AAIB

Air Accidents Investigation Branch

AAIB Bulletin 5/2020

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Air Accidents Investigation Branch
Farnborough House
Berkshire Copse Road
Aldershot
Hants GU11 2HH

Tel: 01252 510300
Fax: 01252 376999
Press enquiries: 0207 944 3118/4292
http://www.aaib.gov.uk

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AAIB Field Investigation Reports

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

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

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

SERIOUS INCIDENT

Aircraft Type and Registration:	Boeing 737-86N, I-NEOT
No & Type of Engines:	2 CFMI CFM56-7B26 turbofan engines
Year of Manufacture:	2002 (Serial no: 33004)
Date & Time (UTC):	1 June 2019 at 1319 hrs
Location:	Bristol Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 6 Passengers -167
Injuries:	Crew - None Passengers - None
Nature of Damage:	None reported
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	55 years
Commander's Flying Experience:	14,750 hours (of which 10,770 were on type) Last 90 days – 174 hours Last 28 days – 60 hours
Information Source:	AAIB Field Investigation

Synopsis

During an unstable approach to Runway 27 at Bristol Airport, I-NEOT descended below the approach path before being instructed to go around by the tower controller. After initially climbing away as expected during the go-around, the aircraft then descended for over 30 seconds reaching a minimum radio altitude of 457 ft. Simultaneously, the crew and the controller realised the aircraft was not climbing away as they expected. The crew corrected the flight path and the aircraft was vectored for a further uneventful approach.

The loss of altitude occurred because the target altitude on the Mode Control Panel was set to the minimum altitude for the approach having not been set to the missed approach altitude before the go-around. Neither crew member noticed initially that the aircraft was descending.

The operator has taken two safety actions as a result of this incident. They have used this incident as part of their annual recurrent ground school to highlight the risks of rushed and unstable approaches. They are also continuing to work on their flight data monitoring programme so that similar approaches will be identified more rapidly and easily in future.

History of the flight

I-NEOT took off from Verona Villafranca Airport at 1135 hrs for a flight to Bristol Airport. At 1313 hrs the crew contacted Bristol Airport radar (callsign Bristol Approach). The crew were advised they had 33 nm to touchdown, and to expect the RNAV (GNSS) Runway 27 approach[1]. The distance is given to crews to assist them in planning their descent. The controller then offered the crew a shorter routing which would give them a track mileage of around 23 nm to the runway threshold. The crew accepted the offer and were radar vectored accordingly. At the point the new routing was offered the aircraft was at FL100 and a Computed Airspeed (CAS) of 280 kt. Once the aircraft began its descent, the crew set the airport QNH of 1019 hPa[2], deployed the speed brakes and increased the Selected Airspeed to 300 kt. As the aircraft passed through 4,715 ft at a vertical speed of -3,000 ft min, the CAS reached 303 kt before starting to decrease.

The controller routed the aircraft direct to the intermediate fix[3] which was at 9.8 nm from the threshold of the runway. This point was named ELROV and the procedure limited the aircraft to a maximum of 210 kt, with an expected altitude of 2,500 ft or above. I-NEOT crossed ELROV at 3,276 ft and 271 kt CAS. The approach chart from the UK Aeronautical Information Publication is shown in Figure 1.

Approximately 11 nm from Bristol Airport, the crew attempted to engage the autopilot vertical navigation mode (VNAV) to perform the approach but the mode would not remain engaged and instead switched to Level Change mode (LVL CHG).

The aircraft descended along the approach path in LVL CHG mode with idle thrust, approximately 250 ft below the designated path with the speed significantly above that needed to fly a stabilised approach. As the aircraft descended, the Mode Control Panel (MCP) altitude remained set at the approach minima[4] (1,000 ft). This meant that as the aircraft approached 1,000 ft, the autopilot/flight director system (AFDS) entered Altitude Acquire vertical mode (ALT AQ). This mode allows the aircraft to level off at the MCP selected altitude. Although the rate of descent decreased, the aircraft remained significantly below the designated path.

At this point the tower controller was engaged with an aircraft pushing back on the apron, but his attention was drawn to I-NEOT by the assistant who was concerned about its altitude. The controller considered that the aircraft was not in the position he would expect and instinctively instructed the crew to go-around. The aircraft was at 1,071 ft (675 ft radio altitude) and 151 kt CAS. The instruction was acknowledged by the crew.

The PF pressed the TOGA[5] button and requested that the flaps be retracted to the setting required for a go-around. As designed, the autopilot disconnected, and the flight director commanded a pitch up. The PF followed the flight director, flying the aircraft manually, and the aircraft began to climb away as expected. However, the altitude selector on the MCP remained at the altitude the crew had set for the approach (1,000 ft) rather than the

Footnote

1 See later section: RNAV (GNSS) approaches.
2 Unless otherwise stated, all vertical points in this report refer to aircraft altitude based on that QNH.
3 Intermediate fix – a fix which marks the end of an initial segment and the beginning of the intermediate segment of the approach.
4 Approach Minima –altitude below which the aircraft must not descend unless appropriate visual references are established.
5 Takeoff/Go-around.

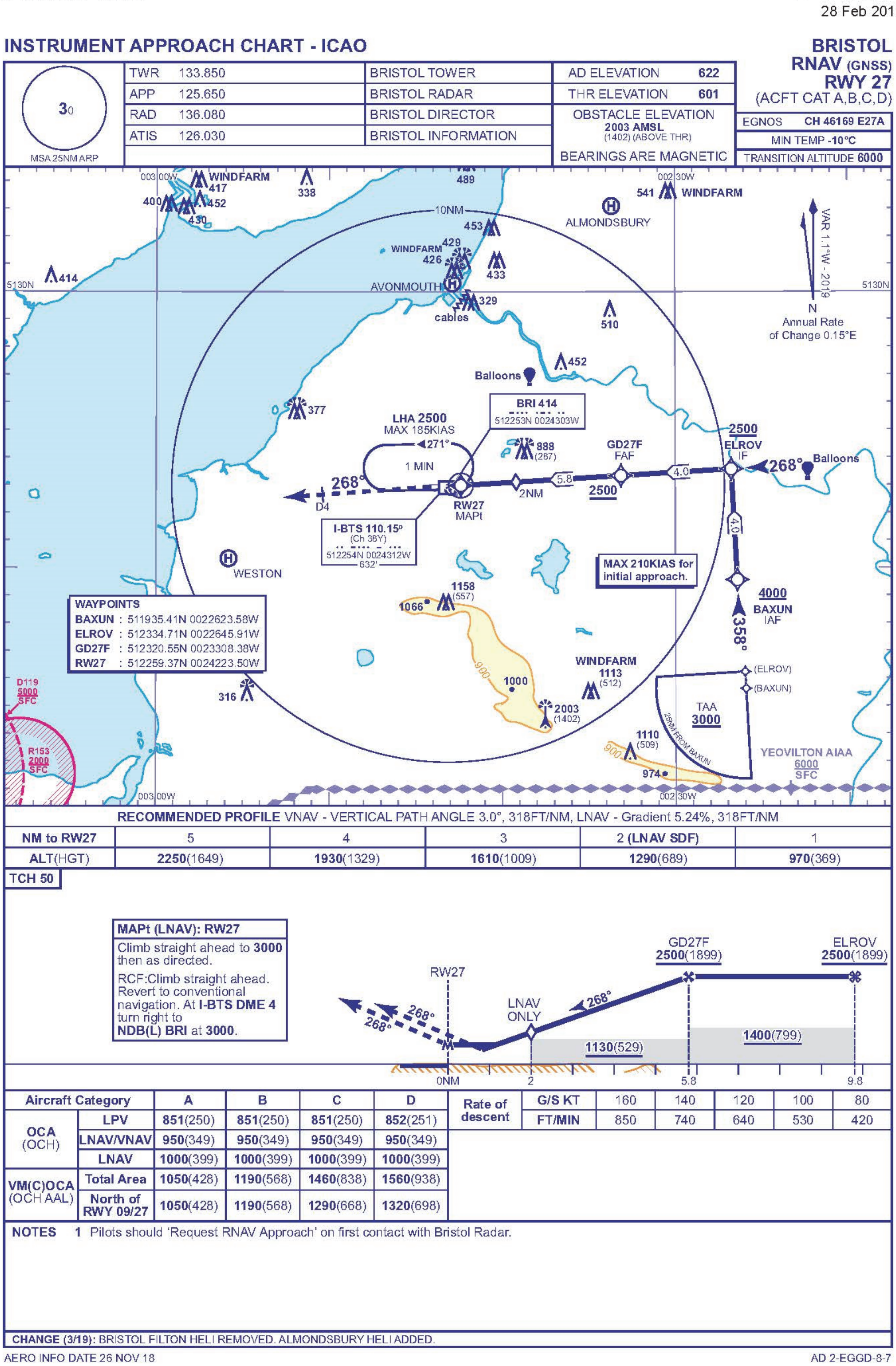

Figure 1

Approach Chart for RNAV (GNSS) Runway 27 go-around altitude (3,000 ft). As a result, the flight director began to command a descent in order to capture the selected altitude, and its vertical mode entered ALT AQ. The aircraft reached 1,302 ft before it began to descend. At some point after this engagement of ALT AQ the crew reselected the correct go-around altitude on the MCP. This action caused the flight director vertical mode to drop out of ALT AQ mode and into vertical speed mode (V/S). This mode maintains the rate of climb or descent of the aircraft at the time that the mode engaged, which in this case was a descent.

The PF followed the flight director, and the aircraft continued to descend for 32 seconds reaching a minimum of 1,047 ft, which was 457 ft radio altitude[6]. The crew then realised that the aircraft was not climbing as expected and adjusted the attitude of the aircraft to begin a climb. Almost at the same time, the tower controller noted that the aircraft was not climbing and instructed I-NEOT to climb to 3,000 ft which was acknowledged by the crew.

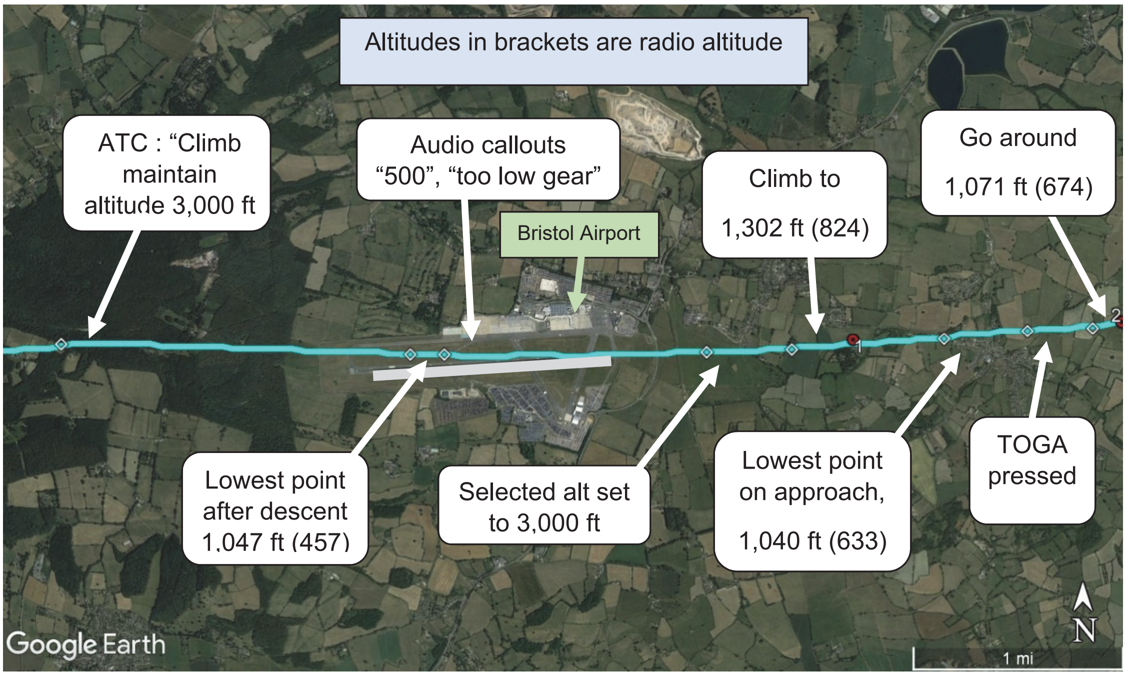

Figure 2
I-NEOT go-around

The crew of I-NEOT was given radar vectors to complete a further approach to landing which was completed without incident.

Airfield information

Bristol Airport is located on a hill to the south of the city of Bristol. The airport elevation is 622 ft amsl, with Runway 27 having a threshold elevation of 602 ft amsl. The airport has a single runway, orientated 09/27 which is 2,011 m long. Runway 27 has a landing distance available of 1,881 m.

Footnote

6 Radio altitude is height above ground level measured by a radio altimeter.

On the day of the incident, the glide path for the ILS on Runway 27 was not available due to work in progress to the south side of the airfield. The details of this unavailability were issued in a NOTAM that the crew received as part of their pre-flight briefing. The NOTAM instructed the crews to expect radar vectors to an RNAV (GNSS) approach to Runway 27 if the westerly runway was in use.

Meteorology

The weather conditions on the day of the incident were fine with a ridge of high pressure bringing warm, dry and mostly sunny conditions to the area. The wind was southerly with an average wind speed of less than 10 kt. At the time of the approach and go-around the visibility at the airfield was greater than 10 km with the cloud reported as scattered at 3,900 ft aal.

Aircraft information

The Boeing 737-800 (B737-8) auto-flight system has a dual AFDS and an autothrottle (A/T) which are controlled through the MCP and the Flight Management Computer (FMC). The MCP allows for the selection of desired modes for the AFDS and A/T. Mode status is displayed to the pilots at the top of both primary flying displays (PFD). These mode displays show the status of the AFDS, A/T modes, pitch modes and roll modes. Mounted on the thrust levers are two TOGA buttons. Pushing either of these buttons will engage the AFDS and the A/T in either takeoff or go-around mode, depending on the phase of flight, if the A/T has previously been armed.

Unless the aircraft is flying an ILS, only a single autopilot may be engaged at a time. With a single autopilot engaged, it will automatically disengage when a TOGA button is pressed. A go-around flown automatically is only available from an approach with dual autopilot engagement on an ILS.

With the first push on a TOGA button, the AFDS enters TOGA mode. The A/T (if engaged) advances the thrust levers to a reduced go-around setting which produces a 1,000 to 2,000 ft/min rate of climb. A second push of a TOGA button will increase the thrust to the go-around N_1 limit. The autopilot will disengage (if engaged) and the flight director pitch command will provide guidance on the PFD to 15° nose-up. The flight director pitch will maintain this guidance until the programmed rate of climb is reached at which point it will command a target pitch to maintain a pre-programmed airspeed for the current flap setting. TOGA mode will terminate once ALT AQ engages although this does not occur before the aircraft reaches the pre-set rate of climb.

VNAV mode provides guidance commands for the vertical flight path and, for an RNAV approach, guidance is provided relative to a pre-programmed vertical profile. If the flight director is selected, the guidance is displayed on the PFD and, if the autopilot is engaged, the aircraft will automatically follow the guidance. Calculations for VNAV guidance are limited such that if the aircraft cannot converge to the required vertical profile VNAV will not engage.

A further AFDS pitch mode is LVL CHG. This mode will execute a climb or descent to the MCP selected altitude at the selected or current speed. For a descent in LVL CHG the thrust will be set to idle if the A/T is engaged.

A landing gear configuration warning horn is provided to warn the flight crew when system logic considers a landing is being attempted with the landing gear not extended. This is a steady warning horn which alerts the crew any time the aircraft is in landing configuration and any landing gear is not down and locked. Criteria for triggering this warning horn depends on flap setting, radio altitude and thrust lever position.

The Enhanced Ground Proximity Warning System (EGPWS) also provides an alerting for protection against an unintentional gear-up landing. Mode 4A is active during cruise and approach with the landing gear and flaps not in the landing configuration; if the aircraft is below 500 ft agl and less than 190 kt CAS, a "TOO LOW GEAR" aural alert is provided.

RNAV (GNSS) approaches

An RNAV (GNSS) approach is a three-dimensional approach (ie it has lateral and vertical guidance) which uses a global navigation satellite system (GNSS). Lateral guidance is provided by GNSS, with vertical guidance provided by the flight management system on the aircraft. This vertical guidance is a defined path programmed into the database of the flight management system that is compared with the barometric altimeters in the aircraft. RNAV (GNSS) approaches are one part of Performance Based Navigation (PBN). It is possible to complete the approach using other vertical modes available on the aircraft if VNAV is unavailable. The operator will specify the procedures required to check the aircraft's actual descent path against that required for the approach regardless of the vertical mode in use. Using modes other than VNAV will increase the approach minima.

Operators regulated by EASA require approval for PBN and there are requirements for crew training and checking. The operator had approval for PBN, and the crew were trained and checked in accordance with the requirements.

The operator of I-NEOT required approaches such as this RNAV (GNSS) and other non-precision approaches to be flown using a continuous descent with no level segment at the approach minima.

Stable approaches

Many regulators worldwide have campaigned on the importance of stable approaches for reducing accidents and incidents in the landing phase of flight. The International Air Transport Association demonstrated the importance of this campaign in their report '*Unstable Approaches: Risk Mitigation Policies, Procedures and Best Practices*[7]':

Footnote

7 https://www.skybrary.aero/bookshelf/books/3603.pdf [accessed February 2020]

'During the data period 2011-2015 considered within the following chapters approximately 65% of all recorded accidents occurred in the approach and landing phases of flight, and unstabilized approaches were identified as a factor in 14% of those approach and landing accidents.'

The report goes on to define a stable approach as:

'one during which several key flight parameters are controlled to within a specified range of values before the aircraft reaches a predefined point in space relative to the landing threshold (stabilization altitude or height), and maintained within that range of values until touchdown. The parameters include attitude, flight path trajectory, airspeed, rate of descent, engine thrust and aircraft configuration. A stabilized approach will ensure that the aircraft commences the landing flare at the optimal speed, and attitude for the landing.'

The operator of I-NEOT includes in its Operations Manual procedures that the flight crew must follow to ensure that any approach that continues to land is stable at a pre-determined height. In IMC this height is 1,000 ft aal, in VMC it is 500 ft aal. At this height, if the aircraft does not meet the criteria, the crew must initiate a go-around. The criteria are:

- *'The aeroplane is in the planned landing configuration*
- *The aeroplane is on the correct flight path*
- *The aeroplane is at the target final approach speed -5/+10 kt*
- *The rate of descent is less than 1,000 FPM for a 3° or nominal 3° approach (visual approach)*
- *The aeroplane is on the correct lateral and vertical flight path*
- *Only small changes in heading/pitch are required to maintain correct flightpath*
- *The thrust setting is appropriate for aeroplane configuration and speed (idle thrust must not be used below 500 ft aal)*
- *The checklist must be completed not later than 500 ft aal.'*

For I-NEOT on the day of the incident, the requirement was to meet these criteria at 500 ft aal (1,122 ft amsl). As the aircraft passed this point on the approach, it was 15 kt above the target approach speed, the landing checklist had not been completed and the aircraft was 278 ft below the correct vertical flightpath. Engine thrust was still at idle, the rate of descent was 1,300 ft/min and the flap handle had been used to select landing flap (Flap 40) one second earlier. There was no discussion between the crew approaching this point about the stability of the approach.

Bristol ATC

Bristol Airport has both a radar-based control service for approach control as well as a tower service. Aircraft are handed over from the area control service (London Air Traffic Control Centre) to Bristol Approach usually around 40 nm from the airport when they are around FL100. The approach radar controllers then give the aircraft descent clearances and routings to position the aircraft for its final approach and landing. These routings will be dependent on other traffic, weather and any congestion at the airport.

At the time of the incident, the controller on Bristol Approach was a trainee who was being supervised by an experienced controller. The initial instructions to the crew of I-NEOT were that they were to expect the RNAV approach for Runway 27, and that they could expect 34 nm to touchdown. About 10 seconds later the trainee controller asked the crew if they could accept a shorter routing, with a track mileage of 23 nm. The crew accepted the shortened routing and the trainee controller routed them direct to ELROV. It remains at the discretion of the crew whether to accept any offer of a shorter routing, or when to ask for a longer routing should the assigned routing not be long enough to allow the aircraft to achieve the right height and speed for the approach. The operator's Operations Manual states that:

> *'If an ATC request (e.g. track shortening) is likely to result in an unstabilised approach, the request shall be declined.'*

As I-NEOT approached ELROV, the aircraft should have been at 210 kt and at or above 2,500 ft. It crossed ELROV at 3,276 ft and 271 kt. As the aircraft approached 8 nm from the runway at a CAS of 242 kt, the approach controller requested I-NEOT to "START REDUCING SPEED PLEASE, 190 KT OR LESS". When passing 7nm, the approach controller handed the aircraft over to Bristol Tower. The tower controller was informed by the approach controller that the aircraft was fast.

The tower controller noted that the aircraft was fast but since the aircraft was number one on the approach he considered that it was safe to allow it to continue. The tower controller and assistant were also attempting to solve a problem that had occurred with a pushback of another aircraft on the ground at the airport. As the controller was busy trying to address the issue on the ground, the assistant noticed that I-NEOT looked low on the approach and brought this to the attention of the controller. The controller felt the aircraft was significantly below where he would expect to see it and immediately instructed the crew to go around.

The Manual of Air Traffic Services (MATS) provides the basis for ATC provision within the UK. It contains *'procedures, instructions and information'*[8] for use by all air traffic service units (ATSUs) within the UK. MATS is split into two parts with Part 1 produced by the CAA containing instructions that apply to all ATSUs in the UK. Part 2 applies to a particular ATSU and is produced by that ATSU although it must be approved by the CAA.

Footnote

8 MATS Part 1 (CAP 493).

MATS Part 1 states that the aerodrome controller can instruct an aircraft to go around:

> *'A landing aircraft, which is considered by a controller to be dangerously positioned on final approach, shall be instructed to carry out a missed approach. An aircraft can be considered as dangerously positioned when it is poorly placed either laterally or vertically for the landing runway.'*[9]

The controller did not check the radar readout on the screens in front of him, which could have given him information about the altitude of the aircraft, but reacted instinctively based on his experience and using known visual references. He considered that the aircraft was dangerously positioned in accordance with MATS Part 1.

Controllers are taught to say nothing to the aircraft once the go-around has been acknowledged by the crew due to the expected high workload in the cockpit. The assistant drew the controller's attention back to the aircraft when he perceived that it was not climbing as expected. After a short period, the controller decided to instruct the crew to climb. The controller reported the incident to his watch management.

Recorded information

The aircraft was fitted with an FDR and CVR; both recorders captured both approaches to Bristol Airport. The recorders were recovered to the AAIB and were successfully downloaded. After an initial review of the CVR, it was apparent that an EGPWS warning had been triggered during the go-around. The EGPWS was then recovered to the AAIB for download.

First approach

Having accepted a shorter routing from Bristol Approach, the crew of I-NEOT increased the speed and deployed the speed brake to increase the rate of decent. As they approached ELROV, the PF selected LNAV mode on the MCP which engaged successfully. The aircraft then followed the lateral path of the approach as programmed in the FMC. With the aircraft level at 4,000 ft en route to ELROV, the PF selected a speed of 210 kt on the MCP, although the aircraft was still at a speed greater than 300 kt. The crew were then given a further decent to 2,500 ft and clearance for the RNAV(GNSS) approach to Runway 27.

I-NEOT passed over ELROV at 3,276 ft and 271 kt (61 kt above the procedure limiting speed). The PF engaged VNAV, but it disengaged after approximately 24 seconds, reverting to LVL CHG. When this occurred, the selected airspeed was 207 kt but the CAS was 265 kt with the aircraft descending at idle thrust with the spoilers deployed. The PF made two further unsuccessful attempts to engage VNAV, but the aircraft continued to descend in LVL CHG.

Footnote

9 MATS Part 1 (CAP 493) Section 2: Chapter 1: Aerodrome Control 19.5.

The aircraft continued its descent below the 2,500 ft pattern altitude before the final approach fix[10] descent point. This meant it crossed this point 227 ft below the required altitude, 70 kt above the target final approach speed (Figure 3). The aircraft continued to descend below the design 3° approach gradient. Between 5 nm and 2 nm, the aircraft was an average of 249 ft below the required altitude, ranging from between 203 ft and 293 ft below. The speed of the aircraft was reducing slowly. The crew were aware and had commented that the aircraft was high and fast. Table 1 shows the recorded altitude and speed of the aircraft compared to the design profile and the target final approach speed.

Distance from threshold (nm)	5	4	3	2
Profile altitude (ft)	2,250	1,930	1,610	1,290
Aircraft altitude (ft)	2,022	1,711	1,351	1,072
Aircraft speed (kt)	200	185	169	150
Difference to target final approach speed (kt)	+57	+42	+26	+7

Table 1

Height and speed comparison for I-NEOT

The crew progressively selected greater flap/slat settings as the speed reduced, selecting the planned landing flap setting (Flap 40) at 1,147 ft and 156 kt CAS.

During the approach the company Operations Manual requires that the crew announce:

> *'crossing altitudes as published fixes and other designated points are crossed, giving the appropriate altitude or height for the appropriate range as depicted on the chart. The pilot flying shall promptly adjust the rate of descent as appropriate.'*

These checks were not announced, and no adjustment was made to the vertical speed to correct to the correct descent path.

As part of the standard procedures for the aircraft, the MCP altitude was set to the approach minima (rounded up to the nearest 100 ft) in order to allow the aircraft to begin its decent down the approach. The approach minima set on the MCP was 1,000 ft. Once an aircraft is established on the approach in either VNAV or V/S mode and at least 300 ft below the restricting go-around altitude (for the RNAV 27 approach this was 3,000 ft), the MCP altitude should be reset to the go-around altitude. However, had this been done with I-NEOT descending in LVL CHG, rather than VNAV or V/S, the aircraft, with the autopilot engaged, would have climbed to the new selected altitude rather than continued with the descent. Similarly, had the autopilot been disengaged but the flight directors left on, they would have indicated a climb rather than a continuation of the descent.

Footnote

[10] Final approach fix – that fix from or over which the published final IFR approach is executed.

As the aircraft approached 1,000 ft, the AFDS vertical mode became ALT AQ as the system attempted to level off at the selected 1,000 ft. This led to a reduction in the rate of descent, and the aircraft path began to close slightly with the design 3° approach gradient. However, from 5.8 nm to 2 nm on the final approach, the minimum obstacle clearance altitude permitted by the procedure is 1,130 ft (shaded grey in Figure 1). Therefore, from a point 2.34 nm from the threshold until the aircraft passed inside 2 nm from the threshold, I-NEOT was below the minimum obstacle clearance altitude[11] in that segment of the approach.

As the crew reached the approach minima they were instructed to go around by ATC.

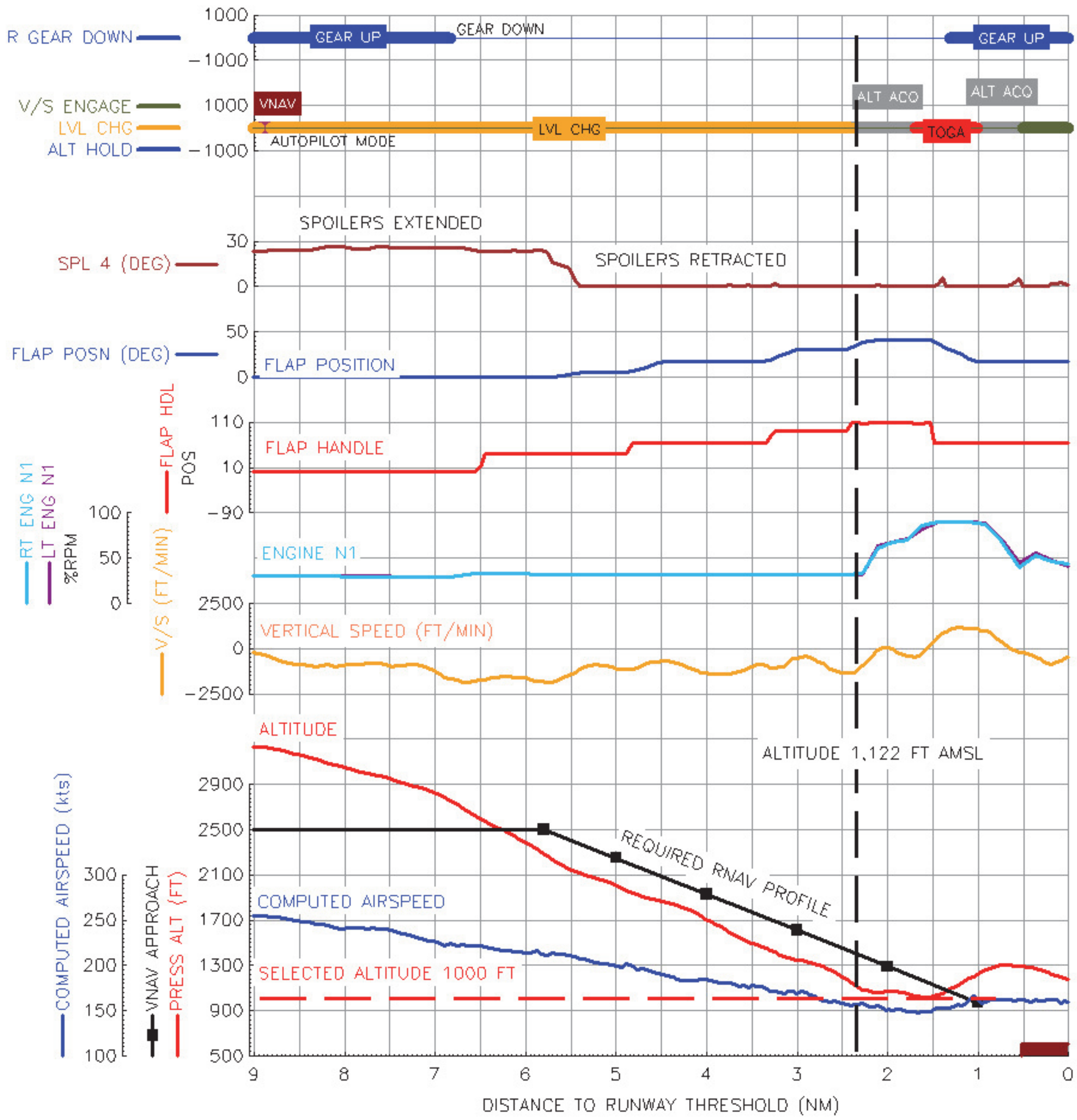

Figure 3

I-NEOT FDR data for initial approach into Bristol Airport

Footnote

11 Minimum Clearance Altitude is defined as a fixed margin to be added to the height of the dominant obstacle in the final approach segment. The minimum obstacle clearance for this approach is 75 m (246 ft) as defined in ICAO Doc 8186, *Aircraft Operations Volume II Construction of Visual and Instrument Procedures,* III-3-3-1. The dominant obstacle in the final approach segment from 5.8 nm to 2 nm stands 888 ft amsl.

Go-around

The PF pressed the TOGA button and the aircraft AFDS system transitioned into go-around modes (Figure 4, label [A]). The vertical and lateral modes became TOGA and the A/T increased the thrust to the calculated go-around setting. The autopilot disconnected as designed. The PF asked for the standard flap setting for the go-around (Flap 15) which was selected by the PM.

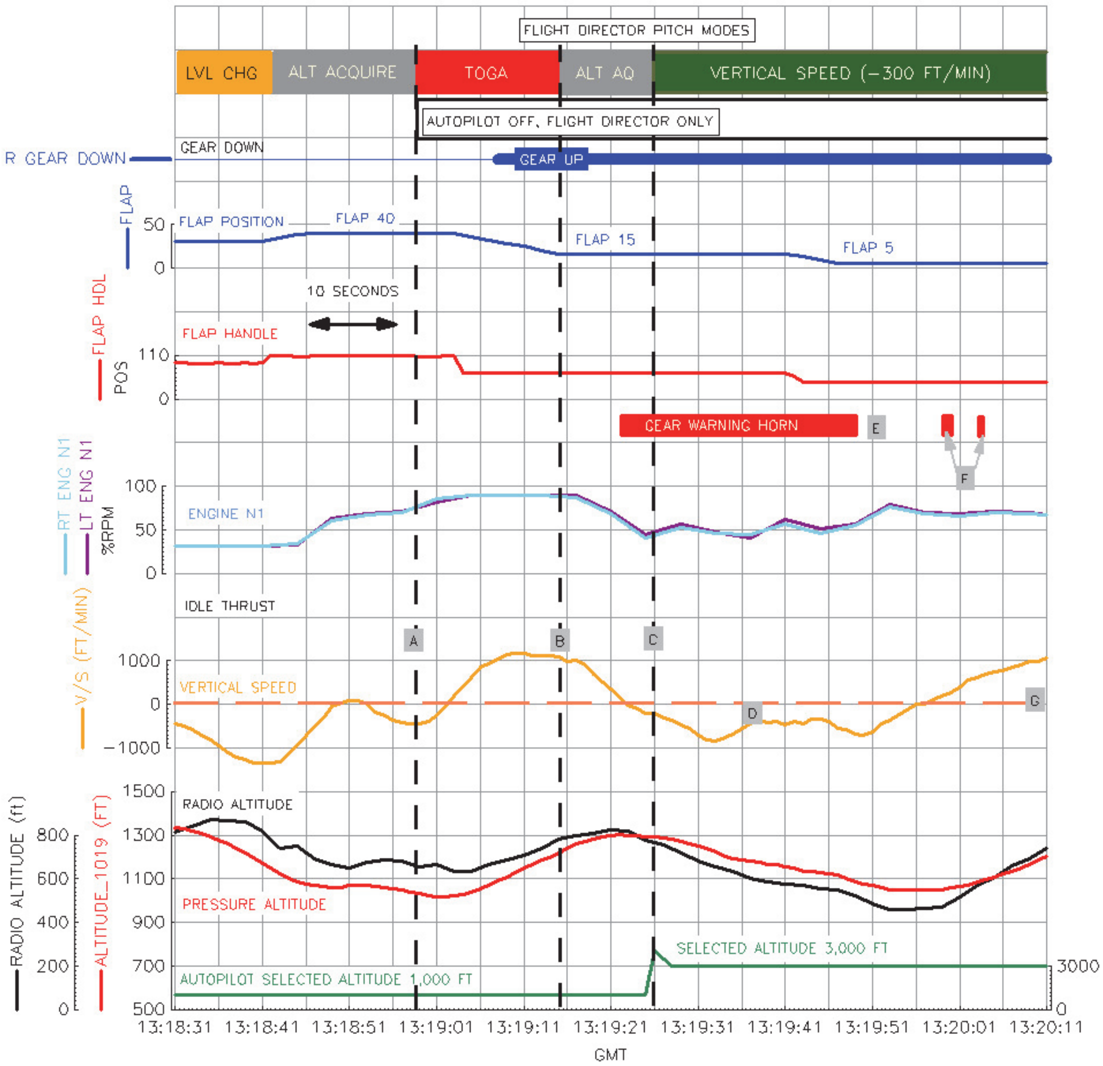

Figure 4

I-NEOT go-around salient parameters

The aircraft pitch began to increase, and the aircraft began to climb. 17 seconds after the PF pressed the TOGA button, the vertical mode changed to ALT AQ as the AFDS attempted to level off at the selected MCP altitude, which had remained at 1,000 ft (Figure 4 [B]). As it did so the A/T mode changed from go-around to a mode which maintains the speed of the aircraft at that moment. This resulted in the thrust levers beginning to reduce towards a lower power setting. As the aircraft was configured with Flap 15, the gear up and a low thrust setting, the gear warning horn sounded. For Flap 15 this requires a thrust lever angle of below approximately 20° and the horn cannot be silenced. In normal go-arounds the horn does not sound because the thrust levers are at a high setting (significantly more than 20°).

The crew adjusted the MCP altitude to the actual go-around altitude of 3,000 ft. Mode reversions of the AFDS in the B737-8 mean that this adjustment of the MCP altitude led the vertical mode to change from ALT AQ to V/S. The vertical speed set in the MCP became that which existed at the moment of mode engagement, which in the case of I-NEOT was a descent of -300 ft/min (Figure 4 [C]).

Although 3,000 ft was now set correctly, I-NEOT was descending in V/S mode with the PF following the flight director commands (Figure 4 [D]). The gear warning horn was still active as the A/T continued to manage the speed with the aircraft in the descent and the thrust lever angle below 20°. As the crew reduced the flap setting to Flap 5, further thrust was applied and the gear warning horn, which had operated for 27 seconds, stopped. This was followed by the EGPWS gear warning call "TOO LOW GEAR, TOO LOW GEAR" which was triggered as the aircraft passed 500 ft radio altitude descending (Figure 4 [E]). The aircraft descended for a further 2 seconds.

The crew realised that the aircraft was not climbing. The commander took control and pitched the aircraft to climb (Figure 4 [G]). As the aircraft began to climb, two further short instances of the gear warning horn were triggered (Figure 4 [F]). This coincided with ATC, noticing the aircraft position, transmitting "ALL STATIONS BRISTOL STANDBY". Eighteen seconds later, as the aircraft continued to climb, ATC transmitted "[CALLSIGN] CLIMB MAINTAIN ALTITUDE 3,000 FT QNH 1018".

As the aircraft began to climb away on the go-around track, the vertical mode was changed to LVL CHG, before ALT AQ engaged as the aircraft levelled off at 3,000 ft in accordance with the procedure. I-NEOT was then radar vectored to the south of the airport and onto another RNAV (GNSS) approach from which the aircraft landed without further incident.

During the go-around the crew noted that the message VNAV INVALID-PERF was shown in the FMC. VNAV INVALID–PERF is shown when there is an unhandled software exception error or unresolved decent path construction error. The crew were unable to engage VNAV for the subsequent approach, and the investigation was unable to establish the cause of this message.

Analysis

The incident began when the crew accepted a shortened routing offered by Bristol Approach. This meant the aircraft was above FL100 with less than 25 nm to run to touchdown. Whilst the trainee controller clearly had good intentions in offering the crew the routing, a more experienced controller might not have considered it appropriate given the speed and height of I-NEOT. However, it is the responsibility of the crew to accept or decline any shortcut offered having assessed whether it is suitable. It remains the prerogative of the crew to ask for extra track miles to touchdown any time they consider the current distance to be too short.

As a result of the shorter routing, I-NEOT had too little distance to descend and reduce speed ready for the approach. The speed of the aircraft over ELROV was 61 kt above the procedure limiting speed. As a result, the crew were unable to make use of the VNAV mode of the AFDS and the approach was begun in LVL CHG. Descending down the approach in LVL CHG meant the crew were unable to reset to go-around altitude as directed in the operator's procedures. Had they done so the aircraft would have climbed straight away because the autopilot was engaged.

I-NEOT did not meet the stable approach criteria laid out in the operator's Operations Manual and, in these circumstances, the operator's procedures required the crew to go around. However, the passing of the stable approach barrier went unmentioned by the crew and was followed shortly afterwards by ATC instructing them to go-around.

The instruction to I-NEOT to go-around was based on an instinctive reaction from the tower controller who considered that the aircraft was dangerously positioned in accordance with MATS Part 1. Whilst the crew were not expecting it and could not understand the reason for it, all crews must be prepared to perform a go-around at any time during an approach. In this event, the fact that the MCP altitude remained set at the approach minima rather than the missed approach altitude caused a significant deviation from a normal go-around with the aircraft descending, unnoticed by either crew member, for a significant period. The controller and the crew members realised almost simultaneously that there was a problem and the aircraft began to climb. During the initial go-around the aircraft descended below 500 ft agl.

The crew experienced a technical issue with VNAV after the go-around which meant they were unable to fly the second approach using this mode. However, this issue was not the cause of VNAV disconnecting at the start of the first approach. That was caused by the significant excess speed that the aircraft had at the start of the approach. Regardless of the reason for the disengagement, all crews should be aware that automatic modes will not always be operational and alternatives or reversions, should they be available, should be discussed before the approach begins.

Conclusion

Flying a shortened routing led to a rushed and unstable approach which did not follow the correct vertical flightpath. This was observed by ATC who instructed the aircraft to go around. The crew found themselves performing a go-around unexpectedly but did not know why they had been required to do so. The go-around was conducted with a mis-set altitude on the MCP, and neither crew member noticed for a significant period that the aircraft was descending during the manoeuvre.

Crews should always be ready to perform a go-around because there can be many reasons why they might have to, either internal or external to the aircraft, such as on instruction from ATC.

Safety actions/Recommendations

The aircraft operator took the following safety action:

- The ground recurrent training syllabus was changed to include stable approach criteria, a review of applicable rules and Flight Data Monitoring (FDM) statistics as well as a presentation of this event.

- The operator improved its FDM system to identify events such as this unstable approach and planned to continue development of the system to make the process easier and more rapid.

Published: 23 April 2020.

SERIOUS INCIDENT

Aircraft Type and Registration:	Boeing 747-436, G-BNLN
No & Type of Engines:	4 Rolls-Royce RB211-524G2-T-19 turbofan engines
Year of Manufacture:	1990
Date & Time (UTC):	9 June 2019 at 1559 hrs
Location:	In flight from London Heathrow Airport to Phoenix International Airport, USA
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 18 Passengers - 320
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	57 years
Commander's Flying Experience:	23,465 hours (of which 2,537 were on type) Last 90 days - 211 hours Last 28 days - 77 hours
Information Source:	AAIB Field Investigation

Synopsis

On reaching top of climb the aircraft experienced unreliable airspeed indications resulting in overspeed warnings and activation of the stall warning system. In recovering, the crew carried out the unreliable airspeed procedure but also carried out the stall warning procedure, which was not required.

The problem was believed to have been caused by a fault with the right Air Data Computer (ADC), although this could not be replicated.

As a result of this incident, the aircraft manufacturer is providing additional information as part of their published unreliable airspeed procedure. The aircraft operator is also reviewing its maintenance procedures due to the accidental erasure of fault codes on the right ADC as part of the post-incident inspection process.

History of the flight

The aircraft was on a scheduled flight from London to Phoenix, USA, with the commander and co-pilot being line-checked by a training captain, who occupied the jump seat. The aircraft took off at 1428 hrs with the co-pilot acting as pilot flying (PF). It had just reached the top of climb at FL330, with the right autopilot and autothrottle engaged, when the Master Warning activated. The crew reported that a line appeared through the Vertical Navigation (VNAV) path on the Flight Mode Annunciator (FMA) and that the Engine Indication and Crew Alerting System (EICAS) indicated a red overspeed warning, ALT disagree, IAS disagree, Rudder Ratio Single, Airspeed Low and Altitude Alert. The crew also reported feeling ear discomfort from a change in cabin air pressure.

The co-pilot recognised the airspeed had become unreliable, notifying the other two pilots before carrying out the recall drill. In doing so, he noted that the autothrottle had reduced thrust to 1.2 EPR before it was disengaged. He set a pitch of 4° nose-up and thrust of 80% N1, as required by the drill.

The crew declared a PAN with ATC and were cleared to remain on their current heading with a block altitude cleared for them to operate within. The commander and training captain then referred to the "Unreliable Airspeed Table" in the Quick Reference Handbook (QRH) from which they determined the required pitch attitude under the prevailing conditions was 3.5° nose-up and the required thrust setting was 87.5% N1.

While the datums were being agreed, and with the aircraft maintaining a pitch attitude of 4° nose-up and engine power setting of 80% N1, the stick shakers activated. The crew briefly discussed whether to maintain the 'Airspeed Unreliable' datums or carry out the stall recovery manoeuvre. They agreed that the stall recovery would be appropriate, and this was carried out by the co-pilot. He decreased the pitch attitude to 1° nose-down, at which point the stall warning ceased, which the crew considered confirmed their belief that the stall warning was genuine. He then slowly increased the pitch and engine power to the datums required in the QRH, however, as he did so the stall warning reoccurred, so the co-pilot reduced pitch again until the warning ceased. As the airspeed increased, the co-pilot gradually increased pitch, however the stick shaker activated once again, causing him to reduce the pitch angle until it stopped activating. He repeated this process several times until the QRH datums were finally attained and there were no further stick shaker activations.

The aircraft had lost about 2,800 ft during these manoeuvres. With the aircraft now stable, the crew completed the rest of the 'Airspeed Unreliable' checklist with the air data source being changed from the right to the centre Air Data Computer (ADC). This allowed the autopilot and autothrust to be re-engaged. The crew also contacted the operator's maintenance office by radio which was able to confirm, via the aircraft health monitoring system, that the right ADC had failed.

The crew and maintenance office both assured themselves that the aircraft was still able to comply with the Required Navigation Performance and Minimum Navigation Performance Specifications and, having done so, the flight continued to the destination with no further incidents.

Aircraft information

Following the incident, the aircraft flew a further five sectors in accordance with an Acceptable Deferred Defect (ADD) before the technical problem was fully addressed. System redundancy enabled continued operation to take place without compromising safety after the right ADC had been isolated and the centre ADC activated to function in its place (in conjunction with restrictions on low visibility operation). A series of rectification actions was proposed, including leak and drain checks on the relevant pitot-static systems, and replacement of the right ADC. These actions were carried out at the conclusion of the five sectors following the event.

The aircraft then flew a further eight sectors, with no subsequent problems encountered. Following these sectors, the aircraft was grounded and permanently removed from service.

Recorded information

The aircraft was equipped with a two-hour CVR, a 25-hour FDR and a Quick Access Recorder (QAR). The CVR and FDR recordings of the incident were not available as they had been overwritten, but data was available from the QAR.

Salient parameters included airspeed, Mach number and pressure altitude recorded from the left and right ADC. The QAR did not record the activation of the stall warning stick shakers when triggered by the right stall warning computer.

Interpretation of QAR data

The aircraft was configured with the autothrottle and right autopilot engaged, with the right ADC selected to provide data to the auto flight system.

Shortly after the aircraft reached the top of climb and levelled at FL330, data started to deviate between the left and right ADC (Point A, Figure 1). Over about 12 seconds, airspeed from the right ADC increased from 300 kt to 407 kt, whilst airspeed from the left ADC remained at 300 kt. In response to the increase in airspeed from the right ADC, the engine thrust was automatically reduced from 89% N1 (1.54 EPR) to 70% N1 (1.2 EPR) (Point B, Figure 1). Thus, whilst data from the right ADC indicated that the airspeed had increased and the aircraft had climbed, data from the left ADC showed that the aircraft's actual airspeed and altitude were gradually reducing due to the reduction in engine thrust.

The autothrottle and autopilot were then disconnected by the crew and the engine thrust manually increased from 70% to 80% N1 and the pitch set to approximately 4.5° nose-up (Points C, Figure 1). After a further 80 seconds, the airspeed from the left ADC stabilised at about 266 kt as the aircraft continued to gradually descend. During this period, airspeed and altitude from the right ADC had continued to deviate from the left ADC by as much as 122 kt and 500 ft.

The engine power was maintained at 80% and pitch at approximately 4.5° nose-up, but there were small variations in pitch consistent with hand flying the aircraft. After a further 90 seconds (Point D, Figure 1), there was a slight increase in pitch to just over 5° nose-up with a corresponding increase in angle of attack. The airspeed and Mach number were 266 kt / 0.73 Mach respectively from the left ADC and 340 kt / 0.92 Mach from the right ADC. At about this time (Point D, Figure 1) the stick shakers were activated by the right stall warning computer. When the flight crew carried out the stall recovery manoeuvre the pitch was reduced to about 0.5° nose-up and engine thrust increased to 87% N1 (1.5 EPR). The pitch was then gradually increased to 4° nose-up, during which the airspeed and altitude deviation between the left and right ADC reduced to approximately zero. The aircraft was subsequently levelled at FL293 where the air data source was changed and the autopilot and autothrottle re-engaged.

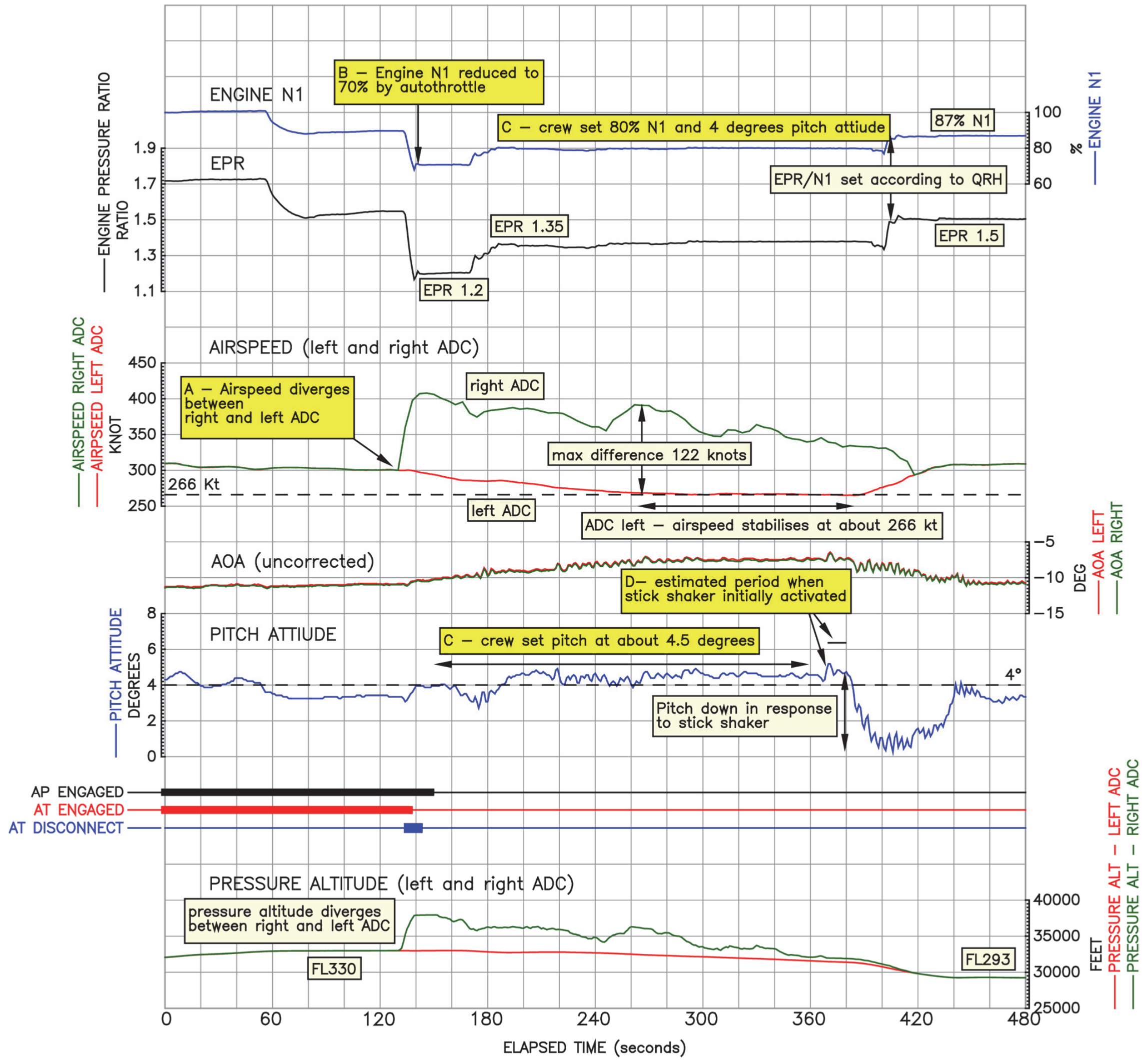

Figure 1

Discrepancy between the right and left ADC

Right Air Data Computer inspection

The removed right ADC unit was forwarded to the operator's avionics overhaul base for inspection. Unfortunately, the non-volatile memory incorporating fault codes was mistakenly erased from the unit as the first action. The unit was then subjected to a series of checks which did not reveal any abnormalities. It was subsequently forwarded to the manufacturer where extensive functional tests were carried out. Despite prolonged operation and testing, the unit did not exhibit any incorrect functioning.

The data plate on the relevant ADC indicated that a number of modifications had been incorporated, one of which was not amongst those applicable to this unit type. It was further determined that a non-mandatory modification, applicable to this ADC type and devised to overcome a previously identified periodic malfunction, had not been incorporated.

Stall warning, in the form of stick shaker operation, requires inputs of vane angle and Mach number to compute proximity to the stall and to operate the stick shake when a predetermined threshold is passed. If the malfunction which the non-incorporated modification was designed to address occurred, it would have resulted in an incorrect Mach number being supplied to the stall warning system. This would then cause the stall warning system to operate erroneously at a safe airspeed (ie a speed corresponding with a safe angle of attack).

Assessment of the recorded data suggested that the malfunction may have occurred on the incident flight.

Unreliable airspeed procedures

Boeing has developed a generic response to unreliable airspeed, the first step of which is to disconnect any related automation which may be reacting to the unreliable indications. This should be followed by setting memorised pitch attitude and thrust settings to stabilise the aircraft before refining these settings by reference to tabulated figures before determining which airspeed source is reliable. This will allow the aircraft to be appropriately re-configured and, where possible, automation to be re-selected.

This generic response has been used to develop the QRH drill for the 747-400 (Figure 2).

Analysis

No evidence was found to account for the initiation of the event sequence, but the sequence of events was consistent with a known fault mode of the model of ADC which was fitted to the aircraft, for which a modification was available but had not been incorporated.

The malfunction of the right ADC was not identified despite extensive functional testing. It is likely that the false warnings had been generated erroneously as a result of an incorrect Mach number being supplied by the right ADC. This would then also have caused the stall warning system to operate erroneously at a safe airspeed.

The identification of the recorded faults within the right ADC unit during the flight was not possible as the fault codes had been deleted after the unit had been received into the operator's avionics workshop.

The QRH procedure applicable at the time of the incident noted that 'overspeed warnings and AIRSPEED LOW alerts may occur erroneously or simultaneously'. Stall warnings were not mentioned specifically as the aircraft manufacturer considered that crews would understand this was included. It is apparent this was not however the case with the crew involved who considered they must react to the stall warning when it occurred. The AIRSPEED LOW alert is a specific warning and the crew considered that as the stall warning was not mentioned separately in the procedural note, operation of the stick shaker should not be considered erroneous. This seemed to be confirmed to them when the stick shaker operation ceased when pitch was reduced, as they would expect after a genuine stall warning. This highlights the importance of clear, unambiguous information being readily available to crews at times of high workload when dealing with potentially critical incidents. It also reinforces the need for crews to understand the protection afforded by adopting the pitch and power settings provided as part of the procedure.

BOEING 10.1

747-400 Flight Crew Operations Manual

IAS DISAGREE
or
Airspeed Unreliable

Condition: The airspeed or Mach indications are suspected to be unreliable. (Items which can indicate unreliable airspeed are listed in the Additional Information section.)

Objective: To identify a reliable airspeed indication, if possible, or to continue the flight using the Flight With Unreliable Airspeed table in the Performance Inflight chapter.

1 Autopilot disengage switch . . . . .Push

2 A/T ARM switch . . . . OFF

3 F/D switches (both) . . . . OFF

4 Set the following gear up pitch attitude and thrust:

Flaps extended . . . . 10° and 90% N1

Flaps up . . . . 4° and 80% N1

Note: Incorrect aileron lockout and yaw damper motion may occur. Avoid abrupt control inputs.

5 The following are **reliable**:

Attitude

N1

Ground Speed

Radio Altimeter

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747-400 version 10.1

10.2 BOEING

747-400 Flight Crew Operations Manual

Note: Overspeed warning and AIRSPEED LOW alerts may occur erroneously or simultaneously.

The Flight Path Vector and Pitch Limit Indicator may be unreliable.

6 Refer to the Flight with Unreliable Airspeed table in the Performance Inflight chapter and set the pitch attitude and thrust setting for the current airplane configuration and phase of flight.

7 When in trim and stabilized, cross check the PFD and standby airspeed indicators. An airspeed indication that differs by more than 30 knots or .03 mach from the airspeed shown in the table should be considered **unreliable**.

Author Note: Two ADC airplanes

8 Choose one:

◆**Reliable** airspeed **can** be determined:

►►**Go to step 9**

◆**Reliable** airspeed **cannot** be determined:

►►**Go to step 10**

Figure 2

Boeing 747-400 Unreliable Airspeed QRH Procedure

Safety Action

The aircraft manufacturer is planning to update the QRH procedure to specifically include stall warnings as part of the note. This update is due to be included in the block revision to the B747-400 FCOM in April 2020. They are also considering similar action with other relevant types.

Since the event, the operator has taken steps to identify the process shortcomings that permitted the loss of the fault codes to occur following arrival of the ADC in their avionics workshop. As a result, procedural changes are being introduced aimed at preventing future loss of troubleshooting and fault data that can assist incident investigations.

Published: 30 April 2020.

SERIOUS INCIDENT

Aircraft Type and Registration:	Bell 429 GlobalRanger, G-WLTS
No & Type of Engines:	2 Pratt and Whitney Canada PW207D1 turboshaft engines
Year of Manufacture:	2014 (Serial no: 57191)
Date & Time (UTC):	2 January 2019 at 1255 hrs
Location:	Melksham Airbase, Wiltshire
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 2 Passengers - None
Injuries	Crew - None Passengers - N/A
Nature of Damage:	None reported
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	49 years
Commander's Flying Experience:	3,890 hours (of which 360 were on type) Last 90 days - 8 hours Last 28 days - 4 hours
Information Source:	AAIB Field Investigation

Synopsis

The report considers two events which occurred while the pilot was conducting a Power Assurance Check. In one, an un-commanded yaw pedal movement caused a rapid rotation of the helicopter through two and a half complete rotations; in the other, a trim runaway was contained by the pilot. The trim runaway was found to be an unknown feature of the Automatic Flight Control System logic.

Following these events, safety action was taken by the helicopter manufacturer and Transport Canada to help crews respond to a yaw trim runaway and to address the underlying causal factor. Also, the flight recorder manufacturer improved the way it reported the results of CVR recording inspections.

Two Safety Recommendations are made: one to Transport Canada in relation to conduct of the Power Assurance Check; and one to the European Union Aviation Safety Agency to ensure that the installation of new equipment on aircraft does not have a detrimental effect on existing equipment.

History of the flight

This report refers to two separate events with the same helicopter, one on 15 June 2018 and one on 2 January 2019.

15 June 2018

G-WLTS had returned to base from a Helicopter Emergency Medical Service (HEMS) task at Redlands, near Swindon. It had been an uneventful flight and a visual approach was flown to the Final Approach and Takeoff (FATO) path followed by a hover taxi to dispersal and landing on a westerly heading. This was the first landing at the base that day, so the pilot planned to conduct a Power Assurance Check (PAC). The Rotorcraft Flight Manual (RFM) refers to both manual and automatic PACs. The operator used the automated PAC, with pilots recording figures manually to help monitor the engine performance trend.

The two technical crew on board were informed about the intent to conduct the PAC, so they vacated the helicopter and entered the operator's building next to the dispersal. Shortly afterwards, one of the technical crew walked to the edge of dispersal and stood in front of the helicopter, helmet still on, to provide safety and fire cover in accordance with the operator's Standard Operating Procedures (SOPs).

In preparation for the PAC, the pilot recalled setting the N_R to 100%, though flight data showed that it remained at 104%. The No 1 generator and the 'Trakka' searchlight power were selected off. At this point the pilot recalled adopting "the standard posture" for doing the PAC: "feet off pedals, knees up to make writing easier and hands guarding the cyclic and collective [controls]". The pilot used a 'chinagraph' pencil to record fuel figures (710 lbs) and landing time (2012 hrs[1]) onto the left knee board of the flying suit and intended to record PAC details in the same way. The pilot selected the PAC screen on the relevant Display Unit (DU), rotated the No 2 throttle to idle and raised the collective lever for the PAC. The data showed that, when the collective lever reached approximately 23% of its range of movement, it stopped for about three seconds during which time the N_R was set to 100% and the autopilots (AP) were both selected off. Just before the APs were selected off, a yaw out-of-detent condition occurred[2]. The collective was then raised to approximately 30% for the PAC. The chinagraph pencil was still in the pilot's right hand ready to record the PAC figures.

Early in the power check, the pilot heard a loud "clunk" or "crunch" from the right side of the helicopter just behind their seat, felt a "lurch" downwards to the right, and thought that the landing gear was collapsing on the right side. The helicopter yawed rapidly to the left, which the pilot described as "lurching" laterally and longitudinally while also bouncing up and down. The pilot's instinct was not to move the flying controls for fear of inducing a rollover. However, feeling very disorientated and realising that action was needed to try and contain the situation, the pilot lowered the collective lever and then tried to move the

Footnote

1 1912 hrs UTC.
2 See later section, *'Yaw trim actuator'*.

engine switches to CUT OFF. After some brief difficulties, both engines were shut down. The pilot applied the rotor brake and, after another approximately 180° of rotation, the helicopter came to rest. During the event the helicopter made two and a half rotations in approximately ten seconds.

2 January 2019

On 2 January 2019 the same pilot was preparing to conduct another PAC in the same helicopter. For this event, however, the pilot's feet remained on the pedals throughout. The pilot noticed unusual feedback forces in the pedals and endeavoured to record the event in as much detail as possible. The technical crew member in the left seat was able to make a short video. In this event, the pedals were trying to drive towards full scale deflection left and, although the pedal loads were significant, they were readily containable through foot pressure. The pilot depressed the FORCE TRIM release button[3] momentarily but this did not clear the out-of-detent condition which now existed or remove the feedback forces. A subsequent and longer press of the FORCE TRIM release button cleared the condition and removed the forces.

Recorded information

15 June 2018 event

Following the event on 15 June 2018, flight data from the combined recorder (ie a single flight recorder that combines the functions of the flight data recorder (FDR) and cockpit voice recorder (CVR)) was obtained by the operator, and a copy was subsequently given to the AAIB. The helicopter manufacturer analysed the data from the electronic data recorder (EDR) in the DUs which recorded the FDR data but at a lower sampling rate. The flight data for the event is plotted in Figure 1 and the key points are:

1. The collective was initially raised [A] with the AP engaged (in ATT mode).
2. The collective was held at about 23% of its range of movement for approximately 3 seconds [B].
3. Total torque (the No 2 engine was at idle, so all torque was from the No 1 engine) exceeds 30% [C].
4. During the three seconds the collective was held at about 23%, the pedals started to drift left [D], the pedal status changed to a yaw out-of-detent condition, the rotor speed reduced to 100% [E] (rpm switch on the collective), and the AP disengaged [F].
5. The yaw out-of-detent condition remained for approximately ten seconds during which time the pedals moved to the left by about 1.5% of their full range of movement.
6. The pedals then suddenly moved to left maximum deflection [G] in about one second.

Footnote

[3] See later section, *'Automatic flight control system'* and *Figure 5.*

7. The yaw out-of-detent condition cleared, and the collective was lowered [H] within one to two seconds of the pedal movement.

8. The helicopter made two and a half rotations to the left in approximately ten seconds [I] during which time both engines were shut down.

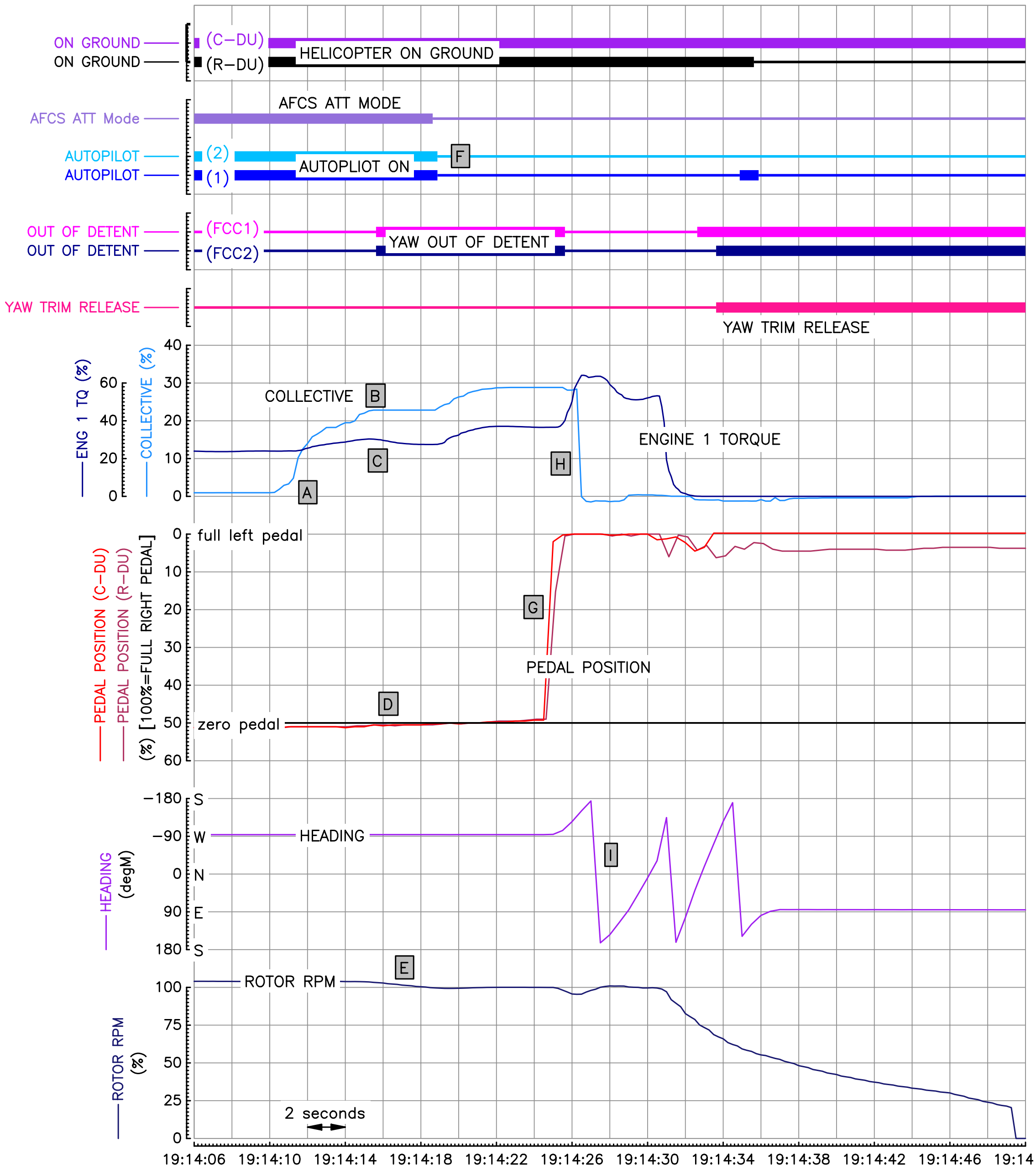

Figure 1

FDR data for 15 June 2018 event

2 January 2019 event

For the event on 2 January 2019, the combined recorder was removed from the helicopter and taken to the AAIB for download and analysis of the flight data and cockpit voice recordings.

The salient flight data for this event is plotted in Figure 2.

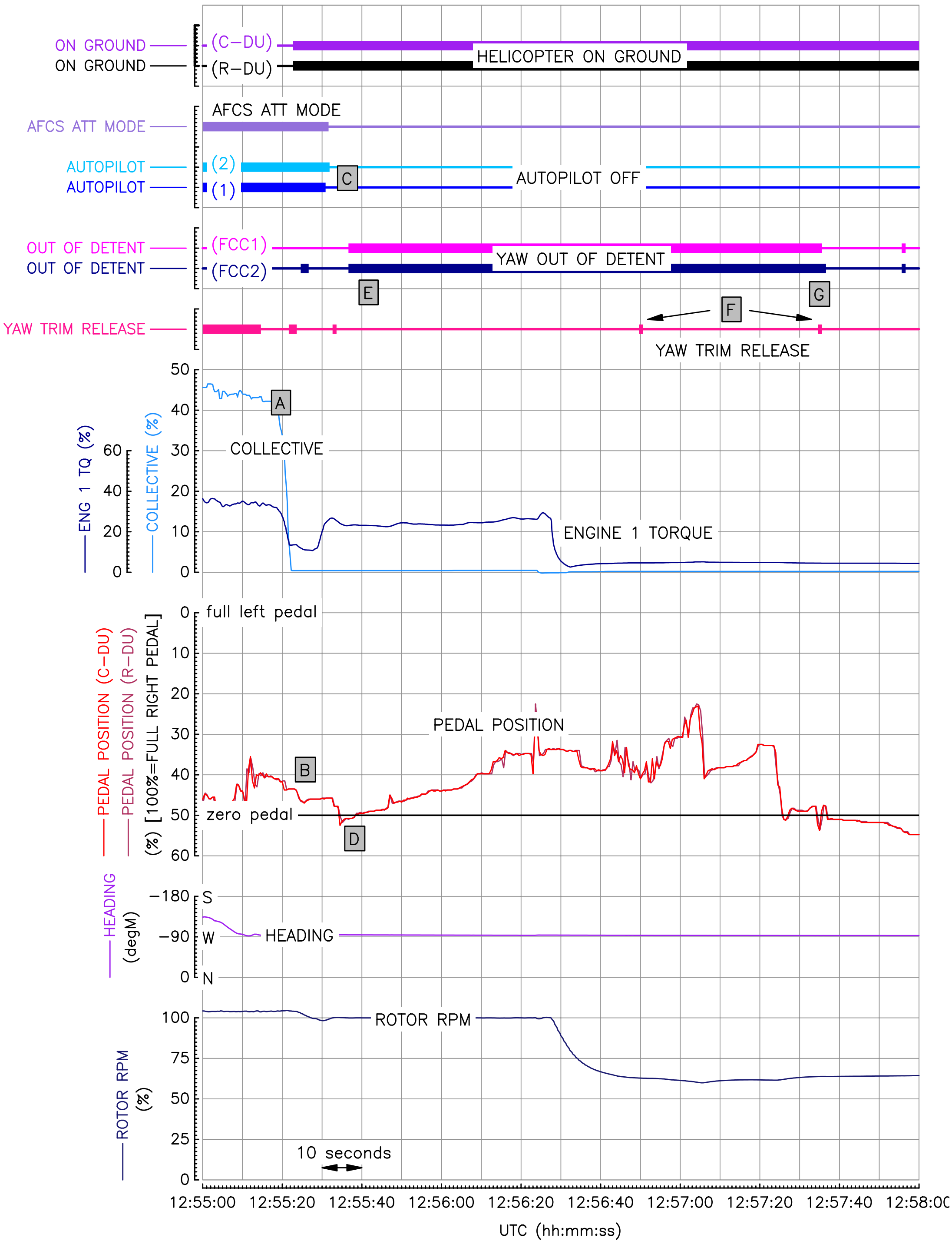

Figure 2

FDR data for 2 January 2019 event

The key points shown in Figure 2 are:

1. The collective was lowered on touchdown [A].
2. A little left pedal input was made and held [B] as the AP was disengaged [C] ten seconds after touchdown.
3. A very brief right pedal input was made [D] before the pedals moved left and a yaw out-of-detent condition was detected [E].
4. The yaw out-of-detent condition remained active for nearly two minutes during which the TRIM RELEASE button was pressed on at least two distinct occasions [F].

   Note: the sampling of the TRIM RELEASE is once every second so these button presses could have been anything from a single press of up to just under two seconds in duration, or multiple presses over the same period. Equally, unless the sampling occurs when the button is depressed, transient presses during any one second will not be recorded.
5. The yaw out-of-detent condition cleared after the second of the TRIM RELEASE button presses [G].

CVR recording issues

When listening to the CVR recordings for the January 2019 event, audio clipping was heard on both crew channels when the crew were speaking. Audio clipping is a form of waveform distortion where the amplitude of the signal waveform has been limited; for speech signals, this can affect the intelligibility[4]. No clipping during flight was evident on the cockpit area microphone (CAM) channel. Figure 3 shows the signal waveforms for the three channels for the two-hour duration of the CVR recording.

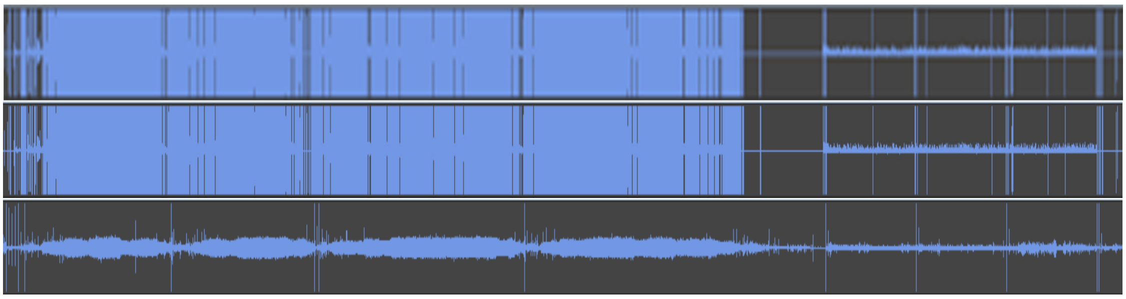

Figure 3

Signal waveforms for the three channels of CVR recording showing the two clipped crew channels (top and middle) and the CAM channel (bottom)

Footnote

[4] Clipping caused by overloading an audio channel reduces the perception of the recorded quality. Provided the clipping is of speech without significant background noise the intelligibility of speech is hardly affected. If the clipping is severe and occurs after speech is mixed with significant noise, and the speech-to-noise ratio is low, the intelligibility can be severely reduced. Therefore, clipping should be minimised as far as possible to maintain good audio quality.

Inspection of flight recorder recordings

Annex IV (Part-CAT) to Commission Regulation (EU) No 965/2012 for the implementing rule CAT.GEN.MPA.195 on the preservation, production and use of flight recordings requires:

> '*(b) The operator shall conduct operational checks and evaluations of flight data recorder (FDR) recordings, cockpit voice recorder (CVR) recordings and data link recordings to ensure the continued serviceability of the recorders.*'

The corresponding Acceptable Means of Compliance (AMC) and Guidance Material (GM) to Annex IV – Part-CAT (February 2016) states that for solid state flight recorders:

> '*…and the flight recorder system is fitted with continuous monitoring for proper operation, the time interval between two inspections of the recording may be up to two years.*'

This was reflected in the flight recorder manufacturer's periodic maintenance requirements for the flight recorder in that a maximum interval of 24 months was specified between inspections of the CVR and FDR recordings. For the inspection of the CVR recording, the action was to '*Replay and evaluate the quality of the in-flight recording*' and, for the FDR recording, to '*Check all mandatory parameters are active and are acceptable quality*'.

For G-WLTS, the operator was using the flight recorder manufacturer to perform these operational and maintenance tasks, which were carried out annually and resulted in a data analysis report being issued. For the CVR, the report was just a statement saying what had been done and found. For the FDR, a similar statement was issued together with a list of the parameters recorded and a plot of them for the 25-hour duration of the recording. The assessment of the CVR recordings was made by listening to extracts. No visual examination of the signal waveforms was made even though the manufacturer's software used to analyse the flight recorder recordings could facilitate this.

CVR recording inspection findings

From 2015, inspections were carried out on 27 August 2015, 24 August 2016, 3 July 2017, 17 July 2018, and 8 January 2019 following the 2 January 2019 event. For each of these five inspections (shared between three different engineers), the report stated that for the CVR recordings '*All channels were found to be clear and intelligible with no trace of distortion*'.

Bell 429 cockpit audio controller

The cockpit audio controller fitted to the Bell 429 has outputs connected directly to the CVR for the crew audio to be recorded. For the original audio controller fitted to the Bell 429 (as installed on first delivery of the helicopter), the signal levels being presented to the CVR would have been evaluated during testing to ensure they complied with the input requirements of the CVR.

Terrestrial Trunked Radio (TETRA)[5]

In May 2015, G-WLTS was fitted with a TETRA communications system that required the original audio controller to be replaced by a third-party system to enable integration with the TETRA 'tactical' radios being fitted. The EASA Part 21 Subpart J approved Supplemental Type Certificate (STC) holder for this work classed the change as minor[6] and made under the privileges of an EASA DOA (Design Organisation Approval).

The design change instruction sheet created by the STC holder, which described each of the tasks to be performed for the change, made no reference to the CVR system. For the system function checks it stated that they were to be done in accordance with a document entitled '*Instructions for Continued Airworthiness*' which itself did not list any checks. Tests were, however, made to verify that there were '*no negative impacts on the operation or performance of the existing and installed aircraft systems due to mutual electro-magnetic effects between systems*' (ie EMC/EMI[7] tests).

The *Instructions for Continued Airworthiness* referenced the installation and operation manual for the new audio controller being fitted, which stated that:

> *'The unit is shipped from the factory with all internal adjustments set to the normal test levels. Once installed in the aircraft, it may be desirable to change some of the settings to best suit the local operating environment. The internal adjustments* [trimpots] *are located on the sides of the unit …* [and] *are used to adjust the levels of the audio in the user's headphones.'*

On inspection after the January 2019 event, the trimpots were found at the factory-set levels.

Following the August 2015 flight recorder inspection, a copy of the report (stating that for the CVR '*All channels were found to be clear and intelligible with no trace of distortion*') was provided to the STC holder.

EASA guidance material for Minor Changes

EASA Certification Specifications and Acceptable Means of Compliance for Large Aeroplanes (CS-25) and for Large Rotorcraft (CS-29) both state (in paragraphs CS 25.1353 and CS 29.1353 respectively) that for electrical equipment and installations:

> *'Electrical equipment and controls must be installed so that operation of any one unit or system of units will not adversely affect the simultaneous operation of any other electrical unit or system essential to the safe operation. Any*

Footnote

5 TETRA is a one-to-many communication radio system with centralised call control so that priority calls can be put through and other calls queued. Features like this make it ideal for use by emergency services.

6 A 'minor change' is one that has no appreciable effect on the mass, balance, structural strength, reliability, operational characteristics, noise, fuel venting, exhaust emission, operational suitability data or other characteristics affecting the airworthiness of the product.

7 EMC – Electromagnetic Compatibility. EMI – Electromagnetic Interference.

electrical interference likely to be present in the aeroplane must not result in hazardous effects upon the aeroplane or its systems except under extremely remote conditions. (See AMC 25.1353 (a).)'

However, AMC 25.1353 refers to '*possible sources of interference'* due to EMC/EMI rather than to equipment that share an interface across which, for example, information is shared. Also, equivalent paragraphs do not exist for Small Rotorcraft (CS-27)[8] applicable at the time when the TETRA was fitted[9].

For applicants who are not DOA holders the minor change (and repair) certification process is managed through EASA and a 'Minor Change/Repair Design Approval' that states in the conditions that:

'Prior to installation of this repair it must be determined that the interrelationship between this repair and any previously installed modification and/or repair will introduce no adverse effect upon the airworthiness of the product.'

Again, this does not specifically identify equipment that share an interface (and information), and it only refers to previously installed modifications and not original equipment.

EASA document *Minor Change Certificate Document*[10] provides guidance that is intended to assist applicants in '*having a more uniform methodology for Minor Changes*'. It is directed specifically to applicants making changes to GA aircraft (and especially those who are not DOA holders). Part 1 of this document covers the description of the change and states in Section 1.3 that:

'If the newly installed equipment is interfaced with other existing equipment on the A/C a description or list/schematic should be provided.'

Part 14 ('*Other possible impacted areas*') then goes on to say:

'Include here the description and reference to other areas where it is believed to have an impact (in line with the interfaces identified in Section 1.3).'

No such guidance exists for changes to CAT aircraft.

Footnote

8 G-WLTS was (predominately) certified to the requirements of Canadian Airworthiness Manual Chapter 527 so the equivalent EASA airworthiness code CS-27 would apply (see next section 'Helicopter information').

9 CS-27 amendment 4 (30 November 2016) has since introduced paragraphs CS 27.1316 (Electrical and electronic system lightning protection) and CS 27.1317 (High-intensity Radiated Fields (HIRF) protection).

10 https://www.easa.europa.eu/download/general-aviation/documents-guidance-and-examples/Minor%20Change%20Certification%20Guidance%20Document%20-%2017.02.16%20-%20v1.docx. (accessed on 6 April 2020).

Helicopter information

The Bell 429 is an eight-seat, twin-engine, Category A, single pilot IFR certified helicopter. The type is predominantly certified to the requirements of Canadian Airworthiness Manual Chapter 527, which defines the specification requirements for Normal category rotorcraft with maximum weights of 7,000 lb (3,175 kg) and up to nine passenger seats. Where necessary for Category A operations, the helicopter was certified to the appropriate paragraphs of Airworthiness Manual Chapter 529, which defines the requirements for Transport category rotorcraft. The equivalent specifications in Europe are CS-27 and CS-29 respectively.

G-WLTS was manufactured in 2014 and is configured for HEMS operations.

Flying controls

The flying controls use conventional mechanical controls that are hydraulically boosted. The boosted controls are powered by four hydraulic servo actuators. Each servo actuator is pressurised by two independent hydraulic systems.

Automatic Flight Control System

The helicopter has an integrated avionics system, which includes DUs a dual digital Automatic Flight Control System (AFCS), and a 3-axis Stability and Control Augmentation System (SCAS).

Two APs reside as independent functions inside two identical, interchangeable Flight Control Computers (FCCs). The APs are engaged and disengaged by depressing their respective pushbuttons on the AP control panel (Figure 4).

Figure 4

Autopilot control panel

The APs can be engaged in two modes of operation using a pushbutton on the AP control panel:

1. Stability and Control Augmentation System (SCAS) mode uses high speed actuators (known as series or SCAS actuators) to improve flight characteristics by adding corrections into the control inputs. SCAS improves helicopter dynamic stability, including stability in windy conditions. SCAS is intended for use where extensive helicopter manoeuvring is required and the pilot wishes to be hands-on without attitude retention mode (see below). When the helicopter is on the ground, SCAS operation is suspended.

2. Attitude retention (ATT) mode maintains helicopter pitch and roll attitude to references that are stored at the time of engagement. If ATT is engaged, the helicopter will return to the previously set attitude after a disturbance with the pilot's hands off the controls. The references are reset to the current condition whenever the cyclic TRIM RELEASE button is pressed and released. In addition, the references can be adjusted using the cyclic trim beep switch. Heading hold and turn coordination are automatic functions that are active when ATT mode is engaged. At speeds less than 40 kt and until the helicopter exceeds 45 kt, current heading is held by the AP using pedal input. If the yaw trim beep switch is operated when ATT mode is engaged, the trim command 'beeps' the internal heading reference, which results in the AP manipulating the pedals to achieve and then hold the new heading reference. This, and the other, AP functions are inhibited when the AFCS is in the 'on-ground' state because when the helicopter is on the ground the airframe cannot move as it would in the air.

The AFCS will transition from 'on-ground' to 'in-flight' if the total torque (the sum of each individual engine torque) exceeds 30%. This transition will occur irrespective of the weight-on-ground switch status, and the AFCS will remain 'in-flight' until the total torque decreases through 25% and the weight-on-ground switches indicate 'on-ground'. This function is a safety feature of the AFCS and is not described in the manuals or taught to pilots. The use of torque to establish flight status is designed to mitigate an erroneous indication of weight-on-ground to the FCC. The threshold is set sufficiently above the minimum on-ground torque to ensure that the AP is disabled when it should be, but low enough to ensure that the AP remains active in low-torque conditions in flight. The on-ground hazard is mitigated by limiting the use of the AP during ground operation. The '*AFCS Limitations'* chapter in the RFM states that '*AFCS shall be disengaged or operated in SCAS mode during prolonged ground operation, except as required for AFCS check.*' The normal procedures chapter states that the AFCS should be selected to SCAS after landing.

Force trim

The force trim system uses spring force to hold the cockpit controls in a set (detent) position. The force is generated by torsional spring (artificial feel) mechanisms in the trim actuators. The detent can be moved anywhere in the control range by releasing the flight control from the spring mechanism and re-engaging it in a different position, or by driving it to a new position using the trim actuator (beep trimming). The flight control is released from the spring mechanism when the pilot presses (and holds) the TRIM RELEASE button on the cyclic stick top. The yaw trim beep switch is on the collective lever and the pitch and roll trim switch is on the cyclic stick top (Figure 5).

Force trim can be turned on and off by pressing a pushbutton on the AP control panel.

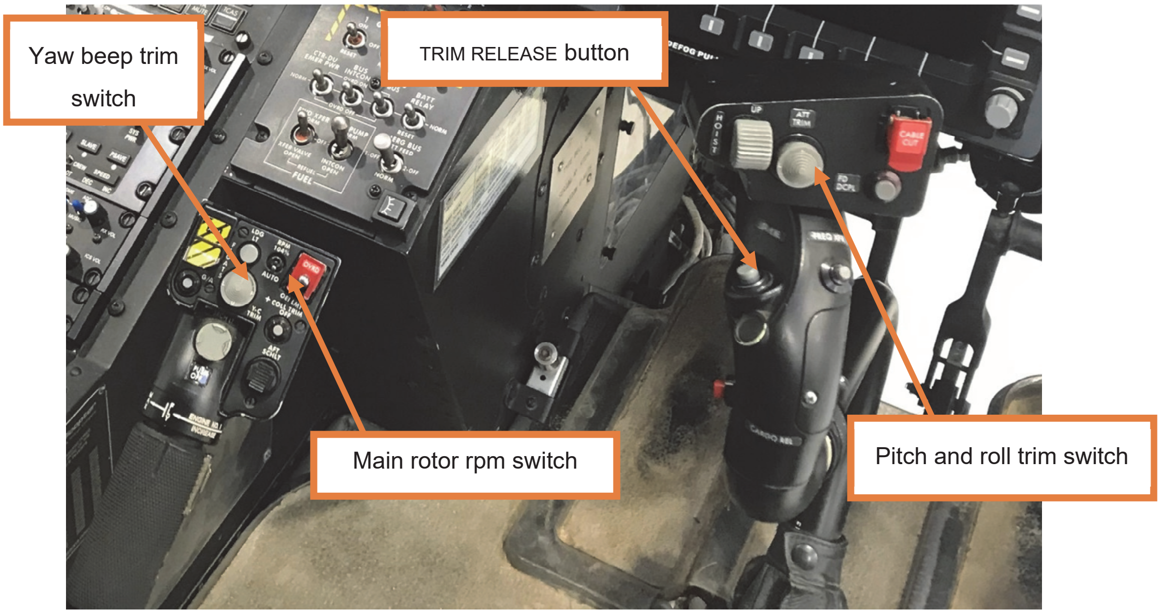

Figure 5

TRIM RELEASE, beep trim and rotor rpm switches

The AFCS and force trim system has a 'fly-through' AP capability. If the pilot makes overriding control inputs, the trim actuator is forced out of the detent position and the AP suspends operation of the associated actuator until the controls return to the detent position.

Directional control system

The tail rotor directional control system allows pitch adjustment of the tail rotor blades for yaw control. Pilot inputs are achieved using two sets of adjustable pedals that are mechanically linked through a torque tube assembly. A push-pull cable connects the torque tube output to the input of two SCAS actuators connected in series in the aft fuselage. The SCAS actuators have a limited range of movement and each actuator is controlled by one FCC. If the respective AP is turned off, the corresponding actuator behaves as a fixed length mechanical control rod. The output from the SCAS actuators is connected to the input of the hydraulic servo actuator that drives the tail rotor pitch change mechanism.

Yaw trim actuator

The yaw trim actuator is controlled by the AFCS and its output lever is connected to the pedal torque tube (Figure 6).

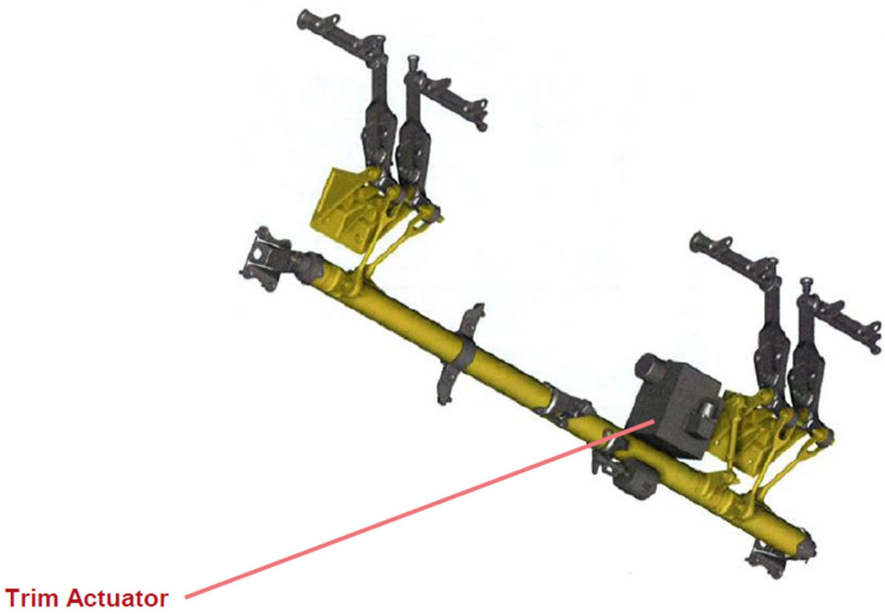

Figure 6

Trim actuator position with respect to the pedals

The actuator comprises an irreversible electric motor assembly that is connected to a preloaded torsion spring (artificial feel force unit) via a clutch and damper. The clutch is engaged when electrically energised and disengaged by pressing the TRIM RELEASE button, which releases the spring from the motor. The output from the spring is connected to the trim actuator output shaft. An electrical microswitch on the spring assembly changes state if the spring is deflected into an out-of-detent condition. This happens if the pedals are moved by the pilot, or if the pedals are prevented from moving when the trim actuator is operated. A Rotary Variable Differential Transformer (RVDT) measures the position of the actuator output lever, which is mechanically linked to the pedals. The FDR uses the output from the RVDT to record the pedal position.

Automatic pedal trim

<u>Description</u>

The yaw axis has an automatic pedal trim function that automatically adjusts yaw trim to match the pedal position during low speed flight. If the trim position matches the pedal position, the pedals are 'in detent'. The function allows the pilot to adjust the pedal trim without using the cyclic TRIM RELEASE or manual beep trim.

Automatic pedal trim is operational when the following conditions exist:

1. Force trim is ON.
2. Airspeed is below 40 to 45 KIAS (turn co-ordination speed).
3. Helicopter heading is stabilised (absolute yaw rate <4°/s second).
4. The pedals have been out of the trimmed (detent) position for >1 second and remain in an out-of-detent condition.

Automatic pedal trim is independent of the AP status and it remains operational on the ground if force trim is ON. This aspect was not mentioned in the RFM or the Integrated Avionics Manual (IAM) and, in July 2019, the helicopter manufacturer amended the latter to include a note about it.

Normal operation

If the pilot makes an input using the pedals, the spring in the trim actuator will deflect. The detent microswitch will change state and an out-of-detent condition will be detected. If the pedals are out-of-detent, a small yellow 'Y' is displayed in the trim status box in the upper right corner of the pilot's DU (Figure 7). Changes in the detent status indication are not accompanied by an audible tone or any other attention getting features, and the pilot's attention was not drawn to the indicator in either incident on G-WLTS.

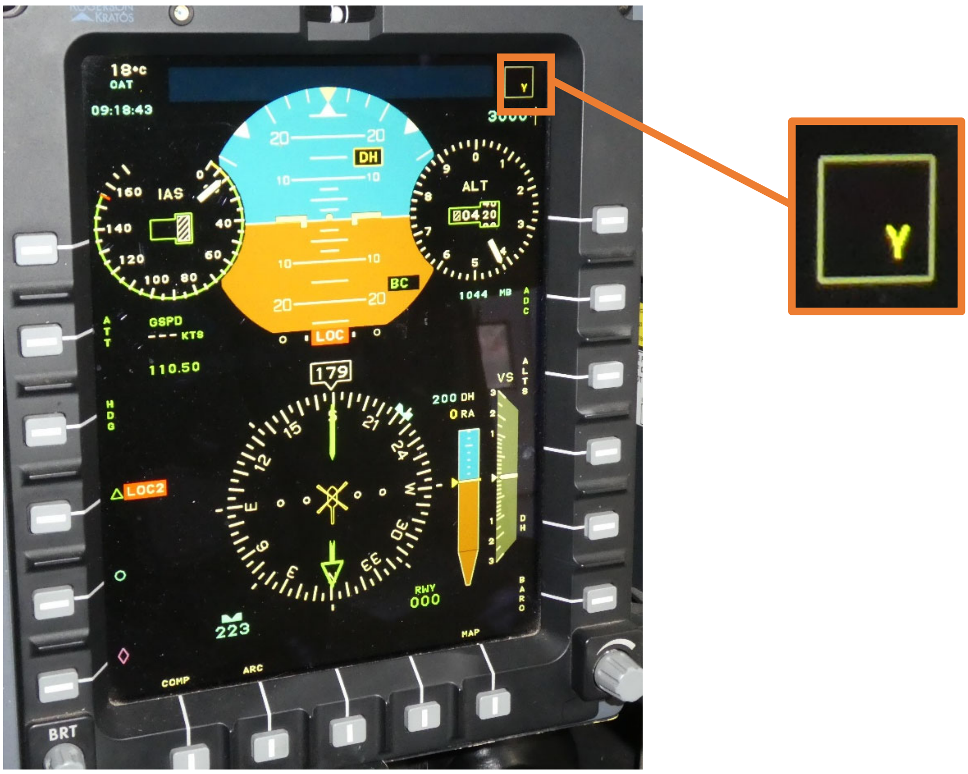

Figure 7

Yaw out-of-detent indication

The AFCS uses the trim actuator RVDT to establish the direction of pedal movement and attempts to restore the detent condition by driving the trim actuator accordingly. The AFCS drives the actuator until the microswitch indicates that the pedals are in detent or the system 'times out' after two minutes of operation. If this occurs, an amber AUTOTRIM warning illuminates in the cockpit.

Automatic pedal trim can be interrupted by:

1. Pressing the TRIM RELEASE button. This releases the spring mechanism and restores the detent condition in the current pedal position.
2. Operating the yaw beep trim. This stops the automatic pedal trim function on the assumption that the pilot will continue to beep-trim the pedals to the desired position.

Normal operation of the automatic pedal trim feature is depicted in Figure 8.

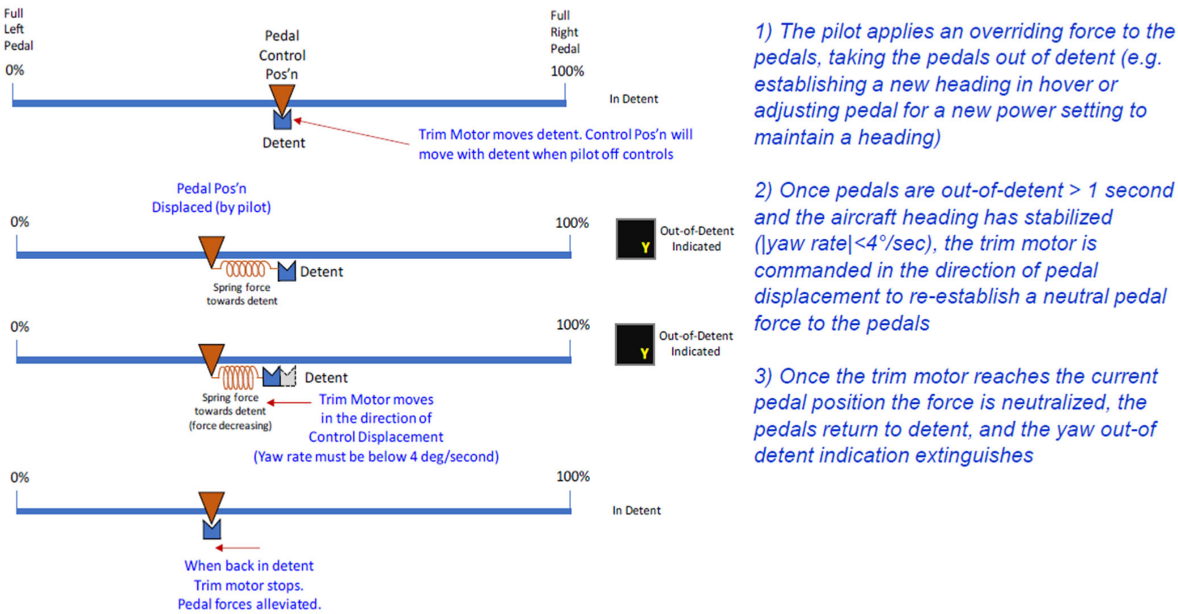

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Figure 8

Normal automatic pedal trim operation

Power Assurance Check

The PAC is referred to in both the RFM and the IAM, although neither document gives a complete explanation of, or defines, the PAC as part of normal procedures. The Category A Supplement to the RFM places the PAC before takeoff in the Normal Procedures.

The IAM describes that the PAC is part of the daily safety routine and verifies proper operation of the engines. The Performance chapter in the RFM briefly outlines two methods for undertaking the check depending on whether the helicopter is in the hover or on the ground. The manual does not contain a definitive procedure for either check and it does not define an AP or AFCS configuration. The Category A supplement to the RFM includes a requirement to carry out a PAC as part of the normal procedures prior to every flight.

If the check is performed in the hover, the pilot must record several parameters to manually derive engine performance using charts in the flight manual.

If the check is performed on the ground, an automated power assurance page on the DU can be used. Engine performance is derived automatically and the results of the last 100 checks are stored electronically. Irrespective of this, however, the flight manual still requires the pilot to record several parameters.

Section 7 of the Bell 429 Integrated Avionics Manual contains a description of the automated power assurance calculations, including a procedure for undertaking the PAC. The procedure is preceded by a warning note that:

> *'UNDER SOME CONDITIONS, IT IS POSSIBLE FOR THE HELICOPTER TO BECOME AIRBORNE WHILE PERFORMING A POWER ASSURANCE CHECK. CARE MUST BE TAKEN TO ANTICIPATE POSSIBLE HOVER FLIGHT CONDITIONS.'*

Helicopter examination

June 2018 – the first incident

The AAIB did not investigate the initial incident and the operator sought assistance from the helicopter manufacturer. Functional checks on the helicopter identified no anomalies.

The manufacturer reviewed information from the EDR in the DUs, which showed a rapid pedal movement immediately before the loss of control. The AP was not engaged when the pedal movement occurred, and the rate of movement exceeded the capability of the SCAS or trim actuators. The pilot's feet were reported to have been off the pedals, so the tail rotor hydraulic actuator was suspected to have 'runaway' to full deflection. The unit was removed for further investigation and hydraulic fluid samples were taken from the helicopter. No faults were found.

The manufacturer wrote to the operator to provide assurance that the design of the tail rotor hydraulic actuator was such that, if the pilot's feet were on the pedals, the pilot would be able to overcome the pedal forces generated by a failure in the main control valve. The manufacturer stated that if the AP was off, the force to stop pedal movement or to hold pedal position would be 20.5 lb and the force to reverse the direction of pedal movement would be 29.5 lb. The operator is understood to have issued guidance that its pilots should guard the pedals whilst carrying out a PAC. Flying operations of G-WLTS resumed after the helicopter had been checked by one of the manufacturer's test pilots.

January 2019 – the second incident

Initial tests

Functional checks of the yaw control system found no anomalies. The control friction and break-out forces were checked, and the left pedal friction was below the minimum allowable limit. This would not have accounted for, or contributed to, the events under investigation. The pedal friction was adjusted to bring it back into the allowable range.

Tests conducted by the AAIB found that the pedals took approximately nine seconds to travel from neutral to full deflection when they were trimmed using the yaw beep trim. The incident pilot assessed the force that was apparent at the pedals and stated that it was much less than the force experienced during the second incident.

Further tests

Additional tests were carried out after the recorded data from both incidents had been reviewed by the manufacturer and the AAIB. These tests identified a set of conditions where it was possible to induce a yaw trim runaway on G-WLTS. If the pedals were displaced away from the detent but reversed before the automatic trim had established a new detent, the AFCS would continue to drive the trim motor in the direction of the initial pedal movement. If the pedals were prevented from moving, the artificial feel spring 'wound up' and the force at the pedals increased. Testing found that when a maximum force of 40 to 60 lb occurred, the trim actuator clutch started to slip. The out-of-detent indication was displayed on the pilot's DU and the increased force at the pedals remained apparent until either of the following two events occurred:

1. The pedals were released. This allowed the spring to 'unwind' rapidly, driving the pedals to a new position. The out-of-detent indication cleared when the spring relaxed, and the pedals entered the detent position.
2. The TRIM RELEASE button on the cyclic stick top was pressed and held. This disengaged the trim actuator clutch, allowing the spring to 'unwind' without driving the pedals. The speed at which the spring unwound was limited by the friction damper in the trim actuator, and the TRIM RELEASE button had to be pressed and held until the force was no longer apparent.

The manufacturer recreated the runaway scenario on another Bell 429 helicopter and, after reviewing the design, concluded that it was a feature of the AFCS logic (Figure 9).

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Figure 9

Automatic pedal trim runaway scenario

Additional analysis of the system logic identified another scenario that could occur if the pedals changed direction within 80 ms of initially being displaced. This would result in the AFCS detecting an out-of-detent condition but capturing the wrong direction of pedal movement. If the pedals were subsequently held in a very narrow range, automatic trim would attempt to drive the pedals in the wrong direction and the force at the pilot's feet would increase. The manufacturer was able to induce this scenario on a test platform but was unable to recreate it on a helicopter (Figure 10).

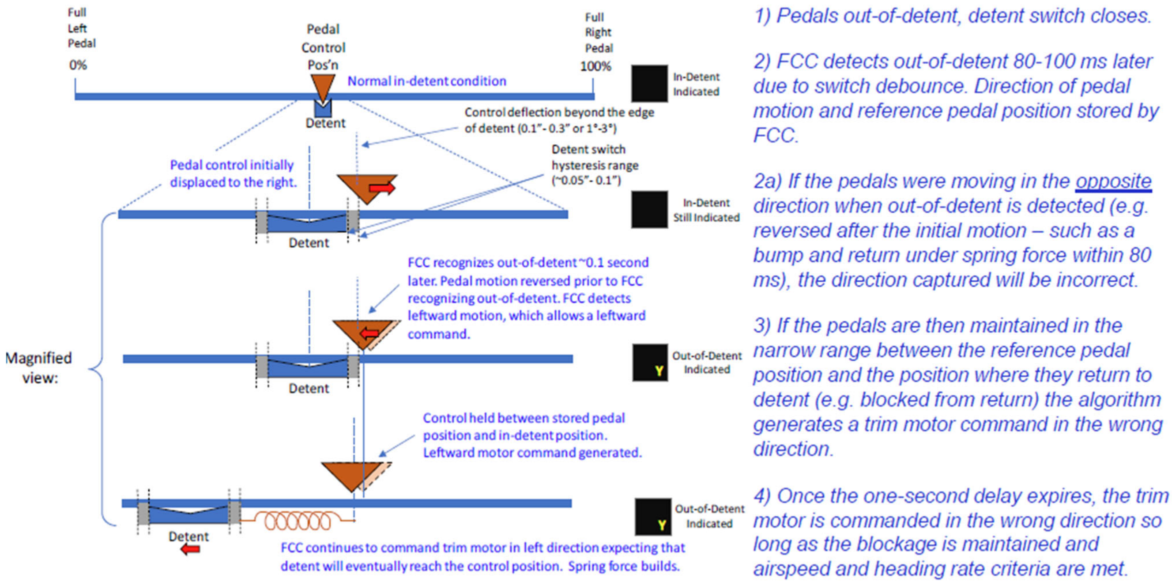

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Figure 10

Theoretical pedal trim runaway scenario

Trim actuator

The trim actuator was removed from the helicopter and returned to the manufacturer for testing and disassembly under the supervision of the AAIB and the helicopter manufacturer. The unit was disassembled and there was no evidence of foreign objects, excessive wear or a jam condition.

Automatic pedal trim runaway

Functional hazard assessment review

The manufacturer reviewed the Functional Hazard Assessment (FHA) that supported the original helicopter certification. There were two failure conditions with similar effects to the runaway scenario that was identified during the investigation:

1. A '*single axis slow over'* can result from a stuck beep trim switch. The failure condition was classified as minor because the '*crew will detect rotorcraft response, by monitoring flight instruments, and take control*'.

2. An '*auto trim runaway'* caused by a failure within the FCC. The failure will result in the trim actuator moving at its maximum rate of travel (normal commanded trim rates are limited to 75% of the full rate). This hazard was classified as minor because the '*crew will detect rotorcraft response and take control'*.

The assessment of both failure conditions was based on airborne IFR operations with the pilot's feet off the pedals because the manufacturer considered this was the most severe case for both conditions. The FHA did not consider the possibility of the failures occurring with an additional fault condition, such as a restriction of the controls during the runaway which is then released. The helicopter manufacturer stated that for ground operation at 100% rpm, they would '*expect the pilot to be on, or closely guarding the controls'*.

Rotorcraft flight manual amendment

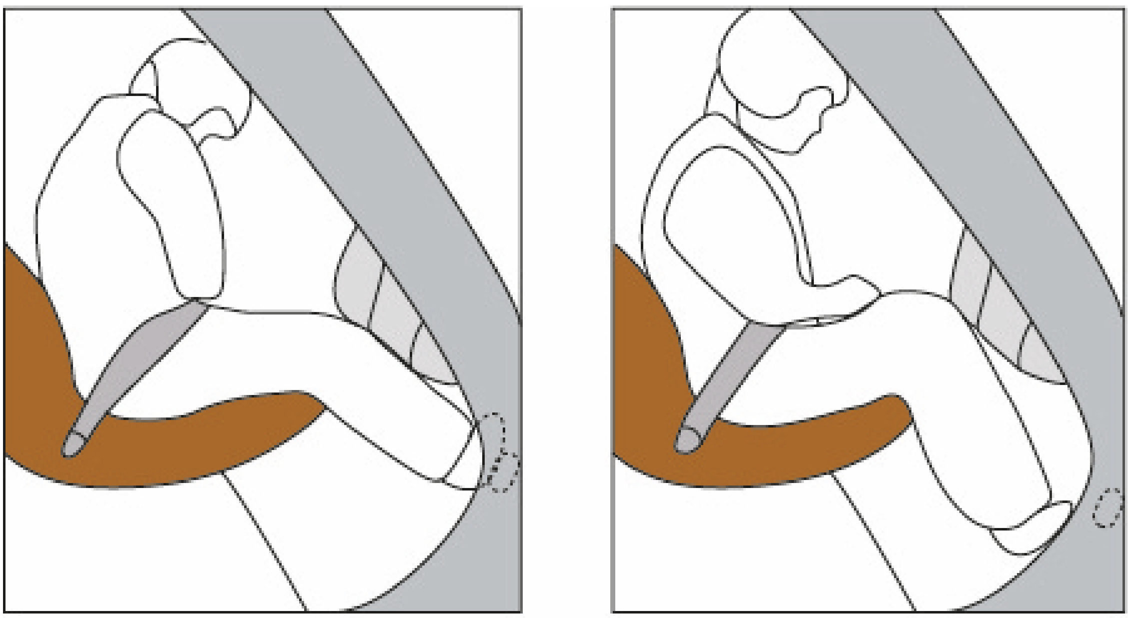
In April 2019, the helicopter manufacturer published a revision to the RFM to reduce the risk of a trim runaway and to provide procedures for responding to a runaway so that control of the helicopter would be maintained.

State of Design Authority assessment

Transport Canada reviewed the investigation findings and assessed the RFM amendment. They agreed that the changes would reduce the level of risk but indicated that the preferred long-term course of action would be to '*change the design of the AFCS to eliminate the potential for force trim (yaw) runaway*'. Emergency Airworthiness Directive CF-2019-16 was issued in May 2019, mandating the incorporation of the RFM amendment and that all flight crews be advised of the changes. The helicopter manufacturer recorded a problem report (PR) against their FCC software and indicated that they would develop enhancements to the automatic pedal trim function in a future revision of the software.

Pilot posture during the power assurance check in June 2018

The pilot of G-WLTS did not think the helicopter would become light on its skids or lift off during a PAC, and several of the operator's pilots stated it was common practice to do the PAC with their feet off the pedals. The pilot was right handed and used a chinagraph pencil to record the necessary figures onto the flying suit's left kneepad (to avoid the writing being rubbed off while flying). The pilot found it more comfortable to do this with feet off the pedals. Figure 11 is a diagram created by tracing the pilot's outline from photographs when performing this task with feet on and off the pedals of G-WLTS. It shows that having feet off the pedals resulted in a more aligned posture with less twist and tilt of the head. In either case, however, the pilot would have been looking down into the cockpit while writing meaning their head would have been tilted in relation to the axis of the yawing movement.



Feet on pedals
Note: awkward posture,
twist and tilt of head

Feet off pedals
Note: more comfortable posture,
head still tilted

Figure 11

Pilot body posture while writing with feet on and off the pedals

Prior to this incident, the pilot had not received training or discussed the possibility of any situation that would result in a rapid, un-demanded yaw on the ground. The pilot reported a sensation of rolling when the helicopter started to yaw on the ground and initially concluded that the helicopter landing gear had collapsed on the right side, having heard about another type of helicopter that was susceptible to landing gear collapse. The pilot reported that the forces experienced during the rotation affected the speed and accuracy with which the engine fuel could be cut off.

Organisational information

When the events occurred, the operator was operating under the provisions of a third-party Air Operator's Certificate (AOC). The operator emailed its flight crew with additional advice on the conduct of the PAC, but the email was not recorded as a formal event in its Safety Management System (SMS) and none of the operator's documents were changed to reflect the new advice.

The operator's intention was to operate to Category A Performance Standards, which requires the helicopter to be operated under the terms of the Category A Supplement to the RFM. The Supplement requires a PAC to be conducted prior to each take off. The operator preferred to conduct the PAC at the conclusion of the first flight back into its operating base each day because the emergency response nature of its operations meant that the helicopter did not fly every day.

The unit only had one paper copy of the RFM and that was carried in the helicopter. At the time of the event, none of the unit's crews had access to the Bell Technical Publications online portal.

Analysis

The event on 15 June 2018

During the first event the recorded data showed that when the pilot pulled up on the collective lever to start the PAC, the APs were ON, the AFCS was in ATT mode and the main rotor RPM switch was set at 104%. The collective was raised to approximately 23% of its range of movement and the total torque exceeded 30%. The AFCS transitioned to 'in-flight' and, with the APs ON and ATT engaged, it would have attempted to maintain the reference attitude (pitch and roll through the main rotor) and heading (using the yaw SCAS and trim actuators). The data showed that the pedals started a gradual movement to the left and the pedal status changed to out-of-detent indicating that the microswitch in the trim actuator changed state. This would happen if the trim actuator was operated whilst the pedals were restricted or if the pilot made an input using the pedals. The latter possibility was discounted because the pilot's feet were not on the pedals.

The out-of-detent condition would have been indicated by a yellow 'Y' in the trim status box on the DU (Figure 7). However, the focus of the pilot's attention was elsewhere, and the trim status box has no attention getting qualities, so the indication was not noticed (and was unlikely to have been).

The main rotor RPM was selected to AUTO (100%) and the collective remained at 23% for about three seconds whilst the pilot turned the APs OFF. This disengaged ATT but the AFCS remained 'in-flight' because the total torque was still above 25%.

The out-of-detent condition continued, and the collective was increased to about 30% of its range to continue the PAC. The data showed a gradual, almost linear, pedal movement of approximately 1.5% to the left over the next 10 seconds before the pedals 'snapped' to full deflection to restore the detent position. When the pedals travelled to full left deflection, the tail rotor pitch angle changed rapidly, generating increased thrust. This additional thrust overcame the frictional force at the skids and the helicopter started to rotate.

The pilot could have stopped the rotation using the pedals but, for several reasons, did not do so. The loud "clunk" and sudden unexpected motion would likely have been startling. The angle of the pilot's head while looking down may have led to disorientation caused by the Coriolis illusion[11]. A fast, un-demanded yaw on the ground had never been trained or discussed and the pilot concluded that the right landing gear must have collapsed. Despite being confused and disorientated, the pilot lowered the collective lever quickly and then shut down the engines and applied the rotor brake to stop the rotation.

Tests on G-WLTS found that it took approximately nine seconds to trim the pedals from neutral to full deflection using the beep trim. When the pedals were prevented from moving, the trim actuator continued to operate, winding up the artificial feel spring. The recorded data from the event indicated that the automatic yaw trim was trying to restore the detent condition but was unable to do so because of a restriction. When the restriction cleared, the spring, which was now under tension, drove the pedals to full deflection. The manufacturer pointed out that, ergonomically, with feet on the floor, it is possible for the right foot to contact the right pedal adjuster, thereby restricting forward movement of the left pedal. In the case of G-WLTS, the pilot did not believe this happened and so the cause of the restriction could not be determined.

The investigation identified two mechanisms where the auto-trim logic could cause a trim runaway. The first, a rapid pedal input reversal across the detent, could be discounted because the pilot's feet were not on the pedals. The second[12] could not be reproduced on a helicopter during testing, but the investigation could not exclude it as a possibility because the FDR sampling rate and limited parameters prevented a comprehensive analysis of the initial pedal movement and out-of-detent condition. Similarly, it is possible that the runaway was triggered by another mechanism that remains unknown. Overall, the investigation was unable to determine what triggered the runaway that occurred on 15 June 2018.

The event on 2 January 2019

The pilot was preparing to undertake a PAC and was holding the pedals in the neutral position using moderate pressure. The force at the pedals increased and the pilot detected an un-demanded pedal movement to the left that was successfully countered. A technical crew member in the left seat had their hands and feet clear of the controls, eliminating them as a possible cause.

The recorded data showed that the pedals were out-of-detent for almost two minutes whilst the pilot attempted to diagnose the cause. The automatic pedal trim tried to restore the detent condition, and the force to hold the pedals in the neutral position increased as the

Footnote

[11] The Coriolis illusion is caused by tilting of the pilot's head out of the plane of rotation while the aircraft is turning. This results in the simultaneous stimulation of two semi-circular canals. It produces a disorienting sensation which may feel like the aircraft is rolling, pitching and yawing at the same time. https://www.faa.gov/pilots/safety/pilotsafetybrochures/media/spatiald.pdf (accessed on 6 April 2020).

[12] See *Helicopter examination – Further tests.*

trim actuator spring wound up. As in the earlier event, the out-of-detent condition would have been indicated in the trim status box on the DU but, as before, it was unlikely to have been noticed.

The pilot reported pressing TRIM RELEASE a couple of times, but the high pedal force remained. The recorded data showed two TRIM RELEASE events, but the parameter is only recorded once per second, so it is possible that other events were not recorded. The first operation was a momentary event that occurred approximately one minute after the out-of-detent condition started. The second operation was longer in duration and, within the limitations of the FDR sampling, commensurate with the pedals returning to the detent condition. Testing showed that if a trim runaway occurs, the TRIM RELEASE button should be pressed and held until the trim actuator spring has unwound through the damper mechanism and the out-of-detent indication in the DU has cleared.

The pilot's description of the event, combined with the recorded data, indicated that a yaw trim runaway occurred with the pilot's feet on the pedals. The limitations of the FDR sampling rate prevented a definitive assessment, but the most likely scenario was that the pilot inadvertently induced a trim runaway by reversing the pedals across the detent.

This event demonstrated that if a pedal trim runaway occurs, a pilot can overcome the pedal forces, which can be eliminated by pressing and holding TRIM RELEASE until the out-of-detent condition on the DU clears.

Power assurance check

The PAC is not mentioned in RFM Normal Procedures for normal operations (ie operations other than Category A operations). The description of the PAC is in the Performance section of the manual, where it states that the PAC should be completed daily. However, it does not define the required configuration for the APs and AFCS and does not specify whether the PAC should be carried out pre- or post-flight. The Integrated Avionics Manual contains information on the PAC, including a warning to '*anticipate possible flight conditions',* but this was not routinely available to the flight crew and, in any case, was probably not considered to be a quick-reference document for operational information. The operator's only copy of the RFM was required to be carried in the helicopter and was therefore not always readily accessible to pilots. These factors reduced access to information and might explain why the operator and its pilots did not expect the helicopter to become light on its skids or the AFCS to transition to 'in-flight' during a PAC. Prior to the first event, therefore, the operator did not foresee these possibilities as hazards to be controlled, perhaps by guarding the pedals during a PAC. Consequently, the operator and its pilots saw no reason not to record figures on their kneeboards during a PAC with their feet clear of the pedals, and the trim runaway on 15 June 2018 was unopposed, allowing the pedals to deflect to the full extent.

By the time of the January 2019 event, the pilots were more aware of the potential for un-commanded yaw on the ground and would guard the pedals during the PAC. With feet on the pedals, the pilot was able to quickly recognise the runaway and easily oppose the movement of the pedals.

The operator conducted the PAC out of sequence with the RFM Category A Supplement, where the intent is to carry it out as part of the pre-flight procedures for every flight. The main body of the RFM does not require the PAC to be conducted on the first start of a day, only that it should be achieved on a daily basis. The PAC is a normal procedure but is not reflected in the Normal Procedures section of the RFM. The inclusion of a defined procedure in Section 2 of the RFM, including starting parameters before the procedure such as AP status, would reduce ambiguity and allow flexibility in the timing of the procedure. Therefore, the following Safety Recommendation is made:

Safety Recommendation 2020-010

It is recommended that Transport Canada require Bell Textron Canada Limited to amend Section 2 of the Bell 429 GlobalRanger Rotorcraft Flight Manual to include a Normal Procedure for the conduct of the daily Power Assurance Check.

CVR recording issue

The fitment of the TETRA communication system on the helicopter in May 2015 required changing the audio controller. This work was carried out as a Minor Change without any reference to the fact that the audio controller directly interfaced with the CVR, and that the signal levels coming from the audio controller needed to be adjusted to input levels that the CVR was expecting. Therefore, the levels remained at those set by the manufacturer which were higher than the input requirements of the CVR resulting in the recorded crew's speech being clipped.

The flight recorder manufacturer was tasked with evaluating the flight recorder recordings to ensure continued serviceability of the flight recorders. Five consecutive annual inspections of the flight recorder recordings, between three different engineers, failed to identify the clipping on the CVR. When listening to an audio recording, the effect of clipping can be subjective because it does not usually affect the intelligibility of speech greatly if the speech-to-noise ratio is high. Because the inspection process of the CVR recording relied on the engineer just listening to extracts from the CVR recording, the obvious indications of clipping present in the signal waveforms were missed.

The software used to analyse the flight recorder recordings had an option to plot the CVR signal waveforms just as it could plot the data of each parameter recorded on the FDR. However, these signal-waveform plots did not form part of the inspection report for the CVR. The parameter data plots formed part of the inspection report for the FDR so that any obvious anomalies or parameters not recorded could be easily identified. As a result of this investigation, the CVR inspection reports now also contain a plot of the CVR signal waveforms.

CVR recording inspections are required to verify that the audio quality of the CVR is acceptable and has not deteriorated due to undetected failures in the CVR system. They are also required when modifications are made to the CVR system or other aircraft systems that interface with the CVR. The inspection process itself is subjective and results in variability in the assessment of what is good quality, and what is of poor quality requiring immediate attention from the operator.

In 2018, the European Flight Recorder Partnership Group (EFRPG)[13], considered the issues of CVR recording inspections so that guidance material could be developed and made freely available to any organisation carrying out these inspections, and to try and remove some of the variability of the overall assessments. The aim of the document was to: promote best practice; show what tests should be carried out and what issues looked for during an assessment; and propose clearer definitions for the assessment rating of 'good', 'fair' or 'poor'. The guidance material, published in October 2018, can be found on the AAIB's website[14].

The STC holder that carried out the Minor Change made no reference in the work package to the fact that the audio controller interfaced directly with the CVR system. There was, perhaps, an indirect reference to the CVR system in the audio controller installation manual that said that the factory-set audio levels may need to be adjusted to '*best suit the local operating environment*'. There was, however, no evidence to suggest this had been done because the output levels of the audio controller had not been altered.

If the newly installed equipment interfaces (and shares information) with other existing equipment on an aircraft, tests must be conducted to ensure the installation has not had a detrimental effect on the existing equipment (these tests must be conducted in addition to any EMC/EMI/HIRF/IEL testing). EASA specifically reminds Minor Change applicants of this in guidance contained in their 'Minor Change Certificate Document'. The document is aimed at applicants making changes to GA aircraft, and especially those who are not DOA holders and who may have limited experience in the change process. There is, however, no equivalent guidance, or even reminder, to organisations qualified and practised in carrying out changes or repairs to CAT aircraft, leaving the potential for these tests to be overlooked and the continued airworthiness of the aircraft to be compromised. Therefore, the following Safety Recommendation is made:

Safety Recommendation 2020-011

It is recommended that the European Union Aviation Safety Agency remind Minor Change applicants of the importance of verifying that new equipment does not have a detrimental effect on existing equipment with which it has a direct interface.

Footnote

13 The European Flight Recorder Partnership Group is an independent voluntary group of European (and United States) flight recorder experts from industry, safety investigation authorities and national aviation authorities that was formed to provide advice and opinion on flight recorder issues and practices to EASA.

14 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/850370/Guidance_on_CVR_recording_Inspections_.pdf (accessed 6 April 2020).

Conclusion

The first event on 15 June 2018 occurred during a PAC when the pilot's feet were clear of the pedals. The yaw trim actuator operated but the pedals could not move because of a restriction, and so the actuator wound up the artificial feel spring instead. When the restriction cleared, the pedals 'snapped' to full deflection as the spring unwound, increasing tail rotor thrust and causing the helicopter to rotate rapidly to the left through two and a half revolutions. The investigation did not determine the cause of the trim runaway or the pedal restriction.

A similar yaw trim runaway on 2 January 2019 was controlled because the pilot's feet were resting on the pedals. The manufacturer determined that the AFCS logic meant that it was possible for pilots to inadvertently induce a yaw trim runway and issued a revision to the RFM to reduce the risk of a recurrence. The manufacturer also undertook to address susceptibilities in the flight control system software identified during the investigation into these events.

The PAC is a normal procedure which was not reflected in the Normal Procedures section of the RFM. A Safety Recommendation has been issued to update the RFM with an appropriate procedure.

It was found that the CVR audio performance was poor after the installation of the TETRA communication system. A Safety Recommendation has been issued to EASA to remind Minor Change applicants of the importance of verifying that new equipment does not have a detrimental effect on existing equipment with which it has a direct interface.

Safety action

Following these events, the following Safety Action was taken:

> Bell Textron Canada Limited published a revision to the Rotorcraft Flight Manual to reduce the risk of a yaw trim runaway. This included procedures for responding to a runaway so that control of the helicopter would be maintained.
>
> Bell Textron Canada Limited amended the Integrated Avionics Manual to include a note that automatic pedal trim remains operational on the ground if force trim is engaged.
>
> Transport Canada issued Emergency Airworthiness Directive CF-2019-16, which mandated the incorporation of the Rotorcraft Flight Manual revision and required all flight crews to be advised of the changes.
>
> Bell Textron Canada Limited recorded a Problem Report against their flight control system software related to the susceptibilities identified. The susceptibilities would be addressed by future enhancements to the automatic pedal trim function of the software

The flight recorder manufacturer included a plot of CVR signal waveforms as part of its CVR recording inspection report to enable anomalies such as clipping to be easily identified.

Published: 30 April 2020.

ACCIDENT

Aircraft Type and Registration:	Jodel D117A, G-AZII
No & Type of Engines:	1 Continental Motors Corp C90-14F piston engine
Year of Manufacture:	1958 (Serial no: 848)
Date & Time (UTC):	8 April 2019 at 1310 hrs
Location:	Full Sutton Airfield, York
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Landing gear, lower engine cowl, engine and propeller damaged
Commander's Licence:	Light Aircraft Pilot's Licence
Commander's Age:	69 years
Commander's Flying Experience:	632 hours (of which 235 were on type) Last 90 days - 10 hours Last 28 days - 5 hours
Information Source:	AAIB Field investigation

Synopsis

The aircraft landed heavily when the pilot's prosthetic adapter disconnected from the control column late in the approach. The pilot was unhurt.

The pilot has since modified the interface between the prosthetic adapter and the aircraft control column. The UK CAA has amended the medical certification pathway for pilots with musculoskeletal disability to include an engineering assessment of interface between any prosthesis and the aircraft flying controls.

History of the flight

The pilot of G-AZII is a left forearm amputee. G-AZII was operated on a Permit to Fly and had no modifications adapting it for the disability of the pilot. When operating the aircraft, the pilot used his right hand to control the throttle. To operate the ailerons and elevator, a rose jointed adapter, which was secured to the prosthesis on his left arm, was attached by an interference fit to the control column (Figure 1). All other controls were conventional.

The pilot was flying circuits at Full Sutton Airfield using Runway 04, with a wind slightly from the left and steady at 10 kt. On the fourth circuit, the pilot established G-AZII on the final approach and trimmed for 50 KIAS. At about 5 ft above the ground, while the pilot was flaring the aircraft, the prosthetic adapter became disconnected from the control column;

the aircraft reverted to its trimmed shallow nose-down attitude and subsequently struck the ground. The landing gear dug into the ground and folded back under the wings, and the nose of the aircraft pitched down further, damaging the lower engine cowl and the propeller, and shock-loading the engine.

Figure 1
Prosthetic adapter in use

The pilot was uninjured and, after making the aircraft safe, exited without difficulty using the left cockpit door.

Pilot

The pilot is a medical practitioner with extensive experience in the management and prosthetic rehabilitation of people with acquired and congenital limb loss. He had held a flying licence for almost 9 years. He had flown a Jodel D117A for almost 5 years of which he had flown more than 2 years and over 230 hours using the prosthetic adapter.

Prosthetic adapter

The prosthetic adapter was made from a length of carbon fibre/epoxy high strength precision tube, the inner diameter of which provided an interference push-fit on the control column with the handgrip removed. The tube had a high tensile 1/4” bolt with a steel washer bonded into it, attached to an aviation rose joint which threaded into a standard artificial arm wrist rotary adapter.

Figure 2
Prosthetic Attachment

The pilot had drawn upon his experience as a doctor in prosthetic rehabilitation and as a pilot to fabricate the bespoke prosthetic adapter. His approach was to modify the person rather than the aircraft, developing an adapter that would enable him to fly other aircraft of the same type. He aimed to make detachment from the control column simple and intuitive for others, such as rescue personnel, in an emergency. While there was no regulatory engineering assessment of the prosthetic adapter and its interface with the aircraft controls, the pilot had informal discussions with an LAA Inspector. The pilot also assessed the force to disconnect the adapter from the control column exceeded that required to detach the standard hand grip.

Medical assessment

The pilot held a Light Aircraft Pilot's Licence (LAPL) medical certificate with an 'APL' limitation (meaning that the medical certificate was only valid when flying with an approved prosthesis). The re-issue of the LAPL medical certificate required the pilot to undergo a medical examination, and a medical flight test (MFT). The latter is intended to assess the ability of the pilot to operate the aircraft controls fully and safely with the prosthesis, and follows the same profile as a flight test for pilots who do not use prostheses. The CAA document *'Guidance for the certification of pilots with a musculoskeletal disability for upper limb amputees'* states[1]:

> *'Pilots often use a prosthesis which can be clamped to the yoke and in general the prosthesis does not need to be certificated by the CAA, providing that failure of the prosthesis (e.g. falling off the stump) would not result in the pilot losing complete control of the aircraft. This should be considered during any medical flight test or simulator check.'*

Footnote

1 Available at https://www.caa.co.uk/Aeromedical-Examiners/Medical-standards/Pilots-(EASA)/Conditions/Musculoskeletal/Medical-certification-of-pilots-with-a-disability/ [accessed October 2019]

The medical examination, conducted by an Aeromedical Examiner (AME), focused on the medical aspects of the amputation, and included an assessment of the prosthesis and its fitting to the limb. The MFT was carried out by a Chief Flying Instructor (CFI) and included discussions about the possibility of disconnection of the adapter and actions to mitigate the consequence of any such occurrence. Typically, this would involve taking hold of the control column with the right hand to enable the pilot to retain control of the aircraft while he re-attached the adapter before resuming normal control. The pilot demonstrated this during the MFT; the CFI noted that the prosthetic adapter was '*solid, well made with no play*'. (Subsequently, the pilot practised regaining control while flying following a disconnection of the adapter from the prosthetic on a regular basis.)

The CAA has since introduced a '*Limb Prosthesis Assessment Form*'[2], to be completed by an applicant's prosthetist, to assess the suitability of the prosthesis itself.

Support organisations

Light Aircraft Association

The LAA is a representative body for amateur-built and vintage light aircraft, providing airworthiness services under direct delegation from the UK's Civil Aviation Authority. Its network of instructors and inspectors is able to provide guidance to pilots wishing to modify the interface with the aircraft controls.

Specialist organisations

Specialist organisations, such as Aerobility, formerly known as the British Disabled Flying Association, have relevant experience, including in modifying aircraft for pilots with limb amputations.

Analysis

The heavy landing occurred because, when the prosthetic adapter detached from the control column, the pilot was unable to regain control of the aircraft before it hit the ground.

The pilot met the requirements which existed at the time to regain his medical category and be cleared fit and capable to fly.

There was no mechanical connection between the adapter and the control column other than the interference push-fit. Accordingly, the pilot has added a Velcro strip attaching the prosthetic adapter and control column, making the interface more secure but still easy to disconnect in an emergency.

Footnote

[2] Available at https://www.caa.co.uk/Aeromedical-Examiners/Medical-standards/Pilots-(EASA)/Conditions/Musculoskeletal/Musculoskeletal-guidance-material-GM/ [accessed October 2019]

Medical assessment process

Medical examination of an amputee is carried out by an AME with the requisite medical competence, and the MFT enables the CFI to assess the pilot's ability to control the aircraft using the prosthesis. However, a CFI may not be competent to assess the robustness of the interface between the prosthesis and the aircraft and the *Limb Prosthesis Assessment Form* does not fulfil this role.

In these circumstances the critical interface is that between the prosthesis and the aircraft controls. Currently there is no requirement for an individual with appropriate engineering competence to assess this interface and to consider the forces involved, the robustness of the arrangement, maintenance requirements, security, and ease of disconnection in the event of an emergency.

The CAA stated that it will amend the MFT form to include an engineering assessment of the prosthesis for general use in the aircraft and its interface with the flight controls.

Modifications

The nature of any disability resulting from an amputation is specific to the individual. The pilot's approach was to modify the prosthesis rather than the aircraft, by fabricating a suitable adapter. Accordingly, the adaption was not viewed as a modification to the aircraft. While the adapter gave the pilot the articulation and control required to fly the aircraft, there was no formal assessment by an individual with engineering competence of the magnitude and direction of the forces involved.

An alternative approach would be to consider modification of the aircraft with an adapter that fits the needs of the individual. While limiting the pilot to being able to fly only the adapted aircraft, this approach would have the advantage of engaging existing regulatory oversight of the required modifications.

Conclusion

The aircraft landed heavily when the prosthetic adapter detached from the control column late in the approach and the pilot was unable to regain control before touchdown.

The pilot met the requirements for medical fitness to fly, but there was no engineering assessment by a suitably qualified individual of the interface between the prosthesis and the aircraft controls. The lack of a secondary device securing the prosthetic adapter to the control column meant that its security was solely reliant upon the interference fit.

Safety action

The following Safety Actions have been carried out:

> The pilot has added a velcro strip, which attaches to the prosthetic adapter and the control column, providing added security to the interface in the axial plane while retaining ease of disconnection in the event of an emergency.

The Civil Aviation Authority of the United Kingdom has reviewed the medical certification pathway of pilots with a musculoskeletal disability and is amending the Medical Flight Test form to implement a 3-stage process involving:

- an assessment by the prosthetist relating to the manufacture and fitting of the prosthetic with regard to use in general in an aircraft, eg flight control system forces and movements;
- assessment of the prosthetic interface with the aircraft control(s) in an aircraft engineering context by a suitably licenced engineer or inspector;
- the conduct of a general medical flight test by a CFI staff examiner or single pilot aircraft senior examiner, either of whom must be designated by the Authority for this purpose, to:

  (a) assess the ability of the pilot to fly and control the aircraft through the use of the prosthetic and operate equipment in normal operations and emergencies including ingress/egress from the aircraft and

  (b) consider how to ensure control of the aircraft is retained in the event of a failure.

Published: 16 April 2020.

ACCIDENT

Aircraft Type and Registration:	Jabiru UL-450, G-ROYC
No & Type of Engines:	1 Jabiru 2200A piston engine
Year of Manufacture:	2003 (Serial no: PFA 274A-13990)
Date & Time (UTC):	27 October 2019 at 1421 hrs
Location:	Gransden Lodge Airfield, Sandy, Cambridgeshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - 1 (Minor) Passengers - None
Nature of Damage:	Substantial
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	57 years
Commander's Flying Experience:	267 hours (of which 28 were on type) Last 90 days - 6 hours Last 28 days - 4 hours
Information Source:	AAIB Field Investigation

Synopsis

G-ROYC was being flown with two pilots onboard. The pilot in the left seat had 28 hours on type and the pilot in the right seat had not flown the type before. The approach to the runway was flown by the pilot in the right seat. During the approach he decided the aircraft was not stable so elected to go around. During the go-around the aircraft descended and drifted to the left. The aircraft collided with a stationary glider which was waiting to launch. One of the occupants of G-ROYC sustained a minor injury; the glider pilot was uninjured.

The investigation found that it is likely that the aircraft did not climb due to a combination of the inadvertent retraction of the flaps, a brief delay in applying full power and the aircraft being slightly above the maximum takeoff weight.

The LAA provides a Pilot Coaching Scheme to enable pilots to safely learn new aircraft types and develop their flying skills with experienced instructors.

The BGA and the gliding club have taken safety action to ensure the risk of ground collisions continue to be minimised.

History of the flight

On Sunday 27 October a local Scout group who frequently flew a motor glider from Gransden Lodge airfield had arranged for several powered aircraft to visit the airfield to provide air experience flights for them. G-ROYC flew from Old Warden airfield to Gransden Lodge airfield in the morning and completed several local flights with members of the Scout group without incident. On completion of the flights another pilot, who had also been providing experience flights for the Scouts in another aircraft, asked if he could fly G-ROYC as he had not flown the type before and was interested in the aircraft. G-ROYC's pilot agreed and gave him a briefing about the aircraft. G-ROYC's pilot sat in the left seat and the other pilot sat in the right seat. The pilot in the right seat operated the controls throughout the subsequent flight with the pilot in the left seat following through on the controls. The pilot in the left seat considered he was the pilot in command.

The aircraft took off from Runway 22 and flew in the local area for approximately 15 minutes. The weather conditions were good with a surface wind from approximately 290° at 10 kt giving a 9 kt crosswind from the right on Runway 22. As the aircraft returned to the airfield and joined the circuit the pilots heard a motor glider reporting downwind on the opposite side of the airfield. They extended downwind to position behind the other traffic. The motor glider landed on the far right of the runway, so the pilot of G-ROYC flew towards the centre of the runway. The pilot, sat in the right seat, started the approach with one stage of flap. The flap selector switch was on the far left of the cockpit so he had to ask the pilot in the left seat to select the flap as he could not reach it from the right seat. The throttle on G-ROYC was located on the seats between the pilot's legs. He reported that he kept operating the throttle in the incorrect sense then having to correct himself as he had not previously flown an aircraft with the throttle in this position. As the aircraft approached the runway, the pilot in the left seat thought the aircraft was too high, so asked the other pilot if he would like full flap. He said "yes" so the pilot in the left seat selected full flap. This caused the descent rate to increase significantly. The pilot in the right seat decided the approach was unstable so, at a low altitude, decided to go around.

The pilot tried to apply full power but inadvertently closed the throttle. The throttle had already been close to idle so this only caused a slight power reduction. He immediately realised his error and applied full power. He also recalled that he left the carburettor heat ON. The pilot in the left seat moved the flap selector switch to the FLAPS UP position but did not return the switch to OFF when the flaps reached the mid position, causing the flaps to fully retract. The pilot in the right seat reported that he was surprised by how much the nose pitched up. He recalled that the control effectiveness was minimal and he was unable to stop the aircraft sinking and drifting to the left.

Three gliders were parked on the left side of the runway in two queues waiting to be winch launched. Several members of the gliding club involved in launching the gliders were also standing in this area. G-CHEK, a SZD-51 single seat glider, was at the front of the queue. The pilot was strapped into the glider with the canopy closed waiting for his turn to launch.

All times are UTC

Several people saw the aircraft approaching. They reported seeing G-ROYC drifting towards the glider with a high nose attitude. Several of them stated that the aircraft was heading towards the glider rather than into wind.

As G-ROYC drifted to the left and descended, it collided with the tail of G-CHEK. The glider spun round to the right and G-ROYC passed across its left wing. G-ROYC continued across the grass coming to rest approximately 25 m away from the glider. The glider pilot was uninjured and was assisted from the glider. The occupants of G-ROYC were able to exit the aircraft unaided; one suffered a minor back injury; the other was uninjured.

Accident site

With agreement of the AAIB, gliding club members photographed the accident site and moved both aircraft off the runway.

Figure 1

G-CHEK SZD-51 glider showing damage to the tail and left wing

Figure 2 shows the left wing of the glider with marks from the tyres of G-ROYC. Measurement of the marks show that the right tyre of G-ROYC passed just behind the canopy of the glider. Figure 3 shows the final position of G-ROYC. Figure 4 shows G-ROYC after the accident with the flaps fully retracted.

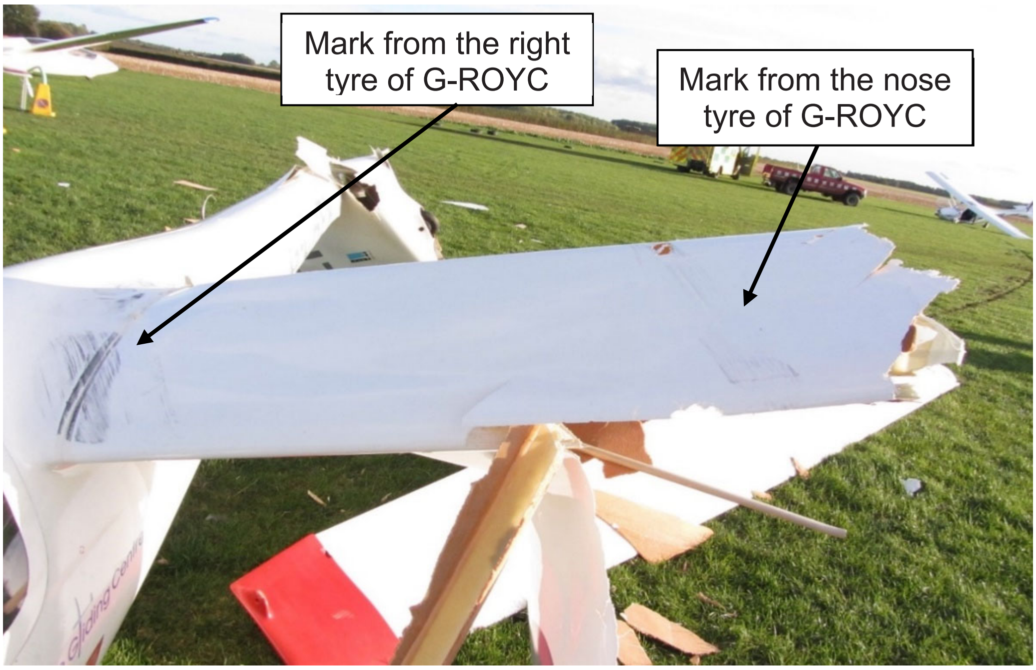


Figure 2

Left wing of G-CHEK showing tyre marks left by G-ROYC

Figure 3

Final position of G-ROYC

Figure 4

G-ROYC after the accident showing the flaps UP

Recorded information

The accident was recorded on CCTV. However, the distance, frame rate and angle of the camera meant it was not possible to determine the aircraft speed, pitch angle or heading with any accuracy. The recording showed the landing motor glider touching down at 1420:19 hrs on the right side of the runway. After slowly rolling across a track that crosses the runway the motor glider started accelerating for another takeoff at 1421:09 hrs. G-ROYC entered the image at 1421:16 hrs and appeared to be in level flight at low level. At 1421:19 hrs G-ROYC started to sink and at 1421:22 hrs collided with the glider. Figure 5 is an image taken from the CCTV recording which shows G-ROYC in flight and the three gliders on the left of the runway. Several members of the gliding club can also be seen standing by the gliders.

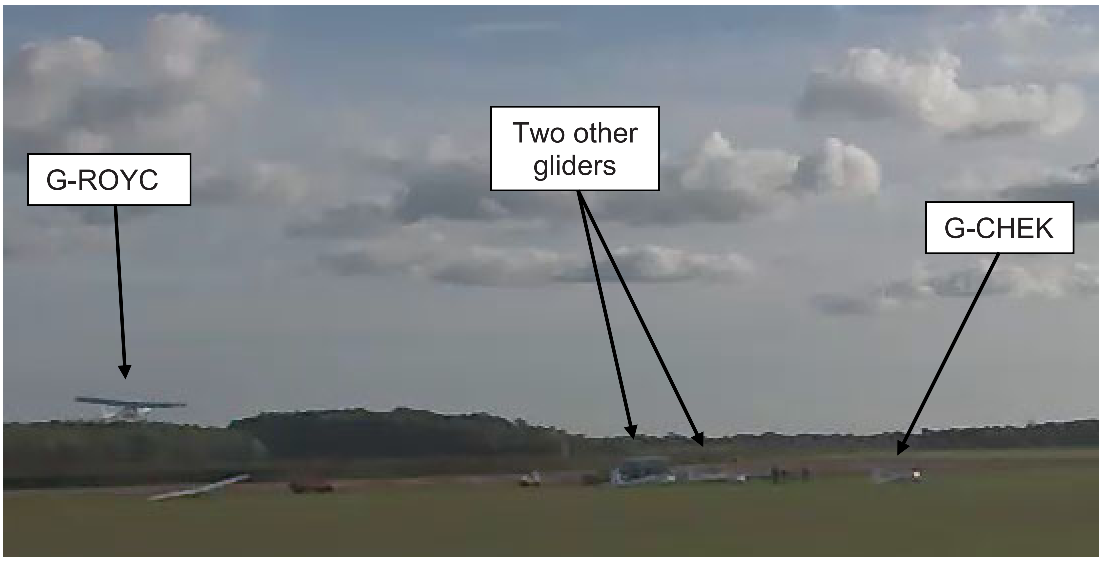


Figure 5

CCTV image just prior to the accident

Aircraft examination

G-ROYC was not examined in detail by the AAIB. However, both occupants of G-ROYC reported that the aircraft and engine appearing to be behaving normally. Photographs taken immediately after the accident show that the flaps were retracted, the flap switch was in the FLAPS UP position and the carburettor heat was pulled out.

Weight and balance

The weight of the aircraft was calculated by the AAIB after the accident to be 463.5 kg as shown in Table 1. The company that recovered G-ROYC after the accident found there was 32 litres of fuel onboard.

The Jabiru UL-450 has a maximum permitted gross weight of 450 kg. The weight schedule displayed in the aircraft stated that the '*Maximum fuel load with two crew of 86 kg each* [is] *16 litres*.'

A placard in the aircraft stated:

> *'Provided that the limitations are observed, any combination of weight at the seat and fuel tank stations will keep the aircraft centre of gravity within the accepted limits which are described in the flight manual'.*

However, as the aircraft was slightly above the maximum weight it is not known if it remained within the centre of gravity limits.

ITEM	WEIGHT (kg)
Aircraft Basic Weight	266.5
Left Seat Pilot	89
Right Seat Pilot	84
Fuel (32 l)	23
Equipment (estimate)	1
TOTAL	**463.5**

Table 1

Weight calculation for G-ROYC

Aircraft information

The Jabiru UL-450 is a high-wing two-seat kit-built microlight primarily constructed from fibreglass. It is powered by a 4-stroke 4-cylinder Jabiru 2200A engine with a fixed-pitch wooden propeller. Fuel is stored in a tank behind the seats. The UL-450 kit was produced by Jabiru until 2007.

The flight controls are operated via standard rudder pedals and a single stick mounted centrally between the two seats (Figure 6). Throttle controls are located on both seats between the occupant's legs. The throttle is pulled towards the pilot for idle power and pushed away for full power.

Figure 6

Jabiru UL-450 controls

G-ROYC was built in 2003. The aircraft had a valid LAA Permit to Fly. When the permit was last renewed, on 27 February 2019, documentation submitted to the LAA recorded that the aircraft had accumulated 471 hours.

The Jabiru UL-450 kit is supplied with manual flaps which are operated via a lever mounted on the side wall to the left of the pilot's head (Figure 7). The lever has a button which latches it in three positions to give flaps up, a mid position or full flap.

Figure 7

Jabiru manual flap lever

However, in 2012, G-ROYC was fitted with electric flaps using an LAA approved modification. The manual lever was replaced with an electric motor similar to that fitted to other Jabiru models. The motor was controlled via a three-position switch mounted on the far left side of the instrument panel (Figure 8). The flaps were extended by holding the switch in the FLAPS DOWN position (the switch is spring loaded back to the middle position). To retract the flaps the switch is moved to the FLAPS UP position where the switch latches. If the switch is left in the FLAPS UP position, the flaps retract fully. To stop the flaps in the mid position the switch must be returned to the middle position.

Figure 8

G-ROYC flap switch (as found after the accident)

The LAA reported that G-ROYC was the only UL-450 in the UK which had been modified with electric flaps.

Jabiru Aircraft reported that all its aircraft are now designed with electric flaps. However, the control switch is spring loaded to the centre in both the retract and extend direction so the pilot must hold the switch up or down to move the flaps. On factory built models the flap switch is located centrally on the instrument panel so it can be easily accessed from either seat. However, Jabiru advised that some kit builders choose to put the flap switch on the left side of the instrument panel as it is easier to access whilst flying in the left seat with the pilot's right hand on the central control stick.

Aircraft handling and performance

Jabiru Aircraft supplied the AAIB with an owner's manual for the UL-450 which was revised in 2005; a similar manual (last updated in 1999) was found in G-ROYC after the accident. The manual contains the following caveat:

> *'This Owners Manual is provided by Jabiru Aircraft Pty Ltd as a guide to the operation of the Jabiru UL-450 kit aircraft. As the UL-450 is an experimental amateur built kitplane, the characteristics, performance, limitations and other information may vary between individual aircraft. As part of the test flight program, The Owner must verify the characteristics, performance limitations and other information is relevant to their particular aircraft and amend any guidance figures that are provided in this Manual.'*

Stall speeds

Table 2 shows the stall speed given in the owner's manual and the speed recorded on G-ROYC during the most recent permit renewal flight test. These speeds assume idle power with the aircraft at the maximum gross weight of 450 kg.

	Owner's Manual (KIAS)	G-ROYC Flight Test (KIAS)
Flaps Up	45	48
Stage 1 (Takeoff)	39	Not recorded
Stage 2 (Landing)	35	35

Table 2

Jabiru UL-450 Stall Speeds

Go-around

The owner's manual found in G-ROYC provides the following guidance for performing a baulked landing or go-around:

> *'In a baulked landing (go-around) climb, the wing flap setting should be reduced to the First Stage immediately after full power is applied and the aircraft has accelerated to a safe climb speed. Upon reaching a safe airspeed, the flaps should be slowly retracted to the full up position, whilst allowing the aircraft to accelerate to the best climb speed.'*

The manual provides the following speed guidance and checklist for a baulked landing[1]:

'Airspeed

Apply full power; allow speed to increase to	*62 KIAS*
Retract Flap to 1st Stage until clear of obstacles	
Then retract flap fully and continue to climb at or above	*62 KIAS*

Checklist

1	*Throttle*	*FULL OPEN*
2	*Carburettor Heat*	*COLD*
3	*Wing Flaps*	*RETRACT to ½ DOWN*
4	*Airspeed*	*50 KIAS until clear of obstacles*
5	*Wing Flaps*	*Retract to 1st Stage until clear of obstacles then retract fully and continue to climb at or above 62 KIAS'*

Footnote

1 The manual provided by Jabiru Aircraft (updated in 2005) contains the same procedure but with slightly different speeds.

Jabiru highlighted that if the flaps are fully retracted prior to obtaining the required speed the aircraft will not maintain height.

The manual recommends a normal approach speed with full flap of 57 KIAS. G-ROYC's pilot recalled that he had been trained to fly approaches and landings at 59 kt if using the first stage of flap and 50 kt if using full flap.

Another pilot with experience of the UL-450 commented that, during a go-around, the aircraft will pitch up as the flaps are retracted and will yaw to the left, but these are easily controllable with normal control inputs.

Crosswind landing

The owner's manual states that the maximum crosswind in which a landing was demonstrated was 14 kt and recommends the use of the wing down crosswind landing method.

The LAA Type Acceptance Data Sheet (TADS) for the UL-450[2] highlights directional control problems that some pilots have experienced when landing in crosswind conditions. The TADS states that because of the relatively small size of the ailerons compared to the wingspan the aircraft suffers from a slow roll response and adverse yaw. G-ROYC had a larger rudder modification fitted which provides greater rudder control authority. Later versions of the Jabiru had a larger fin fitted which further improved the directional stability and reduced the adverse yaw.

Personnel

The left seat pilot held a National Private Pilot's Licence with valid Microlight and Self Launching Motor Glider (SLMG) ratings. He held a valid medical declaration signed by his doctor. He first flew the aircraft 18 months before the accident and had completed differences training. He had accumulated 28 hours in G-ROYC prior to the accident. His total flying experience was 267 hours.

The right seat pilot held a National Private Pilot's Licence with valid Microlight, SLMG and Simple Single-Engine Aeroplane (SSEA(land)) ratings. Additionally, he held a Light Aircraft Pilot's Licence for Sailplanes (LAPL(S)) with valid flight instructor and flight examiner ratings. He held a valid LAPL medical. He had a total of 2,400 flying hours and had flown 54 hours in the 90 days prior to the accident and 9 hours in the previous 28 days. He had not previously flown a Jabiru aircraft.

Airfield information

Gransden Lodge airfield is a former wartime airfield located 10 miles west of Cambridge. Cambridge Gliding Club moved to Gransden Lodge airfield in 1991. The airfield has three grass runways. Runway 22, in use on the day of the accident, is approximately 1,400 m long and 130 m wide (Figure 9). In addition to the powered aircraft providing air

Footnote

2 LAA TADS 274A available at http://www.lightaircraftassociation.co.uk/engineering/homebuilt_vintage.html (accessed 13 November 2019)

experience flights for the Scouts, the gliding club was conducting numerous training flights and supervising solo flights. A total of 48 flights were recorded at the airfield during the day. Flights were suspended after the accident occurred.

The airfield does not have an air traffic control service. Pilots monitored and reported their position on VHF frequency 131.280 MHz.

On the day of the accident, in accordance with the club's normal procedures, gliders were being winch launched from the left side of the runway. Two queues of gliders were established with winch cables run-out down the left side of the runway. Powered aircraft and gliders were landing on the remaining width.

A small track crosses the runway approximately 380 m from the threshold. All the aircraft and gliders seen on the CCTV were landing and stopping before the track. This enabled them to vacate, or be moved off, the runway quickly without needing to backtrack the runway. The gliding club highlighted that all pilots are taught that they should land further along the runway if there is any congestion at the start of the runway.

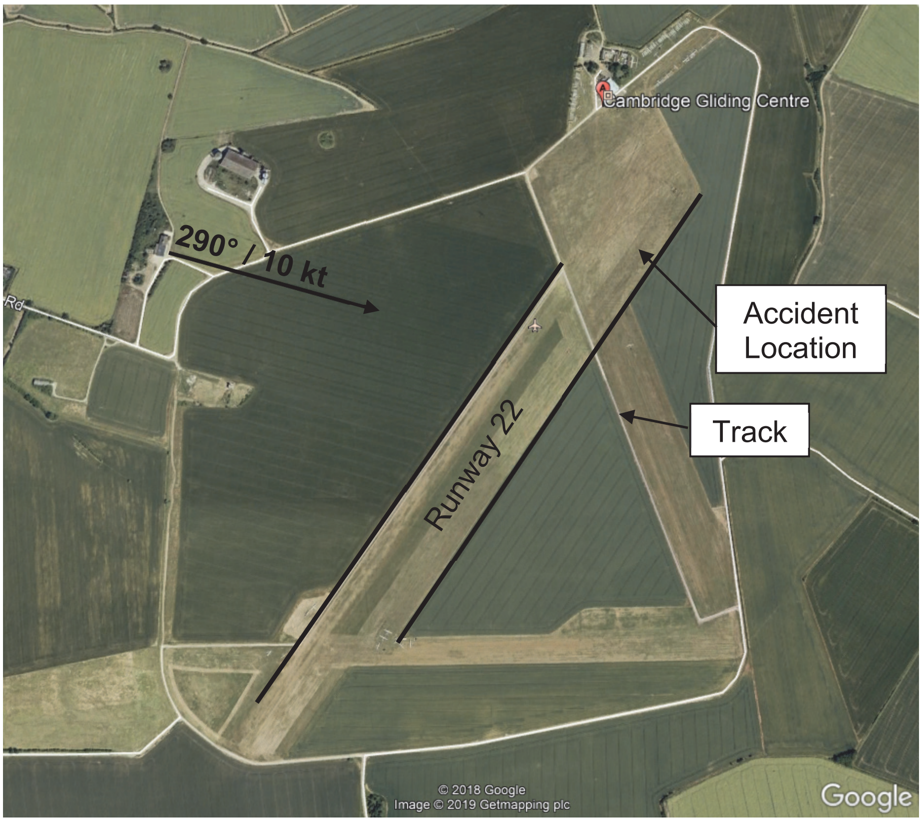


Figure 9

Gransden Lodge airfield with Runway 22 highlighted

Human factors

Qualified pilots operating together

It is common in general aviation for two qualified pilots to fly together in a single pilot aircraft. Doing so can be beneficial but it can also present a hazard if clearly defined roles and responsibilities are not established. In this accident the pilot who sat in the right seat commented that before the flight he did not establish clear roles with the other pilot and did not agree how any non-normal situation would be managed. He felt this contributed to the accident.

A feature published in Aviation Safety Magazine in February 2018 titled *'The Two-Pilot Problem'*[3] highlights this issue and offers advice to manage the risk.

Operating a control in the incorrect sense

The pilot reported that he moved the throttle lever in the incorrect direction. The throttle on a UL-450 is in an unusual position. For an experienced pilot, the act of applying more (or less) throttle is done without conscious thought. This is normally helpful as it requires less mental effort to fly the aircraft, but, when presented with a different or unusual control it can cause a problem if the pilot's instinct is to move the control in the wrong sense.

This type of human error is discussed on page 47 of the CAA CAP 737[4] in the section entitled *'Human Error, Skill, Reliability and Error Management'*. It highlights that once a skill is learned to the point of being automatic it is reliable and robust, but it is also vulnerable to situational and contextual change. This type of human error is common when pilots operate unfamiliar aircraft.

Organisational information

Ground collisions risk

During gliding operations it is normal for several aircraft to be on the runway at the same time. This accident highlights the risk of collisions between landing aircraft and aircraft already on the runway. The BGA reviewed its accident database to determine how often collisions have occurred between landing aircraft and aircraft on the ground. The review showed there have been 35 accidents since 1974 during which time 16.5 million flights were recorded, suggesting the probability of occurrence is low. However, in 2019 alone the AAIB reported on 19 accidents in which a light aircraft deviated from its intended path on landing. The reasons for the deviations vary considerably and they did not result in collisions, but these events show that there is a risk that any landing aircraft may deviate from its intended path.

Footnote

3 Aviation Safety Magazine available at http://www.aviationsafetymagazine.com/issues/38_2/features/The-Two-Pilot-Problem_11459-1.html (accessed 13 November 2019)

4 CAA CAP 737 available at https://publicapps.caa.co.uk/docs/33/CAP%20737%20DEC16.pdf (accessed 13 November 2019)

Supervision for flight operations

The flying orders for Gransden Lodge state that all flying operations at the airfield are conducted under the supervision for the Chief Flying Instructor. Each day this responsibility is delegated to the Duty Instructor. However, on the day of the accident the duty instructor reported that he had not been briefed on the operations being conducted by the Scout group. It was reported that some of the pilots involved in the Scout operation had not attended the morning briefing. Discussion after the accident with members of the gliding club safety committee suggested that the Scout group had been operating under "arms-length" supervision for some time.

There was no evidence that the supervision in place contributed to the accident.

Other information

Learning a new aircraft type

The LAA provide a Pilot Coaching Scheme (PCS) to enable pilots to learn new aircraft types and to develop flying skills. Details of the scheme are provided on their website[5]. Their website states that:

> *'Statistics show that for LAA aircraft the transition of a new pilot onto the type is a frequent source of accidents, more so than the aircraft's initial test flying phase. The same is true of the first flight of any unfamiliar aircraft, whether it is a homebuilt, vintage, or microlight.'*

The PCS provides experienced instructors to help pilots safely learn to fly a new aircraft type.

Analysis

G-ROYC go-around

The pilot flying G-ROYC decided to go around at low altitude as he considered the approach was unstable. During the go-around the aircraft descended and drifted to the left.

The pilot reported that he initially operated the throttle in the incorrect direction which, whilst only resulting in a brief delay in the application of full power, may have caused the airspeed to reduce as the pilot tried to maintain height. The flap switch was selected to the FLAPS UP position but was not returned to the central position, causing the flaps to fully retract.

The pilot reported that he was surprised by how much the aircraft pitched up as he initiated the go-around. Several witnesses reported that the aircraft appeared to be in a very nose high attitude. It is likely that the aircraft failed to climb due to the flaps fully retracting, the brief reduction in power and the high nose attitude causing the speed

Footnote

5 http://lightaircraftassociation.co.uk/PCS/pcs.html (accessed March 2020).

to reduce below the flaps up stall speed. The carburettor heat was left ON during the initiation of the go-around which would have slightly reduced the power available. The aircraft was slightly above the maximum permitted gross weight which would have further decreased its climb performance.

The combination of the crosswind from the right and the aircraft's natural tendency to yaw left when power is applied are likely to have caused the aircraft to drift left. The slow roll response and adverse yaw of the UL-450 combined with the low airspeed are likely to have made it difficult for the pilot to control the drift.

The aircraft had been modified with electric flaps, with a control switch that latched in the retraction position. This design meant that the flaps would retract fully once selected if the pilot was distracted and did not return the switch to the mid position.

Both pilots were licenced to fly the aircraft. The aircraft was being flown from the right seat by an experienced pilot who had not previously flown a Jabiru aircraft. The pilot in the left seat had 28 hours experience in G-ROYC. The right seat pilot reported that they did not clearly agree the roles and responsibilities of each person before the flight. This was particularly relevant in this aircraft because the flap switch could only be operated from the left seat. The accident highlights the importance, when two qualified pilots fly together, of agreeing clear roles and responsibilities particularly when critical controls can only be accessed from one seat.

The LAA provides a Pilot Coaching Scheme to enable pilots to safely learn new aircraft types and develop their flying skills with experienced instructors.

Ground collision risk

As G-ROYC descended and drifted left it collided with a parked glider. During gliding operations there are often multiple aircraft using the same runway, therefore, there is a greater risk of ground collisions. The BGA reviewed its accident database and reported that there have only been a few ground collisions recorded suggesting that historically this risk has been well managed. However, the BGA has taken safety action to highlight the risk to clubs and provide advice to ensure it is minimised. The gliding club will review its operating procedures in light of the advice from the BGA.

Conclusion

Whilst attempting to go around from low height G-ROYC descended and drifted left and collided with a stationary glider which was waiting to launch.

It is likely that the aircraft did not climb due to the combination of the inadvertent retraction of the flaps, a brief delay in the application of full power and the aircraft being slightly above the maximum takeoff weight.

The BGA and the gliding club have taken safety action to ensure the risk of ground collisions is minimised.

Safety actions

Following this accident the following safety actions have been taken:

> The BGA has undertaken to remind all gliding clubs about the risk of landing aircraft colliding with aircraft on the ground and to provide advice on how to minimise the risk.
>
> Cambridge Gliding Club will review its procedures and consider advice from the BGA to ensure that the risk of ground collision remains as low as is reasonably practical.

Published: 16 April 2020.

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 A321-231, G-EUXJ
No & Type of Engines:	2 International Aero Engine V2533-A5 turbofan engines
Year of Manufacture:	2007 (Serial no: 3081)
Date & Time (UTC):	24 November 2019 at 1820 hrs
Location:	On takeoff from Glasgow Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 8 Passengers - 208
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	57 years
Commander's Flying Experience:	20,593 hours (of which 12,061 were on type) Last 90 days - 148 hours Last 28 days - 62 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries by the AAIB

Synopsis

During the takeoff roll the flight crew realised the aircraft was not accelerating as expected. Just prior to V_1 the commander applied full power. The aircraft took off and continued its planned flight without further incident. The flight crew subsequently discovered they had entered an incorrect reduced thrust temperature into the flight management computer.

The investigation found the incorrect entry was probably a result of distraction during the data entry. The subsequent standard procedures and checks did not detect the error.

History of the flight

The flight crew were starting the fourth day of a four-day short haul period of duty. The duty for the fourth day was a single sector from Glasgow Airport to London Heathrow in G-EUXJ; the commander was the pilot flying. During the previous three days they had flown A319, A320 and A321 aircraft. The crew reported that they were well rested.

During passenger boarding the flight crew had a few minutes spare, so, as encouraged by the operator, the commander allowed a couple of passengers to visit the flight deck. Later, whilst the flight crew were entering the takeoff performance figures into the FMGC[1]

Footnote

[1] FMGC – Flight Management and Guidance Computer.

the senior cabin crew member asked if they could accept another flight deck visitor. The commander ignored the request and focused on the data entry but, he reported, it may have distracted him.

The takeoff was planned from the full length of Runway 05. The surface wind was from 080° at 5 kt, the visibility was 2,800 m in drizzle with cloud broken at 400 ft. The temperature was 8°C and the runway surface was wet. The takeoff performance calculation required FLAP 1, a flex[2] temperature of 49°C, a non-standard acceleration altitude of 1,070 ft and takeoff speeds of V_1 139 kt, V_R 147 kt and V_2 151 kt.

The flight crew completed the flight deck preparations and the aircraft was pushed back from the stand on time at 1803 hrs. At 1808 hrs the flight crew received their final load sheet which was consistent with the provisional figures. During taxi air traffic control asked if they could depart from Intersection F as another aircraft was holding at Taxiway G with a technical problem. However, before the flight crew changed the performance figures the crew of the other aircraft resolved their problem and it was able to depart. G-EUXJ continued to the full length of the runway and the flight crew completed the before takeoff checklist. As they started the takeoff roll, their standard review of the Flight Mode Annunciators (FMA)[3] was interrupted by several radio transmissions.

During the takeoff roll both pilots reported that they felt something was wrong, they felt the aircraft was not accelerating as they expected. The commander reported that "something was not right but I could not put my finger on it". At approximately 100 kt the co-pilot verbalised "this does not feel right, have we got enough power". At 137 kt the commander advanced the thrust levers to TOGA[4] power. The co-pilot recalled the aircraft had entered the last 900 m of the runway when the aircraft rotated. Subsequent flight data showed that the aircraft crossed the upwind end of the runway at 276 ft. The aircraft continued to Heathrow without further incident.

After takeoff, the flight crew realised they had entered a flex temperature of 79°C instead of 49°C.

Recorded information

The operator provided a copy of the flight data during the takeoff. Figure 1 shows the takeoff profile in red with an approximation of the expected profile in green.

Footnote

2 Reduced thrust.
3 FMA – Flight Mode Annunciator, displaying the armed and engaged modes of the autopilot and autothrust.
4 TOGA – Takeoff Go-Around.

Figure 1
G-EUXJ takeoff profile

Commander's report

During the takeoff performance data entry the pilot flying is required to read the performance figures from the printed performance calculation. The pilot monitoring enters these into their MCDU[5]. The pilot flying is then required to check these are entered correctly on their MCDU screen. The commander was not sure if he said "79°" when he read the flex temperature or if he said the correct number and the co-pilot inadvertently pressed 7 rather than 4. He highlighted that the 7 and 4 keys are next to each other on the keyboard. He was not sure why he did not spot the error when he checked his MCDU but thought he may have been looking at the non-standard acceleration altitude. The commander highlighted that not many airports require a non-standard acceleration altitude so he may have been focusing on this rather than the flex temperature. During this process the flight crew were briefly distracted by a call from the cabin crew and this may have been why the error was made or why it was not spotted.

After the point where the initial error was made there are several points in the standard procedures when the flex temperature is checked. It is reviewed in the pre-start checks, during the before takeoff checks and in the FMA review on the takeoff roll. However, these checks only require the flight crew to read the temperature and do not refer to the original performance data. The commander subsequently realised that a flex of 79°C was not typical for a A321; the temperature is more typically in the fifties. However, 79°C would not be abnormal for a A319 which the flight crew had flown four times during their tour.

After the incident the commander resolved to ensure a sterile flight deck when loading takeoff performance data, by closing the flight deck door during this time.

Footnote

5 MCDU – Multipurpose Control and Display Unit.

Previous events

On 21 July 2017 a Boeing 737-800 (C-FWGH) taking off from Belfast International Airport struck a runway approach light 29 m beyond the end of the takeoff runway. The investigation found that an outside air temperature (OAT) of -52°C had been entered into the FMC instead of the actual OAT of 16°C. The AAIB have investigated many other serious incidents involving incorrect takeoff performance figures.

The report into the C-FWGH serious incident highlighted that Takeoff Acceleration Monitoring Systems are now available which can alert flight crew to insufficient acceleration during the takeoff roll[6]. The AAIB made a Safety Recommendation to the EASA and the FAA to sponsor the development of technical specifications and, subsequently, develop certification standards for a Takeoff Acceleration Monitioring System.

Analysis

The flight crew inadvertently entered a flex temperature of 79° instead of 49°. The error was not detected during the subsequent procedures and checks.

The error was likely made due to a combination of brief distraction and entering a non-standard acceleration height. The subsequent checks do not require the flight crew to refer back to the source data and, whilst the selected flex temperature was unusual for a A321, it was not usual for the A319 which the flight crew had been operating during the tour.

The flight crew realised there was insufficient power during the takeoff roll and applied TOGA power.

The operator has reminded its pilots about the hazard of distraction during critical data loading and are reviewing their procedures to improve the likelihood that data entry errors are detected.

Safety actions

> The operator has issued a safety notice to all its flight crew highlighting this and previous events. The notice emphasises the importance of avoiding distractions whilst loading the takeoff performance data.
>
> The operator is also reviewing its takeoff performance data entry and checking procedures in order to ensure that there are sufficient opportunities in the procedures to trap any error.

Footnote

[6] https://www.gov.uk/aaib-reports/aircraft-accident-report-aar-2-2018-c-fwgh-21july-2017 (accessed 6 January 2020).

ACCIDENT

Aircraft Type and Registration:	AW109SP, G-VIVE
No & Type of Engines:	2 Pratt & Whitney Canada PW207C turboshaft engines
Year of Manufacture:	2019 (Serial no: 22393)
Date & Time (UTC):	4 November 2019 at 1800 hrs
Location:	Robins Farm, Chiddingfold, Surrey
Type of Flight:	Private
Persons on Board:	Crew -1 Passengers -3
Injuries	Crew - None Passengers - None
Nature of Damage:	Nose landing gear door damaged
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	45 years
Commander's Flying Experience:	3,657 hours (of which 186 were on type) Last 90 days - 26 hours Last 28 days - 12 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft was on final approach to a rural landing site at night. During the later stages of the approach the aircraft sank below the planned approach path and struck power lines. There were no injuries and the aircraft sustained only minor damage.

History of the flight

The aircraft was conducting a passenger flight between two private landing sites. It was night-time but weather conditions were described as CAVOK[1] by the commander and so the flight was conducted in Visual Meteorological Conditions (VMC). The destination site had been surveyed in daylight and the commander was familiar with it. Photographs in the survey indicated the location of the power cables, and the approach was made on an approximately westerly heading as recommended in the site survey. Due to the rural location and the lack of cultural lighting, the commander elected to use the autopilot (AP) Visual Flight Rules (VFR) Approach Mode. The VFR Approach Mode does not ensure obstacle clearance and the pilot is therefore responsible for maintaining a safe flight path. The approach consisted of a 5º approach slope from 1,400 ft amsl down to a 'Gate' of 600 ft amsl (landing site altitude plus 300 ft) and 50 kt IAS. The intention was to fly a

Footnote

[1] CAVOK: visibility 10 km or more; no cumulonimbus or towering cumulus cloud, and no cloud below 5,000 ft or Minimum Sector Altitude (whichever is the greater); and no significant weather at or in the vicinity.

manual approach from the gate to the landing site. A vehicle had been deployed at the site to illuminate the landing area with its headlights, and another pilot was present at the site to give weather updates over the radio.

The commander stated that he would normally set a minimum altitude warning at Gate Altitude but he did not do so on this occasion. He had been informed of mist patches in the vicinity by the pilot at the landing site, and he believed that his concern over the visibility caused him to allow the aircraft to descend about 100 ft below the Gate Altitude before he took manual control. As a result, the manual approach was commenced below the planned approach path. The commander did not recognise the shallower than expected approach and did not recall hearing the radio altimeter automated height call out at 200 ft agl. He did recall being in a stable though shallow, speed-reducing descent toward his Landing Decision Point (LDP), which is defined as a height of 80 ft, groundspeed 20 kt, and rate of descent (ROD) of 200 ft/min +/-50 ft/min. In the final stages of the approach he recalled flaring the aircraft to further reduce speed to the LDP. At this point he saw and then immediately contacted domestic power cables short of the landing site.

The aircraft sank onto the cables from above at very low speed. The commander brought the aircraft to a hover, moved backwards to clear the cables and then landed. All those on board were uninjured. The commander exited through the co-pilot's door as his own door was obstructed by a length of cable which had become entangled on the aircraft. The aircraft with the cable entanglement is shown at Figure 1.

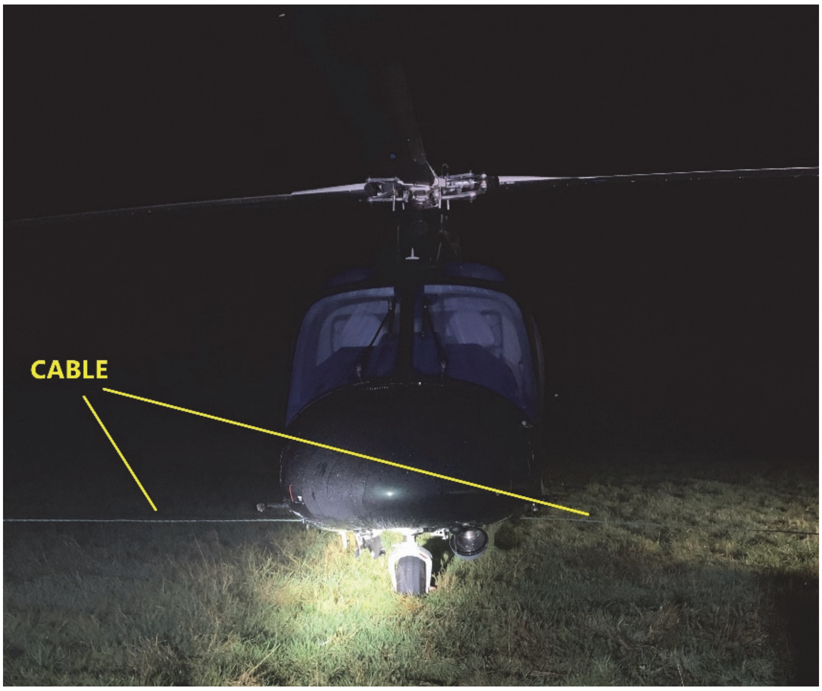


Figure1
Aircraft with cable entanglement

Incident site

The planned landing site and the aircraft actual landing site are shown at Figure 2.

Figure 2

Landing site photograph

The aircraft is parked on an approximately westerly heading which was also the heading used for the approach.

Analysis

The weather for the approach to the landing site was generally good, though a local report of mist in the vicinity caused the commander some concern. He considered that this distraction caused him to not set an altitude warning bug at his planned Gate Altitude. The transition from automatic flight to manual flight was made at a lower altitude than planned and the approach slope was thus shallower than anticipated. The site was illuminated by vehicle headlights but there was very little other cultural lighting.

It is likely the commander's attention was closely focussed on reducing speed towards the LDP while manually flying with limited external references. It is likely that this significantly increased his workload above his expectation and caused him to miss altitude cues, such as the automated height callout. Because of the lower than planned altitude, the aircraft struck the power cables at low speed, short of the planned landing area.

Conclusion

Restricted visual cues led the commander to not recognise a low approach path. The aircraft struck power cables in the undershoot of the planned approach.

CAA comment

CAP 1864, *Onshore Helicopter Review Report*[2], offers extensive information about onshore helicopter operations. Chapter 16 considers off-aerodrome landing sites, and there is a recommendation for:

> *'operators to ensure that their procedures and training material appropriately address the risks associated with off-airfield landing sites and are monitored for effectiveness.'*

Flights operated under Part-NCO[3] regulations, such as the flight operated by G-VIVE, were not within the scope of CAP 1864. However, the CAA commented that the recommendation would be prioritised in the production of a best practice document which would be published for use by all helicopter pilots.

Footnote

2 CAP 1864, *Onshore Helicopter Review Report.* Available: http://publicapps.caa.co.uk/docs/33/CAP1864OnshoreHelicopterReviewReport.pdf [accessed March 2020]

3 EASA Air Operations Regulations (EU) 956/2012 Annex VII, Part NCO, applies to non-commercial flights in other than complex aircraft.

SERIOUS INCIDENT

Aircraft Type and Registration:	Boeing 747-436, G-CIVU
No & Type of Engines:	4 Rolls-Royce RB211-524G2-T-19 turbofan engines
Year of Manufacture:	1998 (Serial no: 25810)
Date & Time (UTC):	20 December 2019 at 1543 hrs
Location:	London Heathrow Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 17 Passengers - 328
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to the No 1 engine cowl and to the rear of a fuel transfer vehicle
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	60 years
Commander's Flying Experience:	28,400 hours (of which 14,800 were on type) Last 90 days - 201 hours Last 28 days - 56 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot, reports submitted by the operator, the refuelling company and the airport authority, and further enquiries by the AAIB

Synopsis

A Boeing 747 collided with a fuel transfer vehicle (FTV) as it was approaching its final parking position on stand at Heathrow. The FTV had remained on stand after refuelling the previous aircraft. Neither the flight crew nor the ground staff responsible for the arrival saw the FTV before the collision.

The operator and airport authority have taken safety action to prevent reoccurrence.

History of the flight

G-CIVU landed on Runway 27R at London Heathrow at 1537 hrs and taxied towards Stand 331 on Terminal 3. The stand was occupied by an Airbus 320, operated by the same company, which was running behind schedule. The Airbus commenced push back at 1539 hrs, pushing back far enough to allow the 747 onto the stand. It was dark and raining heavily.

The commander of the Boeing 747 saw the stand guidance system illuminate with the correct aircraft type and started to taxi onto stand. He reported that his initial focus was to the right of the aircraft to ensure its wingtip was clear of the Airbus. He did not see any vehicles on the stand although he recalled it was difficult to see the white stand markings due to the standing water, heavy rain and the glare of the terminal lights. The aircraft continued onto stand, parked in the normal position and shutdown. After the passengers had disembarked the flight crew were informed that the No 1 engine had collided with a fuel transfer vehicle (FTV) which had been parked on the stand. The FTV driver had been in the cab but had not been injured.

The stand guidance system had been switched on by one of the operator's ground staff who was responsible for supervising the arrival. The supervisor was required to check that the stand was clear of obstructions prior to switching on the guidance system. On this occasion two supervisors had been assigned to the arrival. On arrival at the stand one of the supervisors walked out along the stand centreline as the Airbus pushed back, to check for FOD[1]. He had his hood up due to the rain. As he reached the middle of the stand he turned to the left (away from the FTV) and proceeded to the jetty in preparation from the arrival of the 747. He reported that his intention was to check for FOD; he did not confirm that the stand was clear and did not see the FTV. On arrival the other supervisor went to the stand guidance control panel. He saw his colleague walking the centreline and assumed he had checked the stand was clear so switched on the guidance. He then waited by the stand guidance emergency stop button. However, due to the position of the jetty, ground equipment and parked vehicles it was not possible to see the right side of the stand (where the FTV was parked) from this position. He did not see the FTV and was not aware of the collision, so did not activate the emergency stop button.

The driver of the FTV had been assigned to refuel the Airbus. He reported that having refuelled the Airbus he moved his vehicle forward a few meters but remained on the stand to complete his paperwork and to await confirmation that fuelling was complete from the flight crew. He reported that his tablet computer had frozen and he was trying to fix it when the collision occurred. The vehicle was positioned facing the terminal and the driver was wearing ear defenders so was not aware of the 747 approaching the stand. When the 747's engine collided with the back of the FTV, the vehicle was pushed forward. The driver immediately drove forward a few meters to move away from the aircraft then stopped to report the accident.

Aircraft and vehicle damage

Damage to the aircraft and FTV are shown in Figure 1. Both were repaired and returned to service.

Footnote

[1] FOD – Foreign Object Debris.

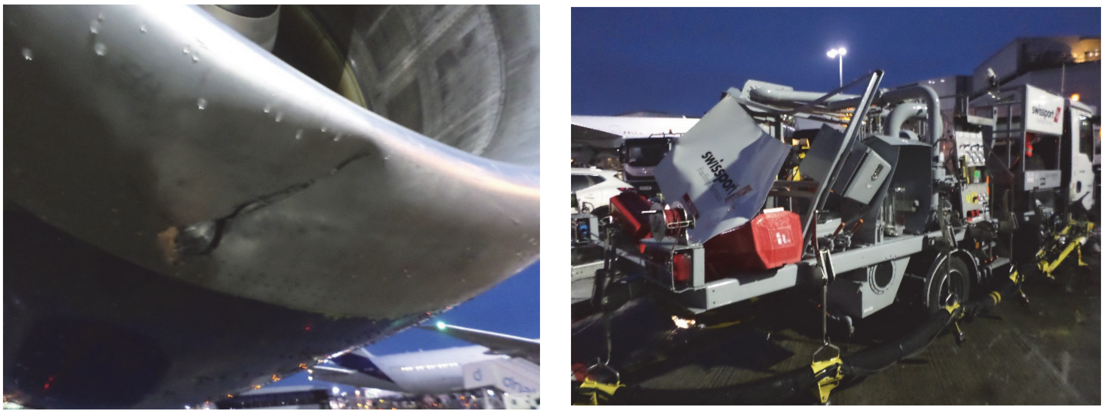


Figure 1
Damage to G-CIVU No 1 engine cowl and rear of the Fuel Transfer Vehicle

Recorded information

CCTV showed the Airbus commence push back at 1539 hrs. The FTV can be seen parked by the Airbus's left wingtip. The supervisor can be seen walking the centreline behind the pushback tug. The collision occurred at 1543 hrs. Figure 2 shows an image from the CCTV just prior to the collision.

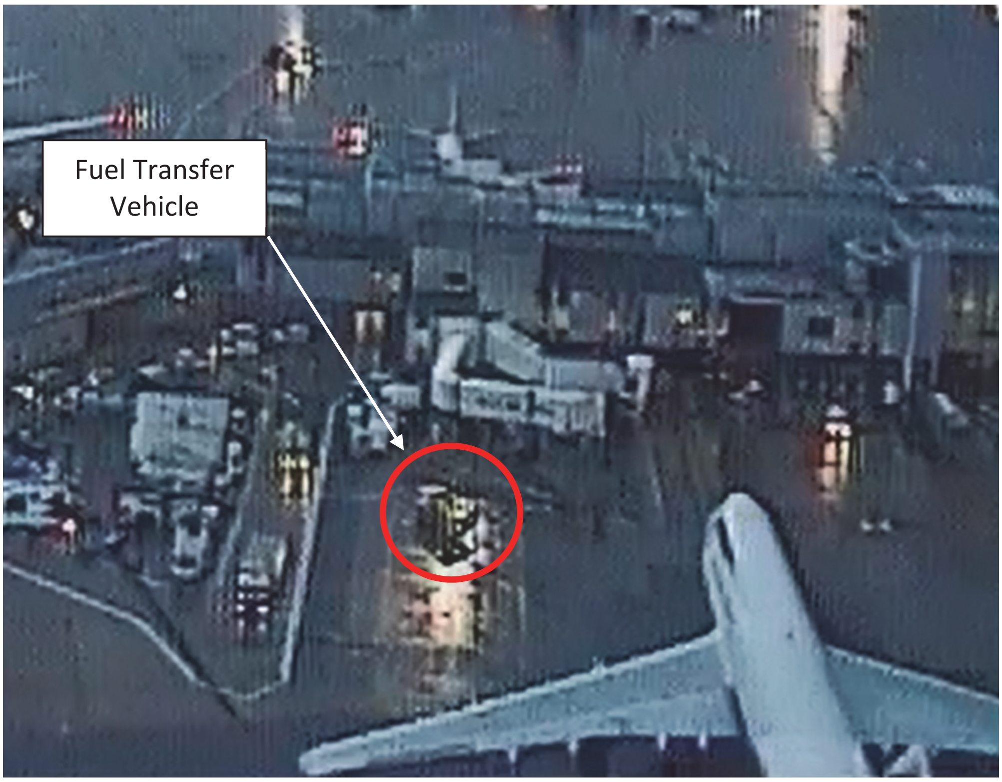


Figure 2
CCTV image showing the B747 approaching the stand and the parked FTV

Heathrow Stand 331

Figure 3 shows an aerial view of Stand 331 at Heathrow with a Boeing 747 superimposed on the image. The approximate position of the FTV when the collision occurred is shown.

Figure 4 is a photograph taken from the emergency stop button position at the head of the stand looking towards the right where the FTV was parked. The photograph shows the obscured view in that direction.

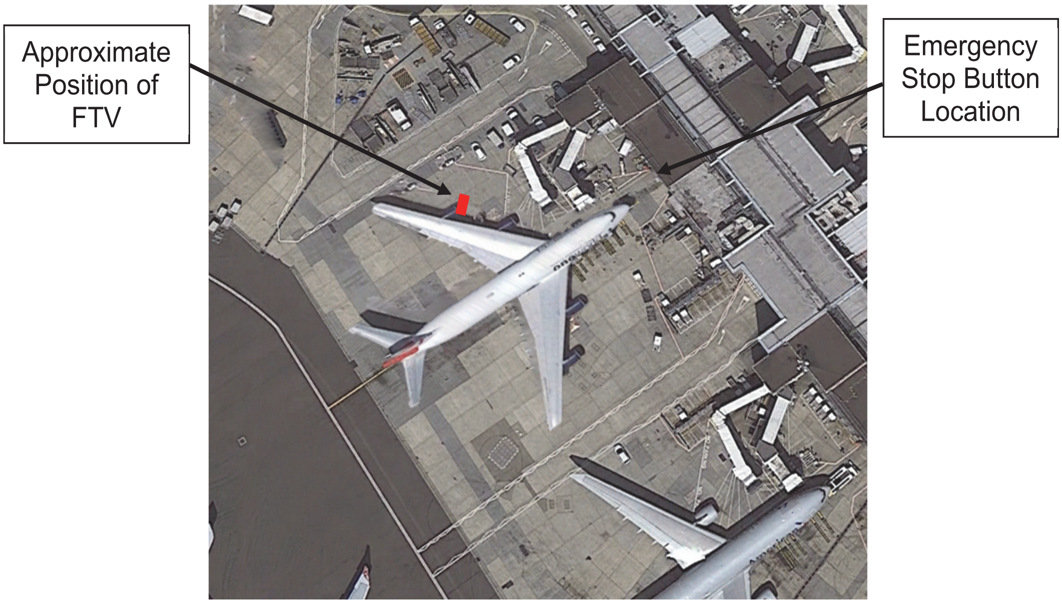


Figure 3

Aerial view of Stand 331 with B747 superimposed

Figure 4

View to the right of the stand from Emergency Stop Button Location

Heathrow procedures

The airport authority publish the following Operational Safety Instruction describing the required procedure for aircraft arrivals on stand[2].

> *'A member of the airline/handling agent staff will be nominated to carry out a safety check of the stand before the arrival of the aircraft. This safety check will include the following;*
>
> *a) Ensure that the stand is unobstructed by vehicles or equipment.*
>
> *b) Ensure that the airbridge(s) is retracted and correctly parked.*
>
> *c) Carry out a full Foreign Object Debris check.*
>
> *d) Check the list of aircraft permitted to use the stand, by checking the notice displayed adjacent to the Visual Docking Guidance System activation switches.*
>
> *These actions should form part of the Airline or Handling Agents aircraft turnround plan.'*

Operator's investigation

The operator's investigation into this incident found that ground handling procedures had undergone significant change in recent years. The procedures referred to the need to check the stand for FOD but did not make specific reference to vehicles parked out of position. The procedures were not written for occasions when two supervisors were assigned to an arrival and did not account for joint responsibilities and communications. The investigation also found that two different versions of the procedure were available in different locations on its computer system.

The investigation found that an instruction had been published on 7 January 2019 stating that a routine centreline walk was not required for every arrival and that a visual check for FOD could be completed from the head of the stand. This change had not been incorporated into the standard operation procedures.

Refuelling process

Having refuelled the Airbus the refueller reported that he was trying to complete the electronic paperwork on his tablet when the accident occurred. The tablet sends refuelling information directly to the flight crew. The flight crew can then accept the fuel electronically. The refueler was also assigned his next task via the tablet. It was reported that the internet signal is poor around some stands at Terminal 3 and this can cause problems with the tablets.

The operator provided a copy of the log for the refuelling process. The times recorded are show in Table 1.

Footnote

[2] Operation Safety Instruction available at https://www.heathrow.com/company/team-heathrow/airside/useful-publications/operational-safety-instructions [accessed 27 January 2020].

TIME	ACTION
14:49	Operator started fuelling
15:09	Operator completed fuelling
15:09	‘Fuelling complete’ message sent to the pilot
15:09	Pilot accepted the final fuel figure
15:36	Operator completed the service order
15:43	Fuel order delay reason edited

Table 1

Airbus refuelling timings from the electronic log

Analysis

As the Boeing 747 approached its final parking position it collided with the FTV which had remained on the stand after refuelling the previous aircraft.

The flight crew did not see the FTV. It is likely that this was due to a combination of the dark conditions, the heavy rain and the glare from the terminal lights. The commander reported that it was hard to see the stand markings and that his attention was initially on the right side of the aircraft to ensure clearance from the Airbus. The stand guidance system had been switched on suggesting to the flight crew that the stand was clear.

The stand guidance system had been switched on by one for the operator’s ground staff. Airport procedures required ground staff to ensure the stand is clear prior to switching on the guidance. However, on this occasion two supervisors were assigned to the arrival. The investigation found that the operator’s procedures did not make it clear who was responsible for ensuring the stand was clear in this situation. The operator had published instructions stating that the ground staff could check the stand from the head of the stand, but on this stand it is not possible to see all of it from this position. The operator is taking the following safety action to resolve these issues:

> The operator will conduct an independent review of the available standard operating procedures and associated documentation to ensure they are;
>
> - clear and workable,
> - the accountabilities and responsibilities are detailed and,
> - there is a single source of information.

The ground staff remained near the emergency stop button during the arrival, but they could not see the FTV from this position. The jetty structure and parked vehicles obscured part of the stand from the stop button position. The operator will take the following safety action:

The operator will establish a procedure to ensure all visually restricted stands have a 'mid-man', in the line of sight, to act as an additional pair of eyes for the colleague manning the emergency stop button at the head of the stand.

The airport authority is taking the following safety action:

The airport authority has changed the parking arrangement on Stand 331 to prevent vehicles obscuring the view from the head of stand.

The airport authority is undertaking a review of the emergency stop button locations on all stands.

The FTV had remained on the stand following the refuelling of the previous aircraft. The fuelling log showed that the refuelling was completed and accepted at 1509 hrs but the vehicle was still on the stand at 1543 hrs when the collision occurred. The refueller reported that he was trying to complete his electronic paperwork but his tablet had frozen. He was trying to reset the tablet when the accident occurred. He was wearing ear defenders and facing away from the stand so did not hear or see the approaching aircraft.

Conclusion

The collision occurred because neither the flight crew nor the ground staff assigned to the arrival saw the vehicle on the stand. The adverse weather conditions are likely to have been a significant factor.

SERIOUS INCIDENT

Aircraft Type and Registration:	Boeing 777-200, AP-BGZ
No & Type of Engines:	2 General Electric GE90-110B1 turbofan engines
Year of Manufacture:	2006 (Serial no: 33782)
Date & Time (UTC):	22 August 2019 at 1625 hrs
Location:	Birmingham Airport
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 11 Passengers - 209
Injuries:	Crew - None Passengers - None
Nature of Damage:	None
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	61 years
Commander's Flying Experience:	22,500 hours (of which 9,000 were on type) Last 90 days - 180 hours Last 28 days - 60 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

Following pushback and engine start the aircraft began to taxi before ground crew and equipment had moved away. The aircraft struck the towbar, damaging it and the taxiway surface.

History of the flight

The aircraft was departing Birmingham en route to Islamabad and, following a normal pushback, it was stopped and the parking brake was applied. The flight crew advised the ground crew to disconnect the ground equipment and give a hand signal when clear to the left. The ground crew disconnected the tug and towbar and positioned the tug to the left of the aircraft nose. The towbar was moved behind the tug so that it could be attached to the rear towpoint for removal from the taxiway.

The flight crew saw the tug clear of the aircraft to the left and observed the ground crew moving around. After a period during which the ground crew did not appear again and did not make contact, the flight crew assumed that he had left the aircraft. They attempted to gain the ground crew's attention with gestures from the flight deck and via the intercom but were unable to do so. The aircraft commander, believing they were ready to taxi, asked the co-pilot to obtain taxi clearance. The flight crew did not ask ATC if they could assist in confirming that all personnel were gone from beneath the aircraft and did not receive the final clearing hand signal from the ground crew. The time interval from the towbar being disconnected from the aircraft to the aircraft starting to move was approximately 23 seconds. The handling agent commented that it would be usual for this period to be about two to three minutes.

Shortly after starting to move, the aircraft struck the towbar and the crew stopped and applied the parking brake. Neither of the ground personnel nor the tug were struck by the aircraft. The aircraft was inspected by the airline ground engineer and subsequently cleared to depart.

The towbar and the taxiway surface were damaged during the event.

Recorded information

Video of the event was recorded by the camera on Stand 55C at the airport. Figures 1-3 show the position of the ground crew as AP-BGZ taxied.

Figure 1
AP-BGZ begins to move

Figure 2
AP-BGZ approaches the towbar and tug

Figure 3
AP-BGZ runs over the towbar

Analysis

After a normal pushback, the ground crew were cleared to remove the ground equipment and intercom in the normal manner. After a while, the commander asked the co-pilot to obtain taxi clearance from ATC even though neither had seen a clearing hand signal from the ground crew. The flight crew tried to contact the ground crew but were unable to do so, and the tug remained in view to the left of the aircraft. They did not ask ATC to remove doubt about the position of the ground personnel and equipment and, as a result, the ground equipment remained in the path of the aircraft when it began to move and a collision resulted.

Conclusion

The commander decided to taxi before all the ground personnel and equipment were clear of the aircraft. Shortly after starting to move, the aircraft struck the towbar.

BULLETIN CORRECTION

When originally published the cover page of this report stated that there were two crew on board the aircraft and 218 passengers, whereas it should have stated that there were 11 crew and 209 passengers. The cover page should also have stated that no crew or passengers were injured during the event.

The online version of the report was amended on 11 June 2020.

ACCIDENT

Aircraft Type and Registration:	1) Learjet 31, N127VL 2) Cessna T206H, N35014
No & Type of Engines:	1) 2 Garrett TFE731-2-3B turbofan engines 2) 1 Lycoming IO-540-AC1A piston engines
Year of Manufacture:	1) 1991 2) 2002
Date & Time (UTC):	4 January 2020 at 1416 hrs
Location:	Terence B Lettsome Airport, British Virgin Islands
Type of Flight:	1) Commercial Air Transport (Passenger) 2) Private
Persons on Board:	1) Crew - 2 Passengers - None 2) Crew - None Passengers - None
Injuries	1) Crew - None Passengers - N/A 2) Crew - N/A Passengers - N/A
Nature of Damage:	1) None reported 2) Small tear on rudder trailing edge
Commander's Licence:	1) Airline Transport Pilot's Licence 2) N/A
Commander's Age:	1) 62 years 2) N/A
Commander's Flying Experience:	1) 8,415 hours (of which 1,744 were on type) Last 90 days - 38 hours Last 28 days - 18 hours 2) N/A
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

During a turn while under the direction of ground staff, the winglet of the Learjet 31 struck the tail of a parked Cessna T206H causing minor damage to the Cessna's rudder.

History of the flight

After landing on Runway 07, Learjet N127VL followed ATC instructions to the parking apron. The weather was clear, the ground surface was dry, and there was a brisk wind from the north-east. There were several rows of aircraft parked, all facing east, and two people wearing yellow vests visible at the end of the last row of parked aircraft, which the flight crew took to be the ground staff to marshal their aircraft into position. The crew followed the ground staff's signals, which took them between two rows of aircraft. When N127VL reached the end of the yellow centreline, the crew was directed to make a turn behind a single engine Cessna aircraft. One of the ground staff was positioned at the right wingtip, next to the Cessna aircraft, and the other moved to the front of the Learjet. Despite the flight crew taxiing cautiously and monitoring the position of the ground crew, the right-seat pilot thought that N127VL contacted the rudder of the Cessna during the turn. The crew stopped the aircraft and shut it down before going out and inspecting both aircraft. The rudder of the Cessna had a tear, about one inch long on the trailing edge, where the Learjet winglet had made contact, but there was no damage to the winglet. The relative positions of the two aircraft and the damage caused are shown at Figure 1.

Figure 1

The winglet of the Lear jet contacted the rudder of the Cessna

The commander stated that, in a swept wing aircraft, the flight crew cannot determine wingtip clearance and therefore rely on the ground staff to ensure a safe clearance is maintained.

ACCIDENT

Aircraft Type and Registration:	Aeroprakt A22-LS Foxbat Supersport 600, G-CHSY	
No & Type of Engines:	1 Rotax 912ULS piston engine	
Year of Manufacture:	2013 (Serial no: LAA 317B-15186)	
Date & Time (UTC):	16 July 2019 at 1515 hrs	
Location:	Otherton Hall Farm, Staffordshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - 1 (Serious)	Passengers - 1 (Serious)
Nature of Damage:	Aircraft destroyed	
Commander's Licence:	Private Pilot's Licence (Aeroplanes)	
Commander's Age:	67 years	
Commander's Flying Experience:	621 hours (of which 524 were on type) Last 90 days - 8 hours Last 28 days - 6 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot and further enquiries made by the AAIB	

Synopsis

The aircraft stalled shortly after becoming airborne. It came to rest upright in a crop field at the end of the runway and both occupants sustained serious injuries. The aircraft was written off.

History of the flight

The pilot, who was the owner of the aircraft, flew it to Otherton Airfield on the morning of the accident. He was accompanied by a friend who also held a National PPL.

The aircraft underwent an annual check at Otherton before the UK importer completed a test flight with the pilot's friend onboard. No anomalies were identified during the annual check and the aircraft instrumentation, handling and performance were reported to be normal throughout the flight.

Accident site

Photographs showed that the aircraft came to rest upright in a crop field immediately beyond the end of the runway. They indicated that the aircraft struck the ground with very little forward speed and with the right wing low. Damage sustained by the propeller indicated that it was turning when the aircraft hit the ground.

It was reported that a visual assessment of the pitot / static system after the accident showed no obvious anomalies.

Figure 1

General view of damage sustained in the accident

Aircraft information

The Aeroprakt A22-LS Foxbat is a high-wing, strut-braced, two-seat microlight aircraft of 450 kg maximum gross weight, with a tricycle undercarriage. It is only available in the UK in the form of a quick-built kit, which is manufactured in the Ukraine. The aircraft is of riveted aluminium construction and the flying surfaces are fabric covered. G-CHSY was equipped with a Dynon Skyview avionics system, which has non-volatile memory (NVM) that records flight data.

Investigation

Weight and balance

The pilot provided comprehensive weight and balance calculations, which indicated that the aircraft was within the acceptable limits with a takeoff mass of approximately 567 kg.

Pilot's Operating Handbook

The Pilot's Operating Handbook (POH) states that the stall speed at Maximum Take Off Weight (MTOW) and full flap is 37 mph (approximately 32 kt). The stall speed at MTOW and with the flaps retracted is 48 mph (approximately 42 kt). The MTOW is 650 kg.

The handbook specifies V_x to be 56 mph (approximately 49 kt) and V_y to be 62 mph (approximately 54 kt).

Runway information and takeoff technique

Otherton is an unlicensed airfield and there are three grass runways. The runway used for the accident departure was Runway 34, which is 300 m long.

According to the POH, the minimum takeoff distance at MTOW for standard ICAO atmosphere, mean sea level, no wind and a hard and even runway is 100 m. The handbook acknowledges that actual takeoff distance will depend on the condition of the aircraft, environment and pilot skill. The handbook describes the recommended techniques for both a short / soft field takeoff and the climb, Figure 2.

5.7 Short/soft field takeoff

1. Flaps – EXTEND FULLY.
2. Hold position – OCCUPY.
3. Takeoff distance – CHECK if sufficient.
4. Rudder pedals – NEUTRAL.
5. Throttle – gradually FULL POWER.
6. Brakes – RELEASE.
7. Yoke – elevator NEUTRAL, ailerons AGAINST CROSSWIND.
8. Rudder pedals – maintain takeoff direction.
9. Yoke – PULL gently to lift the nose wheel at 40 km/h (25 mph, 22 kts).
10. Liftoff – at 65 km/h (40 mph, 35 kts).
11. Accelerate to at least 90 km/h (56 mph, 49 kts) at 1-2 m (3-7 ft) and start to climb.
12. Speed – SET best angle of climb speed V_X = 90 km/h (56 mph, 49 kts).

5.8 Climb

1. Speed – SET: best angle of climb speed V_X = 90 km/h (56 mph, 49 kts) or
   best rate of climb speed V_Y = 100 km/h (62 mph, 54 kts)
   in strong turbulence +10 km/h (6 mph, 5 kts).
2. Flaps – RETRACT SLOWLY at safe altitude.
3. EGT – max. 850°C (1562°F).
4. Coolant temp. – max. 120°C (248°F).
5. Oil pressure – max. 5.0 bar (73 psi).

Figure 2

Takeoff and climb techniques described in the POH

Pilot's description of the events

The pilot reported that the grass was between 100 and 150 mm long and the wind was "straight down the runway at about 6 kt". He noted that prior to the accident flight, there was a discrepancy between the altitude on the back-up instruments and the Skyview display. He reported that these "were seen to disagree with each other by more than the usual few feet". He was running an application that displayed GPS altitude on his tablet computer and he decided to continue with the flight with the intention of diagnosing the altitude anomaly when he was airborne.

The pilot selected first stage of flap for the takeoff, which the aircraft dealer confirmed was appropriate for a departure from Otherton. The nosewheel left the ground at 20 kt and the pilot kept the speed between V_x and V_y using the information displayed on the Skyview.

The pilot reported that the left wing dropped at a height of approximately 100 feet and he tried, unsuccessfully, to correct this using the ailerons. He asked his passenger to retract the flaps and checked the airspeed, which he reported was slightly higher than V_y. The pilot considered the pitch attitude of the aircraft to be normal at this point. As the aircraft reached approximately 60° left roll the pilot reduced the engine power and applied full right rudder to try to correct for the wing-drop. Just before the aircraft struck the ground the engine power was reduced to idle.

The pilot attributed the accident to the Skyview system indicating an incorrect, high, airspeed.

The AAIB successfully downloaded the data recorded by the aircraft's Skyview system, which included the post-check test flight and the accident flight. The data from the accident flight showed that the aircraft became airborne at an indicated airspeed of approximately 30 kt and the speed fluctuated between approximately 26 kt and 32 kt during the climb. When the aircraft achieved its maximum height of about 70 feet above the airfield the indicated airspeed was 28 kt. The data showed that the engine speed started to reduce as the left wing dropped, and that the aircraft achieved a maximum roll angle of approximately 57°. The roll direction reversed as the aircraft descended and the engine speed increased slightly just before the aircraft struck the ground with the right wing low. The aircraft was airborne for approximately 16 seconds.

The AAIB were informed that the Skyview had been tested by an approved repair agent after the accident and there were no anomalies with the processing and display of the flight data, including airspeed and altitude.

Conclusion

The aircraft weight was reported to be below MTOW and the pilot stated that the first stage of flap was used for the take off. The runway distance available at Otherton was sufficent for the aircraft to take off safely and the preceding check-flight from the same runway had been uneventful.

The pilot reported that prior to the flight, there was an anomaly between the altitude on the standby instruments and the Skyview. He stated that he flew the departure between V_x and V_y, as indicated on the Skyview but that he now believed that the airspeed displayed on the Skyview was incorrect.

It was reported that a visual assessment of the pitot / static system after the accident showed no obvious anomalies. Data recovered from the Skyview indicated that the aircraft became airborne very close to the stall speed for an aircraft at MTOW and full flap. The airspeed remained low for the remainder of the flight.

The aircraft climbed to a height of approximately 70 feet and the left wing dropped. The pilot stated that the flaps were retracted after the wing dropped. This would have increased the stall speed such that recovery would be unlikely given the height available.

It was reported that a visual assessment of the pitot / static system after the accident showed no obvious anomalies.

ACCIDENT

Aircraft Type and Registration:	Piper PA-18-150, N162AW
No & Type of Engines:	1 Lycoming O-320-A2B piston engine
Year of Manufacture:	1948
Date & Time (UTC):	25 July 2019 at 1415 hrs
Location:	Private strip, Isle of Mull
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	22 years
Commander's Flying Experience:	1,870 hours (of which 385 were on type) Last 90 days - 90 hours Last 28 days - 59 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The aircraft had landed at a remote field site on the Isle of Mull. During preparations for departure the aircraft unexpectedly left the ground. Despite the application of full power and right aileron the aircraft rolled left, struck the ground and rolled inverted. Both occupants were uninjured.

History of the flight

The aircraft was operating from Glenforsa Airfield on the Isle of Mull to remote field sites. The site where the accident occurred was to the west of Ben More, at an elevation of approximately 1,500 ft amsl and had been visited earlier in the day. Each occupant had a pilot's licence and the passenger flew the aircraft into the landing site. There was no local meteorological information available, but the commander had obtained a forecast wind for the area of 170º at 9 kt. He assessed the wind at the sites as being 190º at 14 kt.

The pilot lined up the aircraft for takeoff and assessed that there was a slight crosswind from the right. While preparing for takeoff the aircraft suddenly lifted into the air and rolled left. The pilot stated that he instinctively applied full power and attempted to correct the left roll. The left wingtip struck the ground, followed by the nose. The aircraft then overturned about the wingtip and nose coming to rest inverted. Both pilots vacated the aircraft unhurt. In his report the pilot stated his belief that a strong, unexpected gust of wind affected the aircraft.

The aircraft was badly damaged by the accident and damaged further during its recovery from the site by helicopter. The damage was subsequently assessed as being beyond economic repair.

Aircraft information

The aircraft was a modified PA-18-150. Its short takeoff and landing characteristics gave it a stalling speed below the minimum speed, 40 mph, that could be displayed by the airspeed indicator. The aircraft was fitted with large diameter tyres to allow operation from unprepared sites.

Information from the pilot

The pilot assessed that a gust of 25 kt would be sufficient to lift the aircraft into the air but that "in a pre-take-off scenario there is not the necessary airspeed to the ailerons to counteract a rolling tendency once the wind has lifted the aircraft into the air."

Meteorology

A summary of findings from a Met Office review of the area meteorology is as follows:

> *'From the information available, the most likely weather conditions across the Island of Mull at around 1415 UTC on Thursday 25th July 2019 were generally fine, good or very good visibility with few or scattered amount of cloud with bases above 3000 ft. The wind direction would have been from a south-east or south-south-east direction, with mean surface speed most likely to be 15-20 Knots, increasing to 20-30 Knots at 2000 ft. The air would have been stable hence gusts would have been unlikely.'*

Analysis

The aircraft had a very low stalling speed and would have been capable of flight at very low airspeeds, and the pilot believed that a gust of 25 kt could lift it into the air. Although the Met Office considered gusts unlikely, its report suggested that the freestream wind at 1,500 ft amsl might have been about 20 kt. It is possible that local wind effects, influenced by the terrain, caused the strong gust of wind near the ground reported by the pilot.

Conclusion

The aircraft rolled out of control at low airspeed, struck the ground and inverted.

ACCIDENT

Aircraft Type and Registration:	Robinson R44 II Raven II, G-LLIZ
No & Type of Engines:	1 Lycoming IO-540-AE1A5 piston engine
Year of Manufacture:	2008 (Serial no: 12140)
Date & Time (UTC):	2 October 2019 at 1058 hrs
Location:	Sherburn-in-Elmet Airfield, Yorkshire
Type of Flight:	Training
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 Passengers - N/A
Nature of Damage:	Beyond economic repair
Commander's Licence:	Student
Commander's Age:	34 years
Commander's Flying Experience:	47 hours (of which 2 were on type) Last 90 days - 8 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

A student pilot was on a solo circuit sortie as part of his PPL course. After landing from the third circuit, the pilot noticed that his jacket, which had been secured on the left seat, had moved. In attempting to retrieve the jacket, it is likely that the pilot inadvertently raised the left collective lever. The helicopter pitched up, yawed to the left and rolled onto its right side. The pilot was able to vacate the helicopter but suffered a head injury in the accident.

History of the flight

The pilot arrived at the airfield to complete a solo circuits flight as part of his PPL training. He was briefed by the supervising instructor and, having completed the external and internal checks on G-LLIZ, he proceeded to start the engine. Whilst the engine was warming up post-start up, the pilot removed his jacket and placed it onto the left seat of the helicopter, using the seat belt to secure it. He also decided to open both the side vents and the nose vent as the carbon monoxide light had illuminated. This is not unusual when the helicopter engine is running for a period whilst stationary. Opening the vents increased the air movement in the cockpit and the light extinguished. Having completed the pre-takeoff checks, the pilot lifted into the hover and proceeded to the centre of the airfield to depart for his first circuit.

After landing off the third circuit the pilot realised that his jacket had moved on the front left seat so that it was now resting next to the open vent in the front left door. The pilot was aware of the risks of items striking the tail rotor when sucked out through the open vent in flight so before commencing his fourth circuit he reached out to retrieve the jacket[1]. Although the pilot does not recall the exact sequence of events, it is likely that the jacket was caught around the left collective lever. As he pulled the jacket, it raised the lever which increased the pitch on the blades and caused the helicopter to pitch nose up. This increase in pitch caused the rear tail stinger to contact the ground. The helicopter then yawed to the left before rolling right, coming to rest on its right side. The sequence is illustrated using snapshots taken from the airfield CCTV shown in Figures 1 to 7.

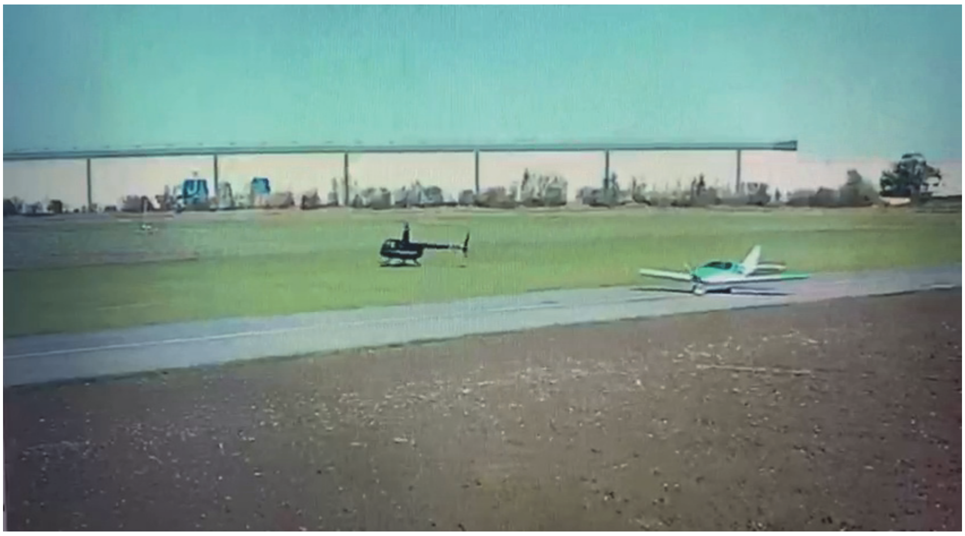


Figure 1
G-LLIZ begins to pitch nose up

Figure 2
The tail stinger contacts the ground

Footnote

[1] Robinson Helicopters Safety Notice SN-30 warns about the risks associated with loose objects in the cabin. Available: https://robinsonheli.com/wp-content/uploads/2015/12/rhc_sn30.pdf [accessed March2020]

Figure 3
G-LLIZ begins to yaw to the left

Figure 4
G-LLIZ yaws to the left and begins to roll right

Figure 5
First blade impacts the ground

Figure 6
Second blade impact

Figure 7
G-LLIZ comes to rest on its right side

The pilot was able to vacate the helicopter via the left door although he had suffered a head injury. The helicopter was damaged beyond economic repair. Figure 8 shows G-LLIZ after the accident.

Figure 8
G-LLIZ after the accident

Aircraft details

The R44 is designed with a centre mounted cyclic control, a collective lever to the left of each front seat, and a set of tail rotor pedals for each front seat. The collective levers also have a twist-grip throttle fitted. The left seat controls may be removed. Although the pilot was flying the helicopter solo, dual controls remained fitted to G-LLIZ. The manufacturer's standard practice is for the controls to remain fitted unless there is to be a person occupying the left seat who is not a rated helicopter pilot. The manufacturer does not suggest removing the dual controls for student solo sorties. Cyclic and collective controls are fitted with adjustable friction devices. These devices allow the pilot to adjust the amount of force which is required to move the controls. There is no friction device fitted to the tail rotor pedals.

The main rotor is two-bladed with a teetering head. The manufacturer states in the pilots' operating handbook that pilots should not raise the collective to slow the rotor during shutdown as this might cause the blades to '*flap and strike the tailcone*'. If the throttle is at idle and the pilot raises the collective, the energy of the blades may not be sufficient to retain them in their normal range as their pitch increases and it is possible that they may flap beyond the limit, with the retreating blade striking the tailcone.

The aircraft checklist requires that all loose articles are removed and stowed as part of the pre-flight checks although the pilot of G-LLIZ removed his jacket after this checklist was complete.

Dynamic rollover

Dynamic rollover is caused when a landing gear wheel or skid is in contact with a fixed object or the surface which stops the wheel or skid moving sideways. The helicopter can then begin to rotate about the wheel or skid and eventually the helicopter's critical rollover angle is reached, which will be different for each helicopter type. Once this angle is reached the main rotor thrust will continue the roll and the situation is no longer recoverable. The application of opposite cyclic will not stop the roll and only rapidly lowering the collective as the helicopter begins to pivot may stop the roll before the critical angle is reached.

Analysis

In reaching to the left side of the cockpit to retrieve his jacket, the pilot did not realise that the jacket had become caught around the left collective lever. As he pulled the jacket, it raised the collective increasing the pitch on the rotor blades and causing the helicopter nose to pitch up. It is possible that his body position as he reached across the cockpit caused an inadvertent application of left pedal which also caused the helicopter to yaw. As the helicopter was in contact with the ground, this yaw caused the skids to catch on the surface, generating a right roll from which there was ground contact.

The pilot was looking inside the helicopter when the movement began, and he had little chance to notice and stop the movement before it went past a point where recovery was possible. Only lowering the collective rapidly could have prevented the roll once the helicopter had begun to pivot about its skids. Although there are friction devices fitted to the cyclic and collective controls, the pilot did not apply them as he was in the middle of a flight and was planning to takeoff shortly after retrieving his jacket. It is possible that the application of the friction devices might have prevented the left collective being pulled up by the jacket. Pilots should always consider the use of the friction devices should they need to move around in the cockpit for any reason when on the ground.

Had the pilot used the twist-grip throttle on the collective lever to reduce the engine rpm and rotor rpm before moving around the cockpit, it is possible that when the collective was inadvertently raised the main rotor would have flapped, contacting the tailcone. This would likely have resulted in a very similar level of damage to the helicopter.

The helicopter manufacturer includes a check for loose items as part of the pre-flight checklist although the pilot removed his jacket after completing this part of the checklist. All loose articles can be a danger in a helicopter or aircraft at any stage of the flight, and pilots should stow belongings or equipment securely. It is best to ensure that the pilot and any passengers are comfortable with their clothing before the flight begins.

Conclusion

An innocuous reach to retrieve a jacket from where it had moved began a sequence of events that led to the helicopter coming to rest on its right side and being damaged beyond economic repair. Whenever a helicopter is stationary on the ground, with the pilot attending to items inside the cockpit, things can rapidly occur that lead to an incident or accident without the pilot being alerted because they may not be looking outside the cockpit. The whole accident sequence of G-LLIZ took just four seconds. Ensuring that all items inside the cockpit are secure and that the pilot and any passengers are comfortable for the flight are essential for minimising the risk of such an event occurring.

ACCIDENT

Aircraft Type and Registration:	Rutan Long-EZ, G-ICON
No & Type of Engines:	1 Continental Motors Corp O-240 piston engine
Year of Manufacture:	2000 (Serial no: PFA 074A-11104)
Date & Time (UTC):	20 January 2020 at 1330 hrs
Location:	Retford Gamston Airport, Nottinghamshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damage to main landing gear, nose fairing, propeller and engine
Commander's Licence:	Private Pilot's Licence
Commander's Age:	78 years
Commander's Flying Experience:	392 hours (of which 98 were on type) Last 90 days – 0.6 hours Last 28 days – 0 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

The pilot of G-ICON started the aircraft's engine in preparation for a short local flight. He ensured that the engine had fully warmed up before calling the tower for taxi, as overnight the temperature was near freezing. After carrying out his pre-flight checks, including a successful engine run-up, he called the tower to take off from Runway 21.

The takeoff was normal until, at about 600 ft aal, the engine began to run less smoothly with a loss of power. He immediately applied carburettor heat, to no effect, before positioning the aircraft for a tight circuit to land back on Runway 21. On short final, he saw that there was another aircraft on the runway which was unable to vacate in time and so thought about landing at the beginning of Runway 31. However, this would have required a series of 'S turns' at low height and low airspeed so he decided to level the wings to land further down Runway 31. Unfortunately, he landed just to the side of Runway 31 about halfway along its length. Although the landing was soft, the aircraft sustained substantial damage when the main landing gear was torn from the aircraft by an irrigation pipe. The cause for the loss of engine power has not been established.

ACCIDENT

Aircraft Type and Registration:	LBL 360A balloon, G-LLGE
No & Type of Engines:	None
Year of Manufacture:	2013 (Serial no: 1401)
Date & Time (UTC):	30 April 2019 at 1905 hrs
Location:	Near Little Sampton, Essex
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 1 Passengers - 14
Injuries:	Crew - None Passengers - None
Nature of Damage:	Minor damage to a house
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	61 years
Commander's Flying Experience:	3,203 hours (of which 176 were on type) Last 90 days - 26 hours Last 28 days - 9 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and additional enquiries by AAIB

Synopsis

A hot air balloon landed in a field and dragged an unexpectedly long distance before stopping close to a house. The envelope deflated over the house and caused minor damage to it. Insufficient slack in one of the control lines may have inhibited the full operation of the rapid deflation system and contributed to the long drag of the balloon. The balloon had recently undergone maintenance work where the parachute line was requested to be lengthened. This work may not have been satisfactorily completed and in the absence of a specific check where the rapid deflation system was operated to its full extent, there was no way for this to be detected.

History of the flight

The balloon took off at 1825 hrs British Summer Time (BST) with 14 passengers. The forecast wind was from 130 at 7 kt gusting 15 kt. After 30 minutes, the pilot performed two low passes over fields and found the ground speed to be 7 to 8 kt. Between 200 and 600 ft agl it was 10 kt on average.

The pilot started to look for a suitable landing field 35 minutes into the flight (1900 hrs BST). Most of the fields in the area contained crops or livestock so were unsuitable. Two approaches made at 1940 hrs and 1942 hrs BST were aborted due to low level changes in wind direction taking the balloon away from the intended landing fields. Another approach at 2000 hrs BST was aborted due to power lines in the field. Ground speed during these approaches was 5 kt.

The pilot was concerned about the fuel situation. All the front tanks were empty and of the two 80 litres rear tanks, one was indicating 20% and the other was not yet indicating its contents but had been used extensively. The pilot was also concerned about losing light; sunset was at 2021 hrs BST.

The pilot sighted a suitable grass landing field beyond a set of high-voltage pylons. Just under 500 m from the intended landing field, the balloon was over the pylons at a height of 166 ft agl with a ground speed of 10 kt. At the field boundary, at 5 ft agl and 8.5 kt ground speed, the pilot deployed the rapid deflation system. The landing was at 2005 hrs BST and the pilot estimated there was 60 m landing distance available. The basket did not stop as quickly as expected and dragged across the field. It stopped on its side just before a tree and the deflating envelope draped over the roof of a house and garage (Figure 1). No one was injured and the basket and envelope were not damaged. There was some minor damage to the property.

Accident site

Figure 1
G-LLGE incident site

Aircraft information

G-LLGE is a 360,000 cubic feet hot air balloon equipped with a Q-vent rapid deflation system.

The Q-vent system enables rapid deflation of the balloon by pulling a 'parachute' in the top of the balloon fully and quickly down into the envelope using a red line operated by the pilot. It should only be operated close to the ground. When the red line is pulled, the red and white 'candy stripe' parachute line, which is used in flight to descend, is pulled up into the envelope. Therefore, operation of the Q-vent system requires there to be sufficient slack in the candy stripe line.

At the end of the 2018 flying season, the pilot reported that the Q-vent system was not able to fully operate because there was not enough slack in the candy stripe line (Figure 2). The red and candy stripe deflation lines are made of poly sheathed Kevlar which shrinks with time due to the heat of the burner and the operating temperature within the envelope.

Figure 2

G-LLGE maximum operation of the rapid deflation system showing the candy stripe line at full stretch taken by the pilot in October 2018. The green line is the turning vent line and is not relevant to the accident.

The operator asked for their maintenance organisation to rectify this alongside the certificate of airworthiness renewal performed in December 2018. The Certificate of Release to Service form stated 'Allow spare out of candy stripe end termination' suggesting that an adjustment had been made as requested.

The pilot reported that he checked the operation of the red line pre-flight by pulling until he could see daylight all around the edge of the parachute. He stated that he did not perform a check of the full operation of the rapid deflation system and considered this to be impractical because it could result in deflation of the balloon. For a pre-flight check of the Q-vent system the flight manual specifies:

> *'Pulling the red line until the parachute is clear of the rim of the aperture. Release the line, then pull on the red and white line until the parachute is taut, and then release. Ensure that there is sufficient slack in the parachute line to allow it to feed into the envelope as the red rapid deflation line is pulled.'*

The pilot had flown G-LLGE three times during the 2019 season after the work was completed but had not needed to fully deploy the rapid deflation system because these flights were made in light winds.

Pilot and chief pilot's comments

The pilot acknowledged that there was pressure to land due to the fuel and light situation, but he was confident of stopping in the distance available. He stated that the fuel and light situation was not yet critical and did not lead him to accept a smaller field.

The chief pilot was experienced at flying an identical balloon and stated that it would have stopped within that distance in similar conditions. After the accident, the pilot and chief pilot inspected the balloon. They both believed that the work to lengthen the candy stripe line had not been successfully completed and that this contributed to the long drag. The chief pilot stated he and the pilot both trusted that the requested work to lengthen the line had been completed because an entry about it had been made in the aircraft logbook.

The pilot also noted that the steep approach made due to the power lines meant that more speed was carried into the landing and the balloon did not slow to 5 kt as it had on the previous approaches.

Analysis

The pilot completed a landing under pressure of reducing light and low fuel and the balloon stopped too close to obstructions that were draped by the deflating envelope. The balloon may have taken a longer distance to stop than the pilot expected because the rapid deflation system did not operate fully due to insufficient slack in one of the control lines. The operator and pilot interpreted an entry in the maintenance paperwork as indicating work had been done as requested to lengthen the line. The pilot performed a pre-flight check of the rapid deflation system but a full check of the operation of the rapid deflation system was not performed. The second part of the pre-flight check is to '*Ensure that there is sufficient slack in the parachute line to allow it to feed into the envelope as the red rapid deflation line is pulled.'* In practice, this is difficult to judge visually because the parachute (candy stripe) line has a large amount of slack in it. The pilot had flown the balloon since the maintainer's work on it but had not needed to use full rapid deflation. This system is rarely used to its full extent because it is only required in stronger wind conditions. It is inconvenient to check pre-flight because of the risk of deflating the balloon when doing so. There was no way to determine whether the control line lengthening work had been satisfactorily completed without fully operating the rapid deflation system.

Conclusion

The balloon dragged for a longer distance than the pilot expected after landing and stopped too close to a house because it was travelling too fast to stop in the space available and the rapid deflation system may not have operated to its full extent.

ACCIDENT

Aircraft Type and Registration:	Pegasus Quasar IITC, G-MYJT
No & Type of Engines:	1 Rotax 582-40 piston engine
Year of Manufacture:	1993 (Serial no: 6582)
Date & Time (UTC):	27 August 2019 at 1950 hrs
Location:	Brindle, Lancashire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Destroyed
Commander's Licence:	National Private Pilot's Licence (Microlight)
Commander's Age:	62 years
Commander's Flying Experience:	349 hours (of which 229 were on type) Last 90 days - 6 hours Last 28 days - 3 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and additional enquiries

Synopsis

The aircraft collided with power lines and was destroyed during a precautionary landing at dusk. The pilot departed with little contingency time before night fell and was delayed by navigation difficulty.

History of the flight

The pilot departed Kenyon Hall Farm airstrip at 1730 hrs and arrived at Rossall Field Airfield at 1800 hrs. The conditions were hazy, but he could see the ground and navigate using a chart. After a brief visit, he departed shortly before 1900 hrs, though he could not recall the exact time. Sunset was at 1859 hrs.

During the return flight, the pilot reported that the haze was worse and he realised he was significantly off track to the east. He turned west towards Winter Hill which was a significant feature that he could still see. He reported that as he flew over the hill, the ground was covered in a carpet of haze that obscured most ground features. He tried to find the track back to Kenyon Hall Farm but was unsuccessful. He attempted to descend below the haze, but it seemed to extend to the ground with visibility ranging from several hundred metres up to approximately 4 km. The light levels were also reducing.

The aircraft was not equipped with a radio that would have been capable of contacting anyone for assistance. Flying low, he passed a radio mast that he had not seen and began to panic. He decided his only option was to land in a field but in his emotional state he struggled to choose one. Eventually he settled on a field but, due to the low light levels, did not see power lines across the approach. According to the electricity provider, the aircraft struck the power lines at 1950 hrs. The aircraft struck the ground and was destroyed. The pilot was injured but he was able to escape from the aircraft.

Meteorology

The pilot's method for checking the visibility prior to flying was to judge whether he could see the horizon from the ground. He used a proprietary internet resource for wind and cloud base forecasts prior to the flight. He reported there was nothing to concern him and he expected the return flight to take approximately the same time as the outbound flight.

The Met Office indicated that there were generally fine conditions with good visibility and that any cloud had relatively high-level bases. The wind was south to south-westerly at 5 to 10 kt.

Another pilot flying from Rossall that evening around the time G-MYJT departed reported that the cloud base was lowering, and the visibility was degrading to the south of Rossall at around 1900 hrs.

Accident site

Figure 1

Map showing departure and destination airfields, Winter Hill and the location of the accident site

Analysis

The pilot departed with little contingency time before night fell and in difficult conditions for navigation. There was nothing in the weather forecast to cause concern but his experience on the outbound flight was an indication that navigation might be difficult on the return flight. The pilot had the option to change his plans and postpone the return flight but decided to continue. He could not recall his exact departure time from Rossall Field. He may not have realised how long he had spent there or anticipated the effect of the weather on his ability to navigate and the light conditions.

The pilot expected that the return journey would take approximately 30 minutes, the same amount of time as the outbound flight. If the flight had gone to plan, he would have landed at Kenyon Hall Farm before the end of civil twilight. The problems with navigation delayed him to the point where it was dark. In this circumstance he had no safe option remaining and decided to perform an emergency landing rather than continue. It is likely that this decision gave the greatest chance of avoiding an accident, but he was unable to see the power lines and could not prevent the collision.

Conclusion

The accident occurred because the pilot departed too late in the day and was delayed by navigational difficulty until it was dark. He decided to perform an emergency landing, but it was too dark to see and avoid power lines on the approach to his chosen field.

Figure 2

G-MYJT after the accident

ACCIDENT

Aircraft Type and Registration:	Quik GT450, G-CFKJ
No & Type of Engines:	1 Rotax 912ULS piston engine
Year of Manufacture:	2008 (Serial no: 8405)
Date & Time (UTC):	2 December 2019 at 0840 hrs
Location:	Field approx 2 miles north-east of Caernarfon Airport, Gwynedd
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Damage to pod, windshield, wheel spat. and electrical systems
Commander's Licence:	National Private Pilot's Licence
Commander's Age:	61 years
Commander's Flying Experience:	534 hours (of which 534 were on type) Last 90 days - 17 hours Last 28 days - 0 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

During a local flight, the engine stopped and could not be restarted. A field was selected for a forced landing and at a late stage of the approach, the aircraft struck overhead power cables which were not seen by the pilot or the passenger. The cables were severed, the aircraft sustained minor damage and the occupants were uninjured. The most probable cause of the engine stopping was carburettor icing.

History of the flight

The pilot planned a local flight from Caernarfon Airport and the aircraft took off at 0820 hrs from Runway 25. The weather was good with the wind from 140° at 3 kt, scattered cloud at 2,500 ft, air temperature of 3°C, dew point at 3°C and 100% humidity. After approximately 15 minutes flying time the engine "spluttered". The engine power was reduced to a normal cruise setting and the engine spluttered a further three times and then stopped. It could not be restarted. The aircraft was at a height of approximately 1,200 ft when the pilot positioned the aircraft for an into wind, field landing; however, late on the approach, the aircraft struck and severed the 11,000-volt power cables which crossed the field (Figure 1). The aircraft sustained extensive damage to its electrical systems and minor damage to the pod, windshield and wheel spat. The occupants were uninjured.

The pilot stated that his forward visibility was partially obscured by condensation on the windshield and his helmet visor which, with the low winter sun, meant it had not been possible to see the power cables. The passenger, whose view was restricted by the pilot, also did not see the cables.

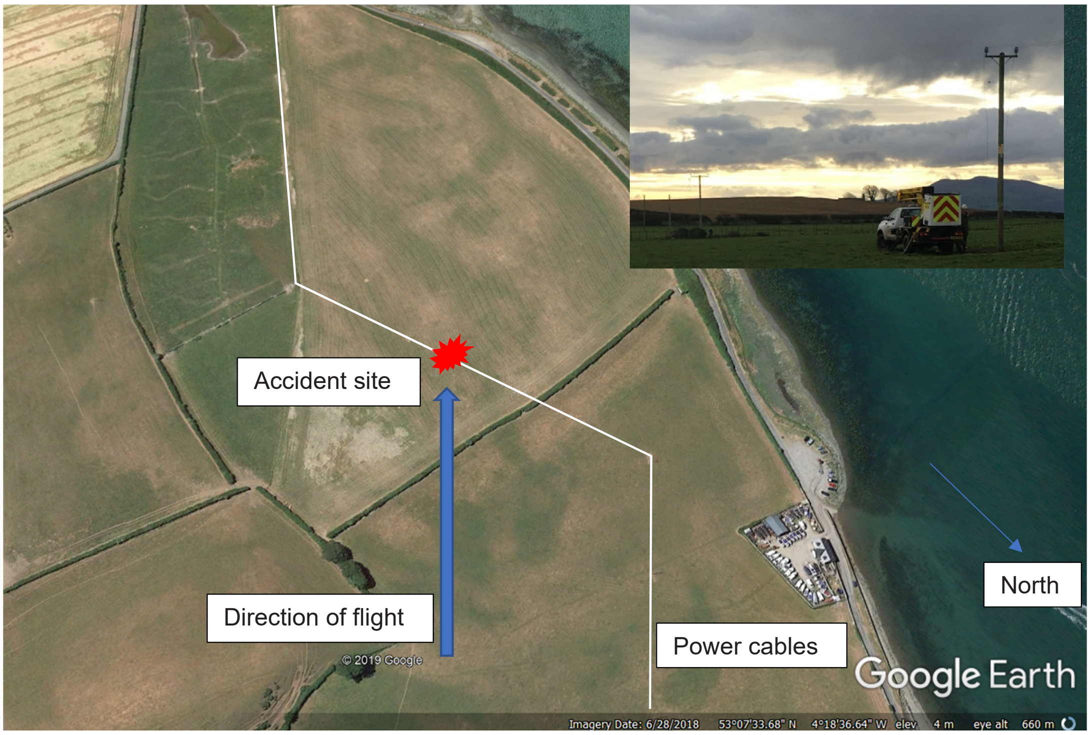


Figure 1

Accident site location

Carburettor icing

Carburettor (carb) icing is caused by a combination of the sudden temperature drop due to fuel vaporisation and pressure reduction as the mixture passes through the carburettor venturi and past the throttle valve. If the temperature drop brings the air below its dew point, condensation results, and if the drop brings the mixture temperature below freezing, the condensed water will form ice on the internal surfaces of the carburettor. This ice gradually blocks the venturi, which upsets the fuel/air ratio causing a progressive, smooth loss of power and slowly 'strangles' the engine. Conventional float type carburettors are more prone to icing than pressure jet types.

Examination of the aircraft

The aircraft (Figure 2) was taken to a maintenance organisation where it was found that all the electronic systems had been damaged when the aircraft struck the power cables. The ignition system was replaced, the engine was tested and ran satisfactorily. The maintenance organisation suspected that the engine stopped due to carburettor icing.

Figure 2
Accident aircraft

The Rotax 912 engine fitted to G-CFKJ relied on hot engine coolant to warm the carburettor body to prevent ice forming. The radiator can be partially covered to ensure that the coolant is maintained at a temperature above 80°C. The maintenance organisation stated that approximately 75% of the radiator area would normally be covered during the winter months to achieve the required temperature; however, on G-CFKJ only 25% of the radiator was covered.

Conclusion

With the high level of humidity, it is probable that the engine stopped as a result of carburettor icing. The aircraft was fitted with a carburettor heating system, but with only 25% of the radiator covered the engine coolant may not have been hot enough to prevent ice from forming in the carburettor. The pilot selected what appeared to be a suitable field, but a combination of the condensation on his windshield and visor, from the high humidity, and the low winter sun meant that he did not see the electrical cables across the field.

BULLETIN CORRECTION

The aircraft registration was wrongly stated on two occasions in the penultimate paragraph of the report.

The online version of the report was amended on 11 June 2020.

SERIOUS INCIDENT

Aircraft Type and Registration:	Ultramagic N-250 balloon, G-CDST
No & Type of Engines:	None
Year of Manufacture:	2005 (Serial no: 250/37)
Date & Time (UTC):	13 July 2019 at 0805 hrs
Location:	North-east of Crowle, north Lincolnshire
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 1 Passengers - 8
Injuries:	Crew - None Passengers - None
Nature of Damage:	Minor tears to the envelope
Commander's Licence:	Commercial Pilot's Licence (Balloon)
Commander's Age:	28 years
Commander's Flying Experience:	375 hours (of which 189 were on type) Last 90 days - 28 hours Last 28 days - 2 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

The balloon landed in a field and the envelope came to rest against some trees causing several tears. The pilot and passengers were unable to pull it away from the trees and it had to be deflated over them. The pilot did not realise that the field was too short for the distance the balloon needed to stop in the conditions.

History of the flight

The pilot arrived at the launch site south of York at 0515 prior to the arrival of the eight passengers at 0530. With only eight passengers the balloon was lightly loaded with 1,100 lb of spare lift. He noted the wind speed and direction was consistent with the forecast, being northerly at 5 kt, gusting less than 10 kt. This was confirmed using a helium meteorological balloon.

After a passenger briefing and uneventful inflation and takeoff, the balloon climbed to 2,000 ft and travelled in a southerly direction for 30 minutes. The pilot found the wind speeds and directions were as expected according to the forecast. The balloon tracked towards the Drax power station and, in order to fly around it at a safe distance, the pilot descended to 500 ft to enter slower wind with a more south-easterly direction of travel. He hoped to land prior to the town of Goole but could not find a suitable field so ascended to a safe height above the town, the M62 and the first of a series of wind turbine farms.

The pilot descended again to 400 ft for most of the remainder of the flight and searched for a landing site. He had flown for approximately 1 hour and 40 minutes when he saw a field with grass and good access that he considered suitable for landing. The pilot saw power lines at the edges of the field parallel to the balloon's direction of travel and asked the passengers to help confirm there were no others. He made a steep approach to the field due to trees. The wind near the surface was gusting up to 15 kt. On landing, the basket bounced once and dragged along the field before coming to rest with the envelope against some trees. The pilot asked the passengers to assist with pulling the envelope away from the trees and back into the field, but the wind was too strong. The balloon had to be deflated with the bottom half over the trees and the top in the neighbouring field.

Meteorology

Time	Surface wind	Gradient wind
0500 UTC (0600 Local)	320 05/10	350/10
0600 UTC (0700 Local)	340 05	350/11
0700 UTC (0800 Local)	360 06/15	350/12

Table 1

Met Office ballooning forecast according to the pilot

Pilot's comments

The pilot commented that he felt under pressure to land because of a combination of factors including the length of flight, his fuel status, his knowledge of more unfavourable landing areas ahead and the rising ambient temperature.

The pilot had a Group B rating and 189 hours flying balloons in this group. He had recently started flying G-CDST which was within Group B but larger than balloons he had previously flown. He stated that his relative inexperience with the larger balloon may have contributed to him misjudging the amount of space needed for it to stop. He also felt that searching for powerlines during the approach may have distracted him from realising the field was too small.

Chief pilot's comments

The operator's chief pilot commented that flying at low level reduces the amount of time available for decision making after sighting a field. He remarked that balloon pilots can give themselves more planning time by using periodic climbs and binoculars to provide an earlier and better view of potential landing areas ahead.

Conclusion

After a long search for a landing site, the pilot landed in a field that was too small. The balloon took longer than he expected to stop due to its speed and spare lift. The pilot felt under pressure to land as soon as possible and was distracted during the approach by power lines in the field.

ACCIDENT

Aircraft Type and Registration:	Aerialtronics Altura Zenith ATX8 (UAS, registration n/a)
No & Type of Engines:	8 electric motors
Year of Manufacture:	2018 (s/n BSS149674003)
Date & Time (UTC):	1 October 2019 at 0910 hrs
Location:	Stoke Gifford, Gloucestershire
Type of Flight:	Aerial Work
Persons on Board:	Crew - N/A Passengers - N/A
Injuries:	Crew - N/A Passengers - N/A
Nature of Damage:	Airfame and gimbal destroyed beyond repair
Commander's Licence:	N/A
Commander's Age:	39 years
Commander's Flying Experience:	466 hours (of which 42 were on type) Last 90 days - 33 hours Last 28 days - 5 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

Shortly after takeoff for a flight from a road bridge above two railway tracks, the UAS in GPS mode started to drift, accelerate and descend away from the pilot. The pilot was unable to regain control before it crashed into vegetation next to the tracks. A subsequent investigation by the operator found that magnetic deviations of up to 140° were observed over localised regions of the bridge below which the railway track's overhead high-voltage wires were being ducted.

History of the flight

Following pre-flight checks for a flight from a road bridge above two railway tracks, the UAS, in GPS mode, took off normally, but as it reached approximately 5 m above the ground it started to drift to the west. As it reached about 10 m it suddenly accelerated to the west and began to lose altitude. The pilot attempted to correct the drift, but the UAS continued to fly away where, out of sight of the pilot and operating crew, it crashed into vegetation next to the tracks.

Network Rail (Route Control and Air Operations) were immediately contacted to inform them of what had happened. They were subsequently contacted again a few minutes later once it was confirmed that the aircraft was not on the tracks. A Network Rail response team later recovered the damaged UAS.

Manufacturer's analysis of the flight log

The manufacturer analysed the flight log data and confirmed that the UAS was in GPS mode, and that the magnetic compass values had varied through about 60° within a couple of seconds of takeoff. It began to drift to the west and, at about 10 m above the ground, the compass stabilized to the correct heading, just as it accelerated and descended in a westerly direction. Although the pilot's corrective inputs were detected, the UAS (still in GPS mode) continued to move away and lose altitude. The whole flight lasted 13 seconds and covered a distance of about 100 m.

Operator's investigation and findings

Takeoff site inspection

The day after the accident flight, the operator went to inspect the takeoff site to try and identify any factors that might explain the aircraft's behaviour. A spectrum analysis of the radio frequencies at the site didn't identify anything of concern. However, when using a hand-held compass to check for any magnetic interference, deviations of up to 140° were observed over localised regions of the bridge below which the railway track's overhead high-voltage wires were being ducted.

Safety actions

As a result of the findings, the operator has made changes in its flying procedures to reduce the possibility of the event reoccurring. These include:

(1) a magnetic interference check using a manual compass of an area 10 m around the planned takeoff location;

(2) a visual check for objects and structures that might have a large magnetic field;

(3) takeoff and landings should take place as far away from any sources of magnetic interference; and

(4) the pilot should always be ready to switch out of GPS mode into atti(tude) or manual flight modes to retake control of the UAS if control is lost whilst in GPS mode.

ACCIDENT

Aircraft Type and Registration:	UAVE Prion Mk 3 (UAS, registration n/a)
No & Type of Engines:	1 four stroke piston engine
Year of Manufacture:	2019 (s/n 3-0007)
Date & Time (UTC):	18 November 2019 at 1417 hrs
Location:	West Wales Airfield, Aberporth
Type of Flight:	Aerial Work
Persons on Board:	Crew - N/A Passengers - N/A
Injuries:	Crew - N/A Passengers - N/A
Nature of Damage:	Front and rear landing gear, tail boom and propeller damaged beyond repair
Commander's Licence:	N/A
Commander's Age:	37 years
Commander's Flying Experience:	50 hours (of which 10 were on type) Last 90 days - 17 hours Last 28 days - 10 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

During an autonomous landing at a secure airfield without public access, the UAS was in a left turn to line up on the final approach path. The autopilot was programmed to control airspeed with power and glideslope with pitch, so when the UAS started to accelerate and descend below the predetermined descent profile, the power reduced to slow it and elevator was used to pitch the UAS up. However, there was a limit to the amount of elevator the autopilot could command, which was insufficient to return the UAS back to the desired altitude, resulting in it flying into the ground just short of the runway.

Following an investigation by the manufacturer (and operator) of the UAS, the autopilot's elevator authority has been increased, and the pre-programmed turn onto finals widened and raised to reduce the amount of elevator required during the approach to land.

AAIB Record-Only Investigations

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

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

The accuracy of the information provided cannot be assured.

Record-only UAS investigations reviewed February - March 2020

02-Oct-19 **Vertical Aerospace HLD1** Llanbedr Airfield, Gwynedd, Wales

During a test flight the prototype UA lost power and descended rapidly resulting in a hard landing. It sustained significant damage to the landing gear, chassis and some propeller blades.

02-Dec-19 **DJI Matrice M210** Brittany Road, Hastings, East Sussex

A loss of data connection occurred between the UAS and the controller at a height of 50 m. The UAS descended to approximately 15 m and then became inverted and crashed onto the pavement in a congested area.

03-Dec-19 **Asc Tec F8** New Cut Waterway, River Avon, Bristol

All eight motors shutdown at a height of 80 m and the UAS fell into the river and could not be recovered. The pilot's display continued to show the UAS camera image and a battery voltage of 11.6 V as the UAS fell indicating that battery failure was unlikely to be the cause of the event.

04-Dec-19 **DJI Phantom 4 Advanced** Alwen Forest, Conwy

After a normal takeoff with the UAS pausing in a hover about 3 m above the ground, the pilot initiated a climb to 50 m. However, as it reached about 6 m, a GPS aerial failure occurred; the UAS inverted and flew into the ground.

04-Dec-19 **Bionic Eye T28** Area North of ESSO Terminal - Avonmouth

During the approach to land, the UAS suffered a structural failure of one propeller arm which led to an uncontrolled descent to ground.

15-Jan-20 **Animal Dynamics Ltd Nano Vquad** Begbroke Science Park, Kidlington

During the maiden flight of the UAS, the pilot lost orientation from about 100 m range due to its small size. He tried to regain orientation but it drifted further away in the wind, so he slowly reduced power to land it out of line of sight. The UAS was not recovered.

19-Jan-20 **DJI Inspire** Ewhurst Park Tadley Hampshire

While photographing a boathouse, the UAV struck the branches of a tree and descended into a lake where it was lost.

26-Jan-20 **DJI Phantom 4 Pro** Ayr, South Ayrshire

The UAS struck the top branches of some trees before descending to the ground.

Record-only UAS investigations reviewed February - March 2020 cont

13-Feb-20 **DJI Inspire 1Pro** Bentwaters Park, Ipswich, Suffolk
A rotor separated from the vehicle during flight causing an uncontrolled descent to ground.

18-Feb-20 **DJI Phantom** Gainsborough, Lincolnshire
The UAS struck a tree in 'Point of Interest' mode and fell to the ground. The UAS was damaged substantially but there was no other damage.

05-Mar-20 **Anafi Parrot** Beeston, Leeds
About 20 seconds after takeoff, the UAS suddenly dropped onto the concrete surface and damaged two propellor arms.

Miscellaneous

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

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

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

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.

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

Published March 2020.

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