COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
IG - 071/CENIPA/2020

OCCURRENCE:	**SERIOUS INCIDENT**
AIRCRAFT:	**PR-FPM**
MODEL:	**EC-120B**
DATE:	**27MAY2020**

NOTICE

According to the Law nº 7565, dated 19 December 1986, the Aeronautical Accident Investigation and Prevention System – SIPAER – is responsible for the planning, guidance, coordination and execution of the activities of investigation and prevention of aeronautical accidents.

The elaboration of this Final Report was conducted taking into account the contributing factors and hypotheses raised. The report is, therefore, a technical document which reflects the result obtained by SIPAER regarding the circumstances that contributed or may have contributed to triggering this occurrence.

The document does not focus on quantifying the degree of contribution of the different factors, including the individual, psychosocial or organizational variables that conditioned the human performance and interacted to create a scenario favorable to the accident.

The exclusive objective of this work is to recommend the study and the adoption of provisions of preventative nature, and the decision as to whether they should be applied belongs to the President, Director, Chief or the one corresponding to the highest level in the hierarchy of the organization to which they are being forwarded.

This Final Report has been made available to the ANAC and the DECEA so that the technical-scientific analyses of this investigation can be used as a source of data and information, aiming at identifying hazards and assessing risks, as set forth in the Brazilian Program for Civil Aviation Operational Safety (PSO-BR).

This Report does not resort to any proof production procedure for the determination of civil or criminal liability, and is in accordance with Appendix 2, Annex 13 to the 1944 Chicago Convention, which was incorporated in the Brazilian legal system by virtue of the Decree nº 21713, dated 27 August 1946.

Thus, it is worth highlighting the importance of protecting the persons who provide information regarding an aeronautical accident. The utilization of this report for punitive purposes maculates the principle of "non-self-incrimination" derived from the "right to remain silent" sheltered by the Federal Constitution.

Consequently, the use of this report for any purpose other than that of preventing future accidents, may induce to erroneous interpretations and conclusions.

N.B.: This English version of the report has been written and published by the CENIPA with the intention of making it easier to be read by English speaking people. Taking into account the nuances of a foreign language, no matter how accurate this translation may be, readers are advised that the original Portuguese version is the work of reference.

SYNOPSIS

This is the Final Report of the 27MAY2020 serious incident with the EC-120B aircraft model, registration PR-FPM. The serious incident was classified as “[LOC-I] Loss of Control in Flight”.

During a transfer flight between a helipad located at the Federal Highway Police Superintendence Headquarters and the Jacarepaguá Aerodrome - Roberto Marinho (SBJR), Rio de Janeiro - RJ, when approaching the M2 position of the apron, the helicopter turned sharply to the right and then touched the ground abruptly.

The aircraft had light damage.

The pilots and the passengers left unharmed.

An Accredited Representative of the Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile (BEA) - France, (State where the aircraft was designed) was designated for participation in the investigation.

CONTENTS

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

AC	Advisory Circular
ADF	Aircraft Registration Category of Federal Direct Administration
ANAC	Brazil's National Civil Aviation Agency
BEA	Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile
CA	Airworthiness Certificate
CENIPA	Aeronautical Accident Investigation and Prevention Center
CG	Center of Gravity
CIMAER	Aeronautical Meteorology Integrated Center
CMA	Aeronautical Medical Certificate
DOA	Air Operations Division
EHST	European Helicopter Safety Team
FAA	Federal Aviation Administration
HMNT	Single-Turbo Helicopter Rating
IAM	Annual Maintenance Inspection
INMET	National Institute of Meteorology
LTE	Loss of Tail Rotor Effectiveness
PIC	Pilot in Command
PCH	Commercial Pilot License – Helicopter
RBAC	Brazilian Civil Aviation Regulation
SBJR	ICAO Location Designator - Jacarepaguá Aerodrome - Roberto Marinho, Rio de Janeiro - RJ
SERIPA III	Third Regional Aeronautical Accident Investigation and Prevention Service
SIC	Second in Command
SIN	Safety Information Notice
SIPAER	Aeronautical Accident Investigation and Prevention System
SN	Serial Number
SPECI	Aerodrome Special Meteorological Reports
UTC	Universal Time Coordinated
VFR	Visual Flight Rules

1. FACTUAL INFORMATION.

Aircraft	**Model:** EC-120B **Registration:** PR-FPM **Manufacturer:** Eurocopter France	**Operator:** Federal Highway Police Department
Occurrence	**Date/time:** 27MAY2020 - 1516 UTC **Location:** Jacarepaguá Aerodrome (SBJR) **Lat.** 22°59'15"S **Long.** 043°22'12"W **Municipality – State:** Rio de Janeiro – RJ	**Type(s):** "[LOC-I] Loss of Control in Flight" **Subtype(s):** NIL

1.1 History of the flight.

The aircraft took off from the Federal Highway Police Superintendence Headquarters helipad, Rio de Janeiro - RJ, to the Jacarepaguá Aerodrome - Roberto Marinho (SBJR), Rio de Janeiro - RJ, at 1501 (UTC), for a transfer flight, with four crewmembers on board.

When approaching the M2 position of the SBJR apron, the aircraft quickly turned to the right and then touched the ground abruptly.

The aircraft had minor damage restricted to the skis.

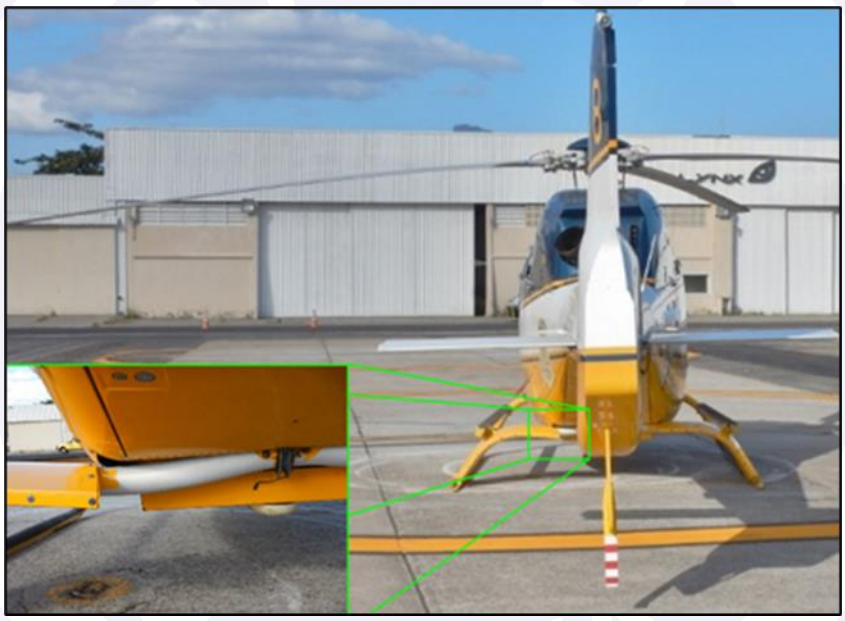

Figure 1 - View of damage to the rear left side of the ski.

The four crewmembers left unharmed.

1.2 Injuries to persons.

Injuries	Crew	Passengers	Others
Fatal	-	-	-
Serious	-	-	-
Minor	-	-	-
None	4	-	-

1.3 Damage to the aircraft.

The aircraft had minor damage.

1.4 Other damage.

None.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Flight Hours		
	PIC	SIC
Total	1.777:17	432:50
Total in the last 30 days	87:12	13:52
Total in the last 24 hours	00:34	00:34
In this type of aircraft	1.344:11	432:50
In this type in the last 30 days	87:12	13:52
In this type in the last 24 hours	00:34	00:34

N.B.: The data relating to the flown hours were informed by the pilots.

1.5.2 Personnel training.

The PIC took the PPH course at *Escola de Aviação Civil Asas Rotativas*, in 2009.

The SIC took the PPH course at *Rangel Escola de Aviação Civil*, in 2012.

1.5.3 Category of licenses and validity of certificates.

The pilots had the PCH License and had valid HMNT Rating.

1.5.4 Qualification and flight experience.

The pilots were qualified and had experience in the kind of flight.

1.5.5 Validity of medical certificate.

The pilots had valid CMAs.

1.6 Aircraft information.

The aircraft, model EC-120B, Serial Number (NS) 1280, was manufactured by Eurocopter France in 2002 and was registered in the ADF Category.

The aircraft's CA was valid.

The airframe and engine logbook records were updated, and the IAM was valid until 20JAN202.

1.7 Meteorological information.

In consultation with the messages from the INMET of the Automatic Station Rio de Janeiro - Jacarepaguá, a wind direction of 287º was detected at 1500 (UTC), with a speed of 2.5kt with gusts of 16.5kt.

The CIMAER's report informed that the weather conditions were favorable for the visual flight.

However, between 1500 and 1520 (UTC), there were surface winds that varied their speed up to 09kt and their direction up to 080°.

Although these conditions were not enough to issue a SPECI, they demonstrate the variation in the direction and intensity of the local wind, a frequent fact in places located near mountainous regions.

Regarding the dynamics of the accident, three different moments were selected containing values of direction, intensity, and relative azimuth concerning the aircraft's heading recorded by the anemometric system of SBJR.

Initially, the time corresponding to 1514 (UTC) (2 minutes before the incident) was separated. Subsequently, the time of the incident was separated, at 1516 (UTC) and, finally, two minutes later, at 1518 (UTC).

15:14 (UTC): 178° wind with 07kt;

15:16 (UTC): 241° wind with 10kt; and

15:18 (UTC): 205° wind with 05kt.

1.8 Aids to navigation.

Nil.

1.9 Communications.

Nil.

1.10 Aerodrome information.

The Jacarepaguá Aerodrome - Roberto Marinho (SBJR), Rio de Janeiro - RJ, was public, managed by the INFRAERO, had an asphalt runway, with dimensions of 900mX30m, thresholds 03/21, and operated under VFR, during the day and night.

1.11 Flight recorders.

Neither required nor installed.

1.12 Wreckage and impact information.

Nil.

1.13 Medical and pathological information.

1.13.1 Medical aspects.

Nil.

1.13.2 Ergonomic information.

Nil.

1.13.3 Psychological aspects.

Nil.

1.14 Fire.

There was no fire.

1.15 Survival aspects.

Nil.

1.16 Tests and research.

After the incident, the aircraft was inspected in a specialized shop, accompanied by technicians from the SERIPA III. No problems were identified in the helicopter's systems that could have contributed to the loss of control.

The damage was restricted to the ski due to the sharp touch against the ground. The aircraft returned to operation after completing inspections related to the hard landing.

1.17 Organizational and management information.

The DOA of the Federal Highway Police was responsible for carrying out aerial patrols on federal highways in support of public and traffic security operations, in addition to aeromedical rescue and transport of people and goods.

1.18 Operational information.

The aircraft was within the weight and balance limits specified by the manufacturer.

The flight was normal until the time to park the aircraft. The SIC, who was piloting, and sitting in the right seat, started a 90° turn around its axis to the right in order to position the helicopter with the heading facing 210°, as required by the Aerodrome.

At that moment, the aircraft started an uncontrolled turn to the right, followed by a sharp touch against the ground, completing another turn by dragging the skis on the floor of the apron (Figure 2).

Figure 2 - Record of the PR-FPM trajectory during loss of control.
Source: SBJR apron monitoring cameras.

1.19 Additional information.

- **Advisory Circular (AC) n° 90-95 - Unexpected Right Yaw in Helicopters**

On 26DEC1995, the AC No. 90-95 published by the FAA described LTE as a low-speed, critical aerodynamic phenomenon that can result in uncommanded yaw and, if not properly corrected, can lead to loss of aircraft control. The LTE is not related to maintenance issues and can occur in different degrees on single main rotor helicopters at speeds below 30kt.

According to the text, the LTE has been identified as a contributing factor in several helicopter accidents involving loss of control in low-altitude, low-speed flight operations. The document highlighted that the tail rotor blades did not stall during an LTE.

Any maneuver that requires the pilot to operate in a high-power, low-speed environment with crosswind or tailwind creates conditions where unexpected yaw to the right or the left can occur, depending on the direction of rotation of the main rotor.

The Advisory Circular also detailed another feature of helicopters, known as weathercock stability. By design, helicopters have a smaller lateral area in front of the center of gravity than the lateral area behind it, generating positive directional stability in forwarding flight. This feature is reinforced both by the fuselage profile and the construction of the vertical stabilizer at the end of the tail cone.

On the other hand, tailwinds of 120º to 240º cause a large workload for the pilot. The most significant feature of tailwinds is that they cause the pre-existing yaw rate to accelerate. Even a slight turning rate can be accelerated abruptly if the pilot does not counter this tendency, applying the pedal opposite to the yaw from the moment the wind hits the tail quadrant (from 120º to 240º).

Thus, the AC stressed that a correct and timely response by the pilot to uncommanded yaw would be critical. Unexpected yaw is usually correctable if the anti-turn pedal is applied

immediately. If the response is incorrect or slow, the yaw rate can quickly increase to a point where recovery is not possible.

A computer simulation showed that the delay in applying the pedal to counteract the unexpected yaw could result in loss of helicopter control and/or delay in stopping the uncommanded turn.

Thus, the Circular continued, the pilot should anticipate an increase in the yaw speed of the helicopter, concentrating on flying the aircraft, not allowing the increase in the turning speed, especially when executing left turns, in the case of a helicopter with a clockwise rotor, in favorable conditions for the occurrence of an LTE.

The following factors contribute to the occurrence of LTE: high weight; low forward speed, left turn (for aircraft with main rotors that turn clockwise); crosswind; tailwind; and rapid changes in power.

Therefore, it's important to understand what an unexpected turn is to avoid it, mainly because it is a contributing factor to some accidents.

About this, on 07MAR2019, Airbus Helicopters published a Safety Information Notice in which it addressed, from another point of view, the unexpected left yaw of a helicopter whose main rotor was rotating clockwise.

- **Safety Information Notice n° 3297-S-00 - Unexpected left yaw (main rotor rotating clockwise), commonly referred to as LTE.**

The document reported that unexpected yaw is a flight characteristic to which all types of single rotor helicopters (regardless of anti-torque design) can be susceptible at low speeds, generally depending on the direction and strength of the wind relative to the helicopter.

According to the publication, this characteristic was initially identified and analyzed in relation to OH-58 helicopters by the US Army, which coined the description "loss of tail rotor effectiveness" (LTE), although the tail rotor always remained fully operational. It is important to clarify that the phenomenon is not associated with any material failure and has nothing to do with the total loss of tail rotor thrust.

Unexpected yaw can be rapid and most often occurs in the opposite direction of rotation of the main rotor blades (i.e. left yaw where the blades rotate clockwise). Immediate corrective action must be taken otherwise, loss of control and a possible accident may occur.

The document warned that the fact that the use of the pedal for correction, at first, did not guarantee that the yaw would decrease immediately, led the pilot to suspect that the effectiveness of the tail rotor was compromised when, in fact, the ability to available tail rotor thrust was still unchanged.

As such, the publication highlighted that the term “Loss of tail rotor effectiveness” was therefore not the most efficient description, as it erroneously implied that the tail rotor efficiency was reduced under certain conditions.

In this regard, Safety Information Notice No. 3297-S-00 provided detailed information on when the situation could arise, why the tail rotor could appear to be ineffective, and how to react to maintain or regain full control of the equipment.

The apparent lack of efficiency in the use of the pedal to avoid unexpected spin can lead to the misinterpretation of total loss of tail rotor thrust (for example, as would be the case after the tail rotor drive ruptures). The symptom (intense unexpected left turn) is similar, and the short-term response to a late and ineffective pedal command is almost zero for both cases.

Only the immediate application of the right pedal in its full range and in a timely manner will be able to counteract the spin and allow the pilot to identify whether he is experiencing an unexpected yaw or a total loss of tail rotor thrust due to malfunction.

If full use of the right pedal does not affect yaw, after a timely correction, an immediate landing is required due to a failure in the tail rotor drive system. If, however, a full application of the right pedal slows the yaw, it is clear that the problem is unexpected yaw, which requires staying well away from the ground and obstacles until a full recovery is achieved.

The most likely reason for accidents after unexpected yaw events is late and very limited application of the pedal.

During an unexpected yaw event, the tail rotor remains fully effective and offers the best chance of recovery. The yaw rate and wind conditions reduce the rotor's effectiveness if it maintains a constant pitch. This must be countered by substantially increasing the tail rotor pitch.

The only early signal the pilot can receive of a possible loss of control is the onset of an unexpected turn.

Therefore, the Safety Information Notice recommended the following actions:

- be especially careful when the wind comes from the right side or the front-right quadrant. Do not fly unnecessarily in these conditions;

- prefer, as much as possible, to turn to the right, especially in conditions of limited performance. It is easier to monitor torque demand at the beginning of the maneuver than when responding to unexpected and abrupt yaw;

- when making a tail turn, do it with a low yaw rate; and

- if an unexpected turn occurs, react immediately and with great amplitude, using the pedal opposite the direction of the turn. Be ready to use the pedal to its full range if necessary. Don't limit yourself to what you think is enough. Your feeling could be wrong. Never put the pedal in neutral before yaw has stopped.

For the description of the phenomenon, a graph from the Safety Information Notice n° 3297-S-00 was used, which addresses the pedal position turn, as a function of the relative wind incidence direction of the helicopter, in a stabilized hovering condition. For each combination of weight, altitude, temperature, and wind speed, there is a corresponding turn (Figure 3).

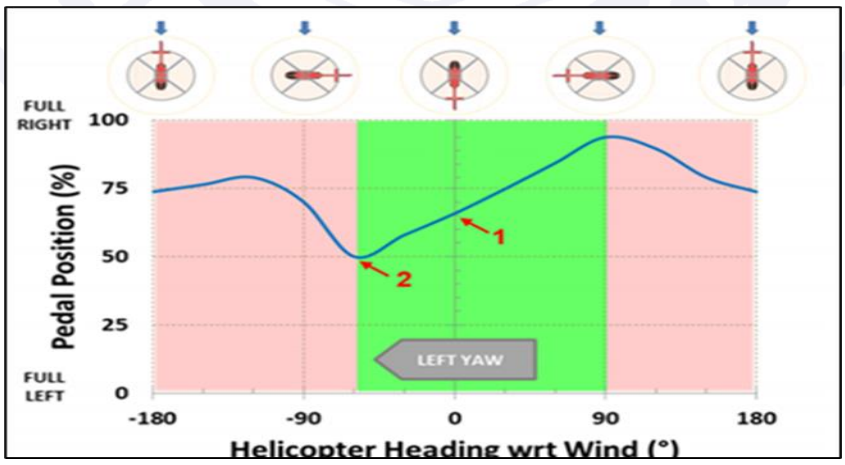

Figure 3 - Stabilized Pedal Position as a Function of Relative Wind.
Source: Airbus Helicopters.

Concerning a helicopter with clockwise rotation of the main rotor, maintaining a hover with a relative wind of 0° (number 1 in Figure 3, wind aligned with the helicopter's heading)

requires the application of about 65% of the pedal, that is, with the pedal a little closer to the right pedal stop (top of the graph) than to the left stop (bottom of the graph).

It is important to note that these are stabilized hover positions. That is, the maintenance of the hover for a certain relative wind direction will occur if the pedal position is adjusted according to the turn presented.

If the pedal command is set to an above-turn position, the helicopter will produce a differential in tail rotor thrust relative to the thrust required to hold the heading and yaw to the right. In contrast, with the tail rotor set to a pedal position lower than those indicated by the turn the helicopter will yaw to the left.

In addition, the green area in Figure 3 corresponds to the range of wind direction in which the helicopter is yaw stable. In this range, if there is a gust of wind changing the helicopter's heading from 0° to -10° without any pedal input (x-axis to the left with no y-axis variation), the pedal percentage will be at a position above the turn (helicopter heading North to heading 350º, which is equivalent to a helicopter heading -10º in relation to the wind direction, maintaining the pedal position that existed with a relative wind heading of 0°). In response (right pedal higher than necessary for this new position), the helicopter yaws to the right until it crosses the turn in a stabilized position for the selected pedal position, which happens at the initial 0° heading. Therefore, when moving away from the stabilized position, a return movement to this position is generated.

The red area in Figure 3 represents an area of yaw instability. When the helicopter is moved from its stabilized position, it moves further away from that initial position. This yaw instability in downwind regions is often recognized by helicopter pilots, generating an increase in the workload for yaw control, especially at low speeds, when vertical drift and the fuselage have little influence on heading maintenance.

The lower limit of the stable range (helicopter heading of about -60° concerning the wind direction) is indicated as number 2 in Figure 3. From this point (-60°), the helicopter's relative heading decrease is linked to the yaw unstable region (left red area of the graph). At this inflection point (number 2 in Figure 3), when a left pedal is applied (from 50% pedal position to 45%), the pedal position is below the lowest point of the pedal turn. This means that, a nose-to-left turn will occur without reaching a stabilized point of relative heading.

Unless the right pedal is added, the aircraft will not cease nose-turning to the left. Starting from this example, by keeping the pedal position at 45% as the helicopter yaws (rotates around its Z axis), the rate of turn is dramatically increased, as the difference between the stabilized pedal position and the applied command starts to increase (distance between the 45% pedal position and the turn). That is, the longer the delay to correct the maneuver using the right pedal, the greater the yaw acceleration, which defines the unexpected yaw (uncommanded increase in turning ratio, which does not reduce on its own.

Regarding the unexpected turn, the Safety Information Notice recommended the following actions:

- be especially careful when the wind comes from the right side or the front-right quadrant. Do not fly unnecessarily in these conditions;

- prefer, as much as possible, to turn to the right, especially in conditions of limited performance. It is easier to monitor torque demand at the beginning of the maneuver than when responding to unexpected and abrupt yaw;

- when making a tail turn, do it with a low yaw rate; and

- if an unexpected turn occurs, react immediately and with great amplitude, using the pedal opposite the direction of the turn. Be ready to use the pedal to its full range if

necessary. Don't limit yourself to what you think is enough. Your feeling could be wrong. Never put the pedal in neutral before yaw is interrupted.

- **Safety Information Notice n° 2335-S-00 - Helicopter Flight Safety - Publication of the European Helicopter Safety Team (EHST) booklet.**

On 07FEB2011, Eurocopter An Eads Company published the Safety Information Notice No. 2335-S-00 which, among other topics, addressed the issue of the LTE or loss of tail rotor effectiveness. The document was based on the booklet on flight safety in helicopters published by the EHST and was based on the analysis of accidents with all types of helicopters that occurred in different countries and regions of the world, including Brazil and Europe.

The Safety Information Notice No. 2335-S-00 noted that in a helicopter with a single main rotor, one of the main functions of tail rotor thrust was to control the helicopter's heading. If the tail rotor thrust is insufficient, unexpected and uncontrolled yaw can occur. This phenomenon has been a driving factor in several helicopter accidents and is commonly referred to as LTE.

As such, the Safety Information Notice considered LTE to be insufficient tail rotor thrust associated with a not enough margin of control, as this can lead to an uncontrolled fast yaw speed. This speed cannot naturally decrease and without correction, it can cause the helicopter to lose control.

The post goes on saying that an LTE is most likely to occur when the critical yaw pedal is near its end-of-travel position.

The yaw pedal, which is regarded as critical, is the right pedal for a clockwise rotating main rotor and the left pedal for a counterclockwise rotating rotor.

An LTE usually occurs at a low forward speed, typically less than 30kt, when:

- the rear drift has a low aerodynamic efficiency;
- the airflow and deflection effect generated by the main rotor interferes with the airflow entering the tail rotor;
- a high-power regulation demands a position of the yaw pedal close to the end of travel;
- unfavorable wind conditions increase the need for tail rotor thrust; and
- turbulent wind conditions demand important and fast yaw and collective commands.

About the recovery of an LTE, the document clarified that during flight planning, pilots must consider the performance of the device in terms of critical wind azimuths, the altitude at which they are flying, the gross take-off weight of the helicopter, and flight characteristics.

Thus, during flight, pilots must always be aware of wind conditions and the available tail rotor thrust margin, which is represented by the critical pedal position (right pedal).

Whenever possible, pilots should avoid a combination of the following conditions:

- unfavorable wind conditions at low speed;
- uncommanded yaw;
- important and fast yaw and collective commands at low speed; and
- low-speed flight in turbulent wind conditions.

The Safety Information Notice went on to state that pilots should be aware that if they enter a flight regime where a condition or a combination of them occurs, they may enter an

LTE situation and should be able to recognize its onset and begin immediately the positive measures of control recovery.

Thus, actions to regain control vary according to circumstances. If the height allows, increase the forward speed without increasing power (if possible, by reducing it). This should solve the inadvertent spin.

Therefore, as these actions can result in considerable altitude loss, it is recommended that pilots identify them before carrying out the operations mentioned above.

The document was finalized indicating the following actions to exit an LTE: fully depress the pedal opposite the direction of the turn; adopt a throttle attitude to increase forward speed and if altitude permits, reduce power.

- **RBAC No. 90, Requirements for Special Public Aviation Operations.**

On 12APR2019, section 90.173 of Subpart M of RBAC No. 90 established that LTE concepts to be disseminated in the ground curriculum for initial training for pilots:

> 90,173 Initial training: ground curriculum
>
> ...
>
> (d) The general knowledge curriculum component must contain:
>
> (i) ground resonance;
>
> (ii) collision with wire;
>
> (iii) LTE;
>
> (iv) dynamic and static rolling;
>
> (v) recovery from abnormal attitudes;
>
> (vi) mast bumping and low G;
>
> (vii) vortex ring;
>
> (viii) runway excursion and incursion; and
>
> (ix) deep stall.

1.20 Useful or effective investigation techniques.

Nil.

2. ANALYSIS.

It was a transfer flight between a helipad, located at the Federal Highway Police Superintendence Headquarters and SBJR.

The pilots had the PCH License and valid HMNT Rating.

They had valid CMA, were qualified, and had the experience to perform the flight.

The aircraft had a valid CA and was operating within weight and balance limits.

The aircraft, model EC-120B, Serial Number (NS) 1280, was manufactured by Eurocopter France in 2002 and was registered in the ADF Category.

The airframe and engine logbook records were updated, and the IAM is valid until 20JAN2021.

No problems were identified in the helicopter's systems that could have contributed to the loss of control. The damage was restricted to the ski due to the sharp touch against the ground. The aircraft returned to operation after completing inspections related to the hard landing.

The flight was normal until the time to park the aircraft. The SIC, who was piloting, and sitting in the right seat, started a 90° turn around its axis to the right in order to position the helicopter with the heading facing 210°, as required by the Aerodrome.

At that moment, the aircraft started an uncontrolled turn to the right, followed by a sharp touch against the ground, completing another turn dragging the skis on the floor of the apron.

The CIMAER report said that the weather conditions were favorable for the visual flight.

However, between 1500 and 1520 (UTC), there were surface winds that varied the speed up to 09kt and their direction up to 080°.

In consultation with the INMET messages from the Automatic Station Rio de Janeiro - Jacarepaguá, a wind direction of 287º was detected at 1500 (UTC), with a speed of 2.5kt with gusts of 16.5kt.

The blue symbol in Figure 4 indicates the direction of the 287º wind gust according to the INMET.

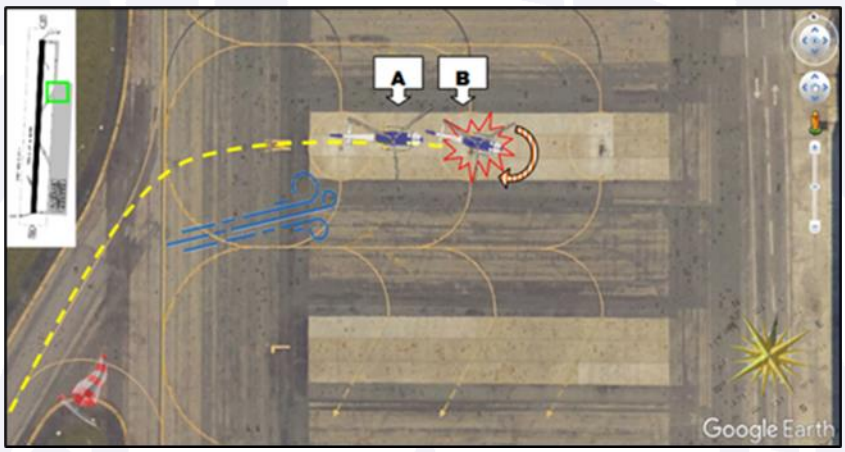

Figure 4 - PR-FPM trajectory, with the arrow indicating the aircraft's direction of rotation.

Although these conditions were not enough for the issuance of a SPECI, they demonstrate the variation in the direction and intensity of the local wind, a frequent fact in places located near mountainous regions.

In order to analyze the aerodynamic effects arising from the inconsistency of the wind, three different moments were selected, containing values of direction, intensity, and relative azimuth concerning the aircraft's heading recorded by the anemometric system of SBJR.

Initially, the time corresponding to 1514 (UTC) (2 minutes before the incident) was separated. Subsequently, the time of the incident was separated at 1516 (UTC) and, finally, two minutes later, at 1518 (UTC).

- 1514 (UTC): 178° wind with 07kt (Azimuth: -58°);
- 1516 (UTC): Wind of 241° with 10kt (Azimuth: -121°); and
- 1518 (UTC): Wind of 205° with 05kt (Azimuth: -85°).

Taking into account that the aircraft's heading, on the occasion of the unexpected turn, was turned in the direction of 120°, the relative wind incident on the PR-FPM varied between -58° and -121° at these three moments (blue rectangle in Figure 5).

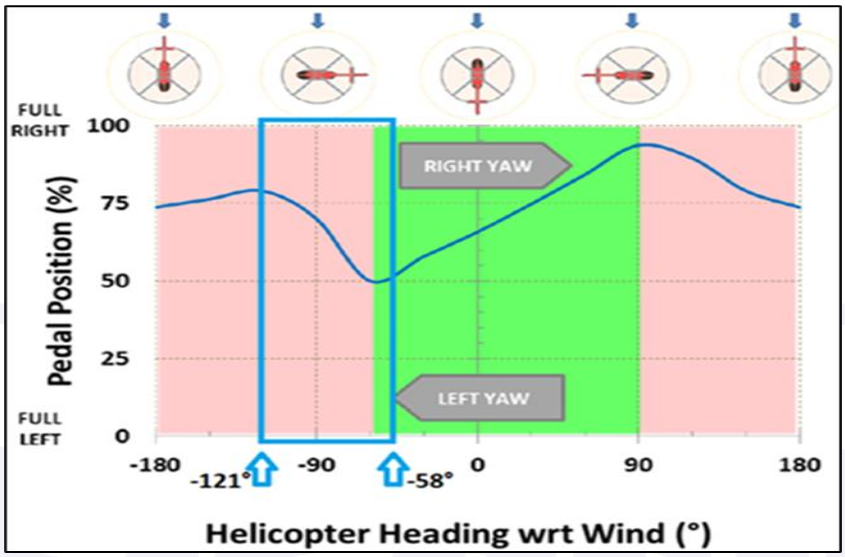

Figure 5 - Example of the pedal turn in hovering. Source: Safety Information Notice No. 3297-S-00.

The critical azimuth is considered the one in which there is the smallest margin for the application of the pedal, which corresponds, in the case of the graph in Figure 5, to the condition of +90°, that is, crosswind coming from the left side in relation to the helicopter. In this condition, the helicopter tends to head the wind and, to counteract it, it is necessary to use the right pedal, which, in this situation, is at approximately 90% of its course.

The blue turn corresponds to the pedal position in the stabilized hover flight. From there on, when the right pedal is applied (i.e., the pedal position moves above the blue turn), the helicopter rotates to the right and when the left pedal is commanded, it rotates to the left (the pedal position moves below the turn).

The helicopter is stable in yaw when the wind direction is from the azimuths -60º and +90º (green area in Figure 5). In this region, a more right nose position (greater relative azimuth), for example, corresponds to a more forward-right pedal position.

Considering that the position of the pedals is measured with the aircraft stabilized in a certain heading, and not during the movement. That is, the pedals are worked to position the aircraft in a certain heading and, with it stabilized in that position, the position of the pedals is read. In practice, this condition brings safety to the operation because if there is an abrupt variation in the wind direction, the aircraft will only rotate until this variation is canceled. In summary, when leaving its equilibrium position, without changing the position of the controls, the aircraft tends to return to it.

Taking as an example a helicopter hovering with a headwind, it can be stated that, if there is a change in the wind direction, and it starts to come from the right (-10º), the pedal position will be above the turn, causing the aircraft to turn to the right, in the direction of the wind, bringing the relative azimuth back to zero. As a result, the aircraft stabilizes on the new heading without the pilot acting on the pedals.

After the limits of the green region (+90º and -60º), there is the red area, which represents a region of directional instability. It is located between the azimuths -60º and -180º (right and tailwind), +90 and +180º (left and tailwind). The region of instability presents a certain difficulty in piloting, as a nose position further to the right, for example, corresponds to a position of the left pedal further forward (reduced position of the right pedal).

This instability caused by both crosswinds and tailwinds is well known to helicopter pilots who know that yaw must be controlled very carefully, especially when the wind is coming from the rear quadrant (tailwind).

In this sense, the helicopter can reach the lower limit of the stable range (-60° in Figure 5) without much notice and, as a result, go from stable directional behavior to totally unstable yaw behavior, as was the case in this serious incident.

This can give the pilot the impression that the helicopter turned on its own, even if this was a result of the pilot applying the pedal commands and the consequences of wind direction on the tail rotor thrust. In a windy situation (right abeam), the tail rotor operates within its turbulent air, creating variations in traction.

In the case of this occurrence, at the moment when there was an unexpected turn to the right, the wind hit the helicopter by the azimuth -121º, that is, in an area of directional instability, in which the position of the pedal to maintain stability, was close at 80%, as recorded in Figure 5.

Bearing in mind that to enter the apron, the pilot had to make a move around his axis to the right, and it required a pedal application in that direction.

Considering the wind azimuth at the time was -121º and, observing Figure 5, it is known that the pilot should command the right pedal forward to start the turn and, soon after, reduce the command amplitude, even reaching to reverse it (right pedal in a lower position than the one it was in before the start of the turn), so as not to allow acceleration of the turn.

In the event of commanding the start of the turn and keeping the pedals in the same position, the aircraft would have the pedals in a position corresponding to the relative azimuth of approximately +60º that is, there would be a heading variation of 180º until reaching the new balance position. Considering the acceleration of the spin, it is reasonable to believe that the aircraft would pass this position, causing the loss of control.

Thus, it is possible that the SIC kept the right pedal applied, or did not reduce it enough after the turn began, allowing the yaw acceleration and the consequent loss of control.

The PIC, who was sitting on the left chair, took over the controls of the aircraft and made the landing while still in a turning condition, dragging the skis on the ground for another 365º (Figure 6).

Figure 6- Details of the markings on the ground after the ground turn (the green arrow indicates the direction of rotation of the aircraft).

Regarding an unexpected turn, the Safety Information Notice recommended the following actions:

- be especially careful when the wind comes from the right side or the front-right quadrant. Do not fly unnecessarily in these conditions;

- prefer, as much as possible, to turn to the right, especially in conditions of limited performance. It is easier to monitor torque demand at the start of the maneuver than when responding to unexpected and abrupt yaw;

- when making a tail turn, do it with a low yaw rate; and

- if an unexpected turn occurs, react immediately and with great amplitude, using the pedal opposite the direction of the turn. Be ready to use the pedal to its full range if necessary. Don't limit yourself to what you think is enough. Your feeling could be wrong. Never put the pedal in neutral before the yaw is interrupted.

3. CONCLUSIONS.

3.1 Facts.

a) the pilots had valid CMAs;

b) b) the pilots had the PCH License and had valid HMNT Rating;

c) the pilots were qualified and had experience to perform the flight;

d) the aircraft had a valid CA;

e) the aircraft was within the weight and balance limits;

f) the airframe and engine logbook records were updated;

g) there was no evidence of malfunction of the aircraft systems;

h) the weather conditions were favorable for the flight;

i) when entering the apron, the aircraft started an uncontrolled turn to the right, followed by a sharp touch against the ground, completing another turn dragging the skis on the floor of the apron;

j) the aircraft had minor damage; and

k) the crewmembers left unharmed.

3.2 Contributing factors.

- **Control skills – undetermined.**

It is possible that the SIC kept the right pedal applied, or did not reduce it sufficiently, after the turn began, allowing the yaw to accelerate and the consequent loss of control.

- **Attention – undetermined.**

It is likely that there was a reduction in the SIC's responsiveness, by not acting quickly and accurately during the unexpected turn of the helicopter.

- **Training – undetermined.**

It can’t be ruled out the possibility that the SIC has not received the fullness of knowledge and other technical conditions necessary to identify and react, promptly, to signs of loss of control of the aircraft.

- **Piloting judgment – undetermined.**

There was a probable inadequate assessment, by the SIC, of certain parameters related to the operation of the aircraft, especially those related to the necessary corrections to be used during the unexpected yaw.

- **Perception – undetermined.**

Probably, there was a reduction in the situational awareness of the SIC, due to its difficulty in recognizing, understanding, and reacting adequately to the signals of loss of control of the helicopter.

4. SAFETY RECOMMENDATION.

A proposal of an accident investigation authority based on information derived from an investigation, made with the intention of preventing accidents or incidents and which in no case has the purpose of creating a presumption of blame or liability for an accident or incident. In addition to safety recommendations arising from accident and incident investigations, safety recommendations may result from diverse sources, including safety studies.

In consonance with the Law n°7565/1986, recommendations are made solely for the benefit of the air activity operational safety, and shall be treated as established in the NSCA 3-13 "Protocols for the Investigation of Civil Aviation Aeronautical Occurrences conducted by the Brazilian State".

Recommendations issued at the publication of this report:

To the Brazil's National Civil Aviation Agency (ANAC):

IG-071/CENIPA/2020 - 01 **Issued on 11/03/2022**

Disclose the lessons learned from the present investigation to the Public Air Units operating under the rules of the RBAC No. 90, in order to complement the guidance contained in the ground curricula of the pilots' initial training, especially about the need to recognize the first indications and the initial actions to be taken for recovery from an unexpected yaw.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

None.

On November 3th, 2022.