constant right turn flight path shows that more lift was being created by the left wing than the right. So much so, that despite the pilot applying full left roll input on the stick, the aircraft continued to fly to the right.

In the absence of an aileron, for the left wing to create more lift, the airspeed over the wings, the wing shape and angle of attack were considered.

The conditions on the day were benign; a clear day with a wind of 170° at 10 kt resulting in an insignificant crosswind. From this it can be concluded that there was very little, if any, difference in airspeed over the left and right wings.

The pilot had flown many hours in this aircraft without incident and, other than the replacement of the covering which necessitated the temporary removal of the flying wires, no recent maintenance had been carried out on the wing structure. A dimensional check at the wing roots showed no measurable difference.

*Influence of the flying wires*

It is likely that the increased tension in the left flying wires due to the twists introduced by the pilot had an effect. In particular, the inner flying wire (acting on the rear spar) was very tight as was the outer flying wire which acted on the spar towards its outboard end. This is likely to have caused the structure to flex downwards very slightly, creating a wing wash-in effect. This would result in a slightly increased angle of attack, and hence increased lift, at the mid to outer section of the wing; a location at which the extra lift would have the most significant effect due to the greater moment arm.

Consideration was given to whether the spoiler bungee tension was a factor in the difficulty the pilot had in controlling the aircraft once airborne. The spoiler bungee tension required is not specified. With no tension, there could be a tendency for the spoiler to lift at higher airspeeds as the negative pressure above the wing increases. How far it might lift or at what airspeed is not known. On G-MVOJ, both spoiler bungees were in tension, albeit the right one was about twice that of the left. The pilot applied full left stick as he was trying to roll the aircraft left and so lift the left, lower tensioned spoiler. The higher tensioned right spoiler is likely to have remained flush with the wing surface. Therefore, it is considered that the difference in tension between the two spoiler bungees was not a factor in this accident.

The rattle and later "ping" sound heard or felt by the pilot was not identified. The aircraft examination found nothing obvious that could have created the sound. As the aircraft became airborne and tension in the flying wires increased, differences in internal structural tension created by the new and taut fabric covering may have caused one of the many dry-riveted joints to have flexed or creaked. The sound could have been amplified sufficiently by the 'drum tightness' of the fabric covering to be heard by the pilot.

## Conclusion

During a high-speed taxi run, the aircraft became airborne unintentionally and, thereafter, became established in a continuous right turn which could not be controlled by the pilot. This was due to an increase in the lift produced by the left wing which was greater than could be countered by the roll spoiler. The increased lift was likely to have been the result of a slight change in the shape of the mid to outer section of the left wing caused by overly tight flying wires.

*Published: 31 October 2019.*

## AAIB Correspondence Reports

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

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

The accuracy of the information provided cannot be assured.

**SERIOUS INCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Airbus A300b4-622R(F), D-AEAD |
| **No & Type of Engines:** | 2 Pratt and Witney PW4158 turbofan engines |
| **Year of Manufacture:** | 1991 |
| **Date & Time (UTC):** | 26 February 2019 at 2302 hrs |
| **Location:** | London Heathrow Airport |
| **Type of Flight:** | Commercial Air Transport (Cargo) |
| **Persons on Board:** | Crew - 3 Passengers - None |
| **Injuries:** | Crew - None Passengers - N/A |
| **Nature of Damage:** | None reported |
| **Commander's Licence:** | Airline Transport Pilots Licence |
| **Commander's Age:** | Not relevant |
| **Commander's Flying Experience:** | Not relevant |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot |

## Synopsis

The aircraft's takeoff clearance was cancelled because a maintenance vehicle that had been manoeuvring on an adjacent taxiway entered the runway. The vehicle driver had become disorientated.

## History of the flight

Temporary work was due to take place overnight on several taxiways in close proximity to Runway 09R, which included an entry point onto the runway. The work was planned to start after the night flight curfew came into force at 2330 hrs and, before it could commence, the work area was to be protected by a series of cones and glim[1] lights placed across the taxiways involved.

The coning-off work was due to be done by two contractors operating from their company vehicle. Both contractors held A Class airside driving permits, which allowed them to drive on airside roadways and aprons, but not on taxiways or runways. As was normal practice, the contractors were permitted to drive on taxiways for the purpose of doing the work if accompanied by a suitably qualified member of the airport's operations staff. Both of the contractors had laid cones on previous occasions, including for this area of work the night before the incident, and had been supervised by a number of different operations staff in doing so.

**Footnote**

[1] A type of mobile and temporary battery-operated lighting used on aerodrome manoeuvring areas.

The procedure for coning-off sections of taxiway was laid out in the airport's Airside Local Operating Procedures (ALOP). This included the requirement for a member of the airport's operations staff to position Bolton barriers[2] across any access points onto the runway, to act as a final safety barrier in stopping people or vehicles straying onto the runway. The instructions did not state at which point in the procedure the Bolton barriers needed to be in place.

About an hour before the work was due to commence, the contractors had attended a general brief about the work to be done that night. This did not include any detail of the proposed coning-off work to be done but the two contractors were told to follow the airport operations department vehicle when it arrived shortly before 2330 hrs. The operations vehicle was driven by a Senior Airfield Officer (SAO) who had been given the task of supervising the coning-off work and placing Bolton barriers across the runway access point within the work area. The SAO's vehicle was equipped with an illuminated 'Follow Me' sign which he had intended to switch on but had overlooked.

The SAO drove out to the works area, followed by the contractors. He was concerned that an aircraft due to depart shortly before the night curfew may need to use some of the taxiways being coned-off and decided to delay starting the work. On arriving at the work area he therefore parked his vehicle to wait for the aircraft to depart. The contractors were unaware of this decision and on reaching the area had placed a row of cones and lights across the first taxiway to be coned off. This was close to where the SAO had parked and, when they had finished, the contractors expected to see the SAO drive on to the next point to be coned-off. When the SAO's vehicle didn't move, the contactors assumed they were expected to continue on their own, as they had done with other supervisors in the past, and drove on. The SAO saw the contactors drive off and chased after them in his vehicle, sounding his horn to get their attention, but without success.

The contactors expected to see the Bolton barriers delineating the entrance to the runway but, when they couldn't, became disorientated and drove onto the active runway. At this time an aircraft was lining up at the threshold of the runway, some distance away, and had been given clearance to take off. The SAO immediately contacted ATC to advise them of the runway incursion and ATC cancelled the takeoff clearance before the aircraft had started its takeoff roll. The contractors, realising they were on the runway, turned around and vacated the runway as quickly as possible.

## Additional information

Training for the A Class airside driving permit does not include information on manoeuvring area or runway markings and lighting, although it does include training on the markings delineating roadways and aprons from manoeuvring areas.

**Footnote**

[2] A barrier made up of a number of red and white reflective panels, normally towed into position by a vehicle, used to block taxiways and runway access points. Several barriers may be joined together to obtain the desired length.

Briefing material provided by the contracting company undertaking the work included information on setting up cones and the care required when working in proximity to a runway. The contractor driving the vehicle at the time of the occurrence had signed to show he had read and understood the briefing material some months before the incident. However, the standard of his English may have affected his ability to both read and understand the documents.

**Investigation by the airport operator**

The incident was investigated by the airport's safety department, as a result of which a number of actions were taken.

It was considered that, as most drivers undergoing training for the A Class driving permit would never need to drive in the vicinity of a runway, the existing training was adequate. However, the airport has now produced a runway safety guide for those drivers required to drive, escorted, on manoeuvring areas. The guide is intended to enable drivers with an A class permit to recognise runway entry points and their associated safety features, such as illuminated red stop bars, runway guard amber lights, signs and ground markings.

A Temporary Advice Notice (TAN) has been issued, amending the ALOP taxiway closure procedures by requiring, where necessary, Bolton barriers to be in place before the commencement of any work by contractors. Also, an associated Safety Alert was issued to companies working at the airport advising them of the amendment.

**Analysis**

Both parties were apparently sufficiently comfortable with the task of closing off the taxiways that neither sought to discuss how they would go about it with the other before commencing. This resulted in a difference in expectations between the SAO and the contractors and demonstrates the importance of ensuring that both those being supervised, and their supervisors, have a clear understanding of each other's intentions.

The airport has now provided additional information to enable drivers to better understand hazards when driving away from roadways and aprons. It is important that this information is not only available to, but also understood by, those for whom it is intended.

This incident highlights the safety benefits of placing Bolton barriers across runway access points to avoid vehicles entering it accidentally. Although the instruction in force at the time did not require the barriers to be put in place before starting any work, the SAO had intended to do this early in the process. The revised ALOP now require this and may reduce the opportunity for another runway incursion in similar circumstances.

## Safety actions

- A runway safety guide has been produced by Heathrow Airport Limited for issue to contractors holding A Class driving permits but driving airside on manoeuvring areas and runways.
- A Temporary Advice Notice (Airside_ASD_TAN_0119) has been published updating procedures for setting up work sites adjacent to runways, including the requirement to place Bolton barriers across runway access points prior to any work commencing.
- A Safety Alert (ASWorks_SA_017) has been issued to contactors at the airport advising of the updated procedures.

**SERIOUS INCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Boeing 737-89P, SP-LWA |
| **No & Type of Engines:** | 2 CFM 56-7B26 turbofan engines |
| **Year of Manufacture:** | 2005 (Serial no: 30682) |
| **Date & Time (UTC):** | 20 May 2019 at 0630 hrs |
| **Location:** | On takeoff from London Heathrow Airport |
| **Type of Flight:** | Commercial Air Transport (Passenger) |
| **Persons on Board:** | Crew - 6 Passengers - 128 |
| **Injuries:** | Crew - None Passengers - None |
| **Nature of Damage:** | None |
| **Commander's Licence:** | Airline Transport Pilot's Licence |
| **Commander's Age:** | 58 years |
| **Commander's Flying Experience:** | 17,500 hours (of which 12,500 were on type)<br>Last 90 days - 80 hours<br>Last 28 days - 50 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the commander, information supplied by the Operator and further enquiries by the AAIB |

## Synopsis

After an uneventful takeoff from London Heathrow the flight crew were informed that the aircraft was 953 kg heavier than indicated on the load sheet. The flight crew corrected the figures in the aircraft's flight management computer and the flight continued without incident.

The load sheet error occurred because a consignment of mail was initially recorded twice in the operator's computer load management system. A correction was applied by both the dispatcher and by an electronic message from the cargo company, which resulted in both entries being removed.

The handling agent and operator have taken safety action to prevent reoccurrence.

## History of the flight

SP-LWA was operating a flight from London Heathrow to Warsaw Chopin Airport in Poland. The load sheet for the flight was produced by a dispatcher from the handling agent used by the operator at Heathrow, using the operator's load management computer system.

The commander recalled that during boarding the dispatcher presented him with a provisional load sheet. However, when the commander entered the figures in the flight management computer (FMC), he noticed that the stabiliser trim was close to limits so asked the dispatcher to check the load sheet. The commander thought that the dispatcher had moved some bags from hold 3 to holds 1 and 2. The dispatcher did not recall being told that the provisional load sheet was close to a limit and did not recall moving any bags. The dispatcher remembered processing several pieces of excess cabin baggage which needed to be loaded in the hold and updating the load sheet accordingly. However, when the dispatcher produced the final load sheet, the commander agreed it was now acceptable and signed it. The load sheet was then used to load the FMC and calculate the takeoff performance. The aircraft pushed back from its stand at 0552 hrs.

The commander reported that the takeoff was normal.

At 0630 hrs, during the cruise at FL350, a new load sheet was received, via ACARS, showing an increase in zero fuel weight of 953 kg and a change to the trim of 3% (centre of gravity forward). The flight crew updated the FMC and the remainder of the flight proceeded without further incident.

**Weight and balance**

Investigation after the flight revealed that the 953 kg of mail, which was loaded into hold 2, had been omitted from the final load sheet.

**Report from the handling agent**

The dispatcher reported that when he initially looked at the loading of the flight on the operator's load management system he saw that a consignment of mail (weighing 953 kg) had been recorded twice. The handling agent reported that this duplicate recording was not uncommon. The dispatcher deleted one of the two entries for the mail and produced the Loading Instruction Report (LIR) which was used to load the aircraft. The LIR was printed at approximately 0500 hrs. Later the dispatcher returned to the computer system to print the load sheet. When he tried to print the load sheet the system displayed a message 'EXTERNAL INPUT ACCEPT/REJECT'. The dispatcher was not familiar with the message and thought it was a system error. He accepted the message and was able to print the load sheet. The load sheet was printed at 0542 hrs. At this stage he did not notice that the consignment of mail had now been removed from the system (but had been loaded onto the aircraft).

After the flight had departed he returned to the system to complete his administrative tasks for the flight. He then realised the consignment of mail had been omitted from the load sheet and sent a corrected load sheet to the aircraft.

**Report from the operator**

After the incident the operator reviewed the load management system logs to understand how the 953 kg had been deleted. The log showed that at 0534 hrs the cargo company sent an electronic message which deleted 981 kg of cargo and added 28 kg of mail to the flight, producing a net reduction of 953 kg.

The cause of the original duplicate entry was not determined.

## Analysis

A consignment of mail was initially recorded twice in the load management system. It was not determined why this had occurred. The handling agent reported that this was not uncommon but that this was normally resolved by the dispatcher. On this incident flight, the dispatcher noticed the duplication and deleted one entry and produced a correct LIR. Shortly afterwards the cargo company sent an electronic message to update the system. This resulted in the 953 kg of mail being removed from the system entirely.

When the dispatcher produced the load sheet the system generated a message to tell him that there had been an external change. However, the dispatcher was not familiar with the message and did not appreciate the implications. The dispatcher did not notice that the consignment of mail was missing from the load sheet.

After the flight had departed the dispatcher realised the mail had been omitted and sent a corrected load sheet to the aircraft.

The handling agent has taken safety action to remind its dispatchers of the importance of checking the load sheet reflects the actual loading of the aircraft. It also recognised that its dispatchers work with many operators who each use slightly different IT systems and that it can be challenging for dispatchers to remember the subtleties of each system. The handling agent has therefore taken safety action to change dispatcher work patterns so that they will cover all IT products they service during one set of shifts. The change aims to ensure dispatchers can remain familiar with all the IT systems they need to use.

The operator has asked the handling company to report any future occurrence of duplicate cargo entries so that they can investigate the cause and rectify the problem.

## Conclusion

The load sheet presented to the commander gave an aircraft weight 953 kg lighter than actual, due to the omission of a consignment of mail loaded in compartment 2.

The mail was initially recorded in the system twice but subsequently both entries were removed.

## Safety action

The handling agent has taken safety action to remind all dispatchers of the importance of checking that the load sheet reflects the actual loading of the aircraft. They have also changed work patterns to ensure dispatchers will remain familiar with the IT systems used by all the operators they service.

The operator has taken safety action by asking for all future occurrence for duplicate cargo figure to be report to them so that they can determine the cause.

**SERIOUS INCIDENT**

| | |
|---|---|
| **Aircraft Type and Registration:** | Boeing 777-236, G-YMMU |
| **No & Type of Engines:** | 2 Rolls-Royce RB211 Trent 895-17 turbofan engines |
| **Year of Manufacture:** | 2008 (Serial no: 36519) |
| **Date & Time (UTC):** | 3 July 2019 at 1530 hrs |
| **Location:** | On departure from London Heathrow Airport |
| **Type of Flight:** | Commercial Air Transport (Passenger) |
| **Persons on Board:** | Crew - 13 Passengers - 259 |
| **Injuries:** | Crew - None Passengers - None |
| **Nature of Damage:** | None |
| **Commander's Licence:** | Airline Transport Pilot's Licence |
| **Commander's Age:** | 56 years |
| **Commander's Flying Experience:** | 24,433 hours (of which 13,397 were on type)<br>Last 90 days - 206 hours<br>Last 28 days - 49 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the commander and information supplied by the operator |

## Synopsis

Shortly after takeoff from London Heathrow the pilots smelt fumes on the flight deck. They donned oxygen masks, carried out the appropriate checklist and returned to Heathrow where the aircraft landed without further incident.

Extensive engineering investigation was carried out and several components were changed, but the source of the fumes was not found.

## History of the flight

On 3 July 2019 G-YMMU was scheduled to operate from London Heathrow to Bengaluru Kempegowda International Airport in India. The aircraft's Auxiliary Power Unit (APU) bleed air valve and right air conditioning pack were isolated, in accordance with the Dispatch Deviations Guide (DDG), following two previous fumes events. The flight was operated by three pilots due to the length of the flight.

After the engines were started but before the aircraft began to taxi, the third pilot smelt fumes. Neither the commander nor the co-pilot could smell anything unusual. After discussing the smell the crew decided to continue with the flight.

Shortly after takeoff, all three pilots smelt fumes on the flight deck. They described the smell as an "organic cheesy, oily smell" which left a metallic taste. The intensity of the smell increased as the aircraft passed through 2,000 ft. The co-pilot donned his oxygen mask and the commander passed control of the aircraft to him. The commander and third pilot then assessed the situation. They asked the Senior Cabin Crew Member (SCCM) to come to the flight deck to confirm the smell and confirm if there were any fumes in the cabin. The SCCM confirmed the smell of fumes on the flight deck and that he had not smelt anything in the cabin. After the SCCM left the flight deck the commander and third pilot donned their oxygen masks and started the 'SMOKE, FIRE or FUMES' QRH checklist.

After completing the first few items of the checklist the crew discussed if they needed to land urgently. At this stage the aircraft was approximately 51 tonnes above the maximum landing weight. As the fumes were isolated to the flight deck and all three pilots were on oxygen the crew decided the safest course of action was to jettison fuel to maximum landing weight rather than land overweight.

The pilots made a PAN (urgency) call to ATC and started jettisoning fuel. The remaining items of the smoke, fire or fumes checklist required the left air conditioning pack to be switched off (to determine if this was the source of fumes). However, as the aircraft had dispatched with the right air conditioning pack isolated, this would have depressurised the aircraft. The crew also realised that they would not be able to determine if selecting the pack off stopped the fumes without removing their oxygen masks. They initially requested descent to FL100 to enable them to depressurise the aircraft but subsequently decided the safest course of action was to leave the left pack on.

Once fuel jettison was completed and the cabin crew and passengers had been briefed, the aircraft returned to Heathrow for a normal approach and autoland.

The cabin crew subsequently reported that during the approach to land, fumes could be smelt around Door 2L[1] and on the left side of the cabin from row 1 to 5.

**Previous fumes events**

Fumes were previously reported on G-YMMU on 29 June 2019 on final approach to land at Heathrow following a flight from Buenos Aires, Argentina. The flight crew reported that they smelt an oily smell but that it was not bad enough to don oxygen masks. They reported the smell to the operator's engineering department, which was unable to replicate the smell on the ground. They suspected the source was the APU bleed, so this was isolated in accordance with the DDG and the aircraft was returned to service pending further investigation.

On 1 July 2019, G-YMMU was returning to Heathrow from Cairo, Egypt. Whilst levelling at FL80 in the Heathrow hold the flight crew smelt "diesel fumes". Both pilots described experiencing a "dry, tickly throat". They donned their oxygen masks and declared a PAN to air traffic control. The aircraft landed at Heathrow uneventfully.

**Footnote**

[1] Door 2L is the second door from the front on the left hand side of the aircraft.

Following this event, the operator's engineering department carried out further work to determine the source of the fumes. Damage was found in the right pack air cycle machine, so this was replaced. Several other components were changed in the air conditioning system. An odour from the APU and right pack was detected during subsequent ground engine runs. The aircraft was returned to service with the APU bleed valve and right pack isolated pending further investigation.

**Subsequent events**

Two further fume events occurred on 8 August and 17 August 2019, neither event required the use of oxygen. On 8 August the flight crew detected oily fumes during takeoff from London Heathrow. The fumes dissipated shortly after takeoff and the flight continued to destination. On 17 August 2019 the co-pilot detected a "wet dog" or "sock" smell on the flight deck at FL90 approaching London Heathrow. The commander initially thought the smell was associated with ozone from nearby thunderstorms. The smell lasted for approximately one minute. The smell reoccurred on the ground as the aircraft taxied to stand.

**Further engineering investigation**

Following the event on 3 July 2019 the operator investigated further, including ground engine runs and a flight test. During the flight test fumes were detected associated with the left pack. Following further inspections, the aircraft was returned to service with the left bleed valve isolated and the APU bleed valve and right pack reinstated.

Further engineering inspections were conducted on 7 and 15 July 2019. Several additional components were replaced and further ground runs were conducted during which no fumes or odours detected. The aircraft was returned to service with the left bleed valve reinstated on 15 July 2019.

After the events on the 8 and 17 August further engineering inspections were conducted but no faults were found.

**Conclusion**

Fumes were reported in the flight deck on five flights over a two month period. Two of the events required the flight crew to use oxygen.

Despite extensive engineering investigation by the operator prior to returning the aircraft to service, at the time of publication, the source of the fumes has not been found.

## INCIDENT

| | |
|---|---|
| **Aircraft Type and Registration:** | 1) Bolkow 207, D-EFQE<br>2) North American T-6 Harvard 4, G-BJST |
| **No & Type of Engines:** | 1) 1 Lycoming O-360 A1A piston engine<br>2) 1 Pratt & Whitney R-1340-AN-1 piston engine |
| **Year of Manufacture:** | 1) 1965 (Serial no: n/k)<br>2) 1953 (Serial no: MM53795) |
| **Date & Time (UTC):** | 25 July 2019 at 1030 hrs |
| **Location:** | RAF Odiham, Hampshire |
| **Type of Flight:** | 1) Private<br>2) Private |
| **Persons on Board:** | 1) Crew - 1 Passengers - 1<br>2) Crew - 1 Passengers - None |
| **Injuries:** | 1) Crew - None Passengers - None<br>2) Crew - None Passengers - N/A |
| **Nature of Damage:** | 1) Minor damage to rudder, elevators and doors<br>2) None reported |
| **Commander's Licence:** | 1) Light Aircraft Pilot's Licence<br>2) Airline Transport Pilot's Licence |
| **Commander's Age:** | 1) 72 years<br>2) 63 years |
| **Commander's Flying Experience:** | 1) 1,722 hours (of which 350 were on type)<br>Last 90 days - 5 hours<br>Last 28 days - 5 hours<br><br>2) 27,000 hours (of which 320 were on type)<br>Last 90 days - 180 hours<br>Last 28 days - 60 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot |

### Synopsis

Following an apparent propwash incident on the ground, the pilot of a Bolkow 207 reported aircraft handling problems during the subsequent flight. The aircraft landed safely, but the tension of the control cables for the rudder and elevators was found to be out of limits.

### History of the flight

A Bolkow 207 was parked on the dispersal apron at RAF Odiham during a visit for the Station's Families Day. The pilot reported he had fitted rudder and elevator gust locks but had left the doors open on the aircraft to assist in ventilating the cockpit in the warm weather. During the day he noted a strengthening breeze blowing from the opposite direction to the way the aircraft was parked, so he returned to the apron with the intention of turning the aircraft into wind. As he approached, he saw a Harvard taxi in and park tail to tail with his aircraft, then increase its engine rpm for a short period before shutting down. The pilot of the Bolkow reported that the propwash created by the Harvard overcame the gust locks on his aircraft, however at the time he assessed any damage as superficial and took no further action.

Later in the day the pilot of the Bolkow took off for the return flight to his home airfield. He reported issues with the control response of the elevators during the flight and requested a straight-in approach to land. The remainder of the flight was uneventful, and the aircraft landed safely.

Further inspection of the aircraft identified a loss of tension in both the rudder and elevator control cables, but no obvious associated damage. The aircraft had undergone an annual maintenance check the week prior to the incident, where the cable tensions were recorded as within limits.

## Conclusion

Based on the information available, it was not possible to determine whether the loss of tension in the Bolkow 207's control cables and the subsequent handling problems were a direct consequence of encountering propwash from the Harvard during the ground incident. There are however, some general safety issues which are highlighted by this occurrence.

The first is that pilots should always have an awareness of their surroundings, particularly when using increased engine rpm, to minimise the risks associated with propwash. The second issue is that pre-flight full and free checks of the control surfaces are an essential part of confirming the airworthiness of an aircraft prior to flight and it is important to check the control surfaces are responding correctly to control inputs. Finally, when an incident occurs where there is the possibility of damage to an aircraft, this should be assessed by a suitably qualified maintenance person prior to further flight, as the damage and its severity may not be immediately obvious.

## ACCIDENT

| | | |
|---|---|---|
| **Aircraft Type and Registration:** | Jodel D112, G-BRCA | |
| **No & Type of Engines:** | 1 Continental Motors Corp A65-8F piston engine | |
| **Year of Manufacture:** | 1963 (Serial no: 1203) | |
| **Date & Time (UTC):** | 4 August 2019 at 0830 hrs | |
| **Location:** | Marshill Farm, near Aylesbury, Buckinghamshire | |
| **Type of Flight:** | Private | |
| **Persons on Board:** | Crew - 1 | Passengers - 1 |
| **Injuries:** | Crew - None | Passengers - None |
| **Nature of Damage:** | Substantial | |
| **Commander's Licence:** | Private Pilot's Licence | |
| **Commander's Age:** | 69 years | |
| **Commander's Flying Experience:** | 1,499 hours (of which 1,282 were on type)<br>Last 90 days - 7 hours<br>Last 28 days - 1 hour | |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot | |

Shortly after the aircraft departed Marsh Hill Farm Airstrip, the pilot realised he had left his car unlocked with the keys in view. He decided to return to lock his car. He levelled off at 600 ft and positioned for landing. Carburettor heat was selected ON but was returned to OFF shortly after, when the aircraft was on it's final approach. As the threshold hedge was crossed, 'sink' was apparent, and the pilot added power to counter it. The engine did not respond as quickly as normal and the aircraft landed "very hard" and bounced in to crops adjacent to the runway, Figure 1.

**Figure 1**

Final position, in crops adjacent to runway

The pilot commented that the engine's slow response may have been due to it not being fully up to temperature. It is also possible that it was due to carburettor icing as carburettor heat was only applied for a short period. Conditions at nearby Oxford Airport (temperature 20ºC, dew point 16ºC) were conducive to serious icing at descent power.

## ACCIDENT

| | |
|---|---|
| **Aircraft Type and Registration:** | Midget Mustang, G-AWIR |
| **No & Type of Engines:** | 1 Continental Motors Corp O-200-A piston engine |
| **Year of Manufacture:** | 1973 (Serial no: PFA 1315) |
| **Date & Time (UTC):** | 21 July 2019 at 1630 hrs |
| **Location:** | Woods near Spanhoe Airfield, Northamptonshire |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - None |
| **Injuries:** | Crew - 1 (Serious) Passengers - N/A |
| **Nature of Damage:** | Destroyed |
| **Commander's Licence:** | Private Pilot's Licence |
| **Commander's Age:** | 56 years |
| **Commander's Flying Experience:** | 677 hours (of which 10 were on type)<br>Last 90 days - 71 hours<br>Last 28 days - 16 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot |

### Synopsis

The pilot overflew the airfield to assess conditions before deciding whether to land. During the pull-up and bank that followed, the aircraft departed controlled flight and descended in to a nearby wood. The pilot was seriously injured, and the aircraft was destroyed.

### History of the flight

The pilot was flying from Leicester Airfield to Sibson Airfield and on the way, he flew over Spanhoe Airfield to check the windsock and decide whether he was going to land there to visit friends. He flew overhead at approximately 600 to 700 ft and then pulled up and banked left. The next thing he remembers is hitting the tree canopy. The pilot sustained serious injuries and the aircraft was destroyed, Figure 1.


**Figure 1**
Aircraft post-accident

## AAIB Comment

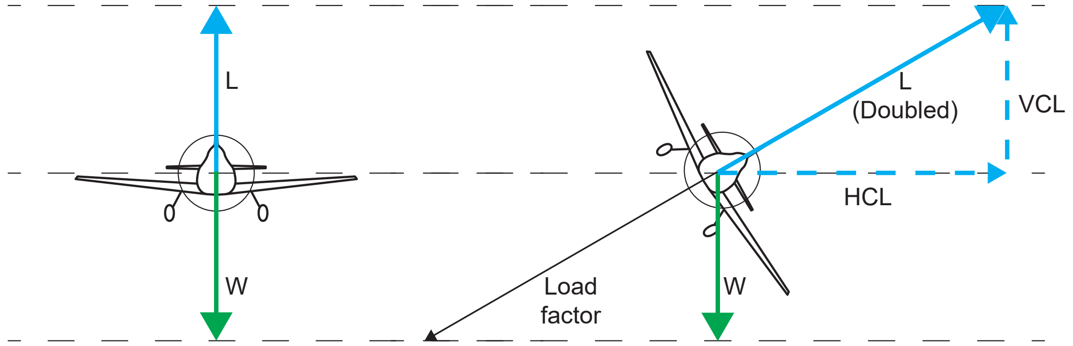
Load factor is the ratio of the lift produced by the aircraft and its weight. In level flight, when the lift produced by the wings equals the aircraft weight, an aircraft experiences a load factor of 1. When an aircraft is banked, lift must be increased to maintain altitude because the lift vector is no longer directly opposing the aircraft's weight. At 60º of bank, the lift must be doubled to maintain level flight, this corresponds to a load factor of 2[1], Figure 2.

As the load factor increases the stall speed of the aircraft increases in proportion to the square root of the load factor so, when maintaining height with 60º of bank and a load factor of 2, the stall speed increases to 1.4 times the normal stall speed. In a level turn at 75º of bank, lift must be increased by nearly four times, and with a load factor of 4, the aircraft's stall speed will double. An additional effect of the increase in lift is that the aerodynamic drag of the aircraft will also increase.

The Midget Mustang has a published stall speed of 60 mph in the clean configuration at its maximum gross weight. A pull-up and steep banking manoeuvre would considerably increase the stalling speed due to the increased load factor. Additionally, if power was not increased, the aircraft would also slow because of the pull-up and the increased drag due to the increased lift needed to maintain the turn.

**Footnote**

[1] When the load factor is 1, all occupants of the aircraft feel that their weight is normal. When the load factor is 2 all occupants feel twice as heavy as usual.




Level flight
Lift = weight

60º bank (level)

Lift = 2 x Weight
VCL = Vertical component of lift (balances weight)
HCL = Horizontal component of lift (turns aircraft)

$$\text{Load factor} = \frac{\text{Lift}}{\text{Weight}} = \frac{2}{1} = 2$$

**Figure 2**
Effect of a level 60º banked turn

## Conclusion

It seems most likely that the final manoeuvre increased the aircraft's stall speed to, or beyond the aircraft's airspeed which caused it to stall and the pilot to lose control of the aircraft with limited height available to recover before the aircraft struck the trees.

## ACCIDENT

| | |
|---|---|
| **Aircraft Type and Registration:** | Hummerchute, G-CJTI |
| **No & Type of Engines:** | 1 Rotax 582 piston engine |
| **Year of Manufacture:** | 2016 (Serial no: 472) |
| **Date & Time (UTC):** | 18 September 2019 at 1828 hrs |
| **Location:** | Freeby, Leicestershire |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - 1 |
| **Injuries:** | Crew - 1 (Minor) Passengers - 1 (Serious) |
| **Nature of Damage:** | Damage to the trike's metal frame |
| **Commander's Licence:** | National Private Pilot's Licence |
| **Commander's Age:** | 69 years |
| **Commander's Flying Experience:** | 30 hours (of which 30 were on type)<br>Last 90 days - 0 hours<br>Last 28 days - 0 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot and further enquires by the AAIB |

### Synopsis

The parachute canopy failed to inflate correctly during the takeoff roll which caused the aircraft to roll to the left as it lifted off the ground. It collided with bushes at the edge of the field injuring the pilot and passenger.

### History of the flight

The pilot had obtained a National Private Pilot's Licence for Powered Parachutes (NPPL(PP)) twelve months before the accident but had not flown since. The pilot was in the process of renewing the aircraft's permit to fly which had expired in April 2019. The aircraft's annual inspection had recently been completed and it now required a flight check. Because of his inexperience he asked a more experienced pilot to complete the initial check flight, which was done just prior to the accident flight. With the initial check flight successfully completed the owner decided to take the aircraft on a short local flight. He was accompanied by another pilot who was experienced on powered parachutes.

The pilot completed the pre-flight checks and set the aircraft up in the centre of the field. Once he and his passenger were seated and secure he started the engine, which caused the canopy to lift off the ground. Having satisfied himself that the canopy was correctly inflated and directly overhead he applied full throttle. The pilot recalled that the aircraft took longer than he anticipated to lift off the ground. He remembered that it lifted off the ground towards the edge of the field and clearing the hedge, then made a sharp turn to the left and collided with bushes.

Both occupants were taken to hospital. The pilot had suffered two broken ribs and a broken sternum. The passenger suffered ten broken ribs and needed to stay in hospital for seven days.

### Witness account

The pilot who had conducted the initial check flight watched the takeoff. He reported that the canopy did not inflate correctly on the left side. This caused the aircraft to roll left as the trike lifted off the ground. He provided the photographs of the takeoff shown in Figure 1 to 3.

The witness reported that, in his experience with powered parachutes, the canopy occasionally fails to inflate correctly. The pilot would normally look backwards during the takeoff roll and, if they saw the canopy was not correctly inflated, would abort the takeoff.

### Aircraft information

The Hummerchute is a powered parachute which can carry two people, manufactured by Aerochute Pty Industries in Australia. The occupants are seated side-by-side on a three-wheeled unit (the trike) suspended beneath the parachute canopy. The trike also accommodates the engine, positioned behind the occupants, driving a pusher propeller.

**Figure 1**

G-CJTI at start of the takeoff roll with left side of canopy incorrectly inflated

**Figure 2**
G-CJTI as it lifted off the ground and rolled left

**Figure 3**
G-CJTI rolling left before colliding with bushes

## Conclusion

The parachute canopy failed to inflate correctly during the takeoff roll, which caused the aircraft to roll to the left as it lifted off the ground.

The pilot had obtained his pilot's licence 12 months prior to the accident and had not flown since. It is likely that his lack of experience and recency contributed to him not seeing that the canopy had not inflated correctly during the takeoff roll.

## ACCIDENT

| | |
|---|---|
| **Aircraft Type and Registration:** | Hurricane 315, G-OHUR |
| **No & Type of Engines:** | 1 Rotax 503 DCDI piston engine |
| **Year of Manufacture:** | 2018 (Serial no: 250218) |
| **Date & Time (UTC):** | 8 September 2019 at 1045 hrs |
| **Location:** | Stoke Airfield, Kent |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - None |
| **Injuries:** | Crew - None Passengers - N/A |
| **Nature of Damage:** | Propeller detached, left wing and fuselage damaged |
| **Commander's Licence:** | Private Pilot's Licence |
| **Commander's Age:** | 58 years |
| **Commander's Flying Experience:** | 1,375 hours (1,100 on microlight aircraft of which 35 were SSDR[1])<br>Last 90 days - 16 hours<br>Last 28 days - 9 hours |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot |

### Synopsis

Shortly after taking off on a flight test to check the propeller setting, the engine started to vibrate and run roughly. The pilot carried out a forced landing on salt marshes during which the aircraft pitched over and came to rest inverted. The cause of the vibration could not be positively determined, but it is possible that carburettor flooding led to engine vibration and loss of power.

### History of the flight

The pilot was undertaking a series of flight tests from Stoke Airfield, near Rochester, Kent to investigate the optimum propeller pitch setting. Following a successful circuit using a pitch setting of 9°, he set the pitch at 6° and carried out engine power checks, which included a magneto check at 4,000 rpm, prior to his next flight. The takeoff was normal with the engine reaching 5,600 rpm; however, at approximately 50 ft (agl) the engine note changed, and the pilot became aware of an "uncharacteristic" significant vibration. Movement of the throttle made no difference. The pilot made a gentle turn to avoid overflying nearby paddocks and a marina, and climbed to between 100 to 150 ft. The engine continued to run roughly and lost

**Footnote**

[1] Single Seat Deregulated Aircraft.

power. Whilst he was diagnosing the problem, the pilot became aware that the airspeed was decaying with the early onset of a stall and therefore carried out a forced landing on the salt marshes next to the river Medway.

On landing, one or both the mainwheels dug into the ground causing the aircraft to gently pitch over, coming to rest inverted (Figure 1). The pilot was initially trapped but was assisted out of the cockpit by a passer-by. During the accident the propeller detached, and the aircraft sustained extensive damage to the landing gear, fuselage and left wing. The canopy was distorted making it difficult to vacate the aircraft.

**Figure 1**

G-OHUR inverted on the salt marshes (picture courtesy of the owner)

## Technical investigation

G-OHUR was classified as a SSDR microlight aircraft and as such it could be designed and constructed privately without the airworthiness oversight of either a member association or the CAA. The pilot had designed and built the aircraft, which was based on a scaled down version of the Hawker Hurricane (Figure 2). The aircraft first flew in May 2018 and had flown 14 hours.


**Figure 2**

Hurricane 315, G-OHUR (picture courtesy of the owner)

Following the accident, the pilot dismantled and examined the engine but could find no evidence of a component failure within the engine or reduction gearbox, though there was an abnormal amount of oil residue present in the crankcase beneath both pistons.

The pilot felt that the rough running and vibration experienced during the accident flight were similar to that of an engine running with an overly rich mixture. However, while one spark plug was wet with fuel, the colour and condition of all the spark plugs indicated that the engine had been running at the correct mixture.

Although the propeller had been damaged during the impact, the angle of both propeller blades was still set at 6°.

## Conclusion

From the condition of the spark plugs, and the oil residue in the crankcase, the pilot was of the opinion that the engine had been running correctly until the onset of significant over-fuelling caused by carburettor flooding. He believed that this caused the vibration experienced immediately after takeoff and the loss of engine power. The cause of the flooding could not be determined.

## ACCIDENT

| | |
|---|---|
| **Aircraft Type and Registration:** | Rans S6-ESD (Modified) Coyote II, G-MYLO |
| **No & Type of Engines:** | 1 Rotax 503 piston engine |
| **Year of Manufacture:** | 1994 (Serial no: PFA 204-12334) |
| **Date & Time (UTC):** | 29 June 2019 at 1120 hrs |
| **Location:** | North East of Trimdon, County Durham |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 Passengers - 1 |
| **Injuries:** | Crew - None Passengers - None |
| **Nature of Damage:** | Aircraft damaged beyond economical repair |
| **Commander's Licence:** | Private Pilot's Licence |
| **Commander's Age:** | 75 years |
| **Commander's Flying Experience:** | 333 hours (of which 140 were on type)<br>Last 90 days - 1 hour<br>Last 28 days - 1 hour |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot |

Whilst flying downwind to land after a cross-country flight, the engine began to run roughly and then stopped. When an attempted restart was unsuccessful, the pilot turned the aircraft into wind and selected a field for a forced landing. The aircraft had to pass over a copse of trees, but as it was sinking more than expected, the pilot attempted to "stretch the glide". The speed reduced until the aircraft stalled and collided with the trees. Both occupants were unhurt. The pilot commented that there was little wind to help the glide.

### AAIB Comment

An aircraft's glide speed is the airspeed where its lift to drag ratio is the highest. This allows the aircraft to glide the furthest distance for a given altitude loss. Any increase or decrease in airspeed from this optimum speed will shorten the glide distance.

Wind affects the distance an aircraft travels over the ground in a given time. When flying at a steady airspeed, a headwind will reduce an aircraft's speed relative to the ground, decreasing the distance travelled in a given time.

# AAIB Record-Only Investigations

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

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

The accuracy of the information provided cannot be assured.

## Record-only investigations reviewed September - October 2019

**12-May-19** **Luscombe 8F** **G-LUSI** Henstridge Airfield, Somerset

After a normal landing on the mainwheels the aircraft pitched forward and became inverted.

**12-May-19** **Cessna F152** **G-GFIB** Sleap Airfield

The wing tip collided with a parked vehicle while taxiing. The student pilot was following signals from someone on the ground who was trying to keep the aircraft away from repairs to the taxiway.

**18-May-19** **Robinson R44 II** **G-RWEW** Portrush, County Antrim

While hover taxiing close to overhead electric wires, rotor downwash caused wires to arc. There was no damage to the helicopter or wires.

**21-Jun-19** **Pegasus Quik** **G-CDOM** Barton Aerodrome, Manchester

During the takeoff roll the aircraft turned to the right but the pilot was unable to correct it. The turn tightened and the aircraft subsequently rolled over and came to rest on its side suffering severe damage. The pilot was uninjured.

**25-Jun-19** **Pitts S2-A** **G-BYIP** Private airstrip, Kilkerran Ayreshire

The aircraft landed with the passenger's foot applying the right brake pedal. The aircraft turned right on landing and overturned.

**29-Jun-19** **Robinson R44** **G-OBSM** Private Airstrip, Newton-on-Trent, Nottinghamshire

The pilot's hand slipped from the collective and the helicopter landed heavily damaging the frame and fire wall.

**04-Jul-19** **Guimbal Cabri G2** **G-CHWJ** Cotswold Airport

The helicopter rolled over during an into-wind landing on the student's second solo flight. The student was not familiar with the cyclic response and correct trim with the instructor absent.

**13-Jul-19** **Vans RV-6** **G-ORVI** Priors Farm, Oxfordshire

The aircraft encountered windshear on landing and undershot the runway. The gear leg was bent and there was propeller tip damage.

**20-Jul-19** **Savannah VG LS(1)** **G-CDEH** Wellesbourne Mountford Airfield

The nose gear collapsed after a heavy landing.

**25-Jul-19** **Ikarus C42 FB80 Bravo** **G-JMRT** Gloucestershire Airport

The student made a heavy landing, the aircraft bounced and on touch down the nose leg collapsed and the propeller struck the runway.

**Record-only investigations reviewed September - October 2019 cont**

| | | | |
|---|---|---|---|
| **25-Jul-19** | **Piper PA-28-161 Cherokee** | **G-GFCB** | 6 nm from Bristol Airport |
| | During a forced landing due to engine failure, aircraft damage was caused due to landing on soft ground. | | |
| **27-Jul-19** | **Cessna T206H** | **N51703** | Owen Roberts International Airport, Cayman Islands |
| | The aircraft struck a stationary fuel truck on the apron causing a fuel leak from the aircraft's wing. The truck had minor damage. | | |
| **29-Jul-19** | **Cessna 152** | **G-GFID** | Sandown Airfield, Isle of Wight |
| | The nosewheel collapsed on landing. | | |
| **29-Jul-19** | **Pegasus Quik** | **G-CCMS** | Barton Aerodrome, Manchester |
| | On landing the microlight was caught in a crosswind and crashed onto runway. | | |
| **29-Jul-19** | **Vans RV-9A** | **G-CFMC** | Yeatsall Farm Strip, Abbots Bromley, Staffordshire |
| | During rollout the nose gear leg collapsed. | | |
| **30-Jul-19** | **Piper PA-28R-201T** | **G-BFTC** | Sherburn-in-Elmet Airfield |
| | During the flare following a glide approach, the propeller blades struck the ground because the landing gear had not been lowered. The pilot went around, lowered the landing gear and landed without further event. | | |
| **03-Aug-19** | **Robinson R44 II** | **G-SPJE** | Private field, Barwell Leicestershire |
| | During lift off from an inclined field, the skid dug in and the helicopter rolled over. | | |
| **03-Aug-19** | **Rotorsport MT gyroplane** | **G-CIFT** | Private Airstrip, Isle of Mull |
| | Whilst taxing down a slight incline to the hangar, a wheel brake pad came off its backing plate and in maneuvering to avoid the hangar the gyroplane rolled onto its side. | | |
| **05-Aug-19** | **Piper PA-28-140** | **G-AXJX** | Oxford Airport |
| | The aircraft landed approx 27 m too short of the tarmac runway and hit a runway approach light. | | |
| **05-Aug-19** | **Cessna 177RG Cardinal** | **G-CIMB** | Peterborough Conington Airfield |
| | The nose landing gear collapsed on touchdown. | | |

**Record-only investigations reviewed September - October 2019 cont**

| | | | |
|---|---|---|---|
| **08-Aug-19** | **Starstreak Shadow SA-II** | **G-BYFI** | Private strip, East Green Suffolk |
| | The aircraft suffered a loss of power on climbout. It subsequently landed heavily in a field. | | |
| **18-Aug-19** | **Luscombe 8E (Modified)** | **G-YRIL** | Insch, Aberdeenshire |
| | As a result of a downdraft on the approach, the aircraft landed heavily, the undercarriage collapsed and the propeller struck the runway. | | |
| **22-Aug-19** | **Pegasus Quantum 15** | **G-MYRY** | Northrepps Aerodrome, North Norfolk |
| | Runway excursion on landing causing extensive damage to the microlight with no injuries. | | |
| **22-Aug-19** | **Beagle Aircraft E3 (Auster AOP II)** | **G-ASCC** | Whittlesford Private Air Strip, Cambridgeshire |
| | On landing the aircraft veered to the right and struck a ditch causing damage to the left wheel and left wing. | | |
| **25-Aug-19** | **Quik R microlight** | **G-CIHA** | Strathaven, South Lanarkshire |
| | Loss of control during takeoff resulting in an excursion into long grass at the side of the runway. The aircraft suffered significant damage. | | |
| **26-Aug-19** | **Vans RV-7A** | **G-JFRV** | Farm Strip, Bethesda, Pembrokeshire |
| | The aircraft landed with a tailwind and struck a hedge at the end of the runway. The nosegear collapsed and there was damage to the wings and propeller. | | |
| **26-Aug-19** | **Cessna F150L** | **G-BBNJ** | Breighton Aerodrome, North Yorkshire |
| | On landing, the aircraft nosed over and inverted with minor injuries to the pilot and passenger. | | |
| **26-Aug-19** | **Reims Cessna F172N** | **G-BEHV** | Cumbernauld Airport |
| | After landing the aircraft veered off the runway at slow speed due to inadvertent application of braking. | | |
| **01-Sep-19** | **Piper PA-28-151** | **G-JAMP** | Duxford Airfield, Cambridgeshire |
| | During pre-takeoff power checks, a strong smell of smoke entered the cockpit. There was no evidence of fire. | | |

**Record-only investigations reviewed September - October 2019 cont**

| | | | |
|---|---|---|---|
| **01-Sep-19** | **Rotorsport UK Calidus gyrocopter** | **G-FLIA** | Clench Common, Marlborough |
| | During the roll out, after landing, the aircraft was caught by a gust of wind and rolled onto it's side damaging the main rotor blades and propeller. | | |
| **01-Sep-19** | **QAC Quickie TRI-Q** | **G-FARY** | Sturgate Airport, Lincolnshire |
| | The pilot was unable to reduce engine power on the approach, so shut the engine down. The nose leg broke when the aircraft touchdown on the runway. The pilot was uninjured. | | |
| **03-Sep-19** | **Bell 429/ Cessna F150G** | **G-RIDB/ G-AVIT** | Wellesbourne Mountford Airfield |
| | The parked Cessna 150 was moved by the downwash from a manoeuvring helicopter that was landing next to it. The wingtip of the Cessna was damaged. | | |
| **04-Sep-19** | **Falconer F-11-3** | **G-AWHY** | Roughay Farm, Hampshire |
| | Loss of control on landing led to damage to the landing gear, cowling and propeller. | | |
| **05-Sep-19** | **Cessna 172S Skyhawk** | **G-OPYE** | Netherthorpe Airfield |
| | The pilot aborted the takeoff due to slower than anticipated acceleration on the soft ground. The aircraft overran the runway and struck a hedge. | | |
| **09-Sep-19** | **DH82A Tiger Moth** | **G-ANDP** | Ballymagreehan, Newtownards, County Down |
| | The aircraft failed to achieve climb performance after takeoff and landed back on the strip but struck the boundary hedge. | | |
| **11-Sep-19** | **Aero AT-3 R100** | **G-SACX** | RAF Linton-on-Ouse, North Yorkshire |
| | The nose gear leg collapsed during landing. | | |
| **15-Sep-19** | **Champion Citabria** | **G-AYXU** | Gloucester Airport |
| | The nosewheel collapsed after landing. | | |
| **19-Sep-19** | **Pegasus Quik** | **G-CCHO** | Sutton Meadows Airfield |
| | While practising circuit flying, the aircraft landed heavily, the nosewheel collapsed and the aircraft turned over. The aircraft was extensively damaged; however, the instructor and student were not injured. | | |
| **21-Sep-19** | **Cessna 152** | **G-BTGX** | Stapleford Aerodrome |
| | A gust of wind caused the aircraft to 'flip over' during a solo student landing. | | |

**Record-only investigations reviewed September - October 2019 cont**

| | | | |
|---|---|---|---|
| **25-Sep-19** | **Guimbal Cabri G2** | **G-LAVN** | Beccles Aerodrome, Suffolk |
| | The aircraft rotated left through 360° during lift off and then landed heavily damaging the tail and skids. | | |
| **12-Oct-19** | **Piper PA-25-260 Pawnee** | **G-PSGC** | Spalding, Lincolnshire |
| | Following an engine failure on approach to land, the aircraft landed in a field short of the runway. | | |
| **15-Oct-19** | **Titan T-51 Mustang** | **G-CMPC** | White Fen Farm private strip, Benwick, Cambridgeshire |
| | The aircraft landed with landing gear retracted. | | |
| **18-Oct-19** | **Mainair Blade 912** | **G-BYTU** | Clacton Airfield, Essex |
| | During an aborted takeoff due to low acceleration on soft ground, a wheel dug in during deceleration and a wing tip struck the ground. | | |
| **22-Oct-19** | **Piper PA-12** | **G-AXUC** | Headcorn Aerodrome, Kent |
| | The aircraft suffered runway excursion on takeoff and struck fence. | | |

# Miscellaneous

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

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

**BULLETIN CORRECTION**

| | |
|---|---|
| **Aircraft Type and Registration:** | Boeing 737-4Q8, G-JMCR |
| **Date & Time (UTC):** | 12 October 2018 at 0155 hrs |
| **Location:** | En-route to East Midlands Airport |
| **Information Source:** | Field Investigation |

**AAIB Bulletin No 10/2018, page 3 refers**

In the last paragraph of the Synopsis of this report it was stated that six Safety Recommendations are made to the operator regarding its safety management system and one to the Civil Aviation Authority.

This is incorrect, it should have read **five** Safety Recommendations are made to the operator regarding its safety management system and one to the Civil Aviation Authority.

The online version of the report was amended on 10 October 2019.

## BULLETIN CORRECTION

| | |
|---|---|
| **Aircraft Type and Registration:** | Cessna 414, N414FZ (previous registration G-AZFZ) |
| **Date & Time (UTC):** | 26 June 2018 at 1320 hrs |
| **Location:** | Farm building at Enstone Airfield, Oxfordshire |
| **Information Source:** | Aircraft Accident Report Form submitted by the pilot and AAIB enquiries |

**AAIB Bulletin No 4/2019, page 36 refers**

The AAIB report published in Bulletin 4/2019 reported in the Synopsis: '*The pilot and passenger both sustained minor injuries*.' This was based on early information. It was later established that the passenger had sustained multiple injuries, including a fractured vertebra. The passenger's injuries are therefore properly classified as 'Serious'.

The Bulletin header information should, therefore, read:

**Injuries:** Crew - 1 (Minor) Passengers - 1 (Serious)

The online version of this report was amended on the 14 November 2019.

**BULLETIN CORRECTION**

| | |
|---|---|
| **Aircraft Type and Registration:** | Grumman AA-5B, G-MPFC |
| **Date:** | 6 July 2019 |
| **Location:** | Sandown, Isle of Wight |
| **Information Source:** | Record only investigation |

**Bulletin No: 10/2019, page 74 refers**

The original entry was incorrect in that it the nose leg actually failed during taxi rather than as a result of striking a pot hole after landing. So, the entry has been amended to read:

> Whilst taxiing, the nose leg failed leading to damage to the propeller and engine. There were no injuries.

**BULLETIN CORRECTION**

| | |
|---|---|
| **Aircraft Type and Registration:** | Ikarus C42 FB80, G-CDSW |
| **Date & Time (UTC):** | 5 April 2019 |
| **Location:** | Deanland Airfield, East Sussex |
| **Information Source:** | Aircraft Accident Report Form |

**AAIB Bulletin No 11/2019, page 64 refers**

The report states that the pilot obtained prior permission for the landing at Deanland airfield while at Lydd Airport during the cross-country flight. The pilot has confirmed that prior permission for landing at Deanland had been obtained during the day preceding the flight.

The report incorrectly states that Runway 26 was in use when the aircraft arrived in the vicinity of Deanland Airfield. The correct designation for the runway in use at the time of the accident was Runway 06.

The online version of the report was amended prior to publication.

**REPORT CORRECTION**

| | |
|---|---|
| **Aircraft Type and Registration:** | Jabiru UL-450, G-KEVH |
| **Date:** | 3 April 2019 |
| **Location:** | Welshpool Airport, Powys, Wales |
| **Information Source:** | Record only investigation |

**Bulletin No: 10/2019, page 71 refers**

The original entry was incorrect in that stated that the runway excursion occurred during take off before passing through a hedge. It actually occurred during landing and the aircraft struck a fence. So, the entry has been amended to read:

> Runway excursion on landing. The aircraft then struck a fence causing damage to the propeller. There were no injuries.

## BULLETIN CORRECTION

| | |
|---|---|
| **Aircraft Type and Registration:** | Jodal D120 Paris-Nice, G-BKCW |
| **Date & Time (UTC):** | 19 June 2019 |
| **Location:** | Perth Aerodrome, Perth and Kinross |
| **Information Source:** | Aircraft Accident Report Form |

**AAIB Bulletin No 11/2019, page 59 refers**

In the Synopsis and the first paragraph of the History of Flight the report incorrectly states that the pilot took off from Runway 21, this should have read Runway 27.

The online version of this report was amended prior to publication on the 14 November 2019.

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

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

Published June 2014.

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

Published September 2014.

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

Published July 2015.

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

Published August 2015.

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

Published October 2015.

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

Published March 2016.

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

Published September 2016.

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

Published March 2017.

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

Published March 2018.

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

Published November 2018.

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

http://www.aaib.gov.uk

# GLOSSARY OF ABBREVIATIONS

| | |
|---|---|
| aal | above airfield level |
| ACAS | Airborne Collision Avoidance System |
| ACARS | Automatic Communications And Reporting System |
| ADF | Automatic Direction Finding equipment |
| AFIS(O) | Aerodrome Flight Information Service (Officer) |
| agl | above ground level |
| AIC | Aeronautical Information Circular |
| amsl | above mean sea level |
| AOM | Aerodrome Operating Minima |
| APU | Auxiliary Power Unit |
| ASI | airspeed indicator |
| ATC(C)(O) | Air Traffic Control (Centre)( Officer) |
| ATIS | Automatic Terminal Information Service |
| ATPL | Airline Transport Pilot's Licence |
| BMAA | British Microlight Aircraft Association |
| BGA | British Gliding Association |
| BBAC | British Balloon and Airship Club |
| BHPA | British Hang Gliding & Paragliding Association |
| CAA | Civil Aviation Authority |
| CAVOK | Ceiling And Visibility OK (for VFR flight) |
| CAS | calibrated airspeed |
| cc | cubic centimetres |
| CG | Centre of Gravity |
| cm | centimetre(s) |
| CPL | Commercial Pilot's Licence |
| °C,F,M,T | Celsius, Fahrenheit, magnetic, true |
| CVR | Cockpit Voice Recorder |
| DFDR | Digital Flight Data Recorder |
| DME | Distance Measuring Equipment |
| EAS | equivalent airspeed |
| EASA | European Aviation Safety Agency |
| ECAM | Electronic Centralised Aircraft Monitoring |
| EGPWS | Enhanced GPWS |
| EGT | Exhaust Gas Temperature |
| EICAS | Engine Indication and Crew Alerting System |
| EPR | Engine Pressure Ratio |
| ETA | Estimated Time of Arrival |
| ETD | Estimated Time of Departure |
| FAA | Federal Aviation Administration (USA) |
| FIR | Flight Information Region |
| FL | Flight Level |
| ft | feet |
| ft/min | feet per minute |
| g | acceleration due to Earth's gravity |
| GPS | Global Positioning System |
| GPWS | Ground Proximity Warning System |
| hrs | hours (clock time as in 1200 hrs) |
| HP | high pressure |
| hPa | hectopascal (equivalent unit to mb) |
| IAS | indicated airspeed |
| IFR | Instrument Flight Rules |
| ILS | Instrument Landing System |
| IMC | Instrument Meteorological Conditions |
| IP | Intermediate Pressure |
| IR | Instrument Rating |
| ISA | International Standard Atmosphere |
| kg | kilogram(s) |
| KCAS | knots calibrated airspeed |
| KIAS | knots indicated airspeed |
| KTAS | knots true airspeed |
| km | kilometre(s) |
| kt | knot(s) |

| | |
|---|---|
| lb | pound(s) |
| LP | low pressure |
| LAA | Light Aircraft Association |
| LDA | Landing Distance Available |
| LPC | Licence Proficiency Check |
| m | metre(s) |
| mb | millibar(s) |
| MDA | Minimum Descent Altitude |
| METAR | a timed aerodrome meteorological report |
| min | minutes |
| mm | millimetre(s) |
| mph | miles per hour |
| MTWA | Maximum Total Weight Authorised |
| N | Newtons |
| $N_R$ | Main rotor rotation speed (rotorcraft) |
| $N_g$ | Gas generator rotation speed (rotorcraft) |
| $N_1$ | engine fan or LP compressor speed |
| NDB | Non-Directional radio Beacon |
| nm | nautical mile(s) |
| NOTAM | Notice to Airmen |
| OAT | Outside Air Temperature |
| OPC | Operator Proficiency Check |
| PAPI | Precision Approach Path Indicator |
| PF | Pilot Flying |
| PIC | Pilot in Command |
| PM | Pilot Monitoring |
| POH | Pilot's Operating Handbook |
| PPL | Private Pilot's Licence |
| psi | pounds per square inch |
| QFE | altimeter pressure setting to indicate height above aerodrome |
| QNH | altimeter pressure setting to indicate elevation amsl |
| RA | Resolution Advisory |
| RFFS | Rescue and Fire Fighting Service |
| rpm | revolutions per minute |
| RTF | radiotelephony |
| RVR | Runway Visual Range |
| SAR | Search and Rescue |
| SB | Service Bulletin |
| SSR | Secondary Surveillance Radar |
| TA | Traffic Advisory |
| TAF | Terminal Aerodrome Forecast |
| TAS | true airspeed |
| TAWS | Terrain Awareness and Warning System |
| TCAS | Traffic Collision Avoidance System |
| TODA | Takeoff Distance Available |
| UA | Unmanned Aircraft |
| UAS | Unmanned Aircraft System |
| USG | US gallons |
| UTC | Co-ordinated Universal Time (GMT) |
| V | Volt(s) |
| $V_1$ | Takeoff decision speed |
| $V_2$ | Takeoff safety speed |
| $V_R$ | Rotation speed |
| $V_{REF}$ | Reference airspeed (approach) |
| $V_{NE}$ | Never Exceed airspeed |
| VASI | Visual Approach Slope Indicator |
| VFR | Visual Flight Rules |
| VHF | Very High Frequency |
| VMC | Visual Meteorological Conditions |
| VOR | VHF Omnidirectional radio Range |

AAIB
Air Accidents Investigation Branch