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SAFETY INVESTIGATION REPORT

Accident to the Guimbal — CABRI — G2 registered **F-HOLA** on 12 May 2022 at Aix-les-Milles (Bouches-du-Rhône)

Time	Around 12:00[1]
Operator	École de pilotage AIX HELI PRO
Type of flight	Instruction
Persons on board	Student-pilot
Consequences and damage	Helicopter substantially damaged
This is a courtesy translation by the BEA of the Final Report on the Safety Investigation. As accurate as the translation may be, the original text in French is the work of reference.	

Loss of yaw control while hover taxiing, hard contact with the ground, in solo instruction

1 HISTORY OF THE FLIGHT

Note: the following information is principally based on statements, radio communication recordings and radar data.

After making two runway circuits in dual flight with an instructor for runway 32, the student-pilot took off again at 11:25 for a solo local flight. Back in the aerodrome traffic after 32 minutes of flight, he joined the right-hand downwind leg for runway 14, at the request of the controller, who told him that runway 14 had just come into use. He was then cleared to land, and the controller stated that there was a 200° wind of 5 to 10 kt.

After a near hover at a height of between three and four metres, the student pilot started hover taxiing over the runway, at a height of between two and five metres. As he was about to turn left to clear the runway at taxiway A, he lost control of the helicopter, which made two or three complete rotations about its yaw axis to the left. The student pilot then lowered the collective pitch control. The helicopter made contact with the ground and bounced before falling back hard and flat onto the runway. On impact, the skids sagged on either side of the fuselage and the helicopter came to a stop on its belly on the runway at taxiway A (see **Figure** 1)

[1] Except where otherwise indicated, the times in this report are in local time.

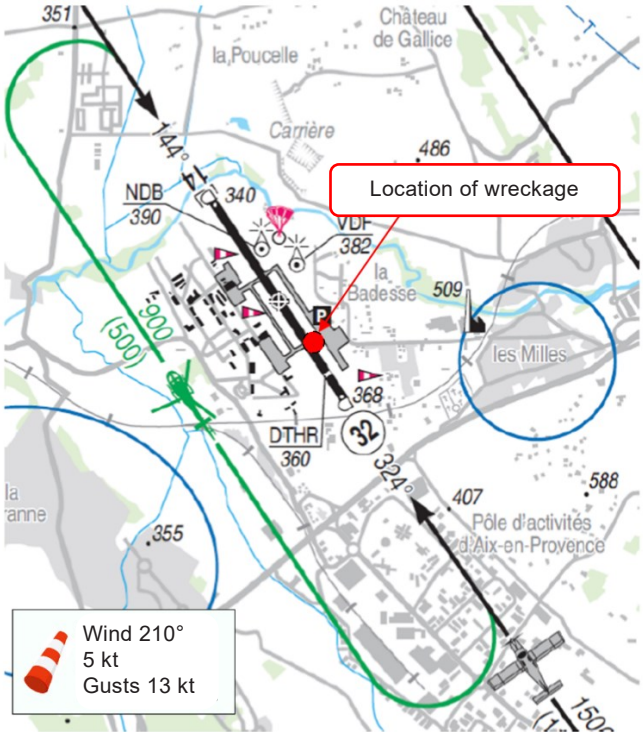

Figure 1: accident site (Source: AIS)

2 ADDITIONAL INFORMATION

2.1 Examination of site and wreckage

The helicopter came to a stop at the junction of the runway and taxiway A. The landing gear rear arch (crosswise) separated from the skids (lengthwise), and the helicopter was lying on the lower section of the fuselage, damaged as a result of the compression of the landing gear. The tail skid and the lower part of the Fenestron were folded 90° to the left. Several blades of the Fenestron were damaged and friction marks from the tail rotor (T/R) blades were visible inside the Fenestron skin structure, at the bottom. Examination of the helicopter showed that all of the damage resulted from the accident (see **Figure 2**).

Figure 2: photograph of the aircraft after the accident[2] (Source: BEA)

[2] The doors were removed by those first on the scene immediately after the accident.

The flight control linkages were continuous at the time of the accident. The transmission linkages between the main gearbox (MGB) and the engine and between the MGB and the tail gearbox (TGB) did not show any anomalies. The throttle/mixture control travel test was nominal. Test bench examination of the engine governor did not reveal any operating anomalies.

2.2 Meteorological information

There are no METAR reports and TAFs for Aix-les-Milles aerodrome. The closest weather reports and forecasts available are those from Marseille-Marignane airport, located 14 km away, which indicated, from 11:30 onwards, good visibility (CAVOK) and a 200° wind of 9 kt, varying in direction between 160° and 230°.

- METAR LFML 121030Z AUTO 21010KT CAVOK 24/13 Q1023 NOSIG=
- METAR LFML 121000Z AUTO 21009KT CAVOK 24/12 Q1023 NOSIG=
- METAR LFML 120930Z AUTO 20009KT 160V230 CAVOK 24/11 Q1023 NOSIG=
- TAF LFML 120800Z 1209/1315 20010KT CAVOK TX27/1314Z TN13/1304Z BECMG 1218/1220 VRB03KT=

The following information was provided by the ATIS for Aix-les-Milles:

Applicable information	Recording time	Runway in service	Wind	Visibility	Temperature
Information B	09:50	32	Calm wind at ground level	10 km	+20 °C
Information C	11:50	14	210° wind of 5 to 10 kt	10 km	+24 °C

Figure 3: information provided by the ATIS

The student stated that, before leaving for flight with the instructor, he consulted the meteorological information provided by the ATIS, and did not consult the SIGWX chart nor the METAR reports and TAF forecast from nearby aerodromes.

The instructor explained that she checked the weather conditions using the Windy website before the student's solo departure.

The read-out of the frequency recordings at the aerodrome's control tower showed that during the two previous runway circuits performed in dual flight, the controller indicated a 200° wind of 6 kt, then 5 kt.

The weather conditions estimated by Météo-France at the time of the accident (12:00) were as follows: 210° wind of 5 kt with gusts up to 13 kt (at a height of 10 m), possible low turbulence at ground level.

The analysis of the data found that the student pilot performed the final approach and hover with a 70° crosswind from the right.

2.3 Helicopter information

The Guimbal Cabri G2 is a light two-seater helicopter equipped with a piston engine delivering 160 hp. It has a main rotor which rotates clockwise and a shrouded tail rotor called "Fenestron". In accordance with Service Letter SL 12-001 A, "Yaw Control in Approach" (see para. 2.4.4), Guimbal demonstrated the Fenestron manoeuvrability with a wind of more than 40 kt in all directions.

The helicopter was equipped with a Multi-Purpose Display (MPD). This computer particularly records specific flight parameters on an SD card. No data from the day of the accident was recorded on the SD card due to a software problem.

Inspection of the fuel and lubrication systems did not reveal any anomalies.

The detailed examination of the cylinders did not reveal any anomalies. The operation of spark plugs[3] was tested as part of an engine test bench examination. This test revealed nominal operation of the spark plugs. However, a visual inspection of the latter found that the ceramic section of two of the four upper spark plugs was cracked. The two cracked spark plugs were then fitted to the engine of another Cabri G2, and a ground test was performed under static conditions with engine running at a specific speed (2,000 rpm). The drop in revolutions observed during the magneto selection proved to be normal. However, no flight test was carried out.

2.4 Cabri G2 yaw control training

2.4.1 Operational Suitability Data[4]

The OSD for Flight Crew, a document approved by the European Aviation Safety Agency (EASA), defines the minimum programme for the Guimbal CABRI G type rating and TASE[5] for the type. It specifies that special attention must be paid to yaw control in approach, during the transition from forward flight to hover, in particular if the pilot is used to flying helicopters equipped with conventional tail rotors (without a Fenestron); The programme indicates that Service Letter SL 12-001 A (see para. 2.4.4) must be studied in detail and that instructors should demonstrate the different amounts of deflection required on rudder pedals depending on the wind. It is not specified whether this must be done before pilots are signed off for their first solo flight.

2.4.2 DTO's[6] training programme

The DTO's theoretical and practical training programme in force at the time of the accident indicated that theoretical training could be provided by several instructors and trainers. The main instructor[7] had to check that the trainee was diligent and progressed well.

The PPL(H) theoretical and practical training is included in the students' training progress log. A trainee attendance sheet, included in the log, is used to monitor students' theoretical training. The instructor or trainer in charge of a course must record the date, his name or trigram and his signature in order to confirm that training has been provided to the trainee.

[3] The ignition system is powered by eight spark plugs. A "PLASMA II" electronic ignition system (approved by Supplemental Type Certificate (STC) no. 1015311 REV 3) supplies power to the four upper spark plugs (model NGK BR8ECM), and a single magneto supplies power to the four lower spark plugs.

[4] Operational Suitability Data (OSD) is a requirement in certification mandating that aircraft manufacturers to submit EASA data it considers important for safe operations. The OSD notably contains pilot training programme requirements.

[5] Training Areas of Special Emphasis.

[6] Declared Training Organisation.

[7] Instructor mainly in charge of the trainee who is placed under the authority of the training manager.

Prior to the first solo flight, the theoretical programme included studying "loss of tail rotor effectiveness" in the form of a theoretical ground training course with one or more student-pilots, lasting between 30 minutes and 2 hours. This course included a presentation of Guimbal's Service Letters and a presentation of tail fin stall depending on the wind.

The student-pilot remembered attending a specific one-hour theoretical module on the specific characteristics of the Fenestron. According to the training manager, the student-pilot attended all the briefings, in particular this specific module based on the SL 12-001 A. As for the instructor, she stated that the specific briefings regarding the Guimbal Service Letter were not formally presented to the student-pilot and that the topic was addressed verbally throughout the training period.

The practical dual-control teaching programme associated with this theoretical module did not include the "loss of tail rotor effectiveness in hover" item. After the first solo flight, it included the following items:

- sideways and backwards hover manoeuvres, particularly in crosswind conditions;
- spot turns.

The training manager and the instructor specified that the training manager demonstrated to the student in flight what tail fin stall was and how to counter a departure in yaw to the left. The training manager was responsible for carrying out the assessment flight with the students before the first solo flight and for carrying out the loss-of-control recovery exercises with them during the training.

Another Cabri student-pilot who attended the training at the DTO stated that during the training, student-pilots were made highly aware of the Fenestron and the loss of tail fin lift on the Cabri depending on the wind. He received theoretical information regarding the Fenestron and yaw control, based on the Cabri G2 flight manual.

He explained that he practised departure in rotation with the training manager, who showed him how to recover yaw control. During these exercises, the training manager was at the controls and the student accompanied him, resting his hands on the controls.

2.4.3 Guimbal Instructor Factory Training (IFT)

Since 2020, Guimbal, the aircraft manufacturer, has been offering IFT, a theoretical and practical training course for instructors with the Cabri G2 rating. This training aims to improve their knowledge of the helicopter, its systems and emergency procedures. One of the training modules is dedicated to the Fenestron and yaw control, reiterating the explanations and flight recommendations published in the Service Letters. In particular, Guimbal recommends that pilots:

- press the right-hand rudder pedal down fully without hesitation. Guimbal specifies that as long as the rotation speed of the main rotor is in the normal speed range, pressing the rudder pedal down fully will stop the rotation;
- remain vigilant when the wind is blowing from the right during approach;
- anticipate the increase in power and the potential resulting loss in tail fin effectiveness, without ever allowing the nose to move to the left.

2.4.4 Guimbal's Service Letter SL 12-001 A, "Yaw Control in Approach"

The document issued by Guimbal indicates that compared to conventional tail rotors equipping most small helicopters, the Cabri G2 Fenestron features a higher disk loading and a shroud giving it a high thrust capability, but with a different Pedal position / Tail rotor thrust curve to that of a conventional tail rotor (see **Figure 4**). Moreover, the tail rotor thrust is null when the left pedal is about 3 cm forward (6 cm between the two pedals).

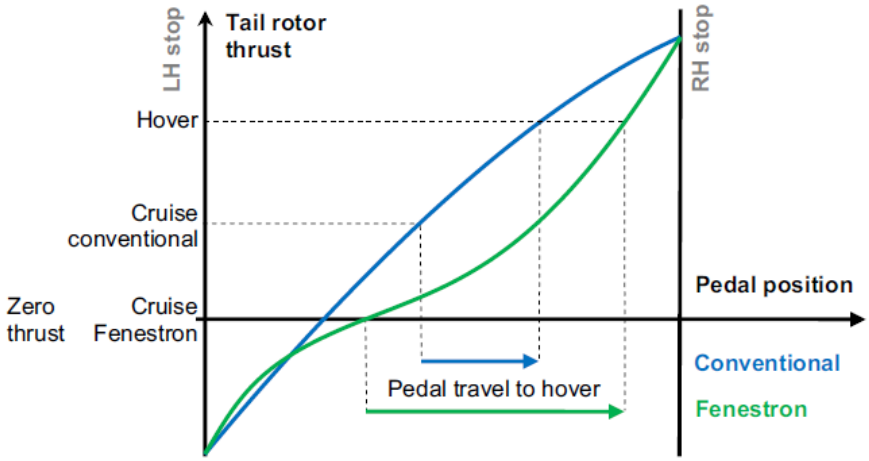

Figure 4: comparison of thrust curves for identical performance Conventional vs Fenestron tail rotors (Source: Guimbal)

The document warns pilots of the importance of remaining vigilant during the reduction of speed. It states that if the pilot does not keep sideslip to zero, the reduction of airspeed causes the tail fin to increase its angle of attack to maintain the torque / antitorque balance. If the pilot fails to react, the helicopter nose moves to the left progressively.

The document also specifies that a significant aggravating factor is crosswind coming from the right and that the yawing to the left and corresponding sideslip can be hidden to the pilot. Moreover, during the speed reduction and "*Then during the flare, the pilot faces in a few seconds, and simultaneously:*

- *A rapid increase in main rotor power, thus in the requirement for antitorque thrust*,
- *A rapid decrease in the tail fin lift […]*"

which "*tend to provoke a departure in yaw to the left, requiring a quick and large right pedal input.*"

If the input on the rudder pedal is insufficient, or if the pilot is slow to react, the helicopter will experience additional leftward acceleration, comparable to a jibe effect[8], as the Fenestron passes through the wind. This effect is accentuated on a helicopter equipped with a Fenestron due to the size and shape of the tail fin. If the pilot raises the collective pitch lever, for example to get away from the ground, the rapid increase in power can result in a drop in main rotor speed and, consequently, a reduced tail rotor thrust and an increased yaw rate.

[8] Term used in marine navigation to describe a change in the position of the sails in relation to the wind. The wind coming from one side suddenly shifts to the other side from behind during the manoeuvre.

SL 12-001 A recommends that pilots act as follows:

- never wait to correct a sideslip, in particular to the left, and use adequate pedal input without any hesitation. If there is a known crosswind, in particular from the right, pay attention to keep the helicopter centreline aligned with the approach path and be prepared to large pedals input;
- never hesitate to apply full pedal to correct the yaw rate before it increases. Keep the pedal on its stop, until the yaw movement stops completely;
- when practising spot-turns[9] at low height, always do it "on the power pedal" to the right in the case of the Cabri G2. Raising the collective lever in the event of a problem will stop the yaw movement.

Questioned during the investigation by the BEA about the content of this document, Guimbal, explained that a distinction had to be made between:

- **an unanticipated and uncontrolled departure in yaw**, for which the manufacturer recommends reacting immediately by applying full right-hand pedal until yaw rate ceases;
- **a moderate departure in yaw to the left** (typically while maintaining power after losing lift on approach), to which pilots must react by applying adequate pressure on the rudder pedals.

EASA indicated that there is no obligation to insert a Service Letter in the flight manual or in a supplement to the flight manual. However, Guimbal attaches Service Letters to the flight manual for new helicopters in the unnumbered section entitled "Safety Tips".

According to the training manager of the training organisation, the flight manual for F-HOLA was directly updated by Guimbal on a regular basis and, at the time of the accident, the Service Letters (in particular SL 12-001 A) were present in the last section of the manual.

2.5 Pilot and instructor information

2.5.1 Student-pilot

The 42-year-old student-pilot was undergoing practical training to obtain his Private Pilot Licence - Helicopters (PPL(H)). He started this training in June 2021 at the DTO. Moreover, he held no aeronautical licences. He had logged 48 flight hours, including 44 hours on the CABRI G2, 3 hours on the ROBINSON R44 and 1 hour on the EC120 COLIBRI aircraft. This was his fifth solo flight since he was signed off for solo local flights in January 2022. During his training, he was monitored almost exclusively by the instructor and the training manager. He completed three theoretical modules and made three flights with a third instructor.

He stated that he did not pay attention to the wind during the approach and landing, as the controller had not indicated to him that the wind was stronger than on his previous flight with the instructor. He explained that he did not look at the windsock, either during the approach or when hover taxiing. He could not remember which direction the wind was blowing, but he did remember that it was light.

He explained that, as he was hover taxiing along the runway centreline, the helicopter suddenly started rotating about its yaw axis to the right and then to the left, without any particular input was made on the rudder pedals to start turning and clear the runway. Surprised by this, he tried to

[9] Rotating about a point while hovering.

regain control of the helicopter, pressing the rudder pedals and making inputs on the cyclic pitch stick. He lost control of the helicopter, which continued to rotate about the yaw axis to the left. He did not remember which of the rudder pedals he actually pressed nor how large was the input after the helicopter started yawing to the left, and did not rule out having pressed the left pedal. However, he explained that he knew the right-hand pedal had to be pressed in the event of a departure in yaw to the left.

2.5.2 Instructor

The 47-year-old instructor is the DTO's manager. She held a Flight Instructor - Helicopter (FI(H)) rating issued in March 2017. She stated she had logged more than 1,600 flight hours, 1,240 hours of which in instruction (1,000 hours on Cabri G2s). She stated that she attended the IFT theoretical training (see para. 2.4.3) at Guimbal in July 2019, then the DTO's training manager[10] delivered her practical training as part of the internal standardisation flights. She explained that she monitored the students' progress by reviewing, on a daily basis with the training manager, the flights made with the students, in addition to a progress chart.

She was supervising the solo flight from the AIX HELI PRO premises when she witnessed the accident. During the first 360-degree rotation to the left, she estimated that the helicopter was between three and ten metres high, and that the yaw rate increased during the second 360-degree rotation. She stated that, during the two runway circuits she made with the student, they hurried to clear the runway, as the air traffic controller was inserting them in the aerodrome traffic. During the second runway circuit, she had to take over the controls to clear the runway quickly, as an aeroplane was on final. After the accident, the student told her that the helicopter deviated to the right and then to the left, and that the rudder pedals had stopped responding.

She stated that she explained to the students the tail fin stall phenomenon, based on SL 12-001 A. She showed them the various diagrams, pointing out that when the wind comes from the right, the tail fin stalls suddenly and that they therefore need to apply right-hand pedal input in a more pronounced manner than when the wind comes from the left or from the front.

2.6 Similar occurrences

The BEA recorded three other similar occurrences (accidents to Cabri G2s), which occurred in France between 2015 and 2022 as a result of a loss of yaw control arising directly from insufficient input on the right-hand rudder pedal:

- accident to F-HOLA on 12 March 2015 at Saint-Jean-de-Vaulx (Isère) ;
- accident to F-HRCR on 31 January 2019 at Pierrevert (Alpes-de-Haute-Provence) ;
- accident to F-HGRE on 18 February 2022 at Grenoble-Isère (Isère).

The report on F-HGRE indicated that, since the entry into service of the Cabri G2, more than 50 % of the Cabri G2 accidents in the world are associated with losses of yaw control. It also stated that half of these losses of control are the result of the pilot's insufficient input on the right-hand rudder pedal, sometimes followed by the pulling of the collective pitch lever.

[10] The DTO's training manager is a helicopter instructor and examiner, as well as a demonstration pilot for Guimbal.

3 CONCLUSIONS

The conclusions are solely based on the information which came to the knowledge of the BEA during the investigation.

Scenario

After making several runway circuits in dual flight for runway 32 with a left crosswind component during each landing, the student-pilot took off again for a solo flight. When he returned to the aerodrome, the aerological conditions had changed, as had the runway in use. He made an approach to runway 14 with a right crosswind component and moderate gusts. After a near hover over the runway, the student-pilot hover taxied at low speed in ground effect (at a height of between two and five metres). While hover taxiing, after the controller gave him the wind force and direction, he considered that the wind was calm and did not observe the windsock to confirm the wind direction.

According to the student-pilot, as he was slowing down and before turning left to clear the runway at taxiway A, the helicopter suddenly yawed to the right. The reason for this possible departure in yaw to the right could not be determined. The student-pilot stated that he countered this departure in yaw by pressing the rudder pedals. The helicopter then started rotating about the yaw axis to the left and the student-pilot lost control. He then lowered the collective pitch lever and the helicopter landed hard after several rotations.

It was not possible to determine the student-pilot's inputs, nor how large these were. The most likely hypothesis is that he lost control of the helicopter after inadequate or insufficient rudder pedal inputs during an unanticipated departure in yaw. It is also possible that, being close to the ground, he initially raised the collective pitch lever by instinct, which may have increased the yaw rate to the left.

The student-pilot finally lowered the collective pitch lever, as he had been taught to do in such a situation, which reduced material damage and bodily injuries resulting from this accident.

Contributing factor

The following factor may have contributed to the student-pilot losing control of the helicopter:

- insufficient consideration given to the wind direction on returning from the solo flight. The student-pilot hover taxied over the runway with a right crosswind component, whereas he had hover taxied in dual control several times with a left crosswind component just before taking off for this solo flight.

4 MEASURES TAKEN BY THE DTO AND GUIMBAL

Measures taken by the training organisation (AIX HELIPRO)

The DTO's training manager indicated that, since the accident, the following measures were implemented in students' Type Rating training:

- the specific study of Guimbal's SL 12-001 A was added to the theoretical briefings before the first solo flight;
- the sign-off requirements for pilots to fly solo were changed: all briefings must be attended and completed before pilots are signed off to fly solo;

- a knowledge assessment questionnaire was introduced, covering several items, including yaw control;
- student skill and progress charts were improved, with the addition of three skills: keeping helicopter centreline aligned with path before rotating (change in direction), approach out of ground effect, stopping a left rotation;
- before their first solo flight, students must have completed several runway circuits for runways 14 and 32, as well as a dual flight on a windy day. During this flight, the instructor must demonstrate how to stop a left rotation by applying full right-hand rudder pedal, and the student must then repeat this in different conditions (hover in ground effect, hover taxiing with a slight wind from the right, approach out of ground effect with crosswind while keeping the helicopter centreline aligned with path when entering hover out of ground effect);
- the obligation for student-pilots to perform the transition from hover taxiing to hover before any change in direction, in particular to the left.

Measures taken or planned by Guimbal

In January 2023, Guimbal updated IFT for instructors with Cabri G2 rating, by adding the following:

- performance of a practical exercise with a left yaw rotation and the countering of this by pressing down fully on the right-hand rudder pedal. Guimbal indicated its intention to introduce this exercise to all Cabri G2 pilot training courses (Type Rating, PPL, CPL);
- a demonstration of tail fin stall in approach when the pilot does not input on the rudder pedal. This demonstration is performed exclusively by Guimbal pilots and is not intended to be included in all general training.

On 19 June 2023, Guimbal circulated to Cabri G2 operators a Cabri G2 Guide for Instructors incorporating the main elements of the IFT concerning the performance of practical exercises by instructors. This document describes the most common practical training exercises and how they should be performed, in particular how the recovery exercise from a high left yaw rate should be performed.

The purpose of this exercise is to:

- show the great authority of the tail rotor: applying full right-hand pedal will always stop the yaw movement to the left as long as the rotor speed remains “within the green arc”;
- assess the amplitude of the rudder pedal travel: the full right-hand pedal position is far from the neutral position;
- understand that applying full right-hand pedal in hover flight will not damage the aircraft;
- develop a reaction in the student in the event of loss of yaw control to the left.

During the investigation, Guimbal told the BEA that the following actions were underway, with the aim of completing them before the end of 2023:

- updating of Operational Suitability Data (OSD), and in particular Training Areas of Special Emphasis (TASE), on Guimbal CABRI G2s, by including a reference to the Guide for Instructors regarding the performance of practical exercises;
- creation of a Cabri G2 type rating training manual, which will be submitted to the DSAC for approval;

- updating of Cabri G2 type rating training documents, in particular to include the yaw control exercises;
- updating of Service Letter 12-001 A, “Yaw Control in Approach”, in particular by providing details to distinguish an unanticipated and uncontrolled departure in yaw from a moderate departure in yaw to the left (see para. 2.4.4).

These documents will be made available to operators.

The BEA investigations are conducted with the sole objective of improving aviation safety and are not intended to apportion blame or liabilities.