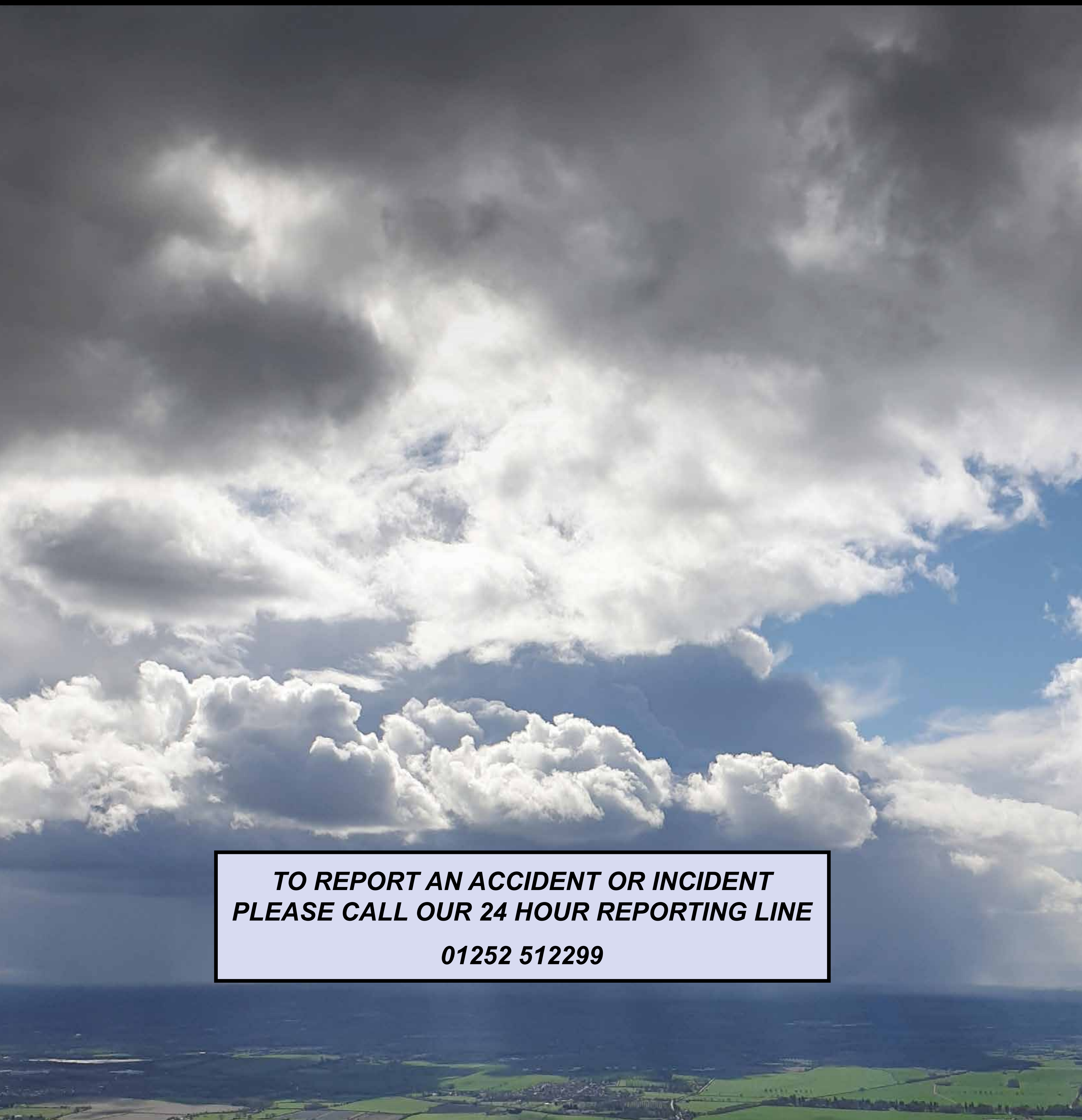
AAIB Bulletin 8/2021



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(ALL TIMES IN THIS BULLETIN ARE UTC)

AAIB Field Investigation Reports

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

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

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

SERIOUS INCIDENT

Aircraft Type and Registration:	Sikorsky S-92A, G-LAWX
No & Type of Engines:	2 General Electric CO CT7-8A turboshaft engines
Year of Manufacture:	2004 (Serial no: 920007)
Date & Time (UTC):	14 October 2019 at 1742 hrs
Location:	Near Shipston-on-Stour, Warwickshire
Type of Flight:	Private
Persons on Board:	Crew - 2 Passengers - 9
Injuries:	Crew - None Passengers - None
Nature of Damage:	None reported
Commander's Licence:	Airline Transport Pilot's Licence (Helicopters)
Commander's Age:	54 years
Commander's Flying Experience:	6,200 hours (441 of which were on type) Last 90 days - 25 hours (25 hours on type) Last 28 days - 15 hours (15 hours on type)
Information Source:	AAIB Field Investigation

Synopsis

On an approach to a private landing site in conditions of reduced visibility shortly before night, the pilots became uncertain of their position and the helicopter descended to within 28 ft of rising terrain close to a house. During the subsequent emergency climb at low indicated airspeed, engine torque increased to 131% and the pitch attitude of the helicopter was unstable. The helicopter made another approach to the landing site and landed without damage or injury to the occupants.

The investigation identified the following factors:

- Standard operating procedures for altitude alert setting, stabilised approach criteria and crew communication were either absent or not effective,
- a strong desire as a customer-facing director not to inconvenience the client, which was potentially in tension with his obligation as the commander to ensure a safe flight,
- uncertainty about the Rules of the Air when landing, and
- attitudes, behavioural traps and biases likely to have contributed to the occurrence.

The circumstances of this serious incident indicate the need for greater awareness of the hazards of operating in degraded visual conditions and highlight the potential safety benefits of Point-in-Space approaches at landing sites.

The AAIB has made eight Safety Recommendations in these areas.

History of the flight

The pilots of the Sikorsky S-92A (S92) had been operating for several days from the landing site (LS) in the northern Cotswolds. They had flown the day before and reported that they were properly rested. On the day of the flight they arranged to meet nine passengers arriving in a fixed-wing aircraft at Birmingham Airport and fly them in the helicopter to the LS.

Planning and positioning to Birmingham

The pilots planned the flight and reviewed the weather, and the commander completed a risk assessment tool known as the Pre-flight Crew Briefing Aide Memoire. The forecast for Birmingham indicated a cloud base of 1,100 ft amsl, with visibility as low as 4,000 m for short periods. Sunset was at 1716 hrs.

The helicopter departed the LS at 1550 hrs with the commander acting as PF in the right seat for the IFR flight from the LS to Birmingham. The pilots assessed the cloud base at the LS as 1,000 ft agl in 5 km visibility. Similar conditions were experienced on the approach to Birmingham, where the commander flew an ILS approach manually.

After landing at 1610 hrs the pilots reviewed the weather, noting that the TAF at Birmingham was unchanged, and were advised that the fixed-wing aircraft was estimated to arrive at 1710 hrs. The commander spoke to Wellesbourne Mountford Airfield (Wellesbourne) and arranged to use it as a diversion in case they were not able to land at the LS. Meanwhile, the co-pilot advised the estate manager at the LS that they would attempt to make an approach there, and that Wellesbourne had been arranged as a diversion.

At about 1705 hrs, the pilots obtained the 1655 Birmingham ATIS. The fixed-wing aircraft landed at 1709 hrs and, while it was taxiing onto stand, the co-pilot spoke by telephone with the manager at the LS, who gave an update on the weather conditions being experienced there. The co-pilot stated that during this conversation, when he discussed flying directly to Wellesbourne, the commander responded with a strong negative signal. The co-pilot then advised that they would tell the client once airborne if they could not land at the LS and would in that case divert to Wellesbourne.

The commander advised staff waiting for the passengers at Birmingham that a speedy transfer was necessary to complete the flight in daylight. While waiting for the passengers to board the helicopter, the pilots discussed the plan and the commander expressed increasing anxiety about completing the flight in daylight, stating "WE ARE REALLY UP AGAINST IT".

The flight to the LS

The commander was again PF in the right seat for the return flight to the LS. Birmingham ATC gave the departure clearance, advised that the cloud base was broken at 800 ft agl, and at 1730 hrs cleared the helicopter for takeoff. On departure, the commander commented that the cloud base was "NOT QUITE SO BAD."

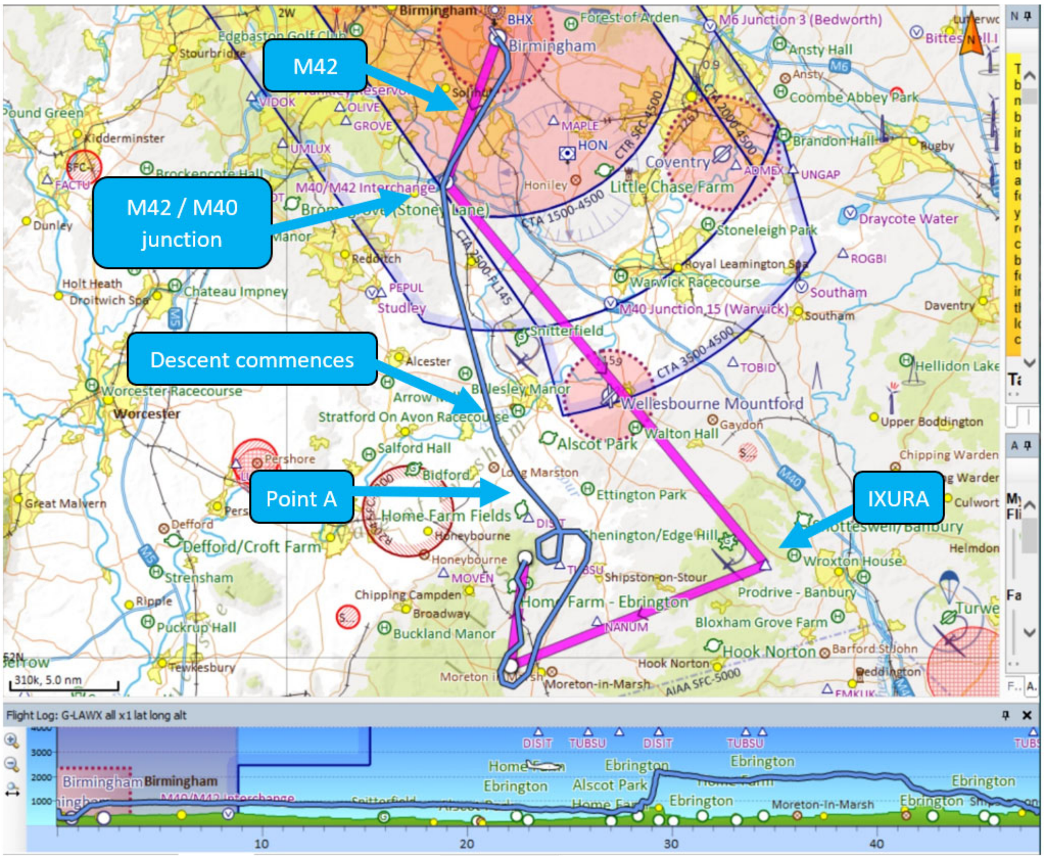


Figure 1

G-LAWX planned flight path (pink line) and actual flight path (blue line)
Chart used with permission of SkyDemon. Not to be used for navigation.

During the climb, as part of the after takeoff checks, the co-pilot prompted for the radio altimeter (radalt) alert value to be set at 500 ft. The CVR recorded the commander responding, "YES PLEASE… SET FOUR HUNDRED PLEASE …FOUR HUNDRED'S FINE." The helicopter levelled at the base of cloud at an altitude of around 950 ft altitude, slightly above 500 ft agl initially. As the helicopter reached the visual reporting point at the junction of the M40 and M42, the commander briefed the co-pilot on the route he was now intending to fly (Figure 1). Shortly afterwards, the Helicopter Terrain Awareness and Warning System (HTAWS), sounded the radalt alert "ALTITUDE, ALTITUDE" several times as the helicopter passed over rising ground near the junction. The commander requested the co-pilot to update the navigational guidance in the Flight Management System (FMS) to proceed direct to the LS, and stated, "I'M GOING TO TRY AND GET [PAUSE]…VFR BEFORE [PAUSE]… WHILE ITS DAYLIGHT."

Over the next 4 minutes, the helicopter flew along the base of cloud, descending steadily from an altitude of 950 ft but remaining mainly above 500 ft agl over lowering terrain. The commander commented that the weather conditions would enable them to divert to Wellesbourne. Around 10 nm north of the LS, the pilots completed the initial approach checks, during which the commander commented that the weather was "marginal". The commander then gave an approach brief to the co-pilot. Passing abeam Wellesbourne, the co-pilot advised the commander that the airfield was 5 nm to the left, which the commander acknowledged.

About 5 nm from the LS, the commander commenced a descent. As the pilots carried out the landing checks the commander began to reduce IAS and advised the co-pilot to delay setting the radalt alert value until they could see the LS. As they descended, based on the radio altitude height above the ground, the HTAWS generated the radalt audio alert, "ALTITUDE, ALTITUDE" twice, which the commander acknowledged. Shortly after completing the landing checks, the co-pilot stated that the LS was 2½ nm away to the right.

The HTAWS sounded the radalt audio alert "ALTITUDE, ALTITUDE" again, and the commander requested the co-pilot to reset the alert value to 150 ft in accordance with the operator's Standard Operating Procedure (SOP). Then, just before turning onto the westerly approach heading, the HTAWS 'CAUTION TERRAIN, CAUTION TERRAIN' alert sounded. The commander could see the ground and acknowledged the alert. He stated that he then selected the LOW ALTITUDE mode on the HTAWS; the commander is heard to state, "LOW ALTITUDE" on the CVR. (The co-pilot did not acknowledge this; he subsequently stated that he did not believe that the LOW ALTITUDE mode had been selected). Shortly afterwards the co-pilot confirmed that the radalt alert value was set to 150 ft and the commander requested that the co-pilot update the FMS guidance direct to the LS.

The commander now began to turn onto a westerly heading to approach the LS. As the helicopter passed through a southerly heading, the HTAWS sounded a separate "WARNING TERRAIN, WARNING TERRAIN" alert which the commander acknowledged, calling "VISUAL". Following the HTAWS alert, the CVR recording indicated some confusion between the pilots over the selection of a waypoint in the FMS. The helicopter turned onto a more westerly track and descended to 230 ft agl, below the elevation of the LS, before climbing again.

As the helicopter began to make a westerly approach to the LS, the co-pilot called, "WIPERS, IF YOU NEED THEM". The commander subsequently stated he could see some lights at that moment. The helicopter was turning slightly right onto a more northerly heading with an airspeed at or below 60 kt, at approximately constant altitude, but its height reduced to below 200 ft agl over gently rising ground.

Despite its earlier climb, the helicopter remained less than 100 ft above the LS. As it approached to within 1 nm from the LS the pilots discussed the visual conditions and whether they could see the LS. The helicopter continued to yaw further right onto a northerly heading, and its airspeed reduced as it climbed to about 250 ft above the LS. Now 250 m east of a steep escarpment which led to a plateau where the LS was located, the helicopter began to accelerate and descend rapidly towards a hill 500 m north of its position.

The helicopter approached the sharply rising ground with a groundspeed of 35 kt. After the helicopter passed over a house, while the pilots were trying to locate the LS visually, the radalt alert "ALTITUDE, ALTITUDE" was generated by the HTAWS. Neither pilot acknowledged this alert and the helicopter continued to fly towards the rising ground, descending to within 28 ft of the ground at its closest point. The pitch attitude, and consequently airspeed, of the helicopter were unstable. It then yawed 30° to the left and climbed, with a nose-down pitch attitude, in response to collective input by the commander. Unable to locate the LS and having lost visual references, at 1742:13 hrs the commander called "GOING AROUND".

Emergency climb

The pilot rapidly raised the collective resulting in the "LOW ROTOR" warning and audio, and engine torque increasing to 131%. The helicopter initially achieved a positive rate of climb but then continued a more level acceleration, as the pitch attitude of the helicopter remained below the horizon. As a result, it flew along a level flight path at less than 300 ft agl. In response to deviation calls by the co-pilot, the commander raised the attitude of the helicopter significantly above the horizon achieving a high rate of climb, as the airspeed reduced back to under 10 kt.

The commander levelled the helicopter at just above 2,200 ft altitude, giving a clearance of 1,500 ft agl and began to turn right while accelerating before stabilising and initially heading east. As they reached the top of climb the co-pilot asked the commander, "DO YOU WANT ANY AUTOMATION" but before the commander responded, the co-pilot called, "WE ARE DESCENDING, WE ARE DESCENDING". He then prompted that he was setting the pre-selected barometric altitude (ALTP)[1] to a value of 2,500 ft, and confirmed it was set. The commander now called visual and shortly afterwards the co-pilot confirmed he was also visual with the ground.

The second approach

The commander suggested that the helicopter route back to the Initial Point (IP). In response, the co-pilot asked if the intention was to make an approach using the Dragon GL3 approach aid (GL3)[2]. The commander confirmed this, stating that Birmingham was the diversion if they could not make an approach to the LS. He later stated that he recognised that a significant over-torque had occurred during the emergency climb. As a result, he was concerned for the serviceability of the helicopter and sought to land as soon as possible.

The commander continued to manually fly the helicopter and declined another suggestion from the co-pilot to use the automation. The helicopter varied in altitude by up to 300 ft and the co-pilot continued to provide deviation calls and guidance on their progress to a point 5 nm from the LS. They then turned towards the LS.

Footnote

1 The pre-selected barometric altitude or ALTP function (pronounced 'ALT-PRE') enables a height to be set by either pilot to be displayed on the PFD. It denotes the height to which the helicopter would climb and level off at if the pilots engaged that function and coupled it to the Flight Director (FD).

2 See section on Dragon GL3 portable approach aid.

The second approach began at 1748 hrs and was conducted at night. During the initial stage of the approach, airspeed and pitch attitude fluctuated, and the heading varied 45° either side of the approach track of 010º (M) as the commander sought to avoid cloud. Throughout the approach the co-pilot gave deviation calls. He also expressed doubts about continuing the approach and at 3 nm from the LS, suggested returning to Birmingham. The commander responded, "I'M JUST GOING TO... ERR... TRY ONE MORE MILE". The co-pilot responded by reverting to providing guidance and deviation calls.

On passing 2½ nm, as the helicopter passed through 800 ft above ground, the commander stated, "IT'S NOT GOING TO HAPPEN". The co-pilot agreed, and the commander responded by saying "WE ARE GOING AROUND".

The co-pilot acknowledged and advised that the ALTP had been set at 2,500 ft; the commander acknowledged but took no action on the controls to initiate a go-around. The co-pilot then advised that they were descending at 1,000 ft/min and had pitch attitude of minus 10°, to which the commander responded and levelled the helicopter. Twenty seconds later the co-pilot advised the commander "...I'M NOT HAPPY WITH THIS", to which the commander responded "GOTCHA, GOTCHA, GOTCHA, GOTCHA" without any relevant action on the controls. Ten seconds later, as the helicopter descended below 1,000 ft altitude and 500 ft agl, the commander called, "THERE'S THE LANDING LIGHT, THERE'S THE LANDING LIGHT". The co-pilot responded by continuing to give guidance and the approach stabilised. The helicopter landed at the LS 2 minutes later. There was no reported damage to the helicopter and the occupants were uninjured.

Reporting

The operator immediately contacted the helicopter manufacturer to assess any engineering implications from the over-torque during the recovery to height. The manufacturer assessed that the helicopter required a range of inspections and cleared it for a ferry flight to a suitable maintenance facility. The same flight crew flew the helicopter to Stansted, where their maintenance provider was based, the day after the incident.

The commander informed the CAA of the incident and submitted a Mandatory Occurrence Report on the following day. On 15 October, the afternoon after the occurrence, the operator notified the AAIB. Based on the information provided the AAIB determined that it was not necessary to conduct a safety investigation. Several days later the CAA provided additional information about the circumstances of the event and the AAIB then determined that this was a serious incident, and that it would investigate.

Personnel

Prior experience

The commander had flown in military, offshore, and onshore corporate roles. Much of his flying was on the Sea King and the AS365N, with time on other types including EC155 and AS355. The commander stated that he was concerned to maintain his manual flying skills, mindful of his limited flying currency. Peers commented that he had good helicopter handling skills.

The co-pilot had military experience including significant time on the Sea King Mk 4. Prior to joining the operator, he had gained experience on the S92 in the offshore oil and gas crew-change role, as well as on other types in other onshore, helicopter emergency medical service (HEMS), and corporate operations.

Roles within the company

The commander joined the company in 2005 as a pilot and, after an absence, later re-joined and took on the role of General and Safety Manager (SM) in 2011. At the time of the incident, he was the managing director (MD), SM and the Air Operator Certificate holder's Accountable Manager (AM). He was also the principal point of contact for the S92 client.

The co-pilot joined the operator two years earlier as a pilot. He was a qualified captain and was one of three of the operator's pilots[3] qualified on the S92.

Training

Both pilots held valid licences and operator proficiency checks. Their training included recovery from unusual attitudes but neither had received training in the techniques for an emergency climb from low to zero speed as a result of inadvertent entry to IMC (IIMC) or loss of visual references (LOVR)[4].

Training records indicated that while the commander had received initial training on the use of the GL3 approach aid, he had not completed his annual refresher training. However, the commander had been the individual responsible for introducing the GL3 into use by the operator.

Recency

The commander only flew the S92 at the time of the incident. He accumulated less than 100 hours each year and had 441 hours on type.

The co-pilot flew over 250 hours on the S92 in the previous year and had completed a Bell 429 type rating, flying both types at the time of the incident. He had flown a total of 732 hours on the S92.

Crew composition

Crewing of the S92 was fulfilled by three pilots. Both the commander and the co-pilot had flown regularly together on the S92, and often operated together away from the operator's base airfield for days at a time. The pilots would alternate in the role of commander and of PF/PM to ensure balance. They reported that this established a good understanding between them and a strong level of trust. The co-pilot commented that he recognised the commander's technical knowledge of the S92, knowledge of the route and LS, and relationship with the client.

Footnote

3 The other two pilots operating the S92 were also nominated postholders for the operator.
4 See *Loss of visual references / Inadvertent entry to IMC training*.

The commander stated that he was "just another pilot" when flying and endeavoured to separate this from his role as MD. The co-pilot's comments supported this. The co-pilot also stated that while there was "a boss gradient", he was confident to voice his concerns to the commander and ask questions. He was however careful on which aspects he would challenge the commander because of his position in the company and his level of knowledge.

Aircraft information

The S92 helicopter (Figure 2) has two gas turbine engines controlled via twin Full Authority Digital Engine Control systems.

The flight deck equipment includes a radio altimeter, weather radar, HTAWS delivered by Honeywell Aerospace manufactured Enhanced Ground Proximity Warning System (EGPWS)[5] Mark XXII (Mk XXII), TCAS and 4-axis Automatic Flight Control System (AFCS). The AFCS consists of dual autopilots with a trim system, Stability Augmentation System, Attitude Hold (ATT) features, and a Coupled Flight Director (CFD).

The S92, without the Gross Weight Expansion (GWE) option has a maximum takeoff mass of 12,020 kg. It is certified for flight under VFR and IFR during day and night, and for flight in known icing conditions with a minimum flight crew of two. G-LAWX did not have the GWE option fitted and was equipped with 16 passenger seats.

Figure 2
G-LAWX (Source: operator's website)

Cockpit displays

The cockpit has five multi-function displays (MFDs) selectable independently. The main pages used are the Primary Flight Display (PFD) page, the Navigation (NAV) page and the Engine Instrumentation Caution Advisory System (EICAS) page (Figure 3).

Footnote

5 EGPWS is a proprietary name used by Honeywell Aerospace for its TAWS system.

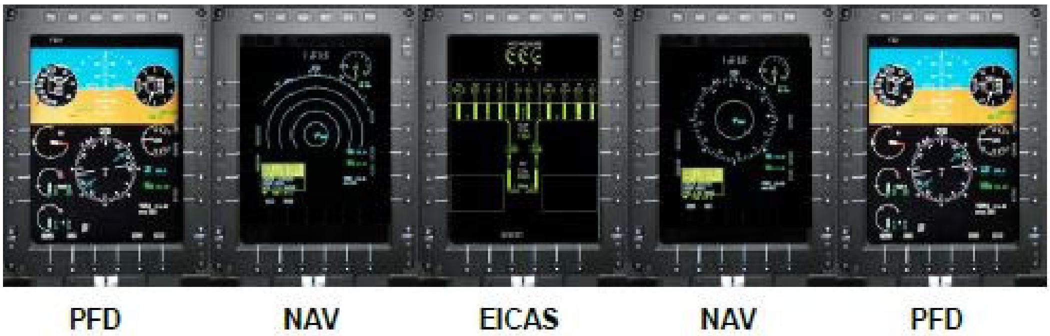


Figure 3
MFD Cockpit displays

The PFD page displays an attitude indicator in the upper half between an ASI and altimeter. The bottom half of the page displays a compass rose, selectable in full or arc mode. To its left critical engine and rotor parameters are displayed. To the right there is a vertical speed indicator and a pictorial display of the radalt (if selected) together with the navigation and bearing source pointer data.

The NAV page displays a compass rose in full or arc mode, on which the FMS flight plan (if selected) and bearing point data is shown. Either EGPWS terrain mapping or weather radar can be displayed, with TCAS data overlaid.

The EICAS page displays engine, main gearbox, fuel, and hydraulic instrumentation and is also the main page for displaying warnings, cautions and advisories.

A display control panel (DCP) is used to set altitude alert values and navigation sources.

Pre-selected barometric altitude

The pre-selected barometric altitude (ALTP) is displayed as a 'bug' on the PFD barometric altimeter and a digital value above. When selected as a function of the automation, this is the barometric altitude at which the CFD will level off.

Radalt alert

The radalt has a height alerting function. The selected radalt alert value is displayed as a 'bug' on the PFD altimeter and a digital value below. The HTAWS generates an aural alert 'ALTITUDE, ALTITUDE' if the radio altitude descends below the selected radalt alert value.

Minimum barometric altitude alert

The minimum barometric altitude (DA/MIN) is displayed as a 'bug' on the barometric altimeter with a digital value above. When the barometric altitude descends below the DA/MIN alert value, the HTAWS generates an audio alert "MINIMUMS, MINIMUMS" once and a visual 'MIN' alert (displayed in yellow on the PFD) flashes for 5 seconds and remains visible while the actual barometric altitude is below the selected value.

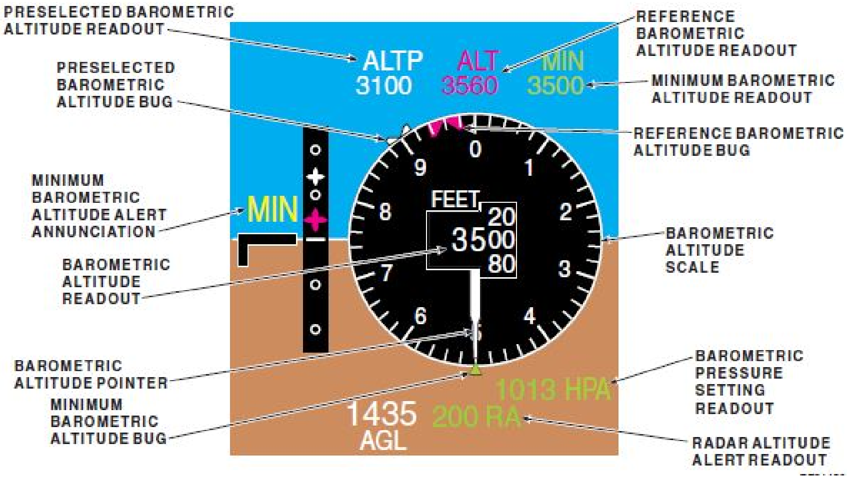


Figure 4

Altimeter with alert bugs
(Source Rotorcraft Flight Manual Part 2 Section 1, *Avionics Management System*)

FMS navigation source data display

The selected navigation source is displayed in the bottom right of the MFDs when either PFD or NAV is selected. When the 'LNAV' button on the DCP is selected as the source, FMS navigation data and the identifier, bearing and distance of the active waypoint will be displayed. For most of the flight and the first approach, the pilots had FMS selected as the navigation source data to display.

The flight plan defined in the FMS can be displayed on the MFDs with NAV page selected and will display the active leg in magenta. This is updated when the 'Direct To' function in the FMS is used. The 'FLIGHT PLAN' was selected on both inboard MFDs, which were displaying the NAV page for the duration of the flight.

If the bearing source knobs on the DCP are selected to 'LNAV', bearing pointers will display the bearing of the active waypoint on the compass rose on both the NAV and the PFD page. The bearing pointer navigation source frequency and DME (if relevant) or distance are displayed on both the PFD and NAV pages.

Use of 4-axis AFCS

On CFD mode engagement, the Rotorcraft Flight Manual (RFM) states, *'The CFD will not couple to the pitch or roll axis when airspeed is below 50 KIAS.'* On the use of the go-around mode, it states:

> *'Go around … must be selected above 50 KIAS. Once go around is engaged the CFD will use the collective axis to capture a 750 fpm vertical climb, the pitch axis to capture 80 KIAS and the roll axis to maintain the present heading.'*

Sikorsky have also issued guidance[6] to operators on the use of the go-around (GA) mode function during departure which stated:

> *'Although not designed or certified to be used during an instrument departure or to recover from an unusual attitude it may assist the pilot in performing these tasks…. Please note, if GA is used … with stick trim force or outside of the parameters for selection of the function, it may result in unexpected aircraft attitudes…. Prior to engaging ANY autopilot … control forces should be neutralized (trimmed to zero).'*

Honeywell Enhanced Ground Proximity Warning System Mark XXII

Terrain display

A digital terrain colour map, with selectable range, can be displayed on the MFDs when selected. It will display automatically when an alert is triggered, and no terrain display is selected. The terrain display shows the elevations of the highest and lowest terrain features displayed.

Terrain, obstacle and airport databases

The Mk XXII terrain database has a maximum resolution of 6 arc seconds (roughly 600 ft). The obstacle database includes the location and height of known man-made obstacles which are more than 100 ft in height, generally excluding power lines. The terrain and obstacle databases are accurate to 25 ft. The database for the terrain where the flight operated was at maximum resolution.

Warning modes

The Mk XXII provides GPWS warning modes and a forward-looking capability for terrain and obstacle avoidance 'LOOK AHEAD' mode to protect against controlled flight into terrain (CFIT). The 'LOOK AHEAD' mode compares the GPS position and geometric altitude[7] of the helicopter to the terrain and obstacle databases. The GPWS modes use radio altitude to identify descent into level or evenly sloping terrain.

'LOW ALTITUDE' cockpit selection

Pilots can select a reduced protection mode known as the LOW ALTITUDE function to minimise alerts during flight at low altitude in VFR conditions by reducing warning boundaries or inhibiting warnings depending upon the mode. The system manufacturer defines low altitude operations as below 500 ft agl.

The alert envelope and alerting

An amber 'caution' and a red 'warning' light are provided near the centre of each pilots field of view on the centre of the PFD. In addition to the normal HTAWS functions, the S92 uses the HTAWS as the aural warning generator.

Footnote

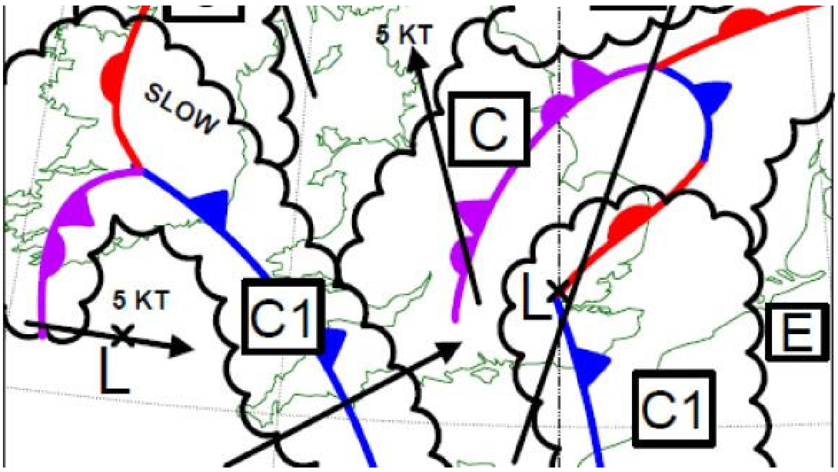
6 Sikorsky, CCS-92-APL-17-0002 'Go Around (GA) Mode during Departure', 7 August 2017.
7 A GPS-derived altitude.

There is a 'TERRAIN INOP' audio and visual alert if the 'LOOK AHEAD' mode is inhibited by a loss of signal integrity. It does not warn pilots when it is outside its functional envelope.

Meteorological information

Forecast conditions

The area forecast (Figure 5) indicated that the overall situation for Area C would be very unsettled with a main cloud base between 1,500 and 3,000 ft amsl. Conditions would deteriorate in early evening in the vicinity of the occluded front, which was forecast to move north, affecting the area. At times, this would result in a cloud base across the area of 1,000 ft amsl but also with lower stratus down to 400 ft amsl. Visibility would also be reduced to 7 km in rain, occasionally deteriorating further to 4,000 m in heavier rain.



AREA	SURFACE VIS AND WX	CLOUD
C	20 KM NIL/-RA OCNL (WDSPR FRONTS) 7 KM RA/-RADZ OCNL 4000 M RADZ/(+RA FRONTS) ISOL 3000 M +TSRA **C1** ISOL 1200 M BR/DZ LAN N FM 17 Z ISOL ʌ MAINLY FRONTS ʌ (ISOL ʌ̂) **C1** E OCNL HILL FG	BKN/OVC AC AS ψ (ISOL ψ **C2**) ʌ ... ... 070 / XXX BKN/OVC (OCNL SCT LEE MON) CU SC ... ... ψ ʌ 015-030 / 070 ISOL EMBD CB 015-050 / XXX **C1** OCNL SCT/BKN ST 004-010 / 015 ... ... (ISOL BASE 001-003 LAN N FM 17 Z)

Figure 5

F215 for 1400-2300 UTC 14 October 2019

The TAF for Birmingham Airport issued at 1057 hrs and valid for 24 hours from 1200 hrs reflected the area forecast, reporting the likelihood of poor conditions throughout the afternoon. It indicated that, although the main cloud base would be at 2,000 ft amsl with visibility greater than 10 km for the period, temporarily the main cloud base would be at 800 ft amsl and that visibility would reduce to 8 km, with further reduction to 4,000 m possible.

The Birmingham TAF issued at 1701 hrs for the period from 1800 hrs indicated a deterioration of conditions with a cloud base of 800 ft amsl and 4,000 m visibility periodically.

The TAFs for Gloucestershire Airport, RAF Brize Norton and Oxford Airport, all to the south of the LS, forecast a slightly lower main cloud base of between 900 and 1,100 ft amsl. However, they also indicated that the base of cloud might be temporarily between 500 and 700 ft amsl.

Actual conditions

Birmingham Airport reported poor conditions throughout the afternoon with a cloud base broken at 800 ft agl, lowering to 400 ft agl at times later in the day. The 1655 hrs ATIS gave a cloud base of 800 ft agl, with visibility more than 10 km and a north-easterly wind.

For the same period, Gloucestershire Airport (elevation 101 ft) reported a cloud base between 800 and 900 ft agl, with some patches down to 400 ft agl; Oxford Airport (elevation 270 ft) reported a cloud base of 600 ft agl during the afternoon, and between 400 and 500 ft agl during the period of the flight. The aftercast provided by the Met Office stated that the '*general conditions in the vicinity of Ilmington would be very similar to the airfield reports …, which are all located around the area.'* This would have suggested a cloud base of between 500 ft and 600 ft agl at Wellesbourne Mountford at the time of the incident.

The weather conditions at the LS

The LS had no weather reporting equipment and the estate manager had no formal meteorological observation qualifications. When the co-pilot spoke to him at around 1710 hrs, the estate manager reported that the weather was "closing in" and that the aerials to the north could not be seen, but that the poor weather was probably confined to that direction because the helipad camera indicated the LS was clearer. The conditions at the LS 10 minutes later are shown in CCTV picture (Figure 6.)

A witness in the house overflown by the helicopter reported that around the time of the incident there was low cloud, poor visibility and drizzle.

Sunset, official night and light levels

Sunset at the LS occurred at 1716 hrs. Night[8] was at 1746 hrs. The approach to the LS lacked significant cultural lighting. The Met Office[9] calculated that the light levels in the vicinity of the LS would have been 457 millilux at 1730 hrs when the helicopter departed Birmingham, 110 millilux at 1740 hrs and 52 millilux at 1745 hrs. A full moon on a clear night provides approximately 250 millilux of the illumination[10].

Imagery from CCTV of the LS at the time of the incident shows the area to be dark; features of the landscape are difficult to distinguish.

Footnote

[8] ANO 2016 Schedule 1 defines "Night" as *'the time from half an hour after sunset until half an hour before sunrise (both times inclusive), sunset and sunrise being determined at surface level*'.

[9] Met Office Night Illumination Model (MONIM) version 2.5.3 released in 2016.

[10] Wikipedia, https://en.wikipedia.org/wiki/Orders_of_magnitude_(illuminance) [accessed September 2020].

Figure 6

View of LS to the West at 1720 hrs, 10 minutes before departure from Birmingham (used with permission)

Accuracy of meteorological forecasts

The UK Aeronautical Information Publication (AIP) Gen 3.5 Met Services describes the provision of meteorological services for aviation in the UK. Section 3.2 states that the attainable accuracy of measurement or observation of cloud height above 300 ft is +/ 10%, and describes the accuracy specified by ICAO[11] for aerodrome, landing, or takeoff meteorological forecasts. It defines the operationally desirable standard as +/- 30% for the height of cloud between 400 ft and 10,000 ft, and +/- 30% for visibility between 700 m and 10 km. This accuracy is to be achieved for a minimum of 70% of forecasts, and 90% for a TREND.[12]

Regarding the significant weather chart, F215, AIP section 4.3.2.1 d.iii states:

> *'The specific value of any elements given in a forecast shall be understood to be the most probable value which the element is likely to assume during the period of the forecast.'*

Crew review of weather

The pilots consulted the standard weather forecast products[13] provided by the Met Office, primarily drawing upon the forecast and actual weather conditions at Birmingham Airport. Prior to departure from the LS to Birmingham, the METAR indicated a main cloud base of 1,900 ft agl but with patches of cloud at 800 ft agl. Based on the difference in elevations between Birmingham and the LS they determined that there would be a cloud base of more

Footnote

[11] ICAO Annex 3 Attachment B – Operationally desirable accuracy of forecasts
[12] A TREND is a forecast of weather conditions expected to affect the aerodrome for the validity period two hours and which is appended to an aerodrome observation (METAR or SPECI).
[13] This included the F215 and F214 and TAF and METARS for Birmingham.

than 500 ft agl at the LS. The commander stated that he was not overly concerned about the temporarily poorer aspects of the forecast because the flight would be short.

The pilots stated that on the ILS approach to Birmingham they encountered visibility of around 5 km with a cloud base of 1,000 ft amsl. On landing, the pilots considered that there had been no change in the weather from their earlier assessment. They noted that the flight would now occur after sunset since the arrival of the fixed-wing flight was delayed, but that they still expected they would land at the LS before night. Based on this assessment, they determined that the weather was suitable to return to the LS under VFR. The Birmingham ATIS reaffirmed their belief that the weather remained suitable and would provide a cloud base of around 500 ft agl at the LS. The Birmingham TAF was updated at 1701 for the period from 1800 hrs onwards but would not have been easily accessible by the pilots from within the cockpit. The report from the estate manager on the conditions at the LS indicated that the weather deterioration there was localised and that the LS itself was clearer.

The commander stated that he recognised the conditions were marginal and that they were “chasing the daylight”. However, he believed that the flight could proceed in visual conditions above 500 ft agl and they would be able to land at the LS if they reached there before nightfall, since the short flight time mitigated the risk of the weather becoming unsuitable once airborne.

Dragon GL3 portable approach aid

The operator uses a battery powered Dragon GL3 alternating single approach path indicator (ASAPI).

Figure 7

Dragon GL3 Flight portable approach aid
(Source: Dragon GL3 Instructions document, Portable System, BauerTech Instruments Ltd)

The system projects two coloured beams of light (red and white), each flashing alternately twice per second (Figure 8). These are synchronised and overlap to produce the indications shown in Figure 8. The approach angle and direction can be set manually by the user.

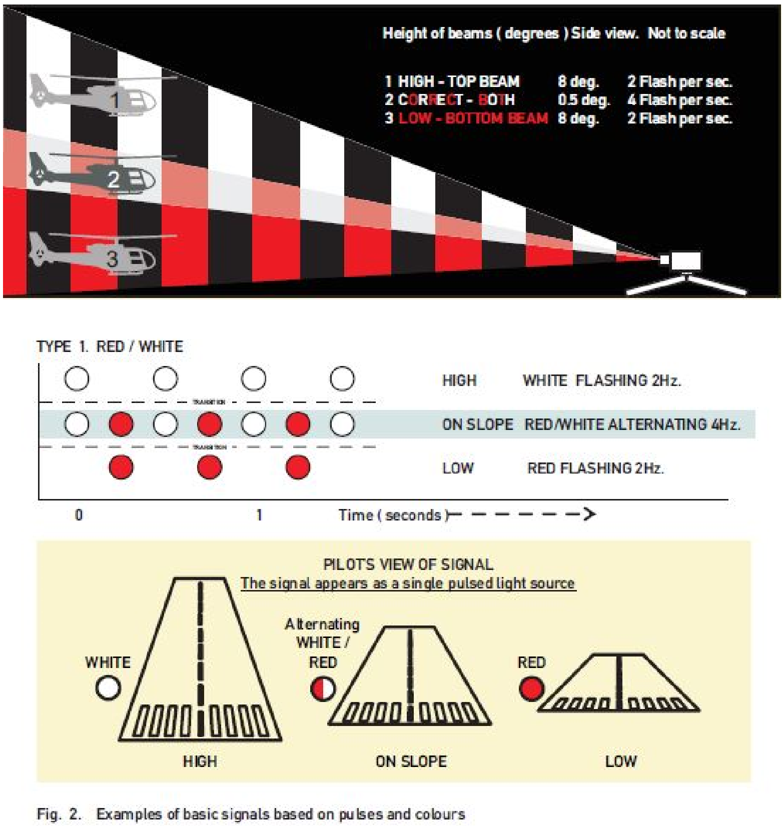


Figure 8

Dragon GL3 ASAPI
(Source Dragon GL3 Instructions document, Portable System, BauerTech Instruments Ltd)

Operator's procedures for using the GL3

The operations manual (OM) stated that only employees who have received initial instruction on its operation are permitted to set up the GL3, and that refresher training was to be carried out annually. The operator's procedures specified that any approach using the GL3 '*should be flown with NAV coupled to FMS/NMS and IAS & VS upper modes selected.*' The operator stated that it expected that the approach aid would only be used in VMC, but this was not expressed in its OM.

After the incident, the operator has added the following clarification to the procedures in the EFB:

> *'NOTE: The GL3 is NOT an aid for poor or marginal visual conditions. To be used as VISUAL Approach Aid in VMC ONLY.'*

Aerodrome information

The landing site

The LS is situated on top of a hill with an elevation of 595 ft (180 m) amsl, at the northern end of the Cotswold escarpment, with low lying ground to the east and the Vale of Evesham to the west, about 20 nm south of Birmingham. There are aerials about 1 km north of the site, extending to 1,000 ft amsl or 345 ft above the LS elevation. The grid Minimum Off-route Altitude[14] is 2,100 ft amsl determined by high ground within 10 nm to the south-west.

The LS had a CCTV camera that provides a view of the LS looking west. The site manager was able to view the CCTV images, but the pilots did not have access to them. There was also a strobe attached to a nearby building to assist location in the dark.

The commander had set up the GL3 at the LS the previous day for an approach from the south to the LS on a heading of 010º (M), with an approach path angle of 4.5º.

Birmingham Airport

Birmingham International Airport has an elevation of 339 ft amsl, 251 ft lower than the LS. It is open 24 hours and has published instrument approaches. The Minimum Sector Altitude (MSA) to the southwest of the airport, in the vicinity of the LS, is 2,500 ft altitude. A car journey from the airport to the LS takes approximately 45 minutes in clear traffic.

Wellesbourne Mountford

Wellesbourne Mountford Airfield has an elevation of 159 ft amsl and is a small aerodrome with an AFIS but no published instrument approaches. During the summer months it is open until 1630 hrs. With prior arrangement, it will remain open later and aircraft are permitted to divert there after it has closed if unable to land at their intended destination due to weather[15].

Located on the western edge of the town of Wellesbourne, it is 3 nm to the east of Stratford-upon-Avon and 8 nm to the north-north-east of the private LS, a car journey of 20 minutes. The operator regularly used the airfield as a weather diversion owing to its low elevation and proximity to the LS.

Diversion plan

The operator considered Wellesbourne the principal VFR diversion option for flights to and from the LS because of its proximity and low elevation. An hour's notice was required to arrange for vehicles to be positioned there. Birmingham Airport was a suitable IFR diversion option but involved a longer car journey for the passengers.

Footnote

[14] The MORA is defined in EASA Rules for Air Operations. See Minimum Flight Altitudes in *Organisational information* section for the definition as given in the operations manual of the operator.

[15] The website for Wellesbourne Airfield, https://www.wellesbourneairfield.com/dataandmap.htm [accessed March 2021], states that it accepts emergency and precautionary diversions as recommended by CAA CAP667 9.2 (c) '*Review of General Aviation Fatal Accidents 1985-1994*'.

Following their initial assessment of the weather before departing the LS, the pilots decided not to make arrangements for a diversion to Wellesbourne and did not warn the estate manager of any need to divert to Wellesbourne.

On landing at Birmingham, the commander ascertained that Wellesbourne would close at the published times, but that the airfield could be used as a diversion in the event of bad weather.

The pilots discussed the possibility of diverting to Wellesbourne. The commander indicated that the proximity of Wellesbourne meant there was no need to move cars there as a precaution, and the co-pilot advised the estate manager that although they had arranged to use Wellesbourne as a diversion, the plan was to fly to the LS, adding "we strongly suspect we will get in …".

As the aircraft bringing the passengers landed at Birmingham, the co-pilot spoke with the estate manager for an update on the weather at the LS, calling from the helicopter cockpit with the APU running. He recalled that when he mentioned operating directly to Wellesbourne, the commander made a strong negative signal. The noisy environment allowed only non-verbal communication between the pilots. The co-pilot stated that he interpreted the negative signal as meaning that the commander did not wish to fly directly to Wellesbourne, but that his intention was to make an approach to the LS. During the investigation the co-pilot indicated that this response did not motivate him to pursue the challenge.

Recorded information

The helicopter was fitted with a Combined Voice and Flight Data Recorder (CVFDR). Following the event, the operator's maintenance provider downloaded the recorder when the helicopter returned to Stansted.

The recordings were analysed by the AAIB. The flight data recording contained 15 hours of operation and the cockpit voice recorder the last 2 hours. The EGPWS was downloaded when more details of the incident became apparent.

Route

The pilots planned to fly from Birmingham to the LS under VFR. The planned route (Figure 1), which was available on their EFB[16] was via the M40/M42 Junction visual reporting point and approximately paralleled the M40, passing overhead Wellesbourne Mountford to IXURA, an IFR waypoint to the west of Banbury, then direct to a point 5 nm to the south of the LS.

The co-pilot entered the planned route into the FMS and included waypoints for the approach to the LS based on the GL3 approach with an initial waypoint at 5 nm from the LS on the approach and a final waypoint at 3 nm, which represented the top of descent point.

Footnote

[16] Electronic Flight Bag – in this case a tablet computer.

As the pilots waited for the fixed-wing aircraft to taxi onto stand, the commander outlined his intentions to fly to maintain VMC but, if that was not possible, to achieve VMC over Wellesbourne, where they understood that the weather was suitable. The CVR recorded the co-pilot commenting "IF WE CAN KEEP THE DAYLIGHT AND GET AHEAD OF DUSK, WE DON'T NEED THE GL3 AND WE CAN JUST MAKE OUR OWN SENSIBLE ROUTE IN".

The actual flight path flown (Figure 1) was more direct, following low ground, but then approached the LS from the east along the valley of a small stream. The routing was not explicitly discussed by the pilots before the helicopter departed Birmingham.

On approaching the M42 / M40 junction VRP, the commander briefed that he would follow the low ground placing the hill with the LS to the right and make a right turn. At this point the commander asked that the FMS be updated to provide guidance direct to the LS. Later, as part of the approach brief, the commander stated, "WE ARE GOING TO TRY AND USE SPEED AND EVERYTHING TO GET IN AS QUICKLY AS POSSIBLE BEFORE WE LOSE THE DAYLIGHT... WHATEVER DAYLIGHT WE'VE GOT LEFT".

Setting of parameters

The ALTP value was set at 1,000 ft prior to departure from Birmingham and reset to 2,500 ft by the co-pilot following the emergency climb, consistent with the CVR recording of the co-pilot stating he had reset the ALTP to 2,500 ft.

The radalt alert value was set at 200 ft for departure. It was reset to 400 ft as requested by the commander during the after takeoff checks and, at the end of the Landing Checks, to 150 ft in accordance with the SOP for a visual approach and landing. It was not reset following the emergency climb and recovery or for the second approach to the LS.

The flight data recorder did not record the selected DA/MIN alert value, and the CVR did not record any annunciation of the 'MINIMUMS, MINIMUMS' alert at any point during the flight.

Cockpit MFDs

The PFD page was selected on the outer MFD on each side with the NAV display selected on the inner MFD. The EICAS page was selected on the middle MFD. On their respective NAV displays, the commander showed EGPWS terrain and the co-pilot the weather radar. Both pilots had TCAS and the FMS flight plan overlaid on their displays. The commander had the full compass rose displayed on his PFD, and an arc compass rose on his NAV page.

Incident flight

After takeoff, the helicopter turned to the right and tracked along the M42 motorway for just over a minute, until reaching the M40 junction. During this phase, radio altitude ranged between 369 ft to 535 ft agl. The helicopter then turned towards the vicinity of the LS (Figure 1).

The altitude profile for the flight from takeoff to Point A in Figure 1 is shown in Figure 9. Parts of this flight were performed at a height of less than 500 ft agl. As the helicopter crossed the M40/M42 junction VRP, the CVR recorded a radalt alert "ALTITUDE, ALTITUDE" on five occasions in quick succession, which the commander acknowledged. At 1733:34 hrs, after one of the alerts, the commander stated, "CHECKED, CAN YOU BUG THAT DOWN." The FDR recorded that the radalt alert value was not altered in response. Further radalt alerts were recorded on the CVR until at 1739:29 hrs, the pilot stated, 'LET'S GO, BUG IT DOWN TO ONE FIFTY PLEASE.' Ten seconds later, the FDR recorded the radalt alert value reducing to 150 ft. At 1737:36 hrs, the helicopter commenced a descent from an altitude of 890 ft (689 ft agl).

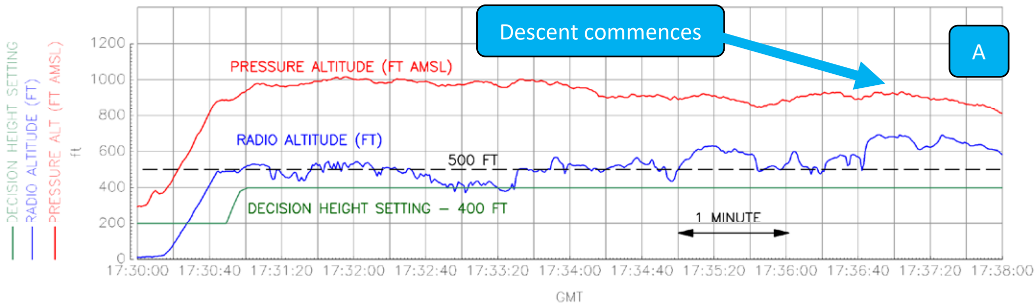


Figure 9

G-LAWX recorded pressure and radio altitude. Point A refers to location in Figure 1

At 1738:01 hrs, the commander asked for the final approach checks.

EGPWS operation

At 1739:37 hrs, the helicopter was flying south-east, approximately 2.2 nm from the LS with the landing gear down. The CVR recorded an EGPWS, "CAUTION TERRAIN, CAUTION TERRAIN" alert and the FDR data recorded an altitude of 692 ft (348 ft agl), with a groundspeed of 110 kt, descending at 500 ft/min.

The commander acknowledged this alert with "ITS COPIED" and climbed the helicopter to an altitude of 730 ft over the next 13 seconds. During this climb, the CVR recorded the commander stating, "LOW ALTITUDE". The helicopter began a slow turn as it climbed.

Relevant FDR parameters are shown in Figure 10 including the derived parameter 'BARO ALT – RADIO ALT', which represents the elevation of the surface underneath the helicopter.

The helicopter then began descending again and fifty seconds after the first EGPWS alert, the CVR recorded an EGPWS, "WARNING TERRAIN, WARNING TERRAIN". The helicopter had descended to an altitude of 610 ft (258 ft agl), at 110 kt groundspeed and with a rate of descent of 500 ft/min. The commander again acknowledged this with "ITS COPIED" and then "VISUAL". The helicopter then climbed to an altitude of 720 ft (343 ft agl) over 30 seconds and reduced speed (Figure 10). There were no further EGPWS alerts for the remainder of the flight.

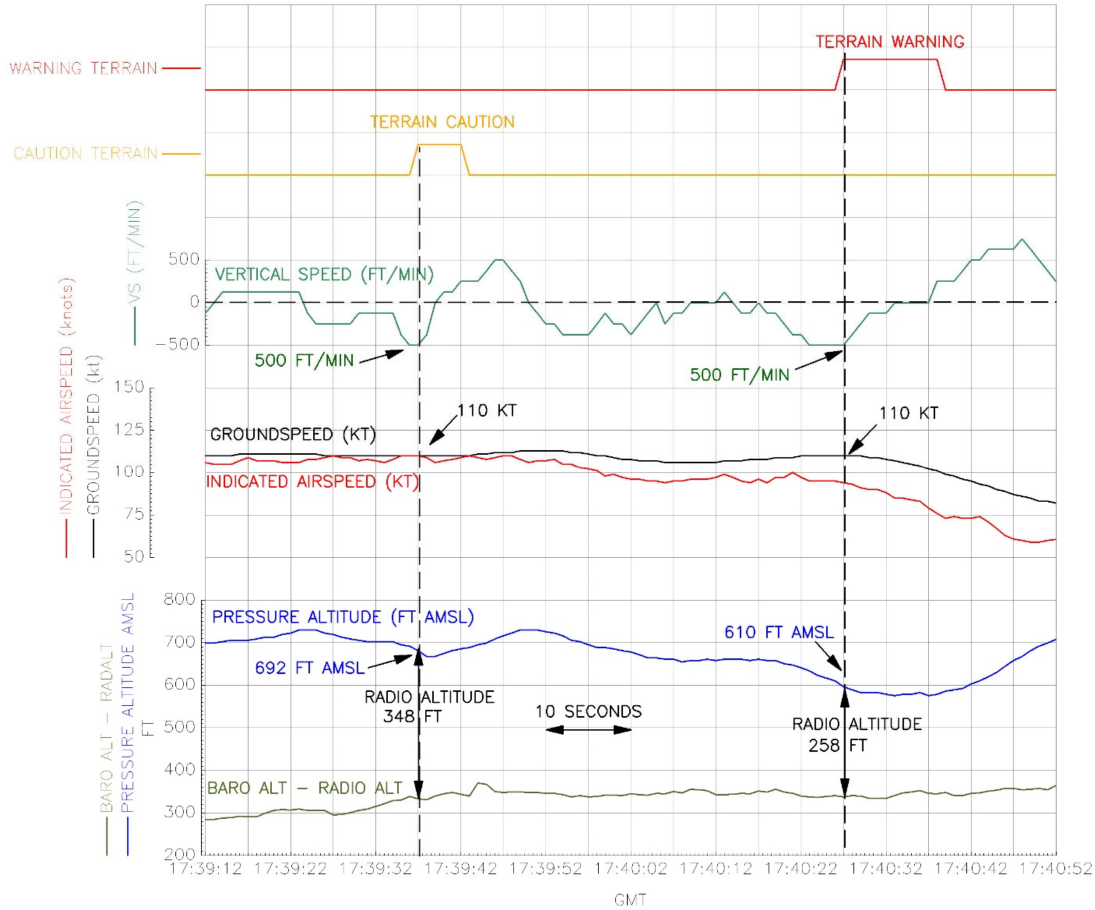


Figure 10

G-LAWX incident flight EGPWS parameters

EGPWS manufacturer comment

The EGPWS manufacturer stated that the system records a snapshot of data 20 seconds prior to an alert and 10 seconds after. There is no continuous logging function. They commented that the data showed the 'LOW ALTITUDE' mode had been selected following the EGPWS 'CAUTION TERRAIN' alert.

They also commented that the EGPWS system was working as expected and conformed to the alerts specified in RTCA DO-309.

First approach to the LS

After the first EGPWS alert, the helicopter started a slow turn to the right. Just after the second EGPWS alert, it began tracking towards the LS (Figure 11)

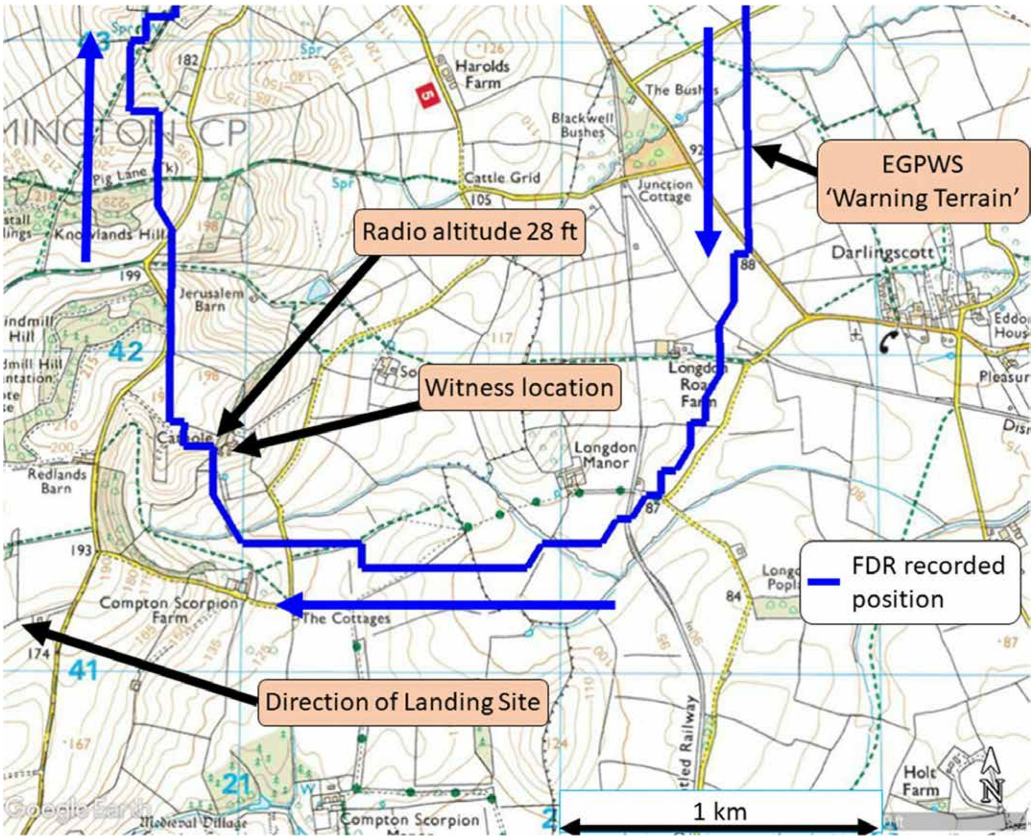


Figure 11

G-LAWX incident flight track (terrain heights are in metres)
© Crown copyright 2020 OS 0100015274
NOTE: FDR position is recorded to the nearest 248 ft

As the helicopter flew in a westerly direction, the pilot had right pedal applied throughout, yawing the helicopter gradually onto a more northerly heading. At 1741:21 hrs, the CVR recorded the co-pilot stating, "ONE MILE TO GO". At 1741:25 hrs, hrs the commander asked, "IS THAT THE HOUSE?" to which the co-pilot replied "LOOKS LIKE IT". The helicopter had descended gradually to an altitude of 654 ft (186 ft agl) with a groundspeed of 49 kt and indicated airspeed of 35 kt. The helicopter continued to slow and yaw to the right but had started to climb because the commander had raised the pitch attitude to +18° (Figure 12).

The co-pilot called, "I'M LOSING VISUALS WITH THE GROUND…I HAVE VISUALS TO THE LEFT... WE ARE CLIMBING AT THOUSAND FEET PER MINUTE" (Figure 13). The helicopter climbed to 883 ft and then descended, its rate of descent increasing to a maximum of 1,125 ft/min as the groundspeed increased to 35 kt.

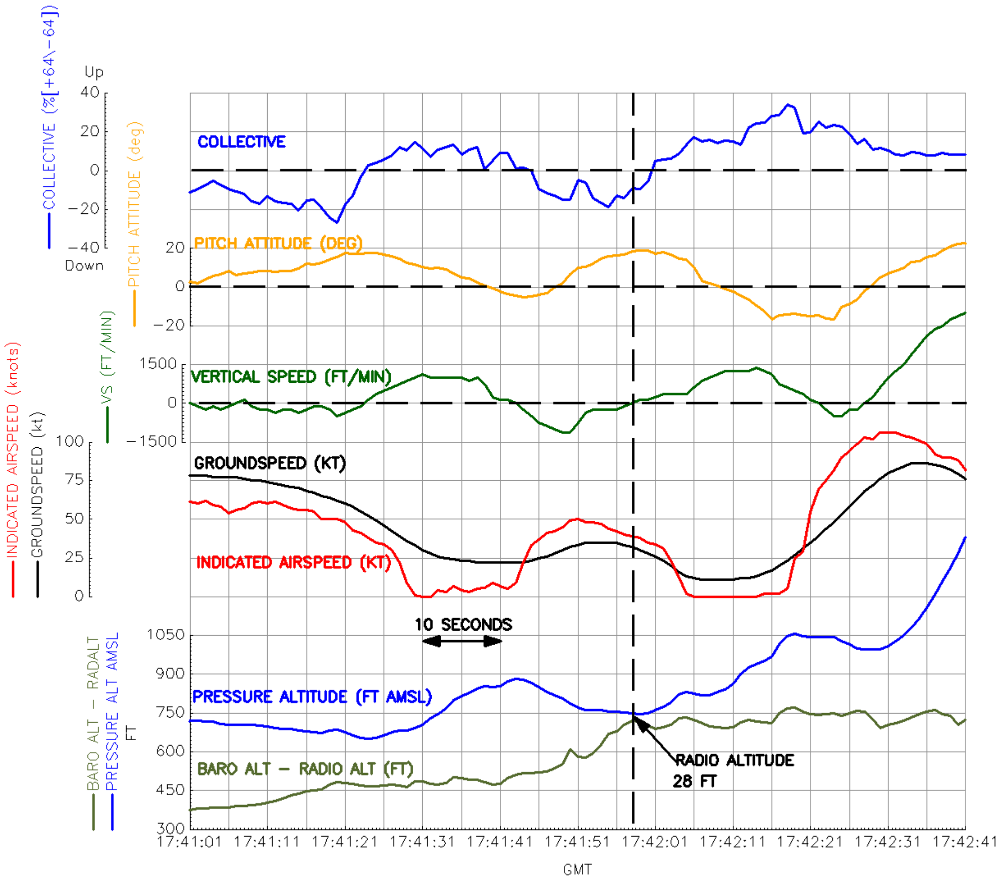


Figure 12

G-LAWX FDR data for first approach

NOTE – the manufacturer stated that the FDR indicated airspeed data is not considered accurate below 30 kt.

The CVR then recorded the following:

Time (hrs)	CVR
1741:51	PF - WE ARE JUST COMING OVER A HOUSE
1741:52	PM - YEAH ROGER…. GOT THE TREES
1741:54	PF - WHERE'S [THE LS]?
1741:55	PM - IT SHOULD BE DIRECTLY ON THE NOSE "ALTITUDE, ALTITUDE"
1741:57	PF - NO, IT'S NOT

Table 1

G-LAWX CVR extracts

At the time of the "ALTITUDE, ALTITUDE" alert, although the helicopter maintained a level altitude of just over 700 ft, the radio altitude decreased through 78 ft agl, having passed through the 'decision height' of 150 ft agl approximately a second earlier. The rate of descent reduced and three seconds later, with a groundspeed of 30 kt and a pitch attitude of +18°, the helicopter probably passed over trees beside a house and on the edge of the field when the radio altitude decreased to 28 ft at its closest point to the ground below.

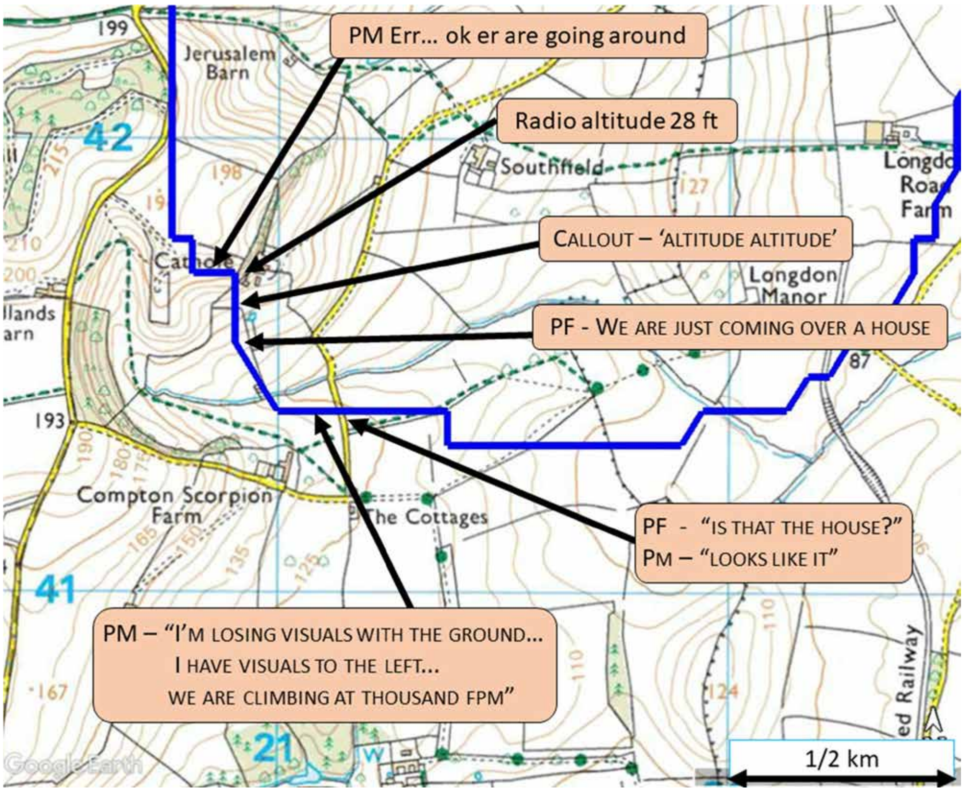


Figure 13

G-LAWX flight path and FDR data (terrain heights are in m)
© Crown copyright 2020 OS 0100015274

During the following 15 seconds, the helicopter passed over a field near the top of the hill, climbing to an altitude of about 900 ft (203 ft agl), while its pitch attitude lowered below the horizon. The pilots were recorded by the CVR trying to find the LS:

Time (hrs)	CVR
1742:00	pm – 'no…ok we are coming over the fields … visual with the ground… a good hover'
1742:10	pf – 'where's [the LS]?'
1742:11	pm– 'i'm looking, i can't see it'

Table 2

G-LAWX CVR extracts

At 1742:13, 15 seconds after the helicopter passed closest to the ground, the commander stated, "ERR…OK WE ARE GOING AROUND".

Emergency climb

The pilot raised the collective, pitched the helicopter down and began the climb. Engine torque increased initially to 103% on both engines after which the main rotor rpm decreased to 90%. This was accompanied by a corresponding, "LOW ROTOR" alert for five seconds, during which the collective was increased and engine torque increased further to a maximum of 131%. Engine torque on both engines was in excess for 120% for seven seconds.

At the same time, the pitch attitude of the helicopter reduced to -17° for a number of seconds while the height remained less than 300 ft agl and the helicopter accelerated in level flight up to 100 kt. The helicopter then pitched up to +23°, leading to a rate of climb of up to 3,500 ft/min, before pitching down and levelling off at an altitude of approximately 2,200 ft.

On levelling off, the co-pilot is heard to state that "YOU HAVE AN ALTP OF TWO THOUSAND FIVE HUNDRED IF YOU NEED IT". After the emergency climb was initiated, the landing gear remained down for the remainder of the flight.

Final approach to LS

The helicopter flew towards the south-west for an approach using the GL3. It turned towards the LS passing the 5 nm point to the south at 1748 hrs and descended from an altitude of approximately 2,000 ft. During the next minute, the helicopter attitude pitched to -14°, up to +16° then back down to -10° pitch before stabilising. This, along with modulation of the collective, caused fluctuations in airspeed from between 72 to 133 kt and a rate of descent up to 1,820 ft/min. During this time the co-pilot called out speed and height information and, when 4.25 nm from the LS, stated "SO, ITS FIFTY KNOTS GROUNDSPEED AT FIVE HUNDRED FT… I DON'T THINK WE ARE GOING TO GET IN ON THIS," to which the commander replied, "NO WE ARE NOT". The approach continued and the co-pilot continued to call out flight parameters. The flight path varied either side of the direct heading to the GL3 and consistently below the 4.5° glide path (Figure 14).

When 3.4 nm from the helipad the co-pilot called, "BACK TO BIRMINGHAM?" to which the commander replied, "I'M JUST GOING TO ERR… TRY ONE MORE MILE". The co-pilot continued to call out flight parameters and when 2.2 nm from the helipad, at an altitude of 1,273 ft (678 ft aal) and airspeed of 75 kt, the commander stated "IT'S NOT GOING TO HAPPEN IS IT", to which the co-pilot replied "NO". The commander stated "…WE ARE GOING AROUND", which the co-pilot acknowledged.

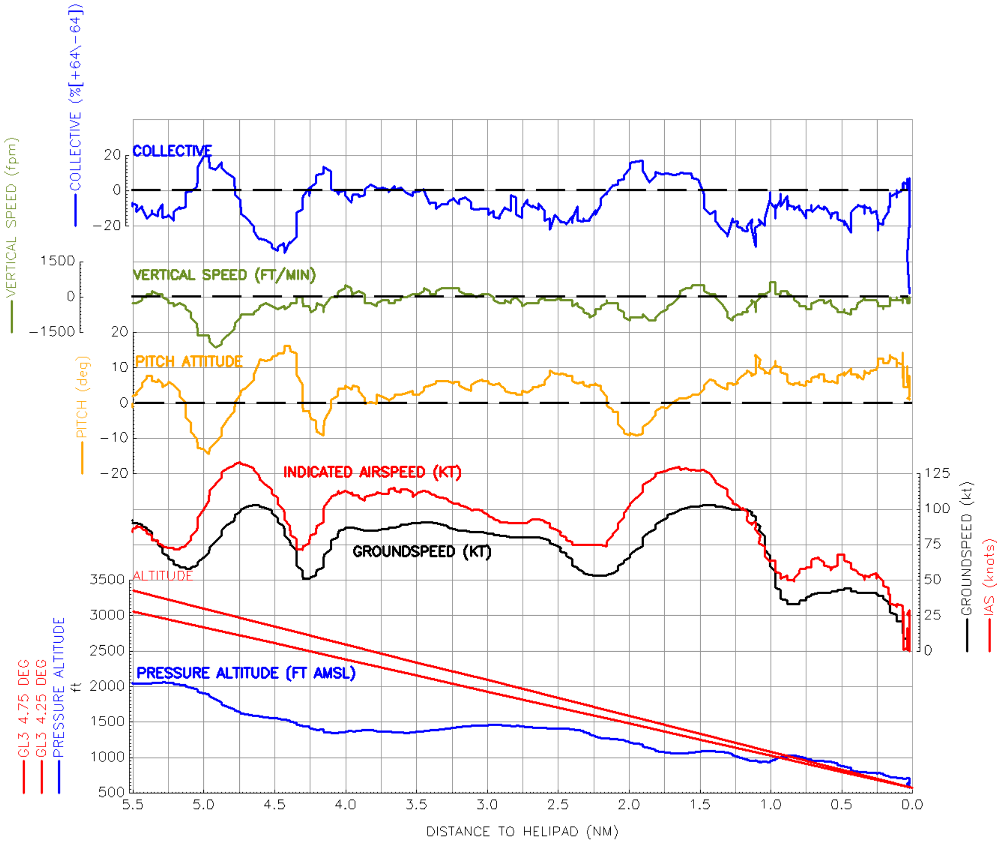


Figure 14

G-LAWX flight data during GL3 approach

The collective was raised, the helicopter pitched down, and airspeed increased from 75 kt up to 130 kt over 23 seconds. The rate of descent reduced but the helicopter did not climb significantly, levelling at an altitude of approximately 1,100 ft for 15 seconds. When it was 1.3 nm from the LS the helicopter was at an altitude of 1,064 ft (469 ft aal), had an airspeed of 110 kt, and was beginning to descend again. The co-pilot stated "<PILOT'S NAME> I'M NOT HAPPY WITH THIS", which the commander acknowledged. Ten seconds later, when 1.1 nm from the LS and at approximately 500 ft aal, the commander stated, "THERE'S THE LANDING LIGHT, THERE'S THE LANDING LIGHT". The co-pilot responded by continuing to give guidance and the approach stabilised. The helicopter landed around 2½ minutes later at 1754:11 hrs.

Unmanned aircraft survey of G-LAWX approach path

The AAIB flew the final stages of the first approach using one of its unmanned aircraft (UA). The route was divided into smaller sections for a series of flights using position and height information from the helicopter's FDR to position the UA. The last of the flights, in the area where the helicopter came closest to the ground, was conducted as close to the start of night as possible.

The flights captured still and moving images along the route in order to better understand the visual cues and features that may have been seen by the pilots. This last flight revealed the limited ambient light levels and scarce light features, and that it was not possible to see the LS from the heights flown as the helicopter approached due to a ridgeline obscuring the line of sight in that direction.

Incident site

Approaching the LS from the east (Figure 15), there is a steep wooded escarpment below a plateau on which the landing site is situated. The helicopter came closest to the ground 1 km east of the LS and 600 ft to the north of the intended westerly approach path, near the top of a hill with an elevation of 650 ft amsl and a gradient of 15 - 20%.

A witness in a house a few hundred feet from the point where the helicopter came closest to the ground stated that they saw the helicopter approach from the south-east and heard it fly overhead.

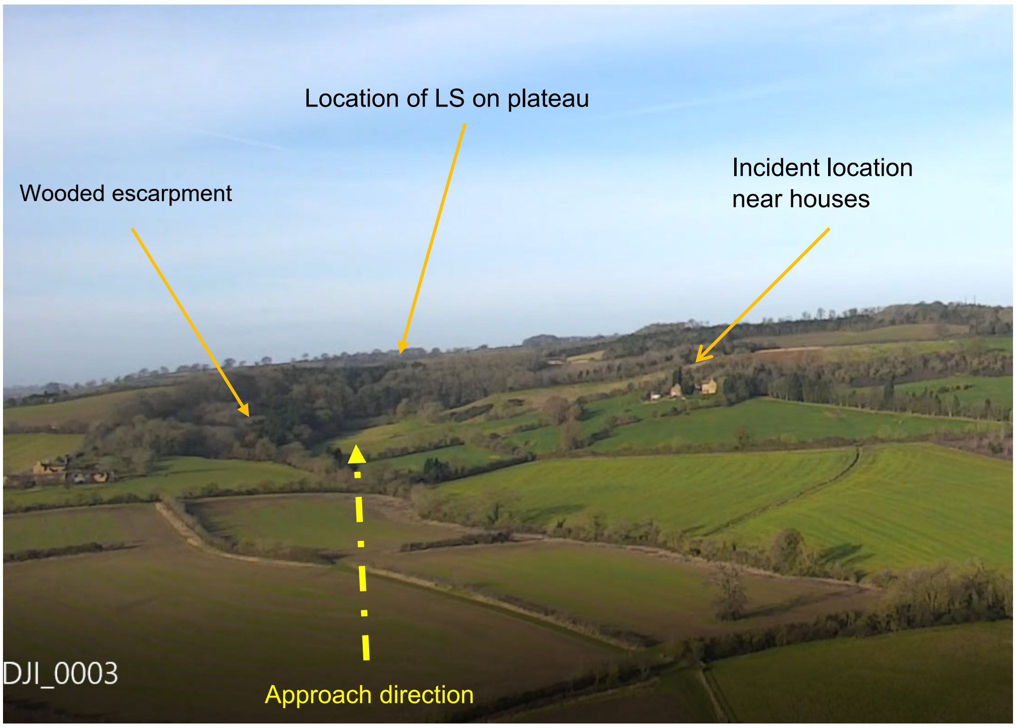


Figure 15

View of the approach to the LS from the east.
(This image does not show the conditions of reduced light and visibility present at the time of the serious incident.)

Aircraft examination

The helicopter was maintained under an approved maintenance programme and all the required checks and inspections had been completed.

The operator and the maintenance organisation reviewed the recorded data with the engine and airframe manufacturers to determine what maintenance actions would be required following the over-torque event.

Maintenance documentation provided by the engine manufacturer defines the extent of maintenance action by plotting the extent and duration of the event on a chart. For this event, the engines did not require any maintenance action.

The airframe manufacturer provided a list of maintenance requirements which included inspections of the main and tail rotor gearbox, the rotor blades and their attachments and control mechanisms. These requirements and inspections were carried out and no anomalies were identified.

The helicopter was returned to service.

Organisational information

The operator

The operator provided helicopter services in onshore corporate and yacht support roles and provided helicopter servicing management services.

The operator held an Air Operators Certificate (AOC) and conducted flights in accordance with EASA Part-CAT (commercial air transport) and occasionally to Part-SPO (specialised operations) standards. It also held a specialised authorisation under Part-SPA.HOFO to conduct offshore operations for NCC operations only. A significant part of its operation involved non-commercial flights under both complex (Part-NCC) and non-complex (Part-NCO); these flights were conducted according to Part-CAT where possible.

In the past five years the operator had experienced significant growth in the number of types it operated and the number of pilots it employed.

The management structure and team had not changed in this time. The safety management structure was integrated within the AOC structure. At the time of the serious incident the SM role was fulfilled by the AM, with the Compliance Manager (CM) acting as deputy. Earlier in the year the CM had been appointed as deputy with a succession plan agreed for the AM to handover SM responsibility in full to the CM over a 12-month period. Over the same five-year period, the operator's continuing airworthiness staff increased from three to five, and the support staff from five to eight.

An external audit of the operator's management system by the business group of which the operator is a part, shortly after the serious incident, found that:

> '[the] *AM* [is] *also SM and MD. 80+ People. This means that although the roles may be being conducted adequately, the separation of responsibilities must be assured in order to maintain a management structure that is credible, and free from actual or potential conflicts of interest.'*

The operator has since appointed the CM as the SM in accordance with the succession plan.

Operator's safety plan and safety culture

The operator updated its safety plan each year. The plan for 2019 identified 'Commercial Pressure', 'Poor Weather Operations', 'Night Off-aerodrome Landings' and 'New Technology' as among the hazards.

Commercial pressure

The safety plan stated:

> *'We still see evidence on a frequent basis that poor decisions can result from either external pressure and/or inappropriate reaction to perceived pressure.'*

It recognised that commercial pressure is a feature of the operation and distinguished between managed commercial pressure – acting as a positive influence on competences and organisational capabilities – and unmanaged commercial pressure, leading to poor judgement and decision making.

It identified a lack of SOPs and adherence to them as risk influencing factors. It sought to address these by conducting scenario-based ground training, expressing a management commitment to support pilots who decided not to operate a particular flight, and implementing management procedures for situations involving higher than normal risk.

Both pilots stated that they did not feel any undue pressure from the client to reach the LS.

Poor weather operations

The safety plan recognised that 'Poor Weather Operations' had contributed to helicopter accidents in the past, and identified accuracy and availability of meteorological information, adherence to SOPs and weather limits, and commercial pressure as risk factors. The safety plan intended to address these through safety workshops, by providing adequate weather reports and training to pilots, the use of TAWS on all flights and by using approved descent and approach procedures.

Off-aerodrome landings

The operator introduced The GL3 system to mitigate the risks arising from approaches to off-aerodrome landing sites at night.

Automation

The safety plan identified lack of familiarity with automation as a risk factor to be managed by adequate conversion training on type. It included a safety action for all pilots to attend a course on automation.

The relationship with the client

The commander was the operator's primary point of contact with the client's office. On individual operations the helicopter crew became the immediate point of contact for delivering the service.

The client used the helicopter as the principal transport to and from the LS in preference to using roads, and successful service delivery involved taking the client to and from the desired destination. This required flexibility while managing the client's expectations of what could be achieved in the circumstances of each day and arranging alternative aerodrome and transport plans often at short notice.

Training

Licence and Operator Proficiency Checks

The operator used an external training provider to deliver licence and operator proficiency checks in a simulator in accordance with its own and the relevant EASA requirements. Training was in accordance with the S92A Approved RFM[17] and included recovery from unusual attitudes but not training for IIMC.

The operator commented that the training was influenced by that provided to offshore operators. This included the use of 3-axis[18] automation for the cruise phase of flight.

Crew resource management

The operator contracted an external training provider to deliver Cockpit Resource Management (CRM) Training in accordance with its own and EASA requirements. Pilots would receive a one-day operator conversion course on joining the operator and a further one-day re-currency course, each year. All subjects were delivered over the course of a three-year cycle.

Recurrent training in 2018/2019 included situational awareness, use of SOPs and decision making. The latter explored crew experience and cockpit gradient, hazardous attitudes and biases, the defences of multi-crew cooperation, and threat and error management (TEM). Both pilots had completed this training.

The training programme included assertive communication and intervention using the *'Probe, Alert, Challenge, Escalate*[19]' (PACE) process. The co-pilot had not yet covered this module in the three-year training cycle.

The recurrent training also explored risks identified through an annual safety survey. In particular, it considered the issue of real versus perceived pressure, and reviewed the pre-flight briefing aide memoire as part of the risk assessment and threat management process before flight. The Chief Pilot used the opportunity to reiterate that the operator would support pilots in their 'go/no-go' decision.

Footnote

[17] S92 RFM-003.
[18] The three axes are pitch, roll and yaw. In the S92 this is referred to as '2 cue'.
[19] Sometimes *'Emergency'.*

Other information

Applicability

The EASA regulations described below are those applicable to the operation of G-LAWX when the serious incident occurred. The regulatory framework has changed since the UK left the European Union but those referred to are retained regulations as specified in the European Union (Withdrawal) Act 2018.

Flight rules and meteorological limits

Minimum heights

An aircraft is permitted to fly within 150 m (500 ft) of the ground under VFR by day other than '*over the congested areas of cities, towns or settlements or over an open-air assembly of persons'*, but must not fly closer than 150 m (500 ft) to '*any person, vessel, vehicle or structure*'.[20] By night, the minimum height for VFR flight is 300 m (1,000 ft) *'above the highest obstacle located within 8 km of the estimated position of the aircraft.'* In both cases there is an exception to these minima for takeoff or landing.

The operator's OM also stated:

> *'Where possible, the minimum transit height shall routinely be 1500ft above the surface. It is important to note that flights should not be flown less than 500ft from any person, vehicle, vessel or structure when operating to the absolute weather minima.'*

And,

> '*The minimum en route altitude for VFR flight over land will be 500 ft agl or in accordance with ANO Rule 5….'*

The Operator has updated the OM to reflect current regulations.

VFR meteorological conditions

By day, outside controlled airspace, an aircraft conducting a VFR flight below 3,000 ft amsl must remain clear of cloud and in sight of the surface, with a minimum visibility of 5,000 m.[21] In the UK, VFR flight is permitted with a lower visibility of 1,500 m when flying at an IAS of less than 140 kt.[22]

Footnote

[20] UK CAA, Official Record Series (ORS) 4, No. 1174 '*Standardised European Rules of the Air - Exceptions to the minimum height requirements'* published 6 June 2016 and SERA.3105 Minimum Heights.
[21] SERA.5001 Tables S51.
[22] UK CAA, ORS 4, No. 1067 '*Standardised European Rules of the Air – Visual Meteorological Conditions (VMC) Visibility and Distance from Cloud Minima'*, published 9 December 2014,).

By night, for flight below 3,000 ft amsl, the cloud ceiling shall not be less than 1,500 ft (450 m) with a minimum visibility of 5,000 m and the pilot shall remain in continuous sight of the surface.[23]

<u>EASA Part-NCC</u>

Part-NCC.OP.180, *Meteorological conditions*, states:

> *'The pilot-in-command shall only commence or continue a VFR flight if the latest available meteorological information indicates that the weather conditions along the route and at the intended destination at the estimated time of use will be at or above the applicable VFR operating minima.'*

Part- NCC.OP.226, *Approach and landing conditions – helicopters*, states:

> *'Before commencing an approach to land, the pilot-in-command shall be satisfied that, according to the information available, the weather at the aerodrome or the operating site and the condition of the final approach and take-off area (FATO) intended to be used would not prevent a safe approach, landing or missed approach.'*

The onshore helicopter industry

<u>Onshore Helicopter Review Report</u>

In November 2019, the CAA published CAP 1864, the report of its review of the onshore helicopter operations in the UK, which considered AOC, Part-NCC and Part-SPO operational management, previous research, pilot training and meteorological issues. It identified 16 safety issues, specified 27 Safety Actions the CAA would take, and made 25 recommendations to the industry. The report stated:

> *'a recurring theme in a number of onshore accidents and incidents has been that of poor decision making and lack of rule-based behaviours….Normalised deviation continues to be cited within the industry as indicated by the confidential survey and some of these accidents suggest that flight operations are being routinely conducted on the margins of safety and legality.'*

And:

> '*helicopter operations will require the flexibility of an off-aerodrome movement as part of the CAT task and nearly always a VFR sector to achieve it* [and] *in operating to the minimum regulatory requirements, maximum flexibility is afforded to the operation, but this concept of minimum compliance exposes crews to uncontrolled task-focussed decision making.'*

Footnote

[23] SERA.5005 (c) (3).

Also:

> *'The company operations manual must fully reflect its operational needs and define not just what is required of the crew at every stage of flight but also define how it should be achieved in practice. This detail equally applies to all personnel concerned with managing the flight on the ground.'*

Among the safety issues identified in CAP 1864 were customer expectations, decision making and human factors, the accuracy of weather forecasting, CFIT, the complexity of new aircraft, loss of control training, compliance with SOPs and the use of ad-hoc IFR let-downs.

Creation of an onshore safety leadership group

Action 27 of CAP 1864 stated:

> *'The CAA will work with the onshore industry to develop and implement similar objectives to the OHSLG[24] through an Onshore Safety Leadership Group for CAT and emergency service operations.'*

The Onshore Safety Leadership Group convened in September 2020.

CAA Safety Notice Safety Notice (SN)-2019/007

In November 2019, the CAA published SN-2019/007, '*Helicopter Operations Flight Planning and Safe Flight Execution'*, updating guidance originally produced in response to AAIB Safety Recommendation 2014-031 made following the accident involving G-CRST at Vauxhall[25]. The purpose of the Safety Notice was to reinforce the need for detailed and appropriate pre-flight planning and risk assessment before conducting any flight, but particularly those flights conducted under VFR.

SN-2019/007 referred operators to the guidance for VFR flight planning outlined in Federal Aviation Regulations (FAR) Part-135.615. These had been promulgated as a result of several Safety Recommendations made in a US NTSB safety study, following helicopter accidents that occurred in the US between 1992 and 2009. It stated:

> *'A commander may deviate from the planned flight path for reasons such as weather conditions or operational considerations. Such deviations do not relieve the commander of the weather requirements or the requirements for terrain and obstacle clearance contained in the operating rules and the Rules of the Air. Rerouting, change in destination, or other changes to the planned flight that occur while the helicopter is on the ground at an intermediate stop require evaluation of the new route...'.*

Footnote

[24] Offshore Helicopter Safety Leadership Group which evolved out of the Offshore Helicopter Safety Action Group that was established as an action following the review into the risks and hazards of offshore helicopter operations in the UK which resulted in the publication of CAP 1145.

[25] Available at Aircraft Accident Report 3/2014 - Agusta A109E, G-CRST, 16 January 2013 - GOV.UK (www.gov.uk) [accessed October 2020].

Management

EASA Part-ORO.GEN.210 states that the AM is the person responsible for establishing and maintaining an efficient management system. AMC1.ORO.AOC.135 states that a '*person may hold more than one of the nominated posts if such an arrangement is considered suitable and properly matched to the scale and scope of the operation.*' AMC2 ORO.AOC.135 states:

(a) *'The acceptability of a single person holding several posts, possibly in combination with being the accountable manager, should depend upon the nature and scale of the operation. The two main areas of concern should be competence and an individual's capacity to meet his/her responsibilities.*

(c) *The capacity of an individual to meet his/her responsibilities should primarily be dependent upon the scale of the operation. However, the complexity of the organisation or of the operation may prevent, or limit, combinations of posts which may be acceptable in other circumstances.'*

CAP 1864 noted '*The management and associated "culture" of an organisation are fundamental to its safe operation….The safety ethos and culture of an organisation is driven from the top and the communication of the company's fundamental safety principles must be clear to all personnel'.* It further highlighted that the operator '*must own its own risk profiles and manage them"* These risks included:

- Terrain and obstacle awareness.
- Inadvertent entry into IMC at low level.
- Pilot disorientation/loss of situational awareness.
- Accurate and timely operating base and en route weather information.
- Illumination of final approach and takeoff area.

It further highlighted that most *'small to medium sized AOCs have compliant but small teams to meet their safety responsibilities….*' and that there is a challenge to manage the multi-tasking of roles, especially by nominated persons. It commented that there is a balance to be found *'between keeping risks as low as reasonably practicable whilst remaining commercially viable and compliant'.*

Operational control and supervision

EASA Part-ORO.GEN.110 (c) *operator responsibilities,* required an operator to establish and maintain a system for exercising operational control which specified the responsibilities for the initiation, continuation and termination or diversion of each flight.

CAP 1864 stated that oversight and supervision of flight operations was the first prevention control against any incident or accidents. The report noted that *'Command and control procedures to manage the flight planning and dispatch process need to be robust'.*

It made the following recommendation:

> *'R4: It is recommended that operators show clear evidence of operational control as defined in AMC1 ORO.GEN.110 (c), ensuring that there is a clear tasking process separating the customer and the flight crew.'*

The operator's OM outlined the responsibilities of the pilots. This required them to:

> *'...*
>
> *(c) Confirm with the Operations Manager the details of the go/no-go procedure and prior to duty carry out any necessary requirements to fulfil the procedure;*
>
> *...*
>
> *(f) Assess the weather and advise the operations manager of the go/no-go decision.'*

Helicopter flight data monitoring programmes

Flight data monitoring (FDM) is the process of capturing data recorded on an aircraft in flight and the analysis of this information to improve safety and increase overall operational efficiency.

CAP 1864 recognised the challenge for helicopter operators to monitor and oversee flight operations, including SOP compliance. It noted the benefits that FDM programs have delivered in the offshore environment and stated that mandating them for onshore operations should be considered.

EASA Part-ORO AMC1 ORO.AOC.130 *Flight Data Monitoring - aeroplanes* states:

> *(b) 'An FDM programme should allow an operator to:*
>
> *(1) identify areas of operational risk and quantify current safety margins;*
>
> *(2) identify and quantify operational risks by highlighting occurrences of non-standard, unusual or unsafe circumstances;*
>
> *(3) use the FDM information on the frequency of such occurrences, combined with an estimation of the level of severity, to assess the safety risks and to determine which may become unacceptable if the discovered trend continues;*
>
> *(4) put in place appropriate procedures for remedial action once an unacceptable risk, either actually present or predicted by trending, has been identified; and*
>
> *(5) confirm the effectiveness of any remedial action by continued monitoring.'*

There is no requirement for the operator to have an FDM Programme.

In 1998 a trial was initiated by the CAA to establish if FDM could be applied to helicopters operating offshore in support of the North Sea oil and gas industry. This led to the international adoption of FDM among operators supporting the offshore industry. No similar work was carried out to establish if FDM could also be applied to onshore operations.

The operator did not have an FDM program at the time of the incident. However, it is now developing an HFDM programme for its planned Part-SPA.HOFO operations.

Threat and error management

The European Helicopter Safety Team (EHEST) published Training Leaflet HE8, '*The principles of Threat and Error Management (TEM) for helicopter pilots, Instructors and Training Organisations*'. It stated:

> *'The objective of error management is the timely detection and prompt appropriate response in flight operations in order for the error to become operationally inconsequential.'*

Safety Notice SN-2019/007[26] stated:

> *'One measure of the effectiveness of a flight crew's ability to manage threats is whether such threats are detected promptly enough to enable the flight crew to respond to them before a UAS[27] develops by taking the appropriate actions.*
>
> *As threat managers, flight crews are the last line of defence to keep threats from negatively impacting flight operations.'*

It is suggested[28] that:

> *'crews that develop contingency management plans, such as proactively discussing strategies for anticipated threats, have fewer mismanaged threats'*

And:

> *'crews that exhibit strong leadership, inquiry, and workload and automation management have fewer mismanaged errors and undesired aircraft states'*

Footnote

[26] *UK CAA Safety Notice SN-2019/007 - 'Helicopter Operations Flight Planning and Safe Flight Execution'.*
[27] Undesired aircraft state.
[28] Helmreich R (2006). Beyond the Cockpit: The Spread of LOSA and Threat and Error Management. 4th ICAO-IATA LOSA and TEM Conference, Toulouse, 16 November.

Flight Risk Assessment Tool

SN 2019/007 stated:

> *'A process such as the European Helicopter Safety Team (EHEST) Pre-departure Risk Assessment tool could make a positive safety impact because its use might prompt pilots to seek management approval before accepting a flight.'* [29]

The operator's OM included a 'Pre-Flight Crew Briefing' aide memoire, also known as a Flight Risk Assessment Tool, to be signed by the commander before flight and referred to the Chief Pilot for final flight authorisation.

Decision making

The EHEST published Training Leaflet HE4 *'Decision making for single pilot helicopter operations'* (focussing primarily on single pilot helicopter operations but containing information relevant to multi-crew operations).[30] It stated:

> *'Research into the human factors related to aircraft accidents and incidents has highlighted decision making as a crucial element. Pilots usually intend to fly safely, but they sometimes make errors. It has been observed that the majority of fatal crashes are attributable to decision errors rather than to perceptual or execution errors. Many incidents are also associated with decision making errors.'*

Hazardous attitudes, behavioural traps and biases

In its *Pilot's Handbook of Aeronautical knowledge'*[31] the FAA identifies 'resignation' as a 'hazardous attitude', commenting

> *'Pilots who think, "What's the use?" do not see themselves as being able to make a great deal of difference in what happens to them.'*

EASA training leaflet HE4 identified six behavioural traps and biases that pilots should take steps to avoid:

- Peer pressure: '*Poor decision making may be based upon an emotional response to peers, rather than evaluating a situation objectively. The solution offered by the peers is accepted without further assessment, even when this solution is wrong.'*

Footnote

[29] https://www.easa.europa.eu/document-library/general-publications/ehest-pre-departure-risk-assessment-checklist#:~:text=This%20tool%20has%20been%20developed,%2C%20passenger%2C%20etc.) [accessed March 2021].

[30] https://www.easa.europa.eu/sites/default/files/dfu/HE4_Single-Pilot-Decision-Making-v1.pdf [accessed March 2021].

[31] FAA, 2016, '*Aeronautical Decision Making*', Pilot's Handbook of Aeronautical Knowledge.

- Plan continuation bias (the tendency to continue with the original plan in spite of changing conditions that make the planned course of action no longer viable, or): *'The tendency to search for or interpret information in a way that confirms one's pre-conceptions or backs up the decision that has already been made. Counter evidence is not considered or discarded. Fixation is the term used when such behaviour persists.'*
- Overconfidence: *'The human tendency to be over-confident in one's skills, competences, and capacities',* such as manual flying.
- Loss aversion bias: *'The strong tendency for people to prefer avoiding losses. Changing the plan means losing all the effort you have already expended on. Explains why decisions are sometimes hard to change.'*
- Anchoring bias: *'The tendency to rely too heavily, "anchor," or focus attention on one or a few elements or pieces of information only.'*
- Complacency: *'A state of self-satisfaction with one's own performance coupled with a lack of awareness of potential risks. Feeling to be at ease with the situation, which often result in lack of monitoring.'*

HE4 noted one manifestation as *'the willingness to please a customer or to complete the mission, even if the weather or other essential mission factors are deteriorating.'*

Monitoring and intervention

Authority gradient is described as the *'established or perceived, command and decision making hierarchy in a crew',* and '*how balanced the distribution of this power is experienced within the crew.'*[32] A significant authority gradient (or imbalance) between crewmembers tends to inhibit feedback and cooperation, to the extent that input may cease altogether, and a process of 'graded assertiveness' is necessary to provide the environment for effective challenge and intervention.

A formal process for monitoring, escalating concerns and, if necessary, taking control helps make challenges procedural rather than confrontational. PACE process is used in aviation, healthcare and other high-consequence operational environments to provide this formality.

The OM stated:

> *'Incapacitation can be gradual or sudden, subtle or overt, partial or complete and may not be preceded by any warning.*
>
> *b Two crew operation*
>
> *…*

Footnote

[32] https://www.skybrary.aero/index.php/Authority_Gradients [accessed March 2021].

iii The "Two Communication" rule of thumb should be used to assist detection of incapacitation. When one of the crew does not respond appropriately to a second verbal communication associated with a significant deviation from a standard operating procedure or flight profile then the other crew member should suspect incapacitation. If the non-handling pilot has reason to believe that the handling pilot has become incapacitated in any way, it is his duty to take control of the aircraft.'

Under its procedures for multi-crew cooperation, the section titled '*Pilot Incapacitation'* outlined the procedure to be used in the event of flight path deviations, stating:

'When a deviation from the planned flight path, descent rate, or airspeed exceeds the prescribed limits, the PM shall call the deviation and the PF will respond with "Correcting." If the PF does not respond to the deviation callout, the PM shall repeat the callout. If the PF still does not respond, the PM should assume that the PF has been incapacitated and that they are taking control of the helicopter.'

The OM did not outline how, in practice, pilots should escalate and intervene if this process was not successful.

Commercial pressure

CAP 1864 observed that:

'Crews are keen to achieve the tasks they are given however if there is a perceived commercial pressure the task may be taken in haste and with inadequate planning, which of course will place more pressure and stress on the flight crew which could erode the safety of the flight.'

And:

'...interaction with the customer prior to the flight is best handled by the operations team so as to separate the flight crew who can focus on the flight planning process and decision-making without any perceived pressure.'

Flights in marginal meteorological conditions

EASA Notice of Proposed Amendment (NPA) 2019-09[33] on '*All-weather Operations: Helicopter and specialised operations*', stated:

'Helicopter flights under VFR in marginal visual meteorological conditions (VMC) are a major contributor to helicopter accidents. Marginal VMC are defined as weather conditions not far above the VFR operating minima, and other conditions where the pilot may inadvertently enter instrument meteorological conditions (IMC).'

Footnote

[33] Available at https://www.easa.europa.eu/sites/default/files/dfu/NPA%202019-09.pdf [accessed March 2021].

A helicopter becomes more and more difficult to control as the visibility and the speed are reduced, whereas a helicopter pilot may be confident in the helicopter's unique capability to fly low and slow.

The limited visibility and relatively low speeds may very well have contributed to many accidents where loss of control and inadvertent IMC was determined to be a root cause.'

CAA Paper 2007/03 '*Helicopter Flight in Degraded Visual Conditions Paper*'

Published in 2007, this paper identified 53 cases involving 100 fatalities covering a 30-year period where degraded visual cues, loss of pilot situational awareness and spatial orientation were primary causal factors. It observed that the yearly increase in accidents was largely as a result of spatial disorientation in a Degraded Visual Environment (DVE). It stated:

'*...accidents tend to occur for VFR operations en route in unrestricted airspace; this suggests that requirements (minima) need to be reviewed and strengthened where necessary….and that IIMC can occur due to reduced visibility and/or an insufficiency of visual cues to support flight by visual references,…'*

Simulator experiments demonstrated that:

'…as visual cues degraded pilot workload did increase rapidly and the overall control strategy became more and more incoherent due to loss of situational awareness, with large error variations building in all axes (height, speed and heading)….Loss of pilot situational awareness in relation to the navigation task can become a severe distraction from the attitude stabilisation and flight path guidance tasks, with inherent risks to flight safety'

The paper concluded that,

'Pilots should be better trained to make informed decisions on whether 'to fly or not' in marginal conditions, or when IMC conditions are developing en-route. This might be achieved by developing a probability index based on factors that contribute to a high-risk accident scenario (e.g. meteorological conditions, visual conditions, visual range, acuity of the visual horizon, aircraft configuration, aircraft handling qualities).'

CAP 1864 noted that the results from the simulator experiments and data analysis reported in the CAA Paper 2007/03, '*firmly established a link between flight safety, visual cueing conditions and helicopter handling qualities*. And:

'deteriorating visibility, low cloud, fog, falling snow or heavy rain or operations at night could lead to a Degraded Visual Environment (DVE) event which in turn may become an inadvertent entry into Instrument Meteorological Conditions (IMC) incident.'

Of the occurrences and accidents that the review covered, '*flight in poor weather/visibility was a major factor in eight (10%) of the 81 occurrences and two (33%) of the six fatal accidents.*' It goes on to note:

> '*However, in all cases the accident could have been avoided by deciding not to fly, which would represent an universal and relatively inexpensive solution…. It is clear, however, that there was potential for pressure to have influenced the pilot in all cases. In addition, it is always possible for the pilot to exercise poor judgement irrespective of any pressure to fly. In any event, had the weather been known to be below limits at the point of departure, en route or at the destination, it would arguably have been more likely that the pilot would have decided not to fly and avoided the occurrence*.'

It concluded that *'…it would appear reasonable to consider introducing higher limits for helicopters*' and recommended:

> *'...that operators review the VFR minima in their operating procedures in the context of their operations and the flight characteristics (e.g. handling qualities) of their aircraft and adopt and apply higher minima where appropriate.'*

Guidance on helicopter flight in degraded visual conditions

Following publication of CAP 1864, the UK CAA updated its guidance on helicopter flight in degraded visual conditions in an Aeronautical Information Circular (AIC) Pink 137/2019, '*Helicopter flight in degraded visual conditions*'. It identified the operational risks to flight safety when operating in a DVE, stating:

> *'A primary influencing factor in determining the likely outcome of such a situation would be the level of pilot workload associated with the control and stabilisation of the aircraft…'*

It stated that research by Qinetiq:

> *'clearly showed that there are likely to be visual cueing conditions, helicopter handling characteristics and pilot capabilities which, although allowed individually by the regulations, can be predicted to be unmanageable in combination.'*

The UK Air Navigation Order (2016) defines '*with the surface in sight'* as:

> *'the flight crew being able to see sufficient surface features or surface illumination to enable the flight crew to maintain the aircraft in a desired attitude without reference to any flight instrument…'*

The AIC highlighted the hazards of overflying rural or unpopulated areas, flight at night or in atmospheric gloom, the lack of any moon or starlight illumination, significant layers of low level cloud, encountering precipitation en route, low levels of ambient light, no or weakly defined visual horizon, few if any cues from the ground plane, and that in these conditions reducing height does not improve perception of the horizon or ground cues.

CAP 1535 – Skyway Code

CAP 1535, published by the CAA, comments on the reduced VFR minima permitted in UK Airspace.

> *'In reality, the limiting factor is usually cloud rather than in-flight visibility – in conditions approaching 1500 m visibility, the cloud ceiling would likely mean flying dangerously low. The legal minima are not a good reference point for decision making because safe VFR flight normally ceases to be possible long before the visibility is that poor.'*

Automation

The EHEST published a training leaflet[34] on automation and flight path management which noted that the introduction of advanced automation capabilities in helicopters has given rise to significant capabilities, but which also recognised that automation has limitations. It notes:

> *'Automation has contributed substantially to the sustained improvement of flight safety. Automation increases the timeliness and precision of routine procedures reducing the opportunity for errors and the associated risks to the safety of the flight. Nevertheless, automation has its limits.'*

It highlighted several operational and human factors which affect optimum use of automation. It identified that the level of trust by the pilot in automation '*strongly influences system performance'*, but that this trust is disproportionately affected by initial and negative experiences as well as system reliability.

The leaflet further states:

> *'…modern medium/large helicopters are designed to be flown using the AFCS upper modes 4-axis to enhance safety and reduce pilots [sic] workload. Automation permits the benefit of AFCS protection improving error management by the crew'.*

And:

> *'the appropriate level is usually the one the pilot feels comfortable with for the task or prevailing conditions, depending upon his/her own knowledge and experience of the systems. Reversion to hand flying may be the appropriate level of automation, depending on the prevailing conditions.'*

Footnote

34 EHEST, 2015, '*Automation and Flight Path Management for helicopter pilots and instructors*', Training Leaflet HE9.

On the use of automation, it states:

> *'During line operations, upper modes should be engaged throughout the flight, especially in marginal weather conditions or when operating into an unfamiliar site or with passengers on board.'*

CAP 737 – Flightcrew human factors handbook

CAP 737[35] discusses the issue of degradation of manual handling skills. It states:

> *'the scientific research on the loss of manual flying skills is limited and somewhat inconclusive.'*

It concludes:

> *'although it seems likely that manual flying skills degrade to some extent due to lack of practice, this remains hypothetical. It is also not possible to know to what extent this occurs, whether it presents a significant risk, or how it can be safely addressed.'*

Operator's OM

The OM set out the policy for use of automation and stated:

> *'Generally,* [the operator's] *helicopters will be operated using the highest levels of automation, (see levels below) available from the autopilot system….Aircraft may be flown under VMC with fewer than all the Flight Director upper modes engaged, or even no upper modes at all. The autopilot is not to be switched off in flight in any circumstances except under training.'*

It described four levels of automation, among which:

> *'Level 3 – Use of Retention Stabilisation. The pilot is flying the helicopter through the AFCS attitude retention system (ATT), with or without the Flight Director (FD) but without the benefit of FD (or 'Upper Modes') coupling. Level 3 is not a normal level of flight operation…. Level 3 should not be used in normal operations when the cloud base is below 1000 ft.*
>
> *Level 4 – Use of attitude retention stabilisation Flight Director, Autopilot and FMS (if installed). The pilot is flying the helicopter through the AFCS attitude retention system (ATT), using the flight guidance system (FD), with input from VOR, LOC, G/S, GPS, FMS and air Data computers (if fitted) to control the helicopters flight path, both laterally and vertically. Level 4 is the normal level of flight operations under both IMC and VMC conditions.'*

Footnote

[35] https://publicapps.caa.co.uk/docs/33/CAP%20737%20DEC16.pdf [Accessed June 2021]

Loss of visual references / Inadvertent entry to IMC training

There was no EASA requirement[36] for a pilot to be trained or examined in a technique to be flown following LOVR/IIMC. CAP 1864 stated:

> *'If crews enter the DVE unintentionally they must be equipped to recover to a safe flight condition.'*

The S92 RFM does not outline a technique to be flown by pilots following LOVR or IIMC in a low or zero speed condition.

Some offshore S92 operators train their pilots for LOVR at low or zero speed.

The training provider used by the operator of G-LAWX taught techniques for IIMC when requested by operators. The technique is applied in the scenario of IIMC following takeoff or missed approach. The training provider commented that the procedure for LOVR at low speed or zero speed is normally reserved for military or SAR pilots who are not required to observe civil regulations.

Prior to the serious incident, the operator's training provider was revising its 14 CFR Part 61 courses (for operations under US regulations) to include enhanced IIMC training. The operator reported that the training provider now includes training for "IIMC at Low Level / Low IAS" as an additional training requirement to be delivered during simulator training.

The operator stated that:

> *General 'Loss of Visual References' is a regular and often repeated scenario as the SIM training passes from VMC to IMC conditions as the training warrants. The more critical startle effect of sudden awareness of some unexpected, unstable or inadvertent flight condition is also considered. This is handled in the Deviation Callout and Transfer of Control situation.'*

Off-aerodrome landings

CAP 1864 identified three measures that would help address the hazards of off-aerodrome landings:

- Establishing VFR 'Stabilised Approach' approach procedures or 'Visual Gate Approaches' for night operations' using the upper modes and the flight control systems.
- Performance Based Navigation (PBN) and Point-in-Space (PinS) approaches instead of ad-hoc let-downs and approaches.
- The use of 'approved portable night approach path aids.'

Footnote

[36] EASA Part-FCL Appendix 9 Training, skill test and proficiency check for MPL, ATPL, type and class ratings, and proficiency check for IRs.

Recommendation R3 of CAP 1864 stated:

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

Stabilised approach criteria

ICAO[37] states:

> *'The primary safety consideration in the development of the stabilized approach procedure shall be maintenance of the intended flight path as depicted in the published approach procedure, without excessive manoeuvring'*

The ICAO has outlined the minimum parameters to be included in an operator's SOPs. Stabilised approach procedures have been widely implemented in fixed-wing-operations.

Operators of multi-engine helicopters use a Landing Decision Point (LDP)[38] or Defined Point Before Landing (DPBL)[39] towards the end of an approach. These 'gates' are defined by height, speed and rate of descent and establish the performance margins for landing, but not stability. While Onshore helicopter operators have in some cases adopted specific approach aid guidance or approach profiles, they have not typically adopted stabilised approach procedures for VFR operations. HeliOffshore[40] has published guidance on the adoption of stabilised approach procedures and criteria[41], stating:

> *'Establishment of energy state criteria as part of an Approach Management policy, is considered an essential element and should be incorporated in Operations Manual guidance….'*

And:

> *'Control of speed in relation to power, collective pitch, and nose pitch attitude (which affects both speed and perspective) are both fundamental factors for helicopters…. Helicopters need to be stabilized on approach to ensure they … arrive at the Landing Decision Point (LDP) within the correct parameters…'*

Footnote

[37] ICAO Doc 8168 '*Procedures for Air Navigation Services, Aircraft Operations Volume III – Aircraft operating Procedures*', published 8 November 2018.

[38] The EASA defines an LDP as the 'the point used in determining landing performance from which, an engine failure having been recognised at this point, the landing may be safely continued, or a balked landing initiated'.

[39] The EASA defines DPBL as 'the point within the approach and landing phase, after which the helicopter's ability to continue the flight safely, with the critical engine inoperative, is not assured and a forced landing may be required'.

[40] HeliOffshore is an industry body, with a global membership, for helicopter operators delivering passenger transport operations in the offshore oil and gas sector focused on delivering safety to the industry through collaboration.

[41] HeliOffshore, '*Flight Path Management (FPM) Recommended Practice for Oil and Gas Passenger Transport Operations*', September 2020. Available at www.helioffshore.org [accessed March 2021].

Also:

> *'Approaches should ideally be stabilized by …500 ft above landing elevation in VMC...'*

The document suggested the criteria that should be met on reaching a pre-defined stabilised approach gate as:

> *'(a) The aircraft is on the correct flight path*
>
> *(b) Only small changes in heading, track and power are required to maintain the correct flight path*
>
> *(c) All briefings and checklists have been completed, except for the final landing check*
>
> *(d) The aircraft is in the correct landing configuration*
>
> *(e) The sustained rate of descent is less than 700 fpm upon arrival at the stabilised approach gate.*
>
> *Anytime the approach becomes 'unstabilized' (out of compliance with the above guidelines) a go-around/missed approach should be executed unless the operator has established a limited number of deviation protocols that can be safely used to return to the stabilized approach.'*

HeliOffshore recognised the challenge of providing standardised criteria for onshore approaches owing to the variability of approach types and variety of helicopter types. However, it stated that applying energy state monitoring criteria and automation principles '*should aid the safe conduct of all types of onshore approaches'.*

The operator of G-LAWX referred to stabilised approaches in its OM. It had adopted the GL3 approach aid for night approaches and adopted approach profiles for specific circumstances. It had not defined a stabilised approach policy, procedures or criteria for VFR approaches.

<u>Helicopter GNSS Point-in-Space operations</u>

GNSS based PinS operations enable helicopters to conduct flight in IMC to or from a PinS abeam the aerodrome or landing site. The helicopter flies to or from the PinS visually.

CAP 1864 noted:

> *'The current IFR situation in the UK for rotorcraft is constrained to using procedures that have been designed for fixed-wing aircraft, and in general; heliports are not well equipped in terms of ground navigational aids….In recognition of the needs of onshore helicopter IFR operations the use of Point in Space (PinS) approaches and departures to an initial departure fix (IDF) is therefore required…..The introduction of PBN and PinS Approaches with the relevant laid down training requirements and strict adherence to the weather minima associated would alleviate some of the issues.'*

EASA NPA 2019-09 stated:

> *'There are real safety benefits in providing helicopter operators with an option to fly some missions under IFR. IFR also has operational benefits as it increases the reliability of the service.'*

However:

> *'the implementation of IFR with helicopters has been difficult due to a number of regulatory obstacles.'*

Consequently, with the aim '*to identify and address any regulatory issues that put IFR with helicopters at a disadvantage compared to VFR, considering that IFR remains the safer option'*, it established the following specific objective for the NPA:

> *'Specific objective 1: Enable onshore IFR operations with helicopters and make best use of helicopter point-in-space (PinS) approaches, departures, and low-level routes.'*

Trials of PBN procedures for HEMS operations indicated they improved safety, especially in bad weather and at night, increasing situational awareness without significantly increasing workload.[42]

Eurocontrol published a safety case for the use of PinS approaches[43], the safety benefits of which included:

- '*The instrument segment of the PinS approach is designed to prevent loss of separation with terrain/obstacle.*
- *The visual segment of the PinS "proceed visually" procedure is protected by specific obstacle protection and identification surfaces and relevant obstacles are published on charts.*
- *The compatibility between the descent gradient and the helicopter speed/ autopilot capabilities is considered during the design of the procedure. MAPt location and approach visual segments are designed to facilitate acquisition, deceleration and landing*.
- *There is no risk of inadvertent entry into IMC for the instrument phase of the approach, which is an important cause of CFIT accidents for certain helicopter operations in VFR. The risk of entry into IMC is still applicable for the visual phase of the approach but with a shorter exposure time.*
- *The use of remote QNH could impact the CFIT risk and would have to be mitigated.'*

Footnote

42 The SESAR JU, September 2016, '*PBN Rotorcraft Operations under Demonstration',* Available at https://ec.europa.eu/transport/sites/transport/files/poster_proud_final_A0_print.pdf [accessed March 2021].

43 Eurocontrol, *'Helicopter Point in Space operations in controlled and uncontrolled airspace; Generic Safety Case'*, Edition 1.4, 2 October 2019, available at https://www.eurocontrol.int/sites/default/files/2019-12/pins-apr-and-dep-safety_case-18122019.pdf [accessed March 2021].

Controlled flight into terrain

CAP 1864 highlighted that deteriorating weather and loss of situational awareness are factors that contribute to CFIT.

It identified HTAWS as a possible mitigation to the threat of a CFIT, stating, *'operators should consider the fitment of these systems to their aircraft.'*

Operator's flight procedures

The operator's OM outlined the following procedures concerning terrain proximity awareness and CFIT:

> *'8.3.4 Audio Voice Alerting Device*
>
> *In the event that undue proximity to the surface is detected by any member of the flight crew, or by the AVAD, it is to be verbally acknowledged by the crew not only for the purposes of their own communication, but also the CVFDR, if fitted. The handling pilot shall ensure that corrective action is initiated promptly, to establish safe flight conditions.*
>
> *8.3.5 Procedures for Avoiding Controlled Flight into Terrain*
>
> *Company aircraft fitted with Ground Proximity Warning System (GPWS)/Terrain Avoidance Warning System (TAWS), should have the unit switched on and armed for all stages of flight. If an alarm is raised and found to be accurate, (by cross checking with such devices as the Rad Alt) then a climb to a safe height above the ground should be made. If the pilot is in sight of the ground, they can assess what the appropriate avoiding action, (if any) should be but if not in sight with the surface, an immediate climb to MSA should be initiated.'*

It contained the following table of radalt settings:

Flight Phase	*PM*	*PF*
Take off	*200*	*200*
En route VFR	*500*	*500*
Finals VFR Approach	*LDP*	

Information on the pilots' EFB indicated that the radalt alert value should be set to 300 ft for approaches using the GL3.

Nuisance alerts

The commander observed that some pilots, when operating onshore, choose not to switch on the HTAWS, set lower alert heights, or use reduced protection modes to decrease the frequency of what they might perceive as 'nuisance' alerts. He observed that a tendency to consider alerts as a 'nuisance' could, in some cases, lead to a culture of ignoring them.

Previous occurrences

Aerospatiale AS355F1 Twin Squirrel, G-CFLT[44]

This accident occurred in 1996 as a result of loss of control in flight following disorientation of the pilot while flying VFR at night. In response to three Safety Recommendations, the CAA stated:

> *'It is important for industry to recognise that, in regulating night visual contact flights, the Authority only provides a regulatory framework within which safe operations are possible. Individual operators have a responsibility not to despatch such flights in circumstances which might lead to safety margins being eroded. To some extent the responsibility can be discharged through operations manual requirements but, additionally, all operators must manage their operations actively and responsibly. For this type of flight, the regulations encompass a broad range of aircraft equipment fit; pilot experience, competency and recency; and visual cueing availability ranging from better than that available in daytime VMC flight in poor conditions to a complete absence of such cues. It is therefore incumbent on operators to despatch flights only in circumstances which safely match their operating capabilities and the prevailing conditions'*

Agusta A109E, G-CRST[45]

The helicopter collided with a crane while flying over central London in conditions of reduced meteorological visibility.

On decision making, the report noted:

> *'…pilots will often be subject to pressures – real or perceived – to complete a task. These pressures might lead pilots to continue with flights in circumstances where otherwise they would not…'*

On pre-flight planning and risk assessment, the report stated:

> *'The changes to FAR Part 135 introduced by the FAA, although applicable to HEMS operations, may also contain beneficial safety improvements with respect to UK commercial helicopter operations. In particular, the proposals relating to pre-flight risk assessment and VFR flight planning are worthy of consideration in relation to: the decision to accept a flight; continued operation in adverse weather conditions; low level flight in the vicinity of terrain or obstacles; and short notice or en route changes to flight objectives and planning.'*

Footnote

44 Report No: 4/1997. Report on the accident to Aerospatiale AS355F1 Twin Squirrel, G-CFLT, near Middlewich, Cheshire on 22 October 1996 (https://www.gov.uk/aaib-reports/4-1997-aerospatiale-as355f1-twin-squirrel-g-cflt-22-october-1996) [accessed June 2021].

45 Report on the accident to Agusta A109E, G-CRST near Vauxhall Bridge, Central London 16 January 2013 EW/C2013/01/02 (https://www.gov.uk/aaib-reports/aar-3-2014-g-crst-16-january-2013) [accessedJune 2021].

The AAIB made the following Safety Recommendation:

> **Safety Recommendation 2014-031**
>
> It is recommended that the Civil Aviation Authority review Federal Aviation Regulations Part 135 Rules 135.615, VFR Flight Planning, and 135.617, Pre-flight Risk Analysis, to assess whether their implementation would provide safety benefits for those helicopter operations within the UK for which it is the regulatory authority.

In response, the UK CAA stated:

'The CAA accepts this Recommendation and has reviewed Federal Aviation Regulations (FAR) Part 135 Rules 135.615, VFR Flight Planning, and 135.617, Pre-flight Risk Analysis, to assess whether their implementation would provide safety benefits for those helicopter operations within the UK for which it is the regulatory authority. In consultation with EASA, the CAA has determined that the elements of the new FARs are broadly covered within the current and future UK and European regulation sets under the requirements for Public Transport and Commercial Air Transport operators to ensure that their operating procedures for planning and executing flights are properly documented in operations manuals and for aircraft commanders to ensure that flights are conducted safely. However, the CAA intends to issue a Safety Notice (SN) to operators by the end of November 2014 reminding them of their responsibilities and highlighting elements of the FARs as appropriate. Additionally, the SN will provide an introduction and link to the European Helicopter Safety Team (EHEST) developed 'Pre-departure Risk Assessment Check List' encouraging operators to consider adopting and adapting this tool for their use.'

Sikorsky S76C, G-WIWI[46]

The helicopter descended below MSA on a visual approach to a private LS.

Regarding aural alerts, the AAIB investigation report stated:

'Both pilots recalled hearing the 'TAIL TOO LOW' warning, issued slightly more than 20 seconds after the 'WARNING TERRAIN.' The earlier audible alerts may have also been announced, but not 'heard' by the pilots, because of inattentional deafness[47] or the effects of overload on the pilots' capacity to process auditory cues.'

Footnote

[46] Sikorsky S-76C, G-WIWI, EW/C2012/05/05, Peasmarsh, East Sussex 3 May 2012 at 2155 hrs (https://www.gov.uk/aaib-reports/aaib-investigation-to-sikorsky-s-76c-g-wiwi) [accessed June 2021).

[47] Inattentional deafness is the failure to perceive auditory stimuli under high visual perceptual load.

On intervention by the co-pilot, the report noted:

> *'When interviewed by the AAIB, the co-pilot recalled informing the commander of his concerns that the helicopter was below the safety altitude without sufficient visual references. However, the co-pilot believed that, rather than pressing this point, his better option was to support the commander as effectively as he could, even though he believed that the commander's actions were flawed.'*

AgustaWestland AW139, G-LBAL[48]

This accident involved a helicopter that departed in fog from a private LS. Evidence suggested that the pilots were subject to a somatogravic illusion during the departure.

On decision making, the report commented:

> *'Discussion with industry participants during the investigation of the accident involving G-LBAL indicates that increased regulation is not a complete solution if these pressures cause pilots to operate a flight in violation of the regulations, and that mitigating the pressures themselves is necessary to improve safety.'*

It continued,

> *'These pressures remain when an aircraft is operated privately, but the private operation is also less comprehensively regulated. In particular, in the absence of minimum visibility requirements for operations at private sites, pilots of helicopters operating privately have no absolute criteria to support a decision whether or not to depart. A combination of appropriate regulation, and techniques for mitigating these pressures, may be required to improve the safety of non-commercial complex helicopter operations.'*

On automatic flight systems, it noted:

> *'Flight in degraded visual conditions places additional demands on pilots. The appropriate use of autopilot functions can assist in minimising workload and allowing maximum attention to be devoted to monitoring the aircraft's attitude and path and other parameters such as speed and groundspeed. Greater reliance on the automatic flight capabilities of the helicopter might have prevented the development of the abnormal pitch attitudes during the departure.'*

Footnote

48 Agusta Westland AW139, G-LBAL, EW/C2014/03/02, near Gillingham Hall, Norfolk 13 March 2014 at 1926 hrs (https://www.gov.uk/aaib-reports/aaib-investigation-to-agusta-westland-aw139-g-lbal) [accessed June 2021].

Sikorsky S-76B, N72EX Calabasas, California[49]

The NTSB investigation determined that N72EX entered a rapid descending left turn into terrain owing to spatial disorientation following entry into IMC which resulted in fatalities and the helicopter being destroyed.

The NTSB found:

> *'The pilot's decision to continue the flight into deteriorating weather conditions was likely influenced by his self-induced pressure to fulfil[sic] the client's travel needs, his lack of an alternative plan, and his plan continuation bias, which strengthened as the flight neared the destination.'*

On managing self-induced pressure, the NTSB commented:

> *'Perhaps a better way to look at it is that professional pilots aren't paid to fly - they are paid to say no when conditions warrant. If paid pilots and those who aren't paid to fly look at it that way, perhaps we will have fewer crashes attributed to "get-home-itis".'*

On automation the NTSB noted:

> *'Autopilots can usually fly an aircraft more precisely than a human pilot and, as it could have helped in this situation, autopilots are not susceptible to spatial disorientation.'*

On Helicopter FDM (HFDM), the NTSB found:

> *'A flight data monitoring program, which can enable an operator to identify and mitigate factors that may influence deviations from established norms and procedures, can be particularly beneficial for operators like* [the operator]*. that conduct single-pilot operations and have little opportunity to directly observe their pilots in the operational environment.'*

On probable cause it found:

> *The National Transportation Safety Board determines that the probable cause of this accident was the pilot's decision to continue flight under visual flight rules into instrument meteorological conditions, which resulted in the pilot's spatial disorientation and loss of control. Contributing to the accident was the pilot's likely self-induced pressure and the pilot's plan continuation bias', which adversely affected his decision-making, and* [the operator's] i*nadequate review and oversight of its safety management processes.'*

Footnote

49 NTSB, '*Rapid Descent into Terrain Island Express Helicopters Inc. Sikorsky S-76B, N72EX, Calabasas, California, January 26, 2020*'. Available at https://www.ntsb.gov/investigations/AccidentReports/Reports/AAR2101.pdf, [accessed March 2021]

Analysis

Overview

The investigation found that the crew were properly licenced to conduct the flight and trained according to existing regulations. The helicopter was serviceable and equipped to operate under VFR or IFR in the prevailing conditions.

Meteorological information available to the crew was sufficiently accurate to indicate that it would be necessary to conduct parts of the flight at the base of cloud in order to maintain the required separation from terrain or obstacles throughout the flight, and that a diversion was a significant possibility. In the event, the helicopter descended to within 400 ft of the M40/M42 motorway junction and flew to within 28 ft of rising terrain close to a house. Throughout the final stages of the first approach, during the emergency climb, and the second approach, the helicopter was significantly unstable.

The commander was familiar with the LS and surrounding area. This probably influenced the level of planning and threat assessment carried out before departure. Whereas Wellesbourne was identified as an alternative aerodrome in principle, there did not appear to be a clear plan for diverting there or returning to Birmingham in the event it was not possible to maintain VMC to the LS.

The decision to attempt to reach the LS in the prevailing conditions, the absence of a clear alternative plan, and the urgency apparent in discussions before leaving Birmingham, indicate that the crew felt under pressure to conduct the flight, but may not have recognised this pressure or the effect it had on their decisions. It is likely this was aggravated by the combination of operational and client-facing roles fulfilled by the commander, increasing his desire to achieve the operator's commercial objectives and diminishing his ability to make safety-focused decisions in the marginal weather conditions.

It is likely that the seniority and perceived experience of the commander, and the structure of the organisation, contributed to a lack of challenge. Whereas the operator had stated in its OM that it would support the decision of a pilot not to fly, there was no formal process for actively challenging a decision to fly.

The conduct of the flight once airborne, particularly the commander's reactions to interventions by the co-pilot, indicates a strong focus on reaching the LS, effectively excluding any other consideration. This aspect of the serious incident is similar to the reported circumstances of the occurrence involving G-WIWI, in which the co-pilot believed that *'rather than pressing* [his] *point, his better option was to support the commander as effectively as he could, even though he believed that the commander's actions were flawed.'*

The unstable flight path approaching the LS reveals the challenge of operating in a DVE and therefore the importance of:

- Avoiding these circumstances in the first place.

- Identifying and actively managing the threats arising from degraded visual environments.
- The use of automation to deliver platform stability.
- Training to transition safely to flight with reference to instruments.

Whether because of this focus on reaching the destination, or because of a misunderstanding of the requirements for flight under VFR, the helicopter flew within 500 ft of a structure before the LS was identified visually, and potentially within 500 ft of persons and vehicles, both there and earlier when crossing the M40/M42 junction.

The circumstances of this serious incident are similar in several significant respects to those of previous serious incidents and fatal accidents, but safety action taken and guidance published after those previous events did not prevent recurrence. Regulatory safety action assumes that those being regulated are motivated to operate safely, but this serious incident and those other occurrences show that the desire to reach the intended destination can overwhelm the desire to be safe.

Regarding previous occurrences the CAA observed that '*all operators must manage their operations actively and responsibly*'; and *'a combination of appropriate regulation, and techniques for mitigating these pressures, may be required'.* This indicates that individuals need to consider their own actions, in the context of their own environments, to address the shortcomings this investigation reveals.

Use of automation

The helicopter's AFCS was serviceable. The commander flew the helicopter manually throughout, effectively using 'Level 3' automation as defined in the operator's OM, which it stated should not be used when the cloud base was below 1,000 ft or when using the GL3.

The commander stated that his choice to fly manually was shaped by his experience that the S92 automation could be challenging to manipulate in the VFR environment, and his concern to avoid skill fade. A decision to fly manually was not consistent with the OM but, whilst CAP 737 states that the science on manual skill degradation is inconclusive, is supported by the guidance in the EHEST leaflet, which states:

> *'the appropriate level is usually the one the pilot feels comfortable with for the task or prevailing conditions, depending upon his/her own knowledge and experience of the systems…'.*

The leaflet also noted that, *'Automation permits the benefit of AFCS protection improving error management by the crew'*.

This indicates that where there is a preference to fly manually, additional training may be helpful in demonstrating the benefits of automation and in giving confidence in its use.

The EHEST leaflet also stated that:

> *'During line operations, upper modes should be engaged throughout the flight, especially in marginal weather conditions or when operating into an unfamiliar site or with passengers on board.'*

This indicates that manual flying should be considered as a reversionary mode, rather than the primary mode of flying a helicopter equipped with 4-axis AFCS, especially in marginal conditions.

The use of automation would have provided greater platform stability, and the process of automation management would have required that the actions and flight path choices by the PF be deliberate, shared with, and monitored by the other pilot. It is likely the explicit communication required by this process would have better supported the crew to identify and manage threats during the flight.

Loss of visual references / inadvertent entry into IMC

The emergency climb was unstable and did not immediately achieve safe terrain or obstacle separation. The deviation calls by the PM during the emergency climb assisted the PF to prevent an increasing loss of control and eventually achieve a safe climb.

Neither pilot had been trained for such a manoeuvre. Training for LOVR or IIMC following a continued takeoff or missed approach does not directly address the challenges of an emergency climb at low or zero speed. Executing such a manoeuvre requires the PF to switch rapidly from visual to instrument flight at a time of elevated stress and workload, when the risk of disorientation is increased. On the S92, the initial stages must be flown manually because of limits on the engagement of automation and the use of the go-around function.

CAP 1864 stated that:

> *'If crews enter the DVE unintentionally they must be equipped to recover to a safe flight condition.'*

Recommendation 5 of CAP 1864 stated:

> *'It is recommended that operators create an Unusual Attitude training programme in line with the current Upset Prevention and Recovery Training (UPRT) as listed under Part ORO, ORO.FC. 220 & 230. The CAA will maintain oversight for the UPRT training within the current oversight program.'*

The CAA informed the AAIB that, in assessing how operators address this recommendation, it will look for evidence of recurrent training for inadvertent entry into IMC and loss of visual references at low airspeed.

Observing the Rules of the Air when landing

Aircraft may descend below the minima specified in the Standardised European Rules of the Air (or the equivalent UK rules) when landing at an aerodrome. The part of the flight considered to constitute the landing is not defined. There is no alleviation from the requirement to remain in VMC when flying under visual flight rules. During this serious incident, descending below 500 ft (potentially within 500 ft of any person, vessel, vehicle or structure) at around 1737 hrs demonstrated either an intention to begin the landing, a willingness to breach the Rules of the Air, or a misunderstanding of those rules. The consequence of this decision to fly at an altitude of less than 500 ft agl, below the elevation of the LS towards high ground, was that the helicopter was in an undesired state.

The pilots had configured the aircraft for landing, were attempting to establish the helicopter on the final approach track and the flight path was unstable. The pilots had not positively identified the LS, and the UA survey of the flightpath indicated it would not have been possible to see the LS from the heights flown as the helicopter approached.

The CAA noted that whilst the Rules of the Air are intended to allow operational flexibility within compliance, *'this concept of minimum compliance exposes crews to uncontrolled task-focused decision making'*.

Pilots planning to use the landing exception to descend below the relevant minimum height before reaching the destination increase their risk of operating in circumstances that are not suitable for visual flight.

The evidence of this serious incident, and the other occurrences to which CAP 1864 refers, indicates that the effect of the regulations when landing is not well understood, and may be causing pilots to act unsafely. Accordingly, the following Safety Recommendation is made:

Safety Recommendation 2021-025

It is recommended that the Civil Aviation Authority publish guidance on the meaning and intention of the phase of flight alleviations in UK SERA where detailed as "except for take-off and landing" to better enable pilots to plan and act on minimum height requirements for safe operations.

Off-aerodrome landings

Stabilised approaches

There is no regulatory requirement for helicopter operators to establish stabilised approach criteria for visual approaches, but CAP 1864 states that stabilised approach procedures can be highly beneficial, especially at night.

An LDP or DPBL allows for a flexible flightpath on the approach to a 'gate' at a point in space close to touchdown and establishes the performance margins for landing; the use of approach aids or appropriately defined approach profiles provides a defined approach path. Neither ensure a stable approach. Applying stabilised approach criteria promotes stability and predictability before reaching the 'gate' and provide the basis on which deviations from the intended flightpath and energy state can be detected and resolved promptly, thereby preventing an undesired aircraft state.

During this serious incident, both approaches exhibited such variations in flightpath that they could not be considered stable. The crew appeared not to recognise that the helicopter was in an undesired state until after it had passed within 28 ft of the ground. It is likely the pilots would have been more aware of the unstable flight path had they trained for and followed an established stabilised approach procedure.

Recommendation 3 of CAP 1864 is intended to address the training aspect.

The operator had not defined stabilised approach criteria in its OM. Therefore, the following Safety Recommendation is made:

Safety Recommendation 2021-026

It is recommended that Starspeed Ltd specify in its operations manual stabilised approach criteria for visual approaches, including at off-aerodrome landing sites.

GL3 approach

The second approach occurred at night, when more stringent VMC criteria applied. The aftercast provided by the Met Office indicated that that the conditions required to remain VFR at night were likely not to have existed.

The operator had introduced the GL3 approach aid as part of its measures to manage the risks of off-aerodrome landings at night. However, it was only intended for use in VMC. At the time of this approach, it was night and the conditions did not allow for flight under VFR.

The operator has amended its standard operating procedure for the use of a GL3 approach aid to emphasise that it is to be used only in VMC.

Helicopter GNSS Point-in-Space operations

The existence of a PinS approach to the LS would have afforded the pilots a more robust alterative means to make an approach in the marginal conditions that were experienced. CAP 1864 identified that PinS approaches provide the opportunity to meet the needs of onshore helicopter IFR operations but did not propose any action to address the current lack of them. Accordingly, the following Safety Recommendation is made:

Safety Recommendation 2021-027

It is recommended that the Civil Aviation Authority encourage the development and deployment of Point-in-Space operations at landing sites.

Degraded visual environment

The serious incident occurred shortly before night in conditions of reduced visibility, low cloud and declining light levels. The unstable flightpath of the helicopter indicates that flying manually in these conditions was challenging.

The hazards of operation in degraded visual conditions are considered in CAA Paper 2007/03 – '*Helicopter Flight in Degraded Visual Conditions*', AIC Pink 137/2019, '*Helicopter flight in degraded visual conditions*', CAP 1145 and CAP 1864.

CAA Safety Notice SN-2019/007 – '*Helicopter Operations Flight Planning and Safe Flight Execution'* focusses on flights intended to be conducted under VFR. Safety Notice SN-2019/008 – *'Helicopter Operations - Guidance on Aerodrome Operating Minima for IFR Departures'* focusses on IFR operations. Both include further consideration of degraded visual conditions, and particularly the hazards of inadvertent entry into IMC.

CAP 1864 identified eight accidents where flight in poor weather or visibility was a major factor. Recommendation 15 of CAP 1864 stated:

> *'It is recommended that operators review the VFR minima in their operating procedures in the context of their operations and the flight characteristics (e.g. handling qualities) of their aircraft and adopt and apply higher minima where appropriate.'*

This addresses the specific issue of operational minima. However, while the documents listed above describe the broader hazards of operating in degraded visual conditions, they do not offer guidance for managing them. Therefore, the following Safety Recommendation is made:

Safety Recommendation 2021-028

It is recommended that the Civil Aviation Authority revise its guidance on helicopter flight in degraded visual conditions to include further information on managing the associated risks.

Use of electronic aids

The helicopter's navigation system was equipped to display the position of the helicopter relative to the LS, but it is likely the pilots' focus on maintaining visual references diminished the assistance the system might have provided.

Altitude alerting

The radalt alert value (400 ft) set after departure was 100 ft below the minimum height for flight under VFR in daylight, in circumstances where it would not be possible to maintain the required separation from any person vehicle or structure.

The radalt "ALTITUDE" alerts that sounded while the helicopter crossed the motorway presented an opportunity for the crew to determine that the cloud base above the LS might have been inadequate.

The radalt "ALTITUDE" alerts next sounded as the helicopter descended towards the LS and the pilots were in the process of carrying out their landing checks (but before the radalt alert value was set for landing). Consequently, though acknowledged, they occurred at a point when the pilots might have treated them as 'nuisance' alerts.

The pilots did not acknowledge or react to the radalt alert as the helicopter approached the hill (over rapidly rising ground), and it is possible that neither perceived it. This is consistent with inattentional deafness in circumstances similar to those reported in the case of G-WIWI, arising from the high workload of visually maintaining sight of the ground and identifying the LS. It is also possible the alert was masked by cockpit communication between the pilots that occurred at the same time.

The radalt alert value was not reset following the emergency climb, which indicates that the pilots did not complete the go-around checks.

The S92 involved in this occurrence was fitted with a system to alert the pilots when the helicopter descended below a selected minimum barometric altitude. Not all helicopters are fitted with this system. No barometric altitude alerts were recorded during the flight, indicating that the barometric alert value was set above or below all the altitudes flown. There was no SOP for the value which should be set when operating under VFR.

Setting alerts at pre-determined en route and approach minima for visual flight provides an additional barrier to inadvertent descent below those minima. Therefore, the following Safety Recommendation is made:

Safety Recommendation 2021-029

It is recommended that Starspeed Ltd describe in its operations manual for the Sikorsky S92 helicopter the criteria for setting barometric altitude alert values at each stage of a flight.

The HTAWS provided cautions and warnings as designed, and the investigation did not reveal shortcomings in the HTAWS fitted to the helicopter that would have affected the outcome. The AAIB has reported previously on developments in this field, and the EASA has stated its intention to develop HTAWS as a mitigation for CFIT.

Perceived 'nuisance' alerts

During the investigation the commander indicated that pilots considered some altitude and terrain alerts a nuisance, creating a distraction and providing no benefit. It is likely this perception influenced the setting of alert values that were not consistent with available SOPs or appropriate for the phase of flight, and to the lack of an effective response to the alerts that were generated.

Operators can address this situation by specifying the alert settings appropriate to each phase of flight and the pilot response required. Every alert requires a response involving identification and resolution of the threat. No alert should be considered a nuisance.

Threat and error management and decision making.

The hazardous attitudes, behavioural traps and biases identified in this report are among the factors that may have adversely affected the decisions of the pilots, despite their training, experience and operating multi-crew.

In this case, these included:

- pressure, self-imposed or otherwise, to complete the mission;
- the wish to avoid disappointing a client (loss aversion);
- a tendency to interpret meteorological information in a way that confirmed the flight's viability (continuation bias);
- overconfidence in the ability to conduct the flight in the prevailing conditions, including when flying manually;
- a perception that a flight in daytime on a familiar route was routine (complacency); and,
- when the expectations for the flight were not shared by both pilots, a feeling that intervention would not be effective (resignation).

Material published by the CAA, EHEST and others indicates that a formal process of threat and error management can provide an effective defence. It is asserted that:

> *'crews that develop contingency management plans, such as proactively discussing strategies for anticipated threats, have fewer mismanaged threats',*

and:

> *'crews that exhibit strong leadership, inquiry, and workload and automation management have fewer mismanaged errors and undesired aircraft states'*

CAP 1864 indicates that effective TEM begins at the organisational level, stating:

> *'The company operations manual must fully reflect its operational needs and define not just what is required of the crew at every stage of flight but also define how it should be achieved in practice.'*

Effective communication and intervention

Exchanges recorded on the CVR indicate that although the co-pilot was able, at times, to call to the PF variations in flight parameters and even occasionally escalate his concerns, he was not able to effectively and consistently escalate his concerns as he was not supported by a formal process.

The co-pilot stated that before the first approach he believed that the conditions would necessitate a diversion to Wellesbourne, but he did not alert the commander to this possibility. Following the emergency climb after the unintended descent towards terrain, and despite prompting the commander to engage the automation flight control system twice, the co-pilot was not able to challenge the commander's preference to fly manually, and was unable to open a discussion about the plan for the remainder of the flight. When the commander stated his intention to discontinue the approach, the co-pilot did not challenge the commander on the subsequent flight path, warn that the helicopter was not in fact performing a go-around, or take control to ensure a safe flightpath.

A formal process for monitoring, escalating concerns and, if necessary, taking control helps make challenges procedural rather than confrontational. The 'PACE' process is used in aviation, healthcare and other high-consequence operational environments to provide this formality.

The operator's external crew resource management training provider covered assertive communication and intervention using the PACE model, but the operator had not implemented the process in its OM. This occurrence indicates that the co-pilot had the greatest difficulty challenging the commander in those areas not covered by a formalised challenge procedure.

Since the incident the operator has amended the OM to include an SOP on deviation calls in multi-pilot operations. However, there are other occasions when a crew member needs to be able to escalate concerns. Therefore, the following Safety Recommendation is made:

Safety Recommendation 2021-030

It is recommended that Starspeed Ltd specify in its operations manual a formal process for crew members to monitor, escalate concerns and, if necessary, take control during a flight.

Potential conflicts of interest

The commander was the operator's MD and fulfilled a client relationship role. He displayed a strong desire not to inconvenience the client and this was potentially in tension with his obligation as the commander to ensure a safe flight. Consciously or otherwise, this may have biased the interpretation of weather information, and subsequent decision making, in favour of proceeding to the LS.

CAP 1864 noted that pilots will often be subject to pressures – real or perceived – to complete a task, and that these pressures might lead pilots to continue with flights in circumstances where otherwise they would not. It recommended that operators show clear evidence of operational control as defined in AMC1 ORO.GEN.110 (c), ensuring that there is a clear tasking process separating the customer and the flight crew. The AAIB investigation of G-CRST amongst others, and its discussions with the CAA, indicate that this is a significant area of concern in the onshore helicopter industry requiring prompt safety action.

Therefore, the following Safety Recommendation is made:

Safety Recommendation 2021-031

It is recommended that the Civil Aviation Authority ensure that operators show clear evidence within their system for operational control as required by UK ORO.GEN.110 (c), of how the tasking process separates the customer from the flight crew.

Helicopter Flight Data Monitoring

The AAIB investigation identified actions contrary to the operator's existing SOPs, breaches of the Rules of the Air and unstabilised approaches. EASA Part-ORO AMC1 ORO.AOC.130 specifies how an operator should use FDM to identify these threats and:

> *'... put in place appropriate procedures for remedial action once an unacceptable risk, either actually present or predicted by trending, has been identified, and*
>
> *... confirm the effectiveness of any remedial action by continued monitoring.'*

In its report on the accident involving S76 N72EX, the NTSB indicated the benefit such programmes would provide '*for operators that … have little opportunity to directly observe their pilots in the operational environment.*'

CAP 1864 highlighted the challenges for onshore operators in achieving this kind of monitoring, often with smaller fleets and more varied operations than the large fixed-wing operations for which these programmes were originally envisaged, but stated:

> *'There is no doubt that Flight Data Monitoring (FDM) as required by legislation for larger aeroplanes and offshore helicopters has had an impact in identifying operations outside the established limits. At present helicopter FDM is not mandated for onshore operations but should be considered.'*

However, the CAA stated that it recognised the challenges of implementing HFDM in the onshore environment and CAP 1864 does not propose action to achieve it. Therefore, the following Safety Recommendation is made:

Safety Recommendation 2021-032

It is recommended that the Civil Aviation Authority assess the safety benefits and feasibility of Helicopter Flight Data Monitoring programmes for onshore helicopter operators conducting commercial operations or non-commercial complex operations and publish its findings.

Conclusion

The helicopter flew unintentionally to within 28 ft of rising terrain because the pilots had lost situational awareness in low visibility approaching night, in conditions that were not suitable for the flight to be conducted under visual flight rules. The available automatic and terrain awareness systems were not employed effectively. The incident could have been avoided by not conducting the flight, by flying to an alternative aerodrome available en route, or by diverting either to the departure aerodrome or to the alternative aerodrome as soon as the flight was no longer able to comply with visual flight rules. The pilots' ability to make effective decisions was probably adversely affected by several cognitive biases arising from the circumstances of the flight and their desire to accomplish the mission.

The helicopter was equipped, and its pilots qualified, to fly under instrument flight rules to an aerodrome with published instrument approaches. The helicopter was equipped with a terrain awareness and warning system that functioned correctly and provided warnings that, if heeded, would have prevented the unintended flight towards terrain.

CAP 1864, the UK Civil Aviation Authority's review of the onshore helicopter operations coincidentally published shortly after the occurrence, identifies many of the issues involved in the event involving G-LAWX. The CAA has stated that it is in the process of implementing the 27 actions listed in CAP 1864 and is working with the Onshore Helicopter Safety Leadership Group to address the 25 recommendations it proposes. The AAIB makes the following eight Safety Recommendations:

Safety Recommendation 2021-025

It is recommended that the Civil Aviation Authority publish guidance on the meaning and intention of the phase of flight alleviations in UK SERA where detailed as "except for take-off and landing" to better enable pilots to plan and act on minimum height requirements for safe operations.

Safety Recommendation 2021-026

It is recommended that Starspeed Ltd specify in its operations manual stabilised approach criteria for visual approaches, including at off-aerodrome landing sites.

Safety Recommendation 2021-027

It is recommended that the Civil Aviation Authority encourage the development and deployment of Point-in-Space operations at landing sites.

Safety Recommendation 2021-028

It is recommended that the Civil Aviation Authority revise its guidance on helicopter flight in degraded visual conditions to include further information on managing the associated risks.

Safety Recommendation 2021-029

It is recommended that Starspeed Ltd describe in its operations manual for the Sikorsky S92 helicopter the criteria for setting barometric altitude alert values at each stage of a flight.

Safety Recommendation 2021-030

It is recommended that Starspeed Ltd specify in its operations manual a formal process for crew members to monitor, escalate concerns and, if necessary, take control during a flight.

Safety Recommendation 2021-031

It is recommended that the Civil Aviation Authority ensure that operators show clear evidence within their system for operational control as required by UK ORO.GEN.110 (c), of how the tasking process separates the customer from the flight crew.

Safety Recommendation 2021-032

It is recommended that the Civil Aviation Authority assess the safety benefits and feasibility of Helicopter Flight Data Monitoring programmes for onshore helicopter operators conducting commercial operations or non-commercial complex operations and publish its findings.

Safety actions

The operator informed the AAIB that it has:

- conducted a training day focussing on the occurrence;
- gained approval from the client to install cloud base and visibility monitoring equipment at the LS;
- transferred the role of Safety Manager from the commander to the Compliance Manager and has begun the process of delegating responsibilities for the SMS from the Accountable Manager to the Compliance Manager;
- added the following note to the front page of the GL3 procedure on the EFB:

  'Note: The GL3 is NOT an aid for poor or marginal visual conditions. To be used as Visual Approach Aid in VMC ONLY.';
- included "Inadvertent IMC at Low Level / Low IAS" as an additional training requirement to be delivered during simulator training;
- issued a Flying Staff Instruction (FSI) updating the OM Part A Section to address operations in marginal weather conditions. The FSI covered the following areas:

  - Definition of 'marginal conditions' by day and night
  - Departure at night in VMC
  - Airspeeds to be flown

- Indicated airspeeds to be flown
- Assessment of cloud base at off airfield landing sites
- Light levels and time of year
- Planning and briefing of approach and departure routes
- Use of the GL3
- The requirement for an alternate plan
- Operational control and supervision of the go/no go decision in marginal conditions
- Operational control and supervision of management post holders when flying;

- revised the OM Parts A, B and D and included an SOP on deviation calls in multi-pilot operations.

The operator stated that it intends to:

- develop pilot intervention training;
- explore the feasibility to install Cloud Base and visibility equipment at other landing sites.

Published: 17 June 2021.

ACCIDENT

Aircraft Type and Registration:	Cessna 185A Skywagon, G-BLOS
No & Type of Engines:	1 Continental Motors Corp IO-470-F piston engine
Year of Manufacture:	1962 (Serial no: 185-0359)
Date & Time (UTC):	7 October 2020 at 1620 hrs
Location:	Pauncefoot Airstrip, Romsey
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Serious) Passengers - N/A
Nature of Damage:	Wings separated and significant fuselage damage
Commander's Licence:	Private Pilot's Licence
Commander's Age:	63 years
Commander's Flying Experience:	395 hours (of which 42 were on type) Last 90 days - 5 hours Last 28 days - 0 hours
Information Source:	AAIB Field Investigation

Synopsis

Soon after takeoff, the aircraft began descending with an increasing ground speed towards a small wooded area. The aircraft struck the trees, becoming increasingly disrupted as it descended through them. The fuselage came to rest upright amongst thick bushes around 1,000 m from the start of its takeoff run. The wings were found approximately 30 m behind the location of the main wreckage.

Witnesses on a nearby road had seen the aircraft descending towards the trees and had alerted the emergency services. The aircraft was located with some difficulty and when the emergency services reached it, the pilot was found lying partially outside the fuselage on the ground at the right hand side. He had suffered serious injuries in the accident.

The aircraft was severely damaged, but extensive examination did not reveal any faults which could have caused or contributed to the accident. It seems likely that the pilot became incapacitated after takeoff and that the aircraft began a descent due either to being slightly out of trim for the climb, or because of an involuntary movement by the pilot on the control column. The pilot could not recall any events of the accident. It was not possible to establish the exact cause of the likely incapacitation.

History of the flight

The aircraft was kept in a purpose-built hangar at a private airstrip near Romsey in Hampshire. The pilot, who co-owned the aircraft, wheeled it out of its hangar and prepared it for a late afternoon flight to Sandown on the Isle of Wight. The wing fuel tanks were full and contained a total of 320 litres (84.5 USG) of Avgas. Having performed the pre-flight checks, the pilot started the engine before taxiing to the runway. He completed the pre-takeoff power checks before lining up on the runway for takeoff. He did note that during the engine power checks the propeller control was slow to react at first, but was satisfactory on a second and third check and gave him no further cause for concern. After takeoff the aircraft climbed normally at first with the pilot making a small heading change to the right as was his normal practice. The aircraft then appeared to level and start to gradually descend, with increasing ground speed, heading directly towards the trees.

The pilot has no recollection after the slight heading change but became vaguely aware of foliage passing the cockpit. At this point, the aircraft was striking the tree tops. This had the effect of slowing the aircraft as it descended through the tree canopy. The main portion of both wings detached as the aircraft collided with thicker tree trunks as it descended to the ground. The fuselage and remainder of the loosely attached right wing root were eventually brought to a stop within dense bushes on the ground. The accident site was approximately 1,000 m from where the pilot had begun the takeoff roll.

Witnesses travelling along a nearby road saw the aircraft disappear into the trees. The emergency services were called, and, with some difficulty, they eventually located and gained access to the wreckage. The seriously injured and semi-conscious pilot was found lying partly out of the aircraft on the ground.

Accident site

The aircraft hit the tops of the trees which were part of a small forest on private land. It had descended through the canopy during which the wings and parts of the landing gear had become detached. The wing fuel tanks had been split open and all the fuel had dispersed. The fuselage was brought to a stop right-side down in dense laurel bushes which were up to 2 m high and covered most of the forest floor (Figure 1). The rear fuselage was distorted and although still attached, the empennage and fin were displaced to the side. The cabin and cockpit had generally retained their shape and the windscreen was missing. Perspex fragments from the windscreen littered the accident site. The wings were found lying approximately 30 m behind the fuselage entangled within the trees and undergrowth.

Figure 1

Accident site showing the top of the fuselage and dense undergrowth

The nose section was dented and misshapen, but all the engine bay panels had remained in place. Both propeller blades were distorted in a manner indicative of rotation under power throughout the accident sequence. There were numerous dents over the entire surface of the spinner (Figure 2).

Figure 2

Nose section, propeller blade distortion and spinner

Recorded information

An electronic tablet with an aviation navigation app was recovered from the accident site. The app records flight logs based on the Global Navigation Satellite System capabilities of the tablet. The recorded flights included the accident flight and previous flights from the same airfield.

The accident flight log started at 1416 hrs (Figure 3). The aircraft taxied along the initial part of the runway and then backtracked to the east end of the runway. The takeoff started at 1433:08 hrs and the last recorded data point was 36 seconds later.

Figure 3

Oblique view of the accident flight

The data for the flight is shown in Figure 4. The aircraft initially climbed at approximately 1,000 ft/min with a ground speed of approximately 70 mph. Weather information, from Southampton Airport 12 km away, indicated a head wind of about 7 mph was present at the time. This indicates that the IAS was above that required for a maximum performance takeoff. The climb rate and speeds were as expected for the aircraft type and similar to previous takeoffs from that location recorded in the tablet.

The aircraft stopped climbing, peaked at approximately 150 ft agl and started descending. The aircraft accelerated in the descent. The energy of the altitude / speed profile in the descent indicates similar engine power was in use as that in the climb. The altitude / speed profiles of the previous takeoffs from the same runway indicated a similar amount of power being produced by the engine (Figure 5).

It is not known whether the logged flights represent the entirety of the pilot's recent flying, that of the aircraft, both or neither. Sixty five flights were logged between April 2018 and the accident flight. The three flights prior to the accident flight were recorded in July 2020 and the flight prior to that was in November 2019.

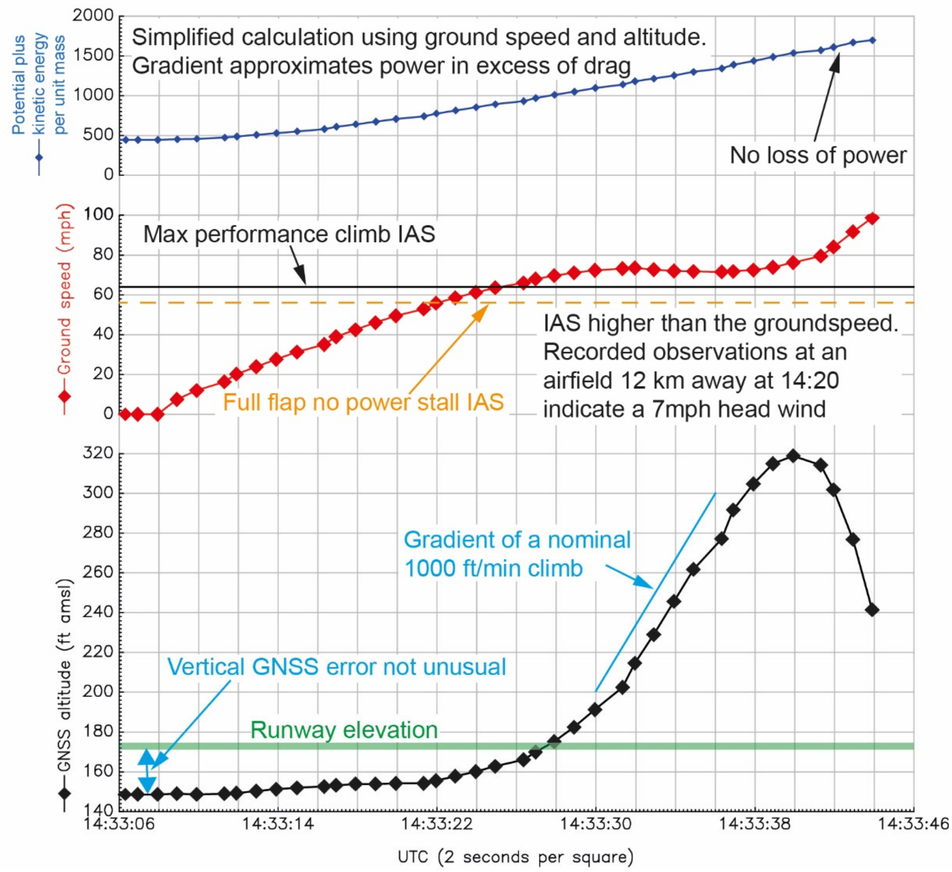


Figure 4

Accident flight data

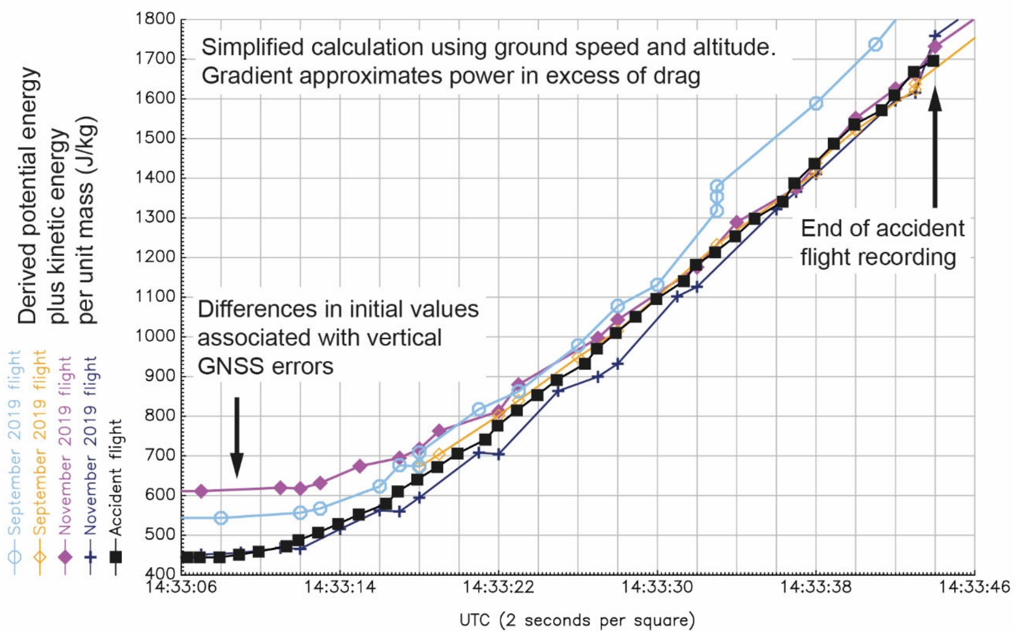


Figure 5

Comparison of the power used during the accident flight takeoff with that used during previous takeoffs from the same location.

Aircraft information

The Cessna 185A Skywagon is a six-seat high-wing all metal monoplane. It has a fixed main landing gear and a tail wheel. It is powered by a Continental horizontally opposed, six-cylinder, fuel-injected engine, driving a two blade variable pitch propeller. It has a mechanical flying control and trim system with manually-operated, five-position flaps. Fuel is contained within two bladder-lined tanks in the inboard portion of each wing. The fuel tank capacity is 84 USG and the aircraft has a maximum takeoff weight (MTOW) of 1451 kg.

The aircraft is fitted with a tailplane trim system which consists of a continuous loop chain and cable assembly driven by a hand wheel mounted on the cockpit floor. Rotation of the trim wheel extends or retracts a pair of jackscrews which are driven by sprockets engaged on the chain section of the continuous loop. They are fixed to the fuselage structure and to brackets attached to the leading frame of the tailplane. The tailplane is pivoted at the rear and the jackscrews alter the angle of attack of the tailplane. A follow-up cable and spring assembly is attached to the tailplane and the elevator control rod to ensure the elevator conforms to the set tailplane trim position. Figure 6 shows a general arrangement of the tailplane trim system and Figure 7 shows the jackscrew assembly.

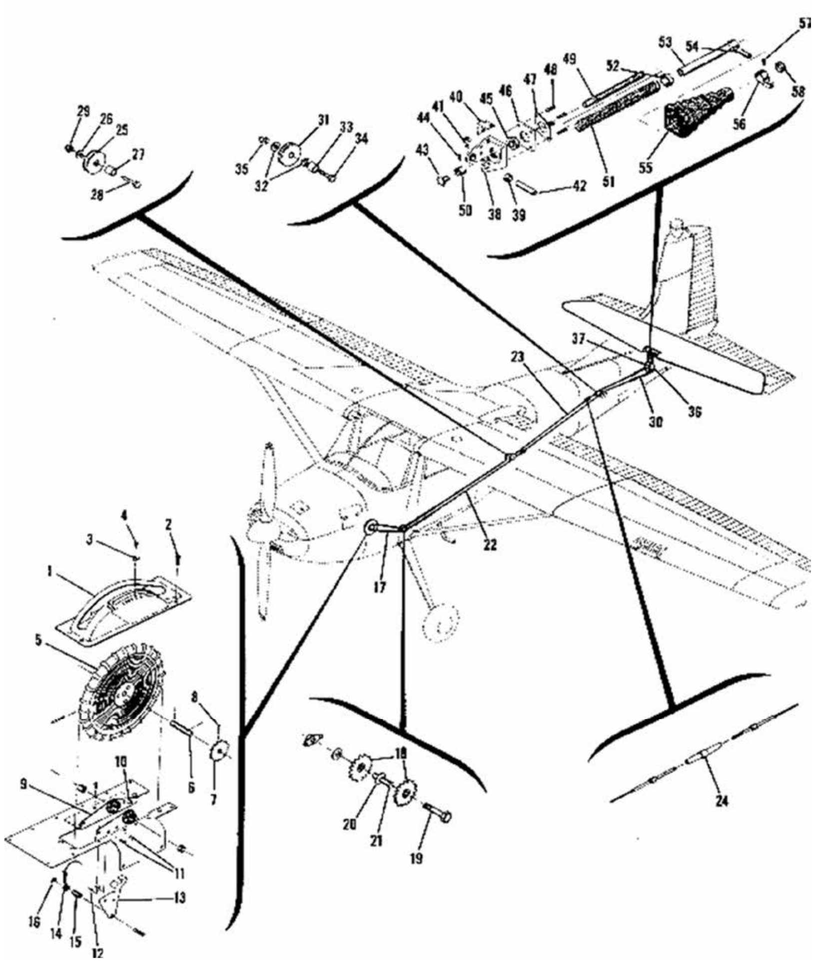
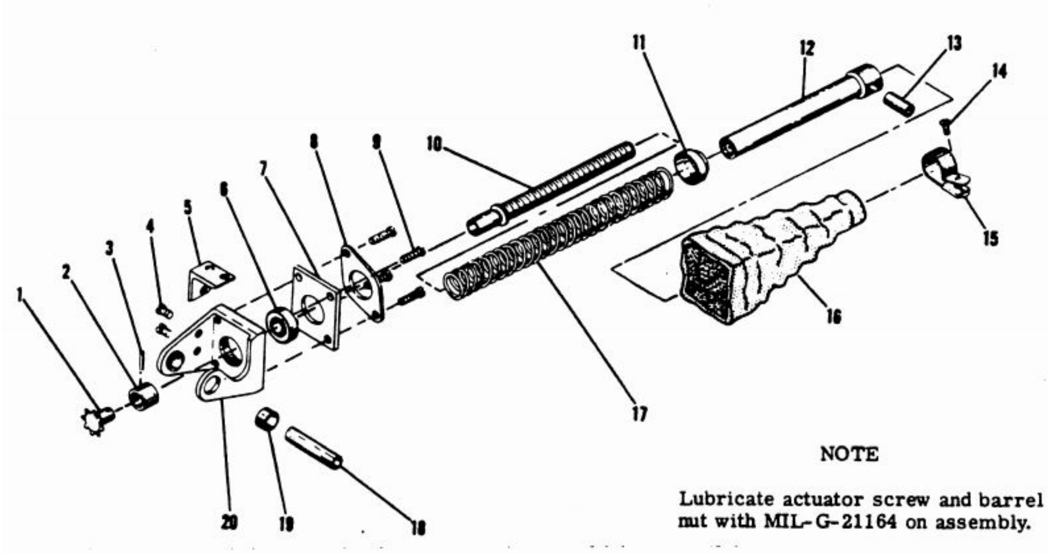


Figure 6

Tailplane trim system schematic



1. Sprocket
2. Retainer
3. Roll Pin
4. Screw
5. Chain Guard
6. Bearing
7. Retainer Cap
8. Retainer Plate
9. Screw
10. Actuator Screw
11. Collar
12. Barrel Nut
13. Eccentric Bushing
14. Screw
15. Clamp
16. Boot
17. Spring
18. Bushing
19. Bushing
20. Hinge Assembly

Figure 7

Jackscrew assembly
(Figures 6 & 7 courtesy of Textron)

The cockpit is fitted with conventional analogue instruments with a variety of toggle switches and push/pull/slide knobs and controls. The air speed indicator is calibrated in MPH. G-BLOS has several minor instrument panel modifications have been added to allow USB power supply connections for personal computer devices.

The pilot's and co-pilot's seats are fully upholstered. They are of a steel frame construction and are attached to the cockpit floor in rails which allow forwards and rearwards adjustment to suit the occupant. A locking peg engages in a hole in the rail to lock the seat in the desired position. The pilot's seat is fitted with an inertia reel anti-runback device which arrests any sudden rearward movement of the seat, should the locking peg become disengaged inadvertently.

Aircraft history

G-BLOS was built in 1962. The aircraft had a valid airworthiness review certificate and its most recent annual inspection was carried out in May 2020. Its engine had also undergone a full overhaul during 2018 and all the ancillary equipment had been overhauled. Perishable rubber and neoprene pipework and fittings had also been replaced with new items.

Aircraft examination

The aircraft was moved to the AAIB hangar for a detailed examination.

Fuselage and cabin

The tail section of the fuselage just in front of the tailplane and fin leading edges had partially separated and was bent around to the left. The leading edge of the tailplane on the left side at the root was also severely damaged.

The aircraft had been made safe by the first responders and the ignition key had been removed. All the cockpit instruments and switches were intact. The barometric altimeter was set to 1015 hPa. All the other primary flying and engine instruments had returned to zero on their scales. The mixture control was fully in so was set to rich, the throttle was also fully in and therefore at a full power setting. The propeller control was also fully in at its high RPM setting. The flap lever had been bent to the right but was found to be set at the first stage of flap. The left control yoke was undamaged and was correctly connected to the aileron and elevator control cables. The right control yoke shaft had broken and was hanging loosely. The spherical yoke bearing mounted on the control panel was distorted on its right side.

The elevator trim wheel was undamaged, and its indicator was slightly aft of the mid position in the scale. The wheel was free to rotate and the trim cable and chain assembly was correctly engaged on its sprocket. It operated in the correct sense and the anti-creep system functioned correctly. The rudder trim wheel was jammed and misaligned with its shaft protruding through its centre.

The cabin heater and cabin air controls were fully in and therefore closed. The cowl flap lever, which is opened and closed to allow optimum engine cooling, was set to HALF.

The pilot and co-pilot's seats were in place, but both had a slight rightwards distortion in their steel frames. The pilot's seat position pins were correctly engaged in the seat rail with no evidence of it having been moved from the setting made by the pilot. The seat anti-run back device was correctly attached and showed no evidence of having operated.

Both safety straps were undone and correctly mounted in their rings on the cockpit floor. The left shoulder strap was hanging loose and was not attached to the cabin roof frame. The ring attachment bolt was broken, and its remains were in the anchor nut. The bolt head was missing and was not found. Apart from this the straps were in a good condition and the buckles and adjustment loops worked correctly. A test was carried out with an individual of a similar size to the pilot and found the straps to have been adjusted to a snug but comfortable fit.

Wings, aileron flying controls and flaps

The left wing had completely detached from the fuselage and a large part of the right wing had detached leaving part of the wing root loosely attached during the accident. Multiple impact marks were present on the remains of the leading edges of each wing. The wings were severely damaged. The left and right wing fuel tank bladders had been ruptured and multiple tears were present in the tank material. No fuel remained in either wing. The spars and wing struts were broken. The aileron control cables had failed in overload, as had the flap operating cables. All the electrical wiring had parted at the wing roots as had the fuel lines. The remains of the flap and ailerons were all present, but it was not possible to precisely determine their positions prior to or during the accident. However, the bend position on the flap lever and marks on its pivot fairing on the cockpit floor show that it had been at the 10° of flap setting. Control cable and linkage continuity, and flap track and aileron hinge integrity could be demonstrated. No pre-existent damage or faults were found on the flap or aileron system. The aircraft was fitted with a heading hold autopilot and its master switch was found in the OFF position.

Rudder, tailplane and elevator controls

The remains of the tail section were removed from the fuselage for disassembly. The rudder was correctly attached by its hinges and its control cables and linkages were damaged but had been correctly routed and operated in the correct sense. The rudder pedal range was restricted by distortion of the cockpit floor and fire wall. A large semi-circular dent was apparent on the left side of the rear fuselage and into the tailplane leading edge root. The tailplane assembly had also been displaced to the right. The tailplane and elevator, although damaged, were correctly attached at their pivot and hinge points. The elevator was free to move and, despite damage to the elevator cables, continuity and operation in the correct sense could be shown throughout the system. The continuous tailplane trim cable chain section at the tailplane had broken. The right trim jack screw drive sprocket was detached and could not be found. The left sprocket had also detached and was lying within the tail section of the fuselage beneath the jack screw.

The distance between the leading edge of the tailplane and its hinge mounting plate was measured at the jack screw mounting bracket and found to be 45 mm (1.75 inches) and indicates the tailplane trimmed position as found (Figure 8).

Examination of the jack screws

The jackscrews were correctly attached to the fuselage frame and to the tailplane leading frame brackets. However, the brackets were distorted and partially separated from the frame due to shearing of their attachment rivets. The rightward displacement of the tailplane had put a slight bend in both the jack screws. Disassembly of the two jack screws found them outwardly to be in very poor condition. Their boots were split and decayed and the grease covering the outer spring was aged and solidified. Despite this, both jack screw threads were free to rotate and extended and retracted correctly (Figure 9). The position on the screw shaft where the sprockets had been fitted showed that both had sheared in overload where the attachment pins passed through the shaft. An examination of the broken chain and the remaining sprocket supported this, with evidence of severe distortion to the sprocket teeth and chain links (Figure 10).

Figure 8

Tailplane trimmed position as found

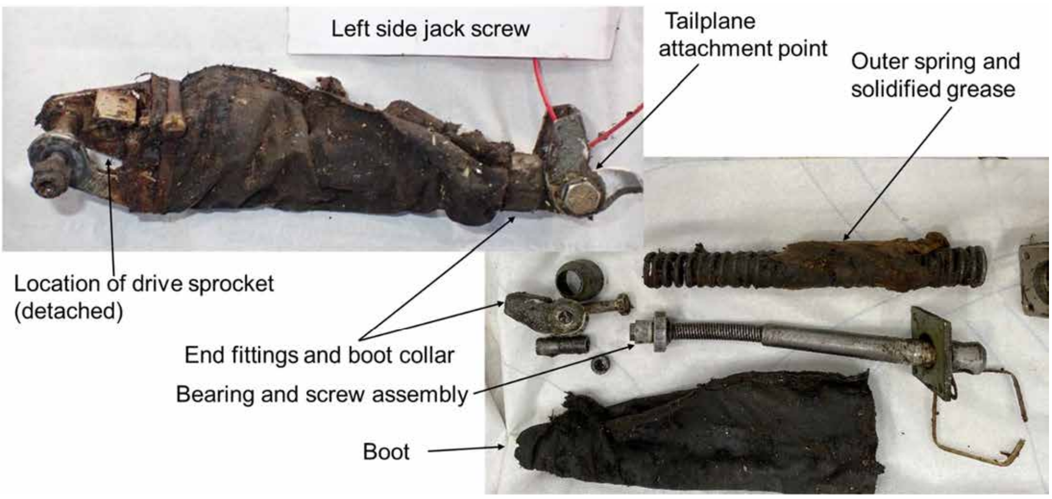


Figure 9

Disassembled left jack screw
(Right jack screw found in the same condition)

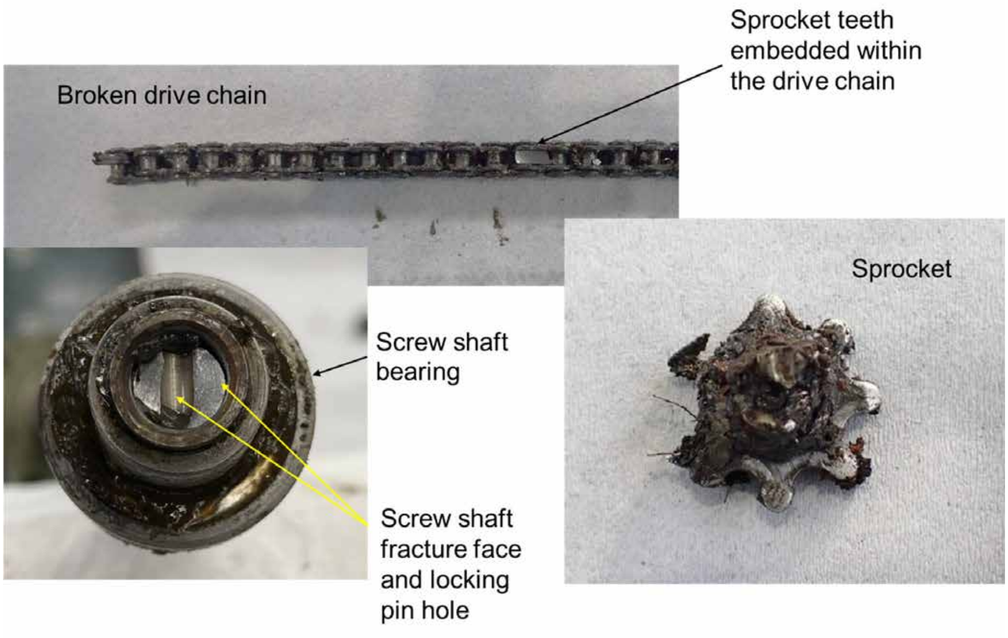


Figure 10

Left sprocket and chain

The upper and lower engine cowling had sustained multiple impact damage. The propeller spinner had multiple dents over its entire surface. Both propeller blades were loose in the propeller boss and the blade pitch change mechanism linkages had broken. One of the blades was twisted and bent rearwards and the other had pronounced multi-directional bending and twisting over its entire length. The tip of this blade had been fractured and was missing (Figure 11).

Figure 11

Condition of the propeller blades and spinner

The engine mounting frame had been slightly distorted but was correctly attached to the fuselage. The left crankcase engine mounting lug had fractured. The engine was free from fluid leakage and clean lubricating oil was at its normal level in the sump. The crankshaft could be moved freely by hand. The engine and its ancillary components were in good condition commensurate with the relatively recent full overhaul. The fuel filter was full of clean fuel with no evidence of water contamination. The filter gauze was free from debris and not blocked.

All the spark plugs were correctly fitted and connected to good condition leads. Examination of the spark plugs found all but one of them showing the engine was in a good state of tune. One of the plugs, the No 4 cylinder upper, was slightly fouled. An internal visual examination of the cylinders found all six to be in good condition. The piston faces were normal and honing marks were present on the cylinder liners as would be expected after the overhaul. The valves and rocker assemblies were also undamaged.

The exhaust manifold was removed from the engine for examination. The stubs and pipes were impact damaged on both sides of the engine. However, they were in a good overall condition and there were no holes or cracks apparent. The exhaust gaskets were also in good condition with no signs of leakage. The exhaust heat exchanger muff was removed, and no evidence was found of exhaust gas leakage from the heat exchanger cylinder within. The colour of the internal surfaces of the exhaust manifold also indicated that the engine was operating normally.

The air intake sponge-foam filter fitted in the lower section of the engine cowling had tree debris embedded in it but was dry, in good condition and prior to the accident had been clean and clear. The air duct leading to the injection carburettor was also free from blockage. The fuel injectors were removed and examined and were clear, as were the injector pipes.

The mixture, throttle and propeller control cables, rods and linkages were correctly attached and were free to move throughout their full range.

Survivability

The cockpit structure had generally retained its shape. The pilot's seat was still correctly attached to its rails although its frame was distorted slightly to the right. The seat position pin remained where it had been set by the pilot and was correctly engaged in the rail. The pilot was wearing the lap strap with a diagonal shoulder strap. During discussions with the pilot, he explained that he was in the habit of always wearing the safety harness and adjusting it so that it was a tight fit. He did this along with a seat position which enabled him to reach all the aircraft controls comfortably. A person of similar stature to the pilot was seated in the cockpit and the strap held in position. This reconstruction demonstrated that the pilot could not fall or slump into the controls.

Of note was the broken shoulder strap roof frame mounting bolt. Examination of the shoulder strap webbing found the mounting ring buckle area stitching to having experienced tensile loading, but it had not parted. The door catches were undamaged; however, distortion of the door aperture frame had allowed the right door to open. The pilot was found on the forest floor to the right of the aircraft underneath the fuselage having apparently fallen out of the open right door. He later described how he had soil and leaf matter in his nose and mouth.

Weight and balance

The aircraft was within the approved weight and balance envelope.

Meteorology

The weather was good with a light westerly wind and visibility of more than 10 km. The temperature was 16ºC and the QFE was 1016 hPa.

Airfield information

The airfield is private and unlicensed leased from the landowner. It consists of a single grass runway which is 660 m long and 16 m wide and is on a heading of 080/260°. It is within a large flat agricultural field bounded by a main road at its easterly end and copse the other side of a small road approximately 300 m from its westerly end. A domestic power line also traverses north to south across the field about 200 m to the west of the runway end. The runway surface is firm, well drained and the grass cut to approximately 8 to 15 cm in length. Two distinct areas of the runway were mown and manicured to allow model flying to take place.

Pilot incapacitation

Pilot incapacitation is the inability of a crew member to fulfil his role due to a physiological or medical event. The range of incapacitation can vary from being conscious but unable to function to be being deeply unconscious. With a single pilot flying a light aircraft, incapacitation can severely compromise the safety of the flight and the result can be a loss of control.

There are a number of possible causes of pilot incapacitation, including:

- The effects of hypoxia (insufficient oxygen) associated with an absence of normal pressurisation system function at altitudes above 10,000 ft.
- Gastro-intestinal problems such as severe gastroenteritis potentially attributable to food poisoning, or to food allergy.
- A bird strike or other event causing incapacitating physical injury.
- A malicious or hostile act.
- Smoke or fumes associated with a fire or with contamination of the air conditioning system.
- A medical condition.

The pilot of G-BLOS had just taken off and was flying alone in daylight when the event occurred. There was no evidence of a bird strike on the aircraft and the pilot reported that he felt fine on the day of the flight. The first four conditions are therefore not considered relevant in the accident investigation.

It is possible that fumes could have entered the cabin of G-BLOS either due to an exhaust fault or some other issue with the seal between the engine and the cabin. This would have meant carbon monoxide entering the cabin, possibly in large quantities. Although the pilot had just taken off, the engine had been running for approximately 17 minutes at the time of the accident. Previous investigations have shown that carbon monoxide can enter an aircraft cabin at levels to cause incapacitation within a short period[1]. However, the pilot did carry a domestic carbon monoxide alarm in the aircraft and does not remember it sounding during this flight.

Medical conditions can cause a transient loss of consciousness (TLoC) or 'blackout'. It is common, affecting up to half the population in the UK at some point in their lives. An estimated 3% of emergency presentations and 1% of hospital admissions are due to TLoC[2]. There are three most likely medical causes of TLoC:

- Cardiac issues, such as coronary heart disease or arrhythmias. Coronary heart disease occurs when coronary arteries become narrowed by a build-up of atheroma, a fatty material within their walls. This can cause pain and if a blockage occurs it can cause a heart attack. Arrhythmias or heart rhythm problems are experienced by more than two million people a year in the UK.
- Epilepsy – one in every four people who are newly diagnosed with epilepsy are over the age of 65. A generalised epileptic seizure can result in the disturbance of the controls and can occur suddenly without warning. Epileptic seizures generally result in the disturbance of multiple limbs in an unpredictable fashion.
- Syncope - also called fainting or passing out. Syncope is a sudden, temporary loss of consciousness, followed by a fall from a standing or sitting position. Syncope from a sitting position is rare and almost always occurs from a standing subject. A syncope episode is usually short and is caused by a decrease in blood flow to the brain. There are a number of known causes of syncope, however, often the cause cannot be identified, and it occurs only as a solitary episode.

The pilot reported no previous medical problems that could have affected his fitness to fly which was confirmed by an examination of his medical records. There were no indications in either his medical history or his post-accident examinations to indicate any obvious reason for a possible incapacitation.

Tests and research

Examination carried out on another Cessna 185 aircraft

Another UK based Cessna 185A of a similar vintage was examined with the assistance of its pilot to obtain more information about the handling characteristics of the type. This pilot had a substantial number of flying hours many of which had been accrued on the C185.

Footnote

1 https://www.gov.uk/government/news/aaib-report-piper-pa-46-310p-malibu-n264db-21st-january-2019 [Accessed 15/05/2021]

2 https://www.gov.uk/government/publications/assessing-fitness-to-drive-a-guide-for-medical-professionals [Accessed 15/05/2021]

Its seating position was set to that found in G-BLOS. With an individual of similar size and build to the accident pilot seated, it was found that a correctly adjusted strap allowed comfortable reach of the controls. However, it did not allow inadvertent pushing of the control yoke if the occupant were to 'slump' forward.

The pilot of the example aircraft described his experience of the handling characteristics as follows:

- He considered the aircraft was generally light on the controls, responsive and was easy to trim.
- The flap setting effect on pitch trim was unremarkable.
- When trimmed for a phase of flight the aircraft would generally stay in trim.
- The aircraft rate of climb was predictable for any given altitude but, with its normally aspirated engine, approximately 100 feet per minute is all that could be expected above 12,500 feet.

The owner was also asked to set the pitch trim to what, in his experience, would be normal for a standard rate of climb after takeoff. A measurement was then taken between the tailplane hinge plate and the tailplane leading frame and found to be 45 mm (1.75 inches) which was the same as found in G-BLOS (Figure 8).

The example aircraft tailplane trim wheel was easy to move with no perceptible freeplay or backlash in the system. It was not possible to accurately assess the external condition of the jack screw assemblies.

Other information

Although the jack screw assemblies were found to work correctly in G-BLOS, their external condition was a cause for concern. The jacks screw assemblies originally had a 500 hour service and overhaul interval but in later revisions of the manuals for later models of the Cessna 180 and 185 series of aircraft this was changed to 3 years or 1,000 hours, whichever is sooner. This relies on accurate record keeping of when the overhaul was last carried out. In this case the tailplane jack screws on G-BLOS where working correctly and were smooth throughout their full range of operation. However, the evidence suggests that G-BLOS jack screws had been serviced in the past, indicated by the presence of a non-standard cable tie around the boot, but had not been removed for some time.

The aircraft was not on a Self-Declared Maintenance Programme (SDMP). It therefore did not have any deviations from the manufacturer's servicing requirements authorised by its owner.

During the investigation, research identified open source discussions regarding tailplane trim runaway held by Cessna 180 and 185 owners around the world. There are uncorroborated reports that under certain aerodynamic conditions, or if the trim wheel drive mechanism malfunctions, the tailplane can move of its own accord and back drive the jack screws up or down. This has the effect of causing an uncommanded pitch up or down of the aircraft. This phenomenon is because the jack screw thread lead[3] is greater than that of a standard thread. In normal circumstances the jack screw threads are well lubricated and supported by a ball bearing designed to aid rotation of the thread spindle whilst under a compressive or tensile force from the tailplane.

Analysis

Aircraft preparation, takeoff and descent

The pilot removed the aircraft from its hangar and prepared for the flight as he had done on many occasions before. The aircraft was full of fuel and, with the single pilot and additional items carried in the cockpit, was within its weight and balance limits. The power checks were carried out without any problems and the aircraft was configured correctly for takeoff. Although the pilot has no recollection of doing so, a slight right heading change was made as was his normal practice. The flap lever was set to the first stage (10º) of flap which was normal for the climb after takeoff. The data held within the tablet showed that the takeoff and initial part of the climb were similar to previous takeoffs. It also showed the point where the climb reduced, and the aircraft nosed over into a descent. The ground speed profile shows the aircraft accelerated during the descent. The data indicated that there was no heading change and the rate of descent continued to increase. There was no evidence that the pilot attempted to alter the aircraft's flight path.

Accident sequence

A witness saw the aircraft descend at a shallow angle into the top of the trees before going out of view. The flexibility of the treetops started to absorb the energy of the aircraft but as it came down through the trees it encountered much thicker trunks and boughs which caused extensive damage to the aircraft. The leading edges show multiple impact marks of varying sizes. During the accident sequence both wings were forced rearwards and detached from the aircraft. Foliage appears to have struck the windscreen which fragmented but larger bits of tree did not enter the cockpit. The tail section struck a large tree trunk at the leading-edge root of the left tailplane, causing the tail section to partially detach. It was this impact that damaged the tailplane trim chain and sprockets and bent the jackscrews to the right.

The dents apparent over the entire propeller spinner surface suggest it was rotating as it descended in the trees. The nose section and cockpit remained relatively intact during the impact sequence.

During this sequence the pilot's shoulder strap mounting bolt on the cockpit roof broke. The exact point when this happened cannot be determined but it resulted in the pilot's upper torso becoming unrestrained. The damage to the flap lever, rudder trim wheel and co-pilot's control yoke suggest the pilot was ejected from his seat to the right having moved sideways out of his lap strap. The injuries sustained by the pilot resulted from unrestrained flailing

Footnote

3 The thread lead is the axial distance travelled during one 360° rotation of a screw thread or helix. A large thread lead can create a condition where, when a compressive or tensile force applied to the 'nut' on the thread it will cause the threaded shaft to rotate. (The same principle is used in a pump action screwdriver.)

of his limbs and then hitting the flap lever and yoke with a substantial force. Although the injuries were serious, the dense undergrowth probably went some way in reducing the potential severity of the injuries.

There was no fire after the accident. This is probably because the significant disruption to the wings and shredding of the fuel tanks some distance behind where the aircraft came to rest meant there was no fuel free draining onto hot surfaces or damaged wiring. Any fuel or oil that remained, stayed within the intact engine bay components.

There was no evidence of a pre-existing fault or malfunction of the fuselage, wings and flying controls. All the damage attributable to the descent through the trees.

Engine power

The condition of the engine and its ancillary components are commensurate with its relatively recent overhaul. The pilot described how he had to exercise the propeller control during his power check as at first it did not appear to respond correctly, but on his second and third attempt it responded correctly and gave him no further concern. Visual inspection of the engine after the accident showed it to be in excellent condition. No explanation could be identified to account for the single fouled spark plug, which it is not likely to have had a noticeable effect on the engine power output. No other defects were identified which would have prevented the engine from operating normally to pilot control inputs.

The marked acceleration in ground speed during the descent towards the trees suggest the aircraft was performing in accordance with the settings made by the pilot on the throttle, mixture and RPM controls. This acceleration would not be expected in an engine off descent. In addition, the nature of the damage to the propeller and spinner suggest the engine was at a high power setting as it hit the trees. Based on the evidence, an engine fault or loss of power was not considered to be a contributory factor in this accident.

Tailplane and elevator controls

The position of the tailplane and elevator is important to this investigation. The data shows the aircraft to deviate from the steady climb. It shows it smoothly change its pitch attitude to adopt a steady descent. The tail plane trim setting when compared to another C185A configured for post takeoff climb was appropriate. It shows the jack screws do not appear to have moved from their setting or ‘runaway’ to an extreme setting. The condition of the jack screw boots and grease surrounding the external spring, whilst unsatisfactory, did not affect the operation of the jack screws.

The elevator controls were damaged by the impact sequence but their integrity and continuity prior to the accident could be demonstrated.

The evidence from the engine, tailplane and elevator do not suggest any malfunction or failure that could have caused the aircraft to deviate from the climb.

Airfield and weather conditions

The airfield and weather conditions were unremarkable and are not considered to be contributory factors in this accident.

Pilot incapacitation

For the accident to G-BLOS to have occurred, the aircraft needed to pitch down from its climb attitude. Since no technical cause could be found, the investigation focused on the possibility that the pilot became incapacitated. The pitch change could have been due to the aircraft being out of trim for the climb so that when the pilot was no longer in control, the pitch of the aircraft dropped to the trimmed elevator position. Although the position of the trim actuators corresponded to the position expected after takeoff in the other C185A examined during the investigation, it is clear that all aircraft are slightly different and even a small out of trim condition could have allowed the aircraft to descend towards the site of the accident. Whilst the pilot recalls the aircraft being in trim, it is possible that he does not remember the status of the trim correctly or he adjusted the trim before becoming incapacitated.

The alternative is that this could have been through a physical movement of the pitch controls of the aircraft by the pilot. The pilot was strapped into the aircraft using a lap and shoulder harness which was not fitted with an inertia reel. Reconstruction using someone of a similar stature to the pilot showed that it was not possible for the pilot to have slumped forward into the controls causing a push on the control wheel, and resultant downward pitch of the aircraft. Any movement of the control wheel is likely therefore to have been the result of disturbance of the controls by the pilot. Given that an epileptic seizure generally results in the disturbance of multiple limbs, the gentle nature of the pitch down of the aircraft, with no apparent turn or yaw would seem to discount this as a possibility.

The pilot has no recollection of the accident sequence after his memory of the aircraft climbing away, trimmed and in control. His next memory is of what he described as "trees flashing past" before regaining consciousness when the emergency services reached him. He suffered significant injuries, including a head injury and the loss of memory may well be related to that rather than any indication of incapacitation.

However, having found no other cause for the pitch down of G-BLOS from its stable climb after takeoff, it seems the most likely cause is a pilot incapacitation of some sort. The aircraft descended either as a result of the aircraft being out of trim, or an involuntary movement of the upper limbs on the control wheel. The pilot was unaware of the imminent accident .

Conclusion

G-BLOS struck trees in a small wooded area less than 1,000 m from the start of its takeoff run. Although the aircraft was extensively damaged, examinations showed no faults or failures that could have caused or contributed to the accident.

The investigation concluded that it is likely the pilot became incapacitated shortly after takeoff. This incapacitation meant that the pilot was unaware and/or unable to react to the descent of the aircraft. The aircraft descent began either due to the aircraft not being perfectly in trim for the climb, or as a result of an involuntary movement of the controls by the pilot. Examination of the pilot's medical records as well as the medical tests undergone after the accident did not show any condition that could have caused an incapacitation. It has therefore not been possible to establish an exact cause for the incapacitation.

Published: 1 July 2021.

AAIB Correspondence Reports

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

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

The accuracy of the information provided cannot be assured.

ACCIDENT

Aircraft Type and Registration:	AgustaWestland AW109SP, G-TAAS
No & Type of Engines:	2 Pratt & Whitney Canada PW207C turboshaft engines
Year of Manufacture:	2013 (Serial no: 22305)
Date & Time (UTC):	22 April 2021 at 1247 hrs
Location:	Carsington Water, Derbyshire
Type of Flight:	Commercial Air Transport (Passenger)
Persons on Board:	Crew - 2 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Shattered left windshield and a hole in one main rotor blade
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	54 years
Commander's Flying Experience:	4,212 hours (of which 2,944 were on type) Last 90 days - 43 hours Last 28 days - 16 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

At about 1,000 ft agl and 140 kt, as the helicopter was descending and turning towards East Midlands Airport on return from a HEMS mission, a bird struck the left windshield. The windshield shattered and the bird entered the cockpit striking the technical crew member (TCM) on the left side of their helmet. The TCM and pilot were unhurt. Debris from the windshield also entered the main rotor disk, making a hole in the trailing edge of one of the rotor blades.

The AgustaWestland AW109 windshield is not designed to withstand bird strikes and the design certification requirements do not require it to do so. Proposed amendments, specifically to the certification of Small Rotorcraft were published in EASA NPA 2021-02 to change this for newly designed rotorcraft. A rule making group is also considering the retrospective application to existing fleets and/or to future production of already type-certified rotorcraft.

History of the flight

The helicopter was returning from a HEMS mission and returning to East Midlands Airport. As it was descending through about 1,000 ft agl and 140 kt, the technical crew member (TCM), seated in the left seat, spotted and shouted "bird". The pilot pitched and rolled the helicopter to the right, but the bird, a type of crow whose remains were later found to weigh 1.32 kg, hit, and went through, the left windshield. It struck the TCM on the left side of their helmet and continued up into the top of the left cockpit door, before becoming wedged behind the pilot's seat. Following the bird strike, the crew reported that there was a "noticeable" vibration in the airframe.

The pilot immediately informed East Midlands ATC of the bird strike and that they were making a precautionary landing. The helicopter landed without incident and was shut down. The TCM was examined by the crew doctor and found to have sustained no injuries.

Damage to the helicopter

The left windshield, which was made of acrylic, had shattered into multiple pieces which were found throughout the cockpit and passenger area (Figure 1). Debris from the windshield also entered the main rotor disk, making a hole in the trailing edge of one of rotor blades (Figure 2).

Figure 1
Damage to the left windshield

Previous bird strike incidents

The AAIB has issued four previous reports after similar events on helicopters certified to the Small Rotorcraft category requirement: N109TK (AAIB Bulletin 2/2012), G-ODAZ (AAIB Bulletin 6/2014), G-BZBO (AAIB Bulletin 11/2016) and M-MYCM (AAIB Bulletin 6/2019).

Figure 2
Main rotor blade trailing edge damage

Helicopter bird strike requirements

The AgustaWestland AW109SP was certified to the European Union Aviation Safety Agency (EASA) regulation CS-27 (Small Rotorcraft) in 2007. CS-27, which applies to rotorcraft with a maximum weight of 3,175 kg (7,000 lbs) or less and nine or less passenger seats, includes the following requirement for windshields:

> ***'CS 27.775 Windshields and windows***
>
> *Windshields and windows must be made of material that will not break into dangerous fragments.'*

The use of acrylic such as Plexiglas® or Perspex® for windshield material is accepted by industry for application where breakage into dangerous fragments is not permitted. There are no requirements in CS-27 relating to bird strike resistance.

In contrast, rotorcraft with a maximum weight greater than 3,175 kg or with more than nine passenger seats are certified to CS-29 (Large Rotorcraft), which includes the following bird strike resistance requirement:

> ***'CS 29.631 Birdstrike***
>
> *The rotorcraft must be designed to assure capability of continued safe flight and landing (for Category A) or safe landing (for Category B) after impact with a 1 kg bird, when the velocity of the rotorcraft (relative to the bird along the flight path of the rotorcraft) is equal to VNE or VH (whichever is the lesser) at altitudes up to 2438 m (8000 ft). Compliance must be shown by tests, or by analysis based on tests carried out on sufficiently representative structures of similar design.'*

EASA Rule Making Task (RMT).0726

As discussed in the AAIB Bulletin 6/2019 on the bird strike incident to M-MYCM, the EASA RMT.0726 '*Rotorcraft occupant safety in event of a bird strike*' was, at the time, in the planning stage. The Terms of Reference for RMT.0276 have since been published (September 2020) and state:

> *'The specific objective of this rulemaking task is to improve rotorcraft occupant safety in the event of a bird strike. This objective can be achieved:*
>
> > *by introducing a new risk-based certification specification to prevent windshield penetration on small rotorcraft (CS-27) with higher passenger capacities; the specification may be similar to CS 29.631 for safe landing, but would only be applicable to the windshield; (Subtask 1); and*
> >
> > *if assessed to be necessary, through a proportionate retroactive application of bird strike certification specifications to the existing rotorcraft fleets and/or to the future production of already type-certified rotorcraft (Subtask 2).'*

EASA Notice of Proposed Amendment (NPA) 2021-02

In February 2021, EASA published NPA 2021-02 for a one-month public consultation of the Subtask 1.[1] After considering the comments received, a decision on any amendments to CS-27, Acceptable Means of Compliance and Guidance Material is planned to be published in the second quarter of 2022.

EASA will consider and plan to publish a decision on Subtask 2 in the second half of 2022.

Conclusion

The helicopter suffered a bird strike which penetrated a windshield. The pilot, who was not hit by the bird remains, made an immediate uneventful precautionary landing. No injuries were sustained by the crew.

The helicopter, certified to CS-27 (Small Rotorcraft), was not required to demonstrate resistance against bird strikes.

Safety action

> The EASA are considering amendments to CS-27 regarding windshield penetration by bird strikes and will publish a decision in 2022.

Footnote

[1] https://www.easa.europa.eu/document-library/notices-of-proposed-amendment/npa-2021-02 [Accessed 4 June 2021]

ACCIDENT

Aircraft Type and Registration:	Druine D.31 Turbulent, G-ARNZ
No & Type of Engines:	1 Volkswagen 1600 piston engine
Year of Manufacture:	1961 (Serial no: PFA 579)
Date & Time (UTC):	18 October 2020 at 1510 hrs
Location:	Damyns Hall Aerodrome, Upminster
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Extensive damage
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	26 years
Commander's Flying Experience:	391 hours (of which 21 were on type) Last 90 days - 32 hours Last 28 days - 9 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

When approaching the airfield to rejoin the circuit, the aircraft's engine began to run rough then lost power completely. During the subsequent forced landing the aircraft came to rest inverted and the pilot sustained minor injuries. A post-accident inspection of the engine revealed a crack on the plastic rocker arm in the fuel pump. After the accident, the LAA issued an Airworthiness Information Leaflet which requires plastic rocker arms to be replaced with metal rocker arms in affected aircraft.

History of the flight

The aircraft took off from Damyns Hall Aerodrome Runway 03 at 1250 hrs. The pilot reported sufficient fuel on board and that the aircraft was within its weight and balance limits.

After flying locally for approximately 1 hr 20 minutes, the aircraft approached Damyns Hall from the south-east. The pilot intended to join overhead for a right-hand circuit to Runway 03 and land.

The pilot had the airfield in sight at an altitude of 1,100 ft when the engine began to run rough, and declared a MAYDAY, citing a partial engine failure, following which the engine failed completely.

The pilot visually identified an area with fields and a golf course ahead, aimed the nose towards it and prepared for a forced landing. The pilot recalled from training "to go under 50 kt can be dangerous" and reported maintaining 55-60 kt.

The pilot further stated that due to the short wings, the Turbulent has a relatively poor glide capability and therefore assessed the golf course was too far. The pilot decided to aim for a nearer field which initially appeared relatively level and smooth. As the aircraft descended, the field began to look boggy with overgrown vegetation.

The aircraft touched down approximately 1.3 nm from the airfield at 1425 hrs. It "flipped over" to the left and came to rest inverted.

The pilot released the harness, switched the magnetos and electrics OFF and vacated the aircraft. There was no fire.

The pilot was airlifted from the accident site 30 minutes later having suffered only minor cuts and bruises. The aircraft sustained damage.

Aircraft description

The Druine D.31 Turbulent is a single seat, low wing monoplane with a conventional landing gear, consisting of two main wheels and a skid. It is fitted with a modified air-cooled, four-stroke automotive engine. A mechanically driven fuel pump supplies fuel to the engine.

The fuel pump fitted to G-ARNZ was a sealed unit and the aircraft had flown 30 hours since its installation. It had a plastic rocker arm which according to the LAA is a recent introduction to after-market pumps for this type of engine. Formerly it was normal for these pumps to have a metal rocker arm. No other fuel pump was installed in G-ARNZ.

The aircraft was operating on a Permit to Fly and its Certificate of Validity was in date.

Aircraft examination

A post-accident engineering inspection revealed the plastic cam driven rocker arm in the mechanical fuel pump had cracked (Figure 1).

Figure 1

Plastic fuel pump rocker arm

Conclusion

The plastic rocker arm in the fuel pump cracked, causing the pump to fail. No other fuel pump was fitted, so this resulted in a loss of engine power and the pilot performed a forced landing.

Safety action

In response to the event, the LAA issued the following Airworthiness Information Leaflet (AIL):

> LAA Airworthiness Information Leaflet (AIL) LAA/MOD/ENG/VW/001 Issue 1, applicable to all LAA aircraft operating with Volkswagen (VW) derivative engines states:
>
> > ‘*mechanical fuel pumps using a plastic rocker arm must not be used on VW derivative engines operating under an LAA administered Permit to Fly’*
> >
> > *‘it must be established beyond doubt whether or not the mechanical fuel pump fitted to the engine uses a plastic rocker arm’*
>
> This AIL requires inspections to be carried out within five flying hours of its issue and must be signed off by a suitable LAA Inspector.

ACCIDENT

Aircraft Type and Registration:	Piper PA-44-180, G-BGCO
No & Type of Engines:	2 Lycoming O-360-E1A6D piston engines
Year of Manufacture:	1978 (Serial no: 44-7995128)
Date & Time (UTC):	12 February 2021 at 1310 hrs
Location:	Blackpool Airport, Lancashire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Damaged beyond economic repair.
Commander's Licence:	Commercial Pilot's Licence
Commander's Age:	70 years
Commander's Flying Experience:	16,500 hours (of which 1,000 were on type) Last 90 days - 45 hours Last 28 days - 17 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot

Synopsis

During an approach to Warton Airfield the landing gear was selected down but the nose landing gear did not lock down. Despite use of the emergency lowering system and repeated efforts to lower the landing gear, the situation could not be resolved. The aircraft diverted to Blackpool Airport where engineering support for the aircraft was available. The nose landing gear collapsed on touchdown.

It is likely that distortion or failure of a 'pivot bolt' in the nose landing gear was sufficient to prevent the nose landing gear locking down.

History of the flight

The aircraft, a twin-engine low-wing monoplane (Figure 1), had been conducting a routine, local flight in the Warton area. During the recovery to the airfield the landing gear was selected down.

Both main landing gear legs indicated locked down with green indicator lights but the nose landing gear leg showed not locked with a gear unsafe indication. The pilot followed the POH checklist actions, which included recycling the landing gear selection and changing the indicator bulbs, but this did not resolve the problem. The pilot then recycled the landing gear selection using varying applications of positive and negative g in an effort to force the nose landing gear down. On every selection the nosewheel was seen to travel using a mirror on the engine cowling, and on each occasion it appeared fully down although the gear unsafe indication remained. The aircraft was flown past the ATC tower for external observation and the nose landing gear appeared to be down. The landing gear emergency down lever was pulled but the indications remained, showing both main landing gear legs locked down but the nose landing gear not locked.

Figure 1

Piper PA-44-180 Seminole

After consultation over RTF with the factory test pilot at Warton, it was decided to fly the aircraft to Blackpool Airport where suitable engineering facilities were available. The aircraft landed on Runway 10 at Blackpool, the nose landing gear collapsed on touchdown and the aircraft came to rest with its nose on the ground (Figure 2). Damage was sustained to both engines, both propellors and the nose landing gear. The pilot was able to vacate the aircraft via the cockpit door and was uninjured.

Figure 2

Aircraft after landing

Technical Information

The aircraft was recovered to the maintenance facilities at Blackpool. When on jacks the landing gear emergency system was reset and the gear raised. On the first attempt to lower the landing gear, using only battery power, the main legs locked down but the nose landing gear indicated unsafe. A second attempt was made with the aircraft connected to a ground electrical supply and the landing gear lowered correctly. During test of the emergency gear lowering system, which relies on gravity and a spring assist, the nose landing gear did not travel from its raised position. The operator stated that significant force from the maintenance engineer was required to pull the nosewheel down, and that the 'pivot bolt' joining the upper and lower landing gear drag link assemblies could not be removed. The operator was aware of previous incidences where distortion or failure of the pivot bolt had occurred.

The damage to the aircraft was assessed as being beyond economic repair, so no further technical investigation into the cause was carried out.

Analysis

The pilot had anticipated the possibility of the nose landing gear collapsing on touchdown and diverted the aircraft to Blackpool so that suitable engineering facilities would be available after landing to support the recovery of the aircraft. The collapse of the nose landing gear precipitated the damage to the engines, propellers and nose landing gear but the aircraft was brought to a safe halt on the runway.

During ground testing the landing gear failed to operate correctly on battery power or through use of the emergency system. There have been previous incidences of distortion or failure of the pivot bolt connecting the upper and lower drag assemblies, and it is likely that this contributed to the difficulty in moving the nose landing gear in the hangar and it not lowering correctly in flight.

Conclusion

It is likely that damage to the pivot bolt in the nose landing gear was sufficient to restrict movement and prevent the nose landing gear locking down.

AAIB Record-Only Investigations

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

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

The accuracy of the information provided cannot be assured.

Record-only investigations reviewed: May - June 2021

11 Oct 2020	**Europa XS**	**G-CEMI**	Gloucestershire Airport, Gloucestershire

While landing the pilot lost sight of the ground in bright sunlight. The aircraft landed heavily which resulted in the nose landing gear leg being bent and damage to the propeller.

13 Apr 2021	**Rans S6-ESD XL (Modified)**	**G-MZBD**	Westonzoyland Airfield, Somerset

The pilot was performing circuits that required a tight turn left to line up with the runway. After performing the turn the aircraft experienced a high sink rate. Despite the application of full power the aircraft's landing gear struck a fence. The subsequent hard landing resulted in damage to the propeller, fuselage and landing gear.

19 Apr 2021	**Pioneer 300**	**G-EWES**	Isle of Jura, Argyll and Bute

The pilot had intended to fly overhead the sandy beach at Shian Bay first to check if it was clear of people before making an approach for a touch-and-go. Whilst descending towards the beach, he saw that it was clear and decided to perform the touch-and-go from this first approach. However, he forgot to lower the landing gear and, upon touching down, the aircraft slid along the beach before coming to a stop. The pilot was uninjured but the aircraft's fuselage, propeller and nose leg were damaged.

22 Apr 2021	**DH82A Tiger Moth**	**G-ANFM**	White Waltham Airfield, Berkshire

Whilst manoeuvring on the ground G-ANFM made contact with a parked aircraft. The wingtip fairing of the parked aircraft was damaged in the collision but there was no damage to the Tiger Moth.

27 Apr 2021	**Grif HX11/Eurofly Snake**	**G-CLJB**	Sutton Meadows Airfield, Cambridgeshire

Just before touchdown, the aircraft veered to the right slightly. On landing, the front wheel separated from the hub as the spokes failed and the aircraft toppled over to the left.

1 May 2021	**Pegasus Quik**	**G-CCGC**	East Fortune Airfield, East Lothian

The pilot decided to abort the takeoff because he believed the aircraft would not become airborne before the end of the runway. He was unable to stop in the remaining distance and the aircraft came to rest inverted after striking kerb stones and a fence.

Record-only investigations reviewed: May - June 2021 cont

5 May 2021 **Marquart MA5 Charger** **G-BVJX** City Airport & Heliport, Greater Manchester

The aircraft hit a bump on the grass runway shortly after touchdown, precipitating a suspension failure which allowed the mainwheels to fold back into the lower wing. Subsequent inspection found evidence of a previously undetected fatigue crack in the suspension support tubes. The owners of G-BVJX alerted the owner of the only other aircraft of this type in the UK to the potential for fatigue cracking in the support tubes.

6 May 2021 **Magni M24C** **G-IROX** Popham Airfield, Hampshire

After hitting a bump during takeoff the aircraft became nose high and moved to the left, the pilot abandoned the takeoff and closed the throttle, which tightened the left turn. The aircraft departed the runway where it struck another bump which caused it to roll on its right side.

7 May 2021 **Bellanca 8GCBC** **G-BGGD** Bidford Airfield, Warwickshire

During 'tailwheel differences training', the aircraft ballooned on landing and then touched down firmly. The left landing gear strut fractured close to the fuselage attachment, resulting in a ground loop and some further damage. A photograph of the fracture surface suggested there was a pre-existing crack before the strut failed, with marks indicating fatigue.

7 May 2021 **DA 42 M** **G-ZATG** Leeds Airport

The crew had briefed to conduct a practice EFATO followed by two asymmetric circuits as part of refresher training, with the first circuit being an overshoot and the second to land; the first circuit was completed successfully. However, because the airport was shortly to close, the crew elected to fly a tighter second circuit and omitted to lower the landing gear. Upon touching down, the aircraft slid along the runway before coming to a stop. The fuselage, nacelles and propellers sustained damage.

16 May 2021 **Rotorsport UK Calidus** **G-CGMD** RAF Mona, Isle of Anglesey

The pilot engaged the pre-rotator system but the rotor rpm did not increase when he advanced the engine throttle. With the engine at high power the brake lever was inadvertently released and the aircraft accelerated rapidly, causing a rearwards movement of the control column. The rotor struck the fin and the aircraft departed the runway, striking the airfield boundary fence. The pilot considered the cause of the accident to be his increasing engine power despite the pre-rotator system failing to increase the rotor rpm, combined with a lack of recent flying practice due to COVID-19 restrictions.

Record-only investigations reviewed: May - June 2021 cont

27 May 2021 **Mainair Blade 912** **G-CBOM** Graveley, Hertfordshire

After flying for 75 minutes in turbulent conditions, described by the pilot as "a heavy workload in a flex-wing", the pilot flew a normal approach and positioned the aircraft to land. However, after the initial flare, he reported encountering "unexpected significant sink" and, despite taking corrective action, the aircraft landed heavily and sustained substantial damage, including a fractured keel tube.

27 May 2021 **Cessna F172M** **G-BBOA** Beccles Airport, Suffolk

The aircraft was taxiing to a parking area after landing and the pilot chose to route between a row of parked aircraft and a parked microlight. Believing he was clear of the microlight, the pilot's attention became focussed on the row of parked aircraft, but the aircraft's wingtip struck the left wing strut on the microlight.

29 May 2021 **Cessna 150L** **G-OKED** City Airport & Heliport, Greater Manchester

The aircraft touched down to the left of the centre line when the student applied full power. The aircraft left the runway, going across the safeguarding area and the parallel runway before coming to a stop south of the taxiway.

29 May 2021 **Piper PA-28R-201T** **G-BMIV** Sandown Airport, Isle of Wight

G-BMIV was following an airport vehicle along a taxiway at low speed to a parking place. There were many parked aircraft on either side due to a flying event at the airfield. The wing leading edge of G-BMIV struck the aileron of a parked PA-28 aircraft.

30 May 2021 **EV-97 Team Eurostar UK** **G-KEJY** Darley Moor Airfield, Ashbourne, Derbyshire

Shortly before touchdown the aircraft encountered a strong crosswind and windshear. The aircraft was slow and touched down before the runway. The propeller and nose landing gear were damaged, and there were no reported injuries.

6 Jun 2021 **Piper PA-25-235** **G-LYND** Rufforth Airfield, York

The pilot reported that the tailspring of G-LYND snapped on the rollout from a normal landing, after encountering a medium-sized bump.

Record-only investigations reviewed: May - June 2021 cont

12 Jun 2021 **Rans S6-ESD XL (Modified)** **G-MZLL** Haxted Airfield, Surrey

After making an approach in variable wind conditions the aircraft descended steeply after passing over some trees close to the runway threshold. The aircraft became airborne after the initial touch-down and, after floating for a short distance, touched down and then became airborne again. When the aircraft touched down again the nose landing gear collapsed and the aircraft came to rest.

15 Jun 2021 **Tecnam P2008-JC** **G-RFCB** RAF Waddington, Lincolnshire

The aircraft bounced multiple times during landing. The student pilot, who was flying solo, attempted to go around. The aircraft landed on its nose gear which collapsed, causing the propeller to strike the runway. The nose gear, propeller and lower engine cowling were damaged, and there was a leak from the fuel tank in the right wing.

Miscellaneous

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

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

BULLETIN CORRECTION

Aircraft Type and Registration:	DJI Inspire 2 (UAS registration n/a)
Date & Time (UTC):	4 April 2021 at 1112 hrs
Location:	Covent Garden, London
Information Source:	Operator notification - Record Only

AAIB Bulletin No 7/2021, page 73 refers

Prior to publication it was noted that the text for the above Record Only report was incorrect.

The original text read:

> The UAS was on the ground in the resting position while the operator was looking at the screen. The UAS suddenly took off and flew into a nearby building before falling to the ground.

This has now been amended to read:

> The UAS was in a stable hover while the operator was looking at the screen. The UAS suddenly flew into a nearby building before falling to the ground.

The online report was corrected on 8 July 2021.

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

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

Published July 2015.

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

Published August 2015.

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

Published October 2015.

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

Published March 2016.

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

Published September 2016.

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

Published March 2017.

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

Published March 2018.

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

Published November 2018.

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

Published March 2020.

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

Published May 2021.

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

http://www.aaib.gov.uk

GLOSSARY OF ABBREVIATIONS

aal	above airfield level
ACAS	Airborne Collision Avoidance System
ACARS	Automatic Communications And Reporting System
ADF	Automatic Direction Finding equipment
AFIS(O)	Aerodrome Flight Information Service (Officer)
agl	above ground level
AIC	Aeronautical Information Circular
amsl	above mean sea level
AOM	Aerodrome Operating Minima
APU	Auxiliary Power Unit
ASI	airspeed indicator
ATC(C)(O)	Air Traffic Control (Centre)(Officer)
ATIS	Automatic Terminal Information Service
ATPL	Airline Transport Pilot's Licence
BMAA	British Microlight Aircraft Association
BGA	British Gliding Association
BBAC	British Balloon and Airship Club
BHPA	British Hang Gliding & Paragliding Association
CAA	Civil Aviation Authority
CAVOK	Ceiling And Visibility OK (for VFR flight)
CAS	calibrated airspeed
cc	cubic centimetres
CG	Centre of Gravity
cm	centimetre(s)
CPL	Commercial Pilot's Licence
°C,F,M,T	Celsius, Fahrenheit, magnetic, true
CVR	Cockpit Voice Recorder
DFDR	Digital Flight Data Recorder
DME	Distance Measuring Equipment
EAS	equivalent airspeed
EASA	European Union Aviation Safety Agency
ECAM	Electronic Centralised Aircraft Monitoring
EGPWS	Enhanced GPWS
EGT	Exhaust Gas Temperature
EICAS	Engine Indication and Crew Alerting System
EPR	Engine Pressure Ratio
ETA	Estimated Time of Arrival
ETD	Estimated Time of Departure
FAA	Federal Aviation Administration (USA)
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

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