ACCIDENT

Aircraft Type and Registration:	Guimbal Cabri G2, G-CJEK	
No & Type of Engines:	1 Lycoming O-360-J2A piston engine	
Year of Manufacture:	2016 (Serial no: 1151)	
Date & Time (UTC):	20 June 2022 at 1059 hrs	
Location:	Near Burton in Lonsdale, North Yorkshire	
Type of Flight:	Private	
Persons on Board:	Crew - 1	Passengers - 1
Injuries:	Crew - 1 (Fatal)	Passengers - 1 (Fatal)
Nature of Damage:	Helicopter destroyed	
Commander's Licence:	Private Pilot's Licence (Helicopter)	
Commander's Age:	66 years	
Commander's Flying Experience:	Approximately 538 hours (of which approximately 258 were on type) Last 90 days – Not available Last 28 days – Not available	
Information Source:	AAIB Field Investigation	

Synopsis

The aircraft departed a private site with the intention of flying a local experience flight. As the helicopter returned to land at the departure point, it made a left turn away from the landing site and began a shallow climb. It began to yaw to the left, initially with a normal attitude before the nose dropped. The helicopter continued to yaw to the left, the nose dropped further and it rapidly descended into a tree. There was an intense post-crash fire. Both occupants were fatally injured. Due to the damage sustained and lack of available evidence, the investigation was not able to reach a definitive conclusion, but a number of possible causes have been identified.

History of the flight

The flight departed a private site at approximately 0930 hrs with the pilot, who owned the helicopter, and one passenger on board. The purpose of the flight was for the passenger to experience his first helicopter flight.

The helicopter departed initially on a westerly track then routed around the Lake District (Figure 1), before returning to the landing site approximately 1 hour and 20 minutes later. The pilot did not report any problems during his routine interactions with ATC throughout the flight.

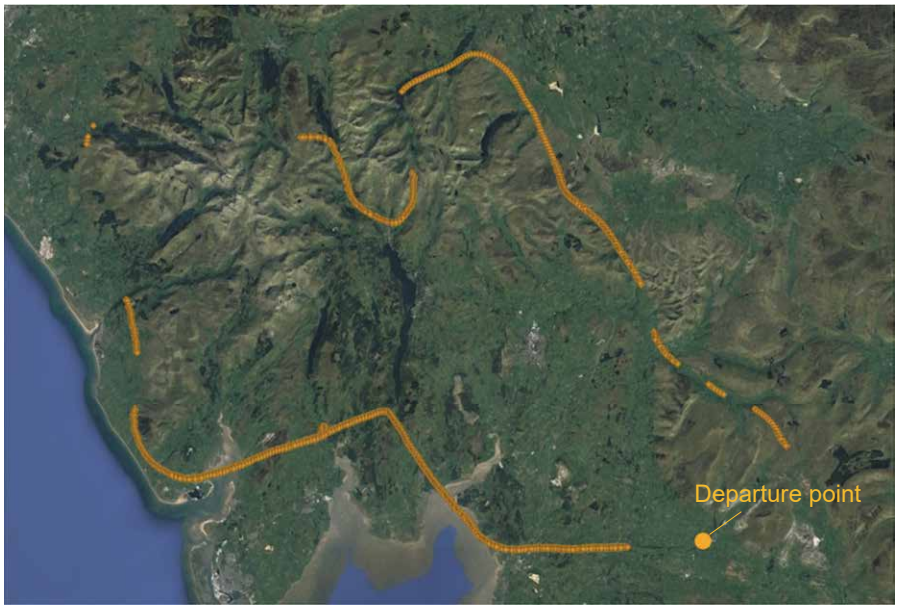

Figure 1

Radar track of route flown

Several witnesses saw the helicopter approaching the landing site and described it flying along the river Greta in a westerly direction. Some witnesses, who lived locally and were familiar with the helicopter landing nearby, stated that the initial approach appeared "normal" and similar to what they had observed on previous occasions.

There was limited closed-circuit television (CCTV) recorded from a nearby farmhouse which captured short periods of the helicopter's flight path prior to the accident. It showed the helicopter initially flying in a westerly direction (Figure 2) before it began what appeared to be a controlled left turn. The helicopter then continued heading approximately south, with decreasing groundspeed and climbed from an approximate height of 70 ft before the turn to about 130 ft when it went out of view of the CCTV.

Although not captured on the CCTV, the helicopter subsequently entered what was described by witnesses as an uncontrolled yaw to the left, initially maintaining altitude before the nose dropped. A witness working close to the accident site described hearing what sounded like a "bang or a pop", before looking up to see the helicopter in a nose-down attitude, descending toward the ground. The CCTV momentarily captured the helicopter descending in a nose-down attitude whilst rotating to the left, before it struck trees.

Witnesses heard the impact, and some attended the scene in an effort to assist the occupants, although they were unable to access the wreckage due to its location. They reported hearing the engine continue to run for approximately 5 minutes after the impact and, once the engine stopped running, the wreckage caught fire. The fire service attended the scene 39 minutes[1] after a call was made by a witness to the emergency services.

Footnote

[1] As recorded on the fire service Incident Report.

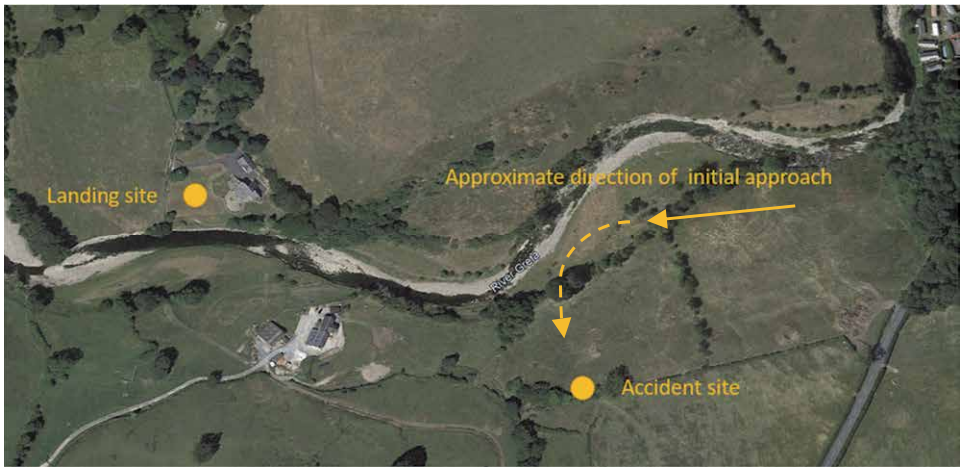

Figure 2

Approximate direction of initial approach

Accident site

The accident site was in a small tree-lined gully within a livestock field, approximately 100 m south of the river Greta and 250 m west of Bentham Road, near Ingleton, North Yorkshire. Witnesses who initially arrived at the scene recalled that the helicopter was suspended in a hawthorn tree, with the engine running. However, after a short period of time, a fire broke out and the helicopter then fell to the ground.

The helicopter fuselage had been destroyed by fire, but it was evident that it had come to rest with the helicopter's nose vertically downwards with the main rotor gearbox to the north, on top of the gully, and the helicopter landing gear to the south, at the bottom of the gully. The pilot's and passenger's bodies lay within the wreckage, underneath the engine. Both of their harness buckles were found to have been correctly fastened.

The main rotor blades all exhibited evidence of having struck the trees with some energy with their fragments surrounding the accident site, and some fragments up to 50 m from the main wreckage. Damage to the trees in the location of the main wreckage suggested that the helicopter entered the trees almost vertically.

The main rotor blades also remained on the top of the gully. Two of the blades and the root of the third blade had been completely consumed by fire, the remainder of the third blade was misshapen with evidence of entanglement with the trees. The main rotor gearbox casing had partially melted exposing its internal gears. These gears were intact and showed no evidence of distress. The blade pitch control links were destroyed by the fire.

The engine was positioned above the rest of the helicopter wreckage, with its front vertically downward and remained in its support frame. The engine output pulley, rotor system input drive pulley, the associated tensioning system and the drive belt had been destroyed in the fire.

The tail rotor had come to rest in the bottom of the gulley. An arc of approximately 180° of the tail rotor structure was fire-damaged. All the tail rotor blades were present and showed no sign of leading edge damage. Drive from the tail rotor drive shaft to the tail rotor, through the tail rotor gearbox, was confirmed. The tail rotor drive shaft had fractured adjacent to the rear firewall bearing and the forward section of the drive shaft was found in the wreckage.

Continuity of the tail rotor pitch control was confirmed from the forward end of the yaw push/pull control cable located in the cockpit to the blades but, due to the fire damage it was not possible to confirm whether the cable was attached to the yaw control pedals.

The helicopter was fitted with dual cockpit controls. The cyclic and collective levers were found within the wreckage, but the fire had melted the aluminium control rods and mixer unit that translate the pilots' control inputs into pitch changes on the main rotor blades, making it impossible to confirm control continuity.

Recorded information

CCTV recordings

CCTV recordings were available from a farmhouse, nearby to the accident site, and are referenced earlier in this report. Three cameras captured G-CJEK's approach – one on the eastern elevation of the farmhouse facing approximately north-east and two other cameras, which were situated on the same outbuilding, that looked towards the western elevation of the farmhouse. No audio was recorded, but some 12 seconds of continuous footage was captured before G-CJEK initially left the cameras' field of view. G-CJEK then briefly re-entered the view from the outbuilding and, approximately 10 seconds later, the same camera shows G-CJEK descending rapidly whilst rotating to the left. The impact with the tree is then captured by the other outbuilding camera.

Photogrammetry

The AAIB undertook a photogrammetry[2] analysis of the CCTV recordings using commercially available software. This established that G-CJEK approached the farmhouse and commenced a left turn, climbing as it turned from a height of approximately 70 ft agl to about 130 ft agl. It was not possible to reliably quantify G-CJEK's groundspeed due to visual artefacts associated with the file compression used on the CCTV recordings, and distortion at the extremities of the CCTV frames.

Flight recorders

G-CJEK was not fitted with a crash-protected flight recorder, nor was it required to be. Later Guimbal Cabri G2's, from serial number 1260[3] onwards, are equipped with a data logger that records, at up to 10 samples a second, time-stamped engine, rotor speed,

Footnote

[2] Photogrammetry is the science of gathering measurements and data about an object by analysing the change in position of the object across a series of recorded images.

[3] G-CJEK was serial number 1151 and was not equipped with a data logger.

pedal position, engine governor and GPS data, amongst other parameters. However, these loggers are not crash-protected and, in three out of four cases after an incident, when the manufacturer has attempted to download the logger, data recovery has not been possible.

Radar and RTF

Radar coverage was lost, due to terrain masking, nine miles to the north-east of the accident site, but was used to confirm the approximate duration of G-CJEK's flight and is shown in Figure 1. RTF recordings were made available to the AAIB, and all communications were routine.

Aircraft information

The Guimbal Cabri G2 is a light two-seat helicopter powered by a Lycoming O-360-J2A piston engine. The engine transmits the drive to the three-bladed main rotor via a belt and pulley mounted on the main gearbox input shaft. The input shaft couples with the tail rotor drive shaft, which in turn drives the shrouded seven-blade tail rotor.

The airframe is composed of three sections: main fuselage, engine section, and tail boom. The main fuselage is a carbon-fibre reinforced monocoque, constructed in five parts. In the cabin there are two side-by-side seats, with the pilot occupying the right position. G-CJEK was equipped with flying controls at both seats. The main fuselage also includes a central structure, baggage compartment and fuel tank. The engine section is isolated from the cabin by a firewall with the engine supported on a tubular steel frame. The composite tail boom incorporates a Fenestron tail rotor, vertical fin and a horizontal stabilizer.

The engine is mounted to the rear of the passenger compartment and drives a pulley at the front of the engine. A belt transmits the drive from the engine pulley to the main input drive of the rotor system via a pulley and freewheel coupling. A clutch mechanism is used to engage the drive from the engine to the rotor system. This is achieved by pivoting the engine about its rear mounts; an actuator lowers the front of the engine which tensions the belt, allowing drive to be transmitted to the rotor system. When the clutch is disengaged, the actuator retracts, lifting the output pulley and disengages the drive.

The main rotor rotates clockwise when looking from above. In the event of an engine failure, the helicopter would tend to yaw to the right. In the event of a loss of tail rotor drive, the helicopter would tend to yaw to the left.

G-CJEK was built in 2016 and had been owned by the pilot from new. It had been regularly maintained in accordance with the rotorcraft maintenance manual. The last recorded maintenance was a 15-hour airframe and a 50-hour / 4-month engine inspection in April 2022. At that time the helicopter and engine had accrued 222.8 hours. The helicopter and engine logbooks were held by the maintenance organisation, but the technical logs for the flights since the last maintenance had been carried in the helicopter at the time of the accident and were extensively damaged in the fire. As a result, accurate total hours for the airframe or engine could not be determined, nor whether there had been any technical

issues noted in that period, but it was possible to identify that the helicopter had flown eight times since the last maintenance.

G-CJEK's Certificate of Registration and Airworthiness Review Certificate were valid at the time of the accident.

Aircraft examination

The wreckage was recovered to the AAIB facility in Farnborough for further examination.

The fractured tail rotor driveshaft was found to have failed in torsional overload in combination with bending. The fracture had occurred where it passed through the rear fire wall. The characteristics of the fracture indicated that, in combination with the tail boom deflecting, the forward end of the drive shaft had stopped whilst the rear was still rotating.

The engine's external components had been extensively fire-damaged, it was therefore not possible to determine the condition of the ignition, carburation or fuel supply systems. Internally, the engine components looked normal, with no indication that the engine was underperforming.

The extensive damage caused by the intense post-accident fire prevented any further assessment of the helicopter.

Weight and balance

It was not possible to establish with certainty what fuel load was on board the helicopter when it departed. However, the investigation considered two scenarios; a full fuel load and the minimum fuel required to fly for the helicopter's actual airborne time.

If the helicopter had departed with a full fuel tank, it is probable that it would have taken off above its maximum takeoff weight but with the centre of gravity within limits. In both scenarios, the helicopter would have arrived at the landing site within the flight manual's stated weight and balance limits.

Aircraft performance

Manufacturer Service Letters

The manufacturer describes a Service Letter's (SL) as documents published for helicopter operators specifically regarding the operation of the aircraft. There is no process to ensure operators have read or acknowledged the publication or contents of a SL.

By comparison, the manufacturer described a Service Bulletin (SB) as a document intended for the helicopter maintenance provider, usually to implement a modification or prescribe a verification. SB's are specific to the maintenance and continuous airworthiness of the aircraft and fall into 'optional', 'recommended' or 'mandatory' categories.

SL 12-001 - Yaw control in approach

This SL, published in 2012, aimed to address handling characteristics which are unique to helicopters with Fenestron-equipped tail rotors. It cites two incidents during which the pilots, who did not have previous experience flying a helicopter with a Fenestron tail rotor, lost control of the helicopter in yaw. Neither accident resulted in fatalities.

SL 12-001 states the Cabri G2 is immune to stall and to what is commonly referred to as 'loss of tail rotor effectiveness' (LTE). It highlights the need for pilots to use a much greater pedal input for a given tail rotor thrust than that which would be required in helicopters with a conventional tail rotor (Figure 3) and the need for pilots to react to uncommanded yaw without delay.

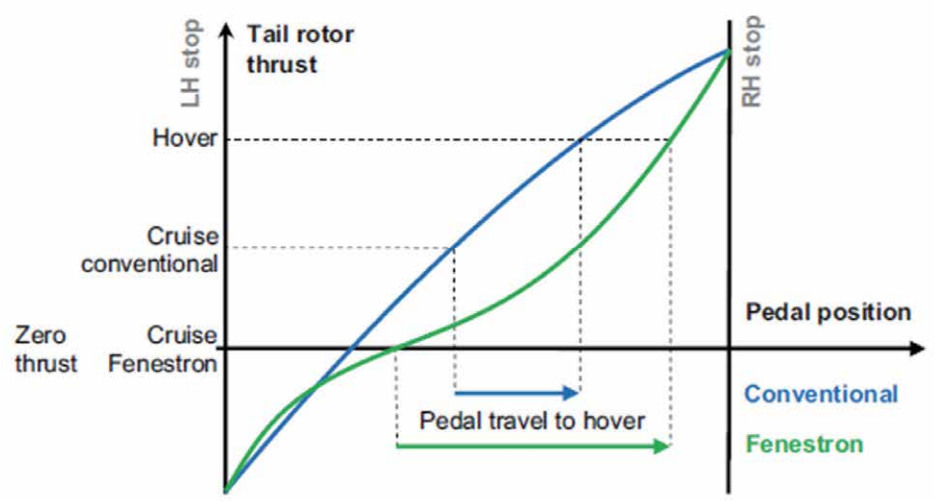

Figure 3

Comparison of thrust curves for
identical performance tail rotors Conventional/Fenestron

The SL states pilots with most experience on helicopters with anti-clockwise rotating rotors are a *'significant aggravating factor'* in loss of control in yaw events, as '*the pilot is used to apply [sic] left pedal rather than right, regardless how good his training was, thus accelerating yaw motion rather than stopping it*'.

The SL concludes with the following advice:

> '***Advice 1***: *Never wait to correct a sideslip – and particularly to the left – when approaching for a standard landing (30 – 60 kt approach). Use adequate pedal without any hesitation. If there is a known cross wind, and particularly from the right hand, pay even more attention to keep the helicopter centreline aligned with the path and be prepared to large pedals input.*
>
> ***Advice 2:* *Never hesitate to apply full right pedal*** *to correct a yawing to the left before it gets faster. Keep the pedal to the stop, until the rotation stops completely.*

> ***Advice 3:*** *When practicing spot-turns at low height above the ground, always do it* ***"on the power pedal"*** *– to the right in the Cabri G2 case. Then raising the collective in case of problem will stop the spin.*
> ……..'

SL 19-002 – Controllability in yaw at low rotor speed

This SL was published in 2019 following an AAIB investigation[4]. It was published in order to:

- *'• clarify the tail rotor behaviour at low RPM,*
- *illustrate associated risks,*
- *provide recommendations to avoid such situations.'*

It states that, although the main rotor is capable of producing lift below 450 rpm, below this figure full right pedal will not produce sufficient anti-torque thrust, and the helicopter will begin to spin uncontrollably to the left. Should this occur close to the ground, the pilot's instinct may be to raise the collective, which will lower the rotor speed more and thus increase the rate of left spin.

The SL summarises its content with the following recommendations:

> *'Low rotor speed situations can always be avoided by taking adequate precautionary measures.*
>
> *Nonetheless, in case of a low rotor speed, if full right pedal is applied, or is close to being applied, the following recommendations must be used;*
>
> ***Do not raise the collective****, it would aggravate the situation,*
>
> ***Lower the collective as much as possible;***
>
> - *If height is sufficient, increase airspeed using forward cyclic input,*
> - *If height is low, manage the contact with the ground,*
>
> ***Do not try to increase the rotor speed by turning the twist grip,*** *it can only aggravate the situation.*
>
> *Overall, always consider that excessive right pedal input cannot hurt.'*

Footnote

[4] AAIB Accident Report G-PERH, available at Guimbai_Cabri_G2_G-PERH_Correction_09-21 [accessed on 22 March 2023].

Meteorology

The forecast for the area was for benign conditions with clear skies and a light north-westerly wind. An assessment of the reported conditions conducted by the Met Office for the AAIB investigation described the conditions as '*generally settled with good visibility and little or no significant cloud*.' The recorded wind at 1050 hrs at Blackpool Airport, located 29 nm from the accident site, was from 310° at 8 kt.

Personnel

The pilot held a valid licence and medical. The pilot first obtained his PPL (H) in 2001 and flew Robinson R22 and R44 helicopters until 2016, when he purchased the Cabri G2. His logbook was onboard the helicopter when the accident occurred and therefore his total hours could not be confirmed. However, his declared total time on an application form submitted to the regulator in May 2022 was 538 hours.

Post-mortem reports

The pilot's post-mortem report recorded the cause of death as '*unascertained*'. It identified evidence of risk factors, such as coronary disease, which may have caused the pilot to become incapacitated but there was no evidence of an acute medical event which would have certainly caused the pilot to be unable to control the helicopter. An aeromedical expert commented that, based on the evidence, it was possible that '*a complete or partial incapacitation could* [have] *occur*[ed] *suddenly'.*

The passenger's post-mortem report established the cause of death was blunt head injury resulting from the initial impact before the post-accident fire.

Analysis

Analysis of all the evidence available was inconclusive and so the investigation considered a number of scenarios which may have led to this accident. Mechanical failure, helicopter handling, inadvertent control input/restriction and pilot incapacitation are discussed further below.

Mechanical failure

At the time of the accident G-CJEK had a valid Airworthiness Review Certificate and was correctly registered. The helicopter was well maintained and had no outstanding technical issues at the time of its last service, nor reported defects during the flight. The helicopter was within weight and balance limits.

Except of fragments of the main rotor blades (which were located around the accident site), all the helicopter wreckage was in a confined area, indicating that the helicopter was intact when it struck the tree. The main rotor blade fragmentation showed that the main rotor had energy at that time. This is also corroborated by the fractured tail rotor drive shaft, which failed at the time the helicopter struck the trees and confirmed that the engine was providing power to the rotor system.

Witnesses observed that the helicopter departed from controlled flight whilst in a progressively tightening left turn. When considering technical issues that could induce a left turn, a tail rotor drive or pitch control issue were the most likely causes. Examination of the wreckage found no evidence of loss of tail rotor drive or discontinuity of the pitch control system before the accident. Due to the extensive fire which resulted in most of the aluminium components being destroyed, full continuity of the yaw control system could not be established, therefore the investigation could not completely rule out a mechanical issue.

Cabri G2 Handling characteristics

The manufacturer's SLs and previous events indicate a recurrent theme of a loss of controllability in yaw for Cabri G2 helicopters. In the absence of evidence to the contrary, pilot handling or undesirable environmental conditions leading to a loss of control, as described in the SLs, could not be ruled out.

The pilot could have found himself in conditions described in '*typical situations'* in SL 12-001 and that he did not react with either:

- sufficient right pedal or,
- a timely input or,
- maintain input for sufficient time.

However, the pilot did not fit the profile of those most likely to be unaware of the unique characteristics of a Fenestron tail rotor. He was not a student or low hours helicopter pilot, he had 20 years of experience, and he did not routinely fly another helicopter type with an anti-clockwise rotating main rotor. As a consequence, his instinctive pedal input would likely have been the correct one. Approximately half of his total flying experience was on the Cabri G2 and he was operating in a familiar environment.

Alternatively, in the scenario outlined in SL 19-002, it cannot be discounted that the helicopter may have made the approach with low rotor rpm, to which the pilot did not apply the appropriate response outlined in the SL and, as a consequence, the helicopter departed controlled flight.

Although these scenarios and risks identified in the manufacturer SLs 12-001 and 19-002 cannot be ruled out, the pilot's experience and the circumstances of the accident, reduce the likelihood.

Inadvertent control input/restriction

The left seat dual controls were found within the wreckage and confirmed to have been connected. Based on the available evidence, the possibility of an inadvertent passenger input on fitted dual controls could not be ruled out as a potential explanation for the departure of the helicopter from controlled flight.

Medical incapacitation

Based on the results of the pilot's post-mortem report, and in the absence of conclusive evidence which explains the loss of control of the helicopter, the investigation concluded that medical incapacitation of the pilot could not be ruled out.

Conclusion

The evidence recovered in this investigation was not sufficient to determine the cause of the accident. Based on the evidence available, the investigation concluded the cause was likely to be one or more of the following factors; a mechanical failure, an incorrect pilot response to unexpected environmental conditions, an inadvertent passenger input or restriction on the controls, or pilot partial or complete medical incapacitation.

Published: 1 June 2023.