COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A - 065/CENIPA/2019

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PP-MMG**
MODEL:	**AS 350 B3**
DATE:	**24APR2019**

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 by taking into account the contributing factors and hypotheses raised. The report is, therefore, a technical document that 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 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 into the Brazilian legal system by 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 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 24APR2019 accident with the AS 350 B3 aircraft model, registration PP-MMG. The accident was classified as “[LOC-I] Loss of Control in Flight”.

During a shooting training circuit on board at the Military Police of the Minas Gerais State (PMMG) stand, in Ribeirão das Neves - MG, there was a loss of control of the aircraft after making a left turn at low speed. The helicopter began a series of uncontrolled spins until it crashed the ground.

The aircraft was destroyed.

The Pilot in Command (PIC) and the Second in Command (SIC) suffered minor injuries.

Of the three shooters who occupied the back seat, all PMMG soldiers, one of them left unharmed, and the other two had serious injuries.

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
ADE	Direct State Administration Registration Category
AFM	Aircraft Flight Manual
AGL	Above Ground Level
ANAC	Brazil’s National Civil Aviation Agency
BEA	*Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile*
Btl Rpaer	Military Police Air Radio Patrol Battalion
CA	Airworthiness Certificate
CIV	Pilot`s Flight Logbook
CIPM	Military Police Instruction Center
CENIPA	Aeronautical Accident Investigation and Prevention Center
CMA	Aeronautical Medical Certificate
ComAvE	State Aviation Command
CORPAER	Air Radio Patrol Companies
DCTA	Department of Science and Airspace Technology
DECEA	Airspace Control Department
DIVOP	Operational Disclosure
EHST	European Helicopter Safety Team
FAA	Federal Aviation Administration
HMNC	Conventional Single Engine Helicopter Rating
HMNT	Single Turbo Helicopter Rating
IPEV	Institute for Research and Flight Testing
LTE	Loss of Tail Rotor Effectiveness
METAR	Meteorological Aerodrome Report
MOP	Operation Manual
NADSO	Acceptable Level of Operational Safety Performance
NSCA	Aeronautics Command System Standard
NTSB	National Transportation Safety Board (USA)
OGE	Out Ground Effect
OM	Maintenance Organization
PCH	Commercial Pilot – Helicopter category
PIC	Pilot in Command
PMD	Maximum Takeoff Weight
PMMG	Military Police of the Minas Gerais State
PPH	Private Pilot License – Helicopter
PSO-BR	Brazilian Program for Civil Aviation Operational Safety
RBAC	Brazilian Civil Aviation Regulation

RBHA	Brazilian Aeronautical Certification Regulation
SBBH	ICAO Location Designator - Pampulha Aerodrome, Carlos Drummond de Andrade, Belo Horizonte - MG
SCT	Scattered (3 and 4 oktas)
SERIPA III	Third Regional Aeronautical Accident Investigation and Prevention Service
SIC	Second in Command
SIPAER	Aeronautical Accident Investigation and Prevention System
SN	Serial Number
SOP	Standard Operational Procedures
TSN	Time Since New
UAP	Public Air Unit
UTC	Universal Time Coordinated

1. FACTUAL INFORMATION.

Aircraft	**Model:** AS 350 B3 **Registration:** PP-MMG **Manufacturer:** HELIBRAS	**Operator:** Military Police of the Minas Gerais State
Occurrence	**Date/time:** 24APR2019 - 1920 UTC **Location:** Military Police Instruction Center **Lat.** 19°47’43” S **Long.** 044°04’05” W **Municipality – State:** Ribeirão das Neves – MG	**Type(s):** “[LOC-I] Loss of Control in Flight” **Subtype(s):** NIL

1.1 History of the flight.

The aircraft took off from the Military Police Instruction Center (CIPM), Ribeirão das Neves - MG, at around 1845 (UTC), to carry out traffic circuits for on-board shooting training, with five crewmembers on-board, two of them pilots and three shooters, all PMMG soldiers.

In the sixth training circuit, while executing a sharp turn to the left at low speed, the aircraft began an uncontrolled spin, losing height until it collided with the ground in a forest region.

The aircraft was destroyed by fire.

Figure 1 - View of the PP-MMG destroyed by fire after the accident.

Of the five crewmembers, two had minor injuries, two had serious injuries and one left unharmed.

1.2 Injuries to persons.

Injuries	Crew	Passengers	Others
Fatal	2	-	-
Serious	2	-	-
Minor	1	-	-
None	-	-	-

1.3 Damage to the aircraft.

The aircraft was destroyed.

1.4 Other damage.

None.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Flight Hours		
	PIC	SIC
Total	777:00	127:00
Total in the last 30 days	12:45	11:30
Total in the last 24 hours	00:50	01:05
In this type of aircraft	720:00	89:00
In this type in the last 30 days	01:45	04:25
In this type in the last 24 hours	00:50	01:05

N.B.: The data relating to the flown hours were obtained through the pilots' CIVs.

1.5.2 Personnel training.

The PIC took the PPH course at EFAI - *Escola de Pilotagem* Ltd., Contagem - MG, in 2012.

The SIC took the PPH course at EFAI - *Escola de Pilotagem* Ltd., Contagem - MG, in 2017.

1.5.3 Category of licenses and validity of certificates.

The PIC had the PCH License and a valid HMNT Rating.

The SIC had the PPH License and had valid HMNC and HMNT Ratings.

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 AS 350 B3, Serial Number SN - 7209, was manufactured by HELIBRAS in 2011 and was registered in the ADE Category.

The aircraft's CA was valid.

The airframe and engine logbook records were outdated.

The last aircraft inspection, the "7 days/10 hours" type, was carried out on 23APR2019 by the PMMG, with 4 hours and 20 minutes flown after the inspection.

The last major inspection of the aircraft, the "5,000h/72 months" type, was carried out on 28MAR2018 by the OM Claro Aviação in Belo Horizonte - MG, with 297 hours and 40 minutes flown after the inspection.

Item 6 Tail Rotor Failure, Section 3.1 - Emergency Procedures of the AS 350 B3 Flight Manual recorded that a failure of the tail rotor in powered flight would result in a yaw to the left and that the spin speed would depend on the power and the velocity at the time of the event (Figure 2).

6 TAIL ROTOR FAILURE

6.1 Tail Rotor Drive Failure

Loss of the tail rotor in power-on flight results in a yaw movement to the left ; the extent of such rotation will depend on the power and speed configuration at the time the failure occurs.

6.1.1 Failure of the Tail Rotor in Hover or at Low Speed

- I.G.E. : set the twist grip to the idling detent and cushion touch-down by pulling the collective pitch lever.
- O.G.E. : reduce collective pitch moderately, to reduce yaw torque, and simultaneously start to pick up speed.

6.1.2 Failure in Forward Flight

- In forward flight reduce the power as much as possible and maintain forward speed (weathercock effect), select a suitable landing area for a steep approach at a power enabling a reasonably coordinated flight.
- On final approach, shut down the engine and make an autorotative landing at the lowest possible speed.

Figure 2 - Tail rotor failure. Source: Flight Manual AS 350 B3.

Item 4 Airspeed-Height Envelope, of Section 5 - Regulatory Performance Data of the AS 350 B3, established that conducting the flight in zone Z, delimited by points A, B, C, and D, should be avoided (Figure 3).

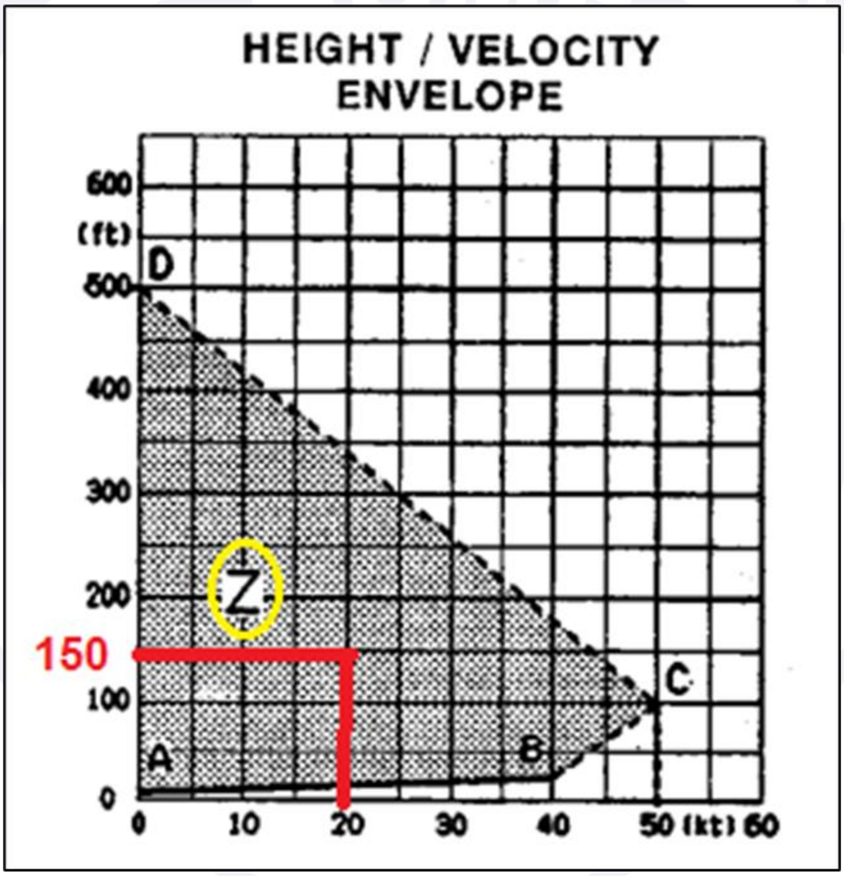

Figure 3 - Height/Speed Envelope. Source: Flight Manual of the AS 350 B3.

The graph in Figure 3, also known as the “Dead Man's Curve”, refers to the relationship between speed and height at which, in the event of an engine failure, an autorotation flight would guarantee a safe landing, if the flight was being driven outside Zone Z.

According to the information obtained, in the moments before the accident, the PP-MMG was flying with a speed close to 20 kt at a height of 150 ft AGL.

1.7 Meteorological information.

The METAR from the Pampulha Aerodrome - *Carlos Drummond de Andrade* (SBBH), Belo Horizonte - MG, approximately 18 km from the accident site, provided the following information:

METAR SBBH 241900Z 07007KT 9999 SCT045 28/16 Q1020 =

Weather conditions were favorable for the visual flight with visibility above 10 km and scattered clouds at 4,500 ft. The wind had a direction of 070° with an intensity of 07 kt.

1.8 Aids to navigation.

Nil.

1.9 Communications.

Nil.

1.10 Aerodrome information.

The occurrence took place out of the Aerodrome.

1.11 Flight recorders.

Neither required nor installed.

1.12 Wreckage and impact information.

The collision with the ground occurred in the CIPM. The distribution of the wreckage was of the concentrated type.

The first impact occurred against the treetops at a height of 20m and an approximate angle of 40°. Subsequently, there was a collision with the ground, leaving the helicopter inclined 45° to the left in relation to the terrain. The impact caused the main rotor blades, skis, and main transmission to break.

The fire broke out after the total stop. The fire was not controlled, and the aircraft had a large part of its structure and components consumed by the fire(Figure 4).

Figure 4 - Aerial view of the accident site, with the presence of fire.

1.13 Medical and pathological information.

1.13.1 Medical aspects.

No evidence was found that problems of physiological nature could have affected the flight crew performance.

1.13.2 Ergonomic information.

Nil.

1.13.3 Psychological aspects.

Nil.

1.14 Fire.

There was no evidence of fire in flight. However, after impacting the ground, the fire consumed more than 75% of the aircraft. The helicopter's degree of destruction and carbonization made it difficult to verify several components and instruments.

1.15 Survival aspects.

After impact with the ground, the five crewmembers abandoned the aircraft by their means.

1.16 Tests and research.

Tail Rotor Examination (control and transmission)

The components of the tail rotor assembly were analyzed by an accredited professional from the SERIPA III and representatives of HELIBRAS, BEA, and AIRBUS.

After disassembling the tail rotor, relevant marks were observed on the stops, which showed the command to the right. Additionally, the rear servo control was analyzed, and it was locked due to the action of the fire, with its rod extended 10 cm.

For comparison, the right pedal command was performed on a similar aircraft. After measuring the aircraft's rear servo control rod, it was observed that it also had an extension of 10 cm (Figures 5 A and B).

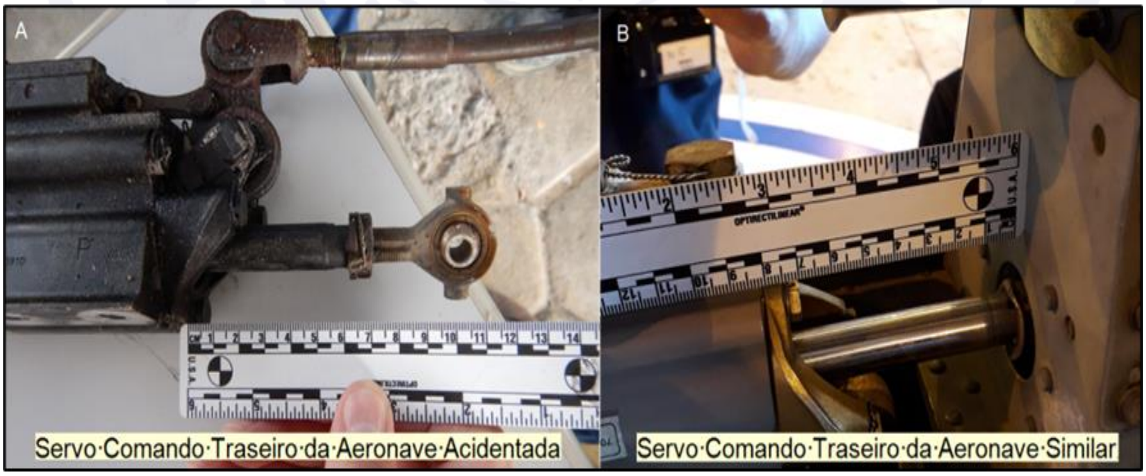

Figure 5 A and B - Position of the command servos.

In addition to this measurement, the tail rotor drive forks were locked with the same measurements (Figures 6 A and B).

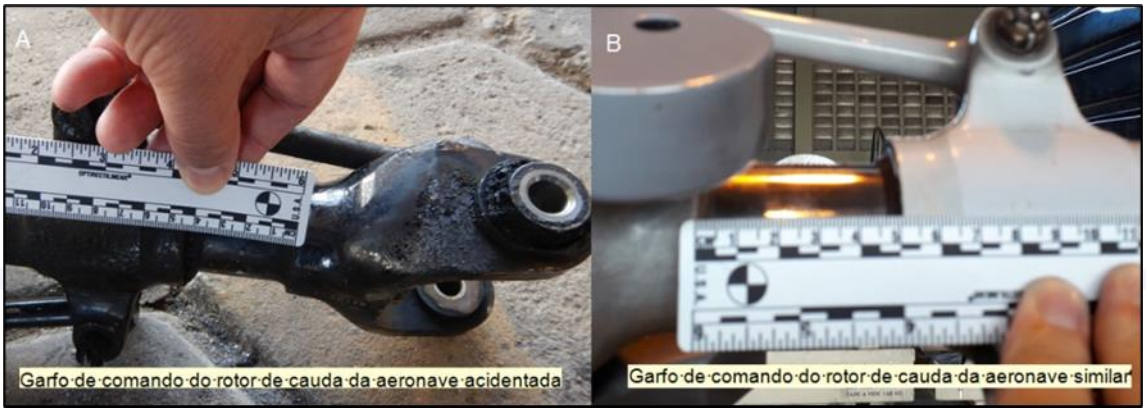

Figure 6 A and B - Tail rotor control fork.

After disassembling the tail rotor fixing fork, it was found that its alignment stop was marked with an impact. This fact allowed us to conclude that the tail rotor was working at the moment of impact.

The examinations confirmed the continuity of the tail rotor drive system and the presence of energy (rotation and torque) in its blades at the time of the accident.

Arriel 2B1 Engine Examination, SN 511525.

The analysis of the engine that equipped the PP-MMG was carried out at the Safran Group in Xerém, municipality of Duque de Caxias - RJ. The accredited representatives of the BEA, HELIBRAS, accredited professionals from the SERIPA III, engineers from the DCTA, and technicians from the maintenance sector of the Safran Group participated in this analysis.

The analysis aimed to check the operating condition of the engine during the occurrence, verifying the possibility that some improper functioning could have contributed to the occurrence.

For this analysis, the module 05 was opened, and the alignment mark that existed on the drive gear and the fixing nut was verified. A misalignment of the marks was observed (Figure 7) which indicates that the engine was delivering power at the time of the impact with the ground.

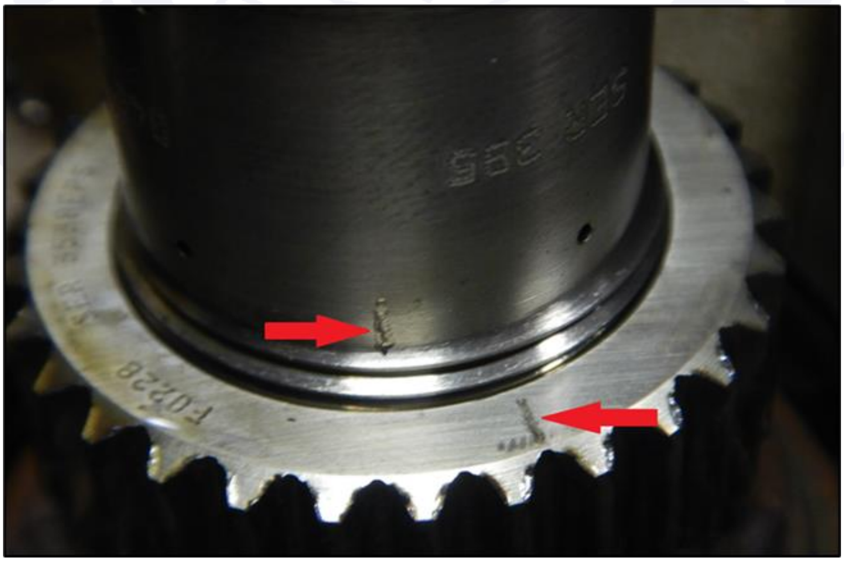

Figure 7 - Misalignment marks overview.

It was found that all the power turbine blades profiles were lost following blade shedding (Figure 8).

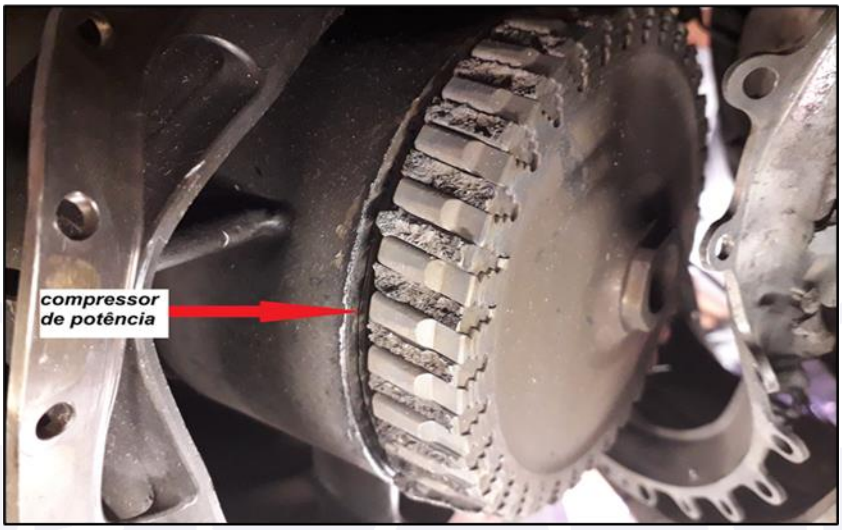

Figure 8 - Power turbine overview with loss of all the blades.

To analyze the engine internally, an inspection was performed using a borescope device. In this exam, no abnormalities were found, and its internal presentation was compatible with its TSN, with more than 2.804 hours.

Probably, all engine damage happened due to the ground impact and the fire.

Thus, the tests performed revealed that the engine had a normal operation and developed high power in the moments that preceded the collision of the aircraft with the ground, thus eliminating the influence of this component as a contributing factor to the occurrence.

1.17 Organizational and management information.

The Btl Rpaer, subordinated to the ComAvE, had as main activities the following tasks:

> Preventively patrol the airspace, carry out rescues in car accidents and places of difficult access, prevent and fight fires, transport human organs for transplants, perform searches and rescues at height and water, locate fugitives, and support police on land, in the various missions carried out by the Military Police.

These were some of the activities that were part of the Btl Rpaer daily routine carried out by the CORPAER, located in Belo Horizonte, Uberlândia, and Montes Claros.

The Battalion used helicopters and an airplane, performing work of fundamental importance for society, flying to protect life and guarantee human dignity.

The analysis of the information collected from the aircraft operator revealed that the training sector of the Military Organization, although it had established manuals, had an organizational culture that did not reinforce standardization, not being identified in the organization's manuals, a standardized flight profile for the type of instruction being performed.

On the date of the occurrence, Public Safety air operations were governed by the requirements established in Subpart K of the RBHA No. 91, and, regarding training, section 91.959 established that:

> [...]
>
> (d) It is the responsibility of the Agency to establish minimum standards for training crews concerning public security and/or civil defense operations specified in paragraph 91.953(b) of this regulation.
>
> [...]

Only as of 12APR2019, with the publication of the RBAC No. 90, entitled "Requirements for special public aviation operations", the necessary training requirements for the tactical air operator of the Units were established in Subpart N. Public Airlines.

Also, in Subpart T of the RBAC nº 90, the requirements for the on-board shooting were published, as transcribed below:

> 90,295 Use of on-board weapons and ammunition (on-board shooting)
>
> (a) For the use of on-board weapons and ammunition (on-board shooting) the public agency or entity must carry out risk management in such a way that the risks to the aircraft, crew, other people with a function onboard, passengers, persons, and land properties are within the NADSO, established in the risk matrix for operational safety.
>
> (b) The use of weapons and ammunition on-board public civil aircraft, including, but not limited to, on-board shooting and ammunition launching carried out by public agencies and entities, with due legal attribution, must observe the following procedures:
>
> (1) Firing, such as on-board shooting or launching ammunition from inside the helicopter, may only be carried out when:
>
> (i) previously coordinated with the pilot-in-command of the aircraft;
>
> (ii) in compliance with the UAP's SOPs and MOP; and
>
> (iii) the crewmembers and other people with function on board are properly trained for this operation in the terms outlined by the UAP;
>
> (2) the shooter must use the EPIs necessary for his safety; and
>
> (3) Long guns used for firing from within the aircraft must have collectors or deflectors for the ammunition shells.
>
> (i) In the absence of collectors or deflectors, the UAP shall have security procedures in place in the SOP to ensure that the capsules and ammunition do not reach the crewmembers, other people with functions on-board, the aircraft, or passengers in flight.

Regarding low-altitude tactical flight, in Subpart V of the RBAC No. 90, the following general requirements were established in section 90.311:

> (a) The initial requirement for low-altitude tactical operation is that control of the risk inherent in the operation, including the protection of aircraft, crew, personnel onboard, passengers, and third parties, is within the NADSO.
>
> [...]
>
> (g) The pilot-in-command shall avoid long flights within the restriction area imposed by the height versus speed diagram (dead man curve) established in the helicopter's AFM.
>
> (h) The flight crew shall establish, whenever possible, emergency landing areas or clear go-around procedures to mitigate risks in the event of an emergency landing.

For this special training, the ANAC did not require that the process be sent to that Agency for approval. However, training for pilots (initial, periodic, leveling up, transition between models and differences) depended on the ANAC approval.

1.18 Operational information.

The aircraft was within the weight and balance limits specified by the manufacturer, operating with a total weight of 1,842 kg at the time of the occurrence.

The flight was conducted with two pilots on board and three snipers in the rear, in the following configuration: one sniper on each side and a shooting instructor positioned between them. The respective side door remained open for firing. For each shooter, the training session lasted from 5 to 8 minutes.

According to research performed, this type of training was part of the training course for operational crewmembers at the PMMG and had already been carried out in previous years by both the PIC and the SIC.

According to the pilots' report, the lateral fire training circuit consisted of a vertical take-off, from a location close to the firing range, a climb to reach a height of approximately 150 ft (AGL), a series of passes close to the target area to allow the training of the shooter on the right and, later, a series of passes to enable the training of the shooter on the left.

At the end of the passes, a traffic circuit was performed with turns to the right to return to the landing site.

According to the PIC, there were five take-offs in the afternoon to carry out onboard shooting training.

On the sixth circuit of the day, after completing training in the target area, the PIC passed the flight controls to the SIC during a sharp left turn at low speed. At that moment, the wind was in the right rear quadrant of the helicopter.

It was reported that the PIC passed the command of the aircraft without it being stabilized. After this transfer, the PP-MMG started the left turn, losing height until the impact with the ground.

According to the PIC, upon noticing the loss of control, he immediately took over the command of the helicopter.

As recommended by the Doctrine Section of the unit, in the event of an adverse situation, the command of the aircraft should be transferred to the instructor pilot.

Despite this action, it was not possible to stabilize the helicopter. Also, according to the PIC, the device experienced an uncontrolled turn to the left, with a loss of height, before impacting the ground (Figure 9).

Figure 9 - Sketch of the accident. Source: adapted from Google Maps.

There were no perceived problems with power loss, pedal locking, or heard any audible or light warnings or alarms during the event.

The PIC and SIC also confirmed that the cyclic and collective control were operating normally before the loss of control.

1.19 Additional information.

DIVOP No. 001/2018.

Due to an accident that occurred with a helicopter model AS 350 B3, the CENIPA published a DIVOP that dealt with Loss of Tail Rotor Effectiveness (LTE) or inadvertent yaw.

On this subject, it is important to clarify that the loss of effectiveness of the tail rotor or inadvertent yaw is a critical aerodynamic phenomenon characterized by a sudden and uncommanded yaw around the vertical axis of the helicopter. This phenomenon does not stop without the correct intervention of the pilot and can cause the loss of control of the aircraft.

According to the DIVOP, LTE, or inadvertent yaw, is not related to equipment or maintenance failures and can occur in all helicopters (one main and one tail rotor) when they are operating at low speeds, generally less than 30 kt.

In this phenomenon, the tail rotor does not stall but becomes inefficient and does not produce the traction needed to prevent yaw.

Several factors can contribute to the occurrence of LTE, including:

- the variable, swirling airflow of the main rotor blades, particularly in high power settings;

- environmental conditions;

- operations with low translational speed (below 30 kt);

- operations at high altitudes and weight close to the PMD (Maximum Take-Off Weight);

- operations close to large constructions or large natural obstacles, which may cause turbulence; and

- the intensity and direction of the relative wind.

Advisory Circular n° 90-95 – Unintended Right Yaw in Helicopters

On 26DEC1995, AC No. 90-95, published by the FAA described the 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, to varying degrees, on single main rotor helicopters at speeds below 30 kt.

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 unintended yaw to the right or the left can occur, depending on the direction of rotation of the main rotor.

The AC 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 flight ahead. This feature is reinforced by both, 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 counteract this tendency by applying the pedal opposite 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 an uncommanded yaw would be critical. Unintended 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 the point where recovery is not possible.

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

Thus, the pilot should anticipate any 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 rotor in the opposite direction time, in favorable conditions for the occurrence of an LTE.

The following factors contribute to the occurrence of an LTE:

- high weight;

- low speed ahead;

- left turn (for aircraft with main rotors that turn clockwise);

- crosswind;

- tailwind; and

- rapid power variations.

During the investigation of another accident that had similar characteristics to an inadvertent swerve, which occurred at the same time and with a helicopter of the same model, the IPEV requested to issue a Technical Opinion, as follows, on the topic under analysis in this occurrence:

Technical Opinion No. 001/IPEV/2021.

In Technical Opinion nº 001/IPEV/2021, the IPEV recorded that all helicopters in the single-rotor configuration with a tail rotor are susceptible to unintended yaw at low speed, depending primarily on the wind condition (intensity and direction), among other factors. For the helicopter on this occurrence, with clockwise rotation of the main rotor, the consequent inadvertent yaw would be the one with the nose to the left, as observed in this occurrence.

In this sense, the Technical Opinion addressed some theoretical aspects of the LTE, namely:

<u>LTE tail rotor efficiency loss</u>

The LTE or unintended yaw is a critical aerodynamic phenomenon characterized by a sudden and uncommanded yaw around the vertical axis of the helicopter. This phenomenon does not stop without the correct intervention of the pilot and can cause the loss of control of the aircraft.

<u>LTE due to main rotor disk vortex interference</u>

Relative winds of 45° to 75° (front right sector) at speeds of about 10 to 30 kt can induce vortices from the main rotor towards the tail rotor (Figure 10, letter “A”). As a result, the tail rotor can operate in an extremely turbulent environment, producing a reduction in thrust as it enters the main rotor disk vortex area.

In the case of a left turn, with the wind in the 2h sector, it is observed that the main rotor vortex increases the angle of attack of the tail rotor blades (increasing the traction and inducing the nose of the helicopter to the right), which requires pilot action on the left pedal to reduce the extra traction produced.

However, after the influence of the main rotor vortices ceases, the tail rotor's angle of attack is reduced, which can lead to an acceleration in yaw to the left, which may surprise the pilot, since the pedal input appears not to match the response of the aircraft, with high yaw rate. If the sudden swerve is not promptly counteracted with effective right pedal command, the turn tends to accelerate quickly, which can compromise the yaw control.

LTE due to tailwind interference on the tail rotor

Tailwinds of 120º to 240º typically cause an increase in pilot workload (Figure 10, letter "B"). Given the influence of relative wind on the fuselage and vertical drift, tailwinds act as an accelerator on the yaw rate, requiring corrective pedal action to counter the aircraft's tendency to align with the wind. A delay in this correction or controlling the desired yaw rate can initiate an accelerated turn on the vertical axis.

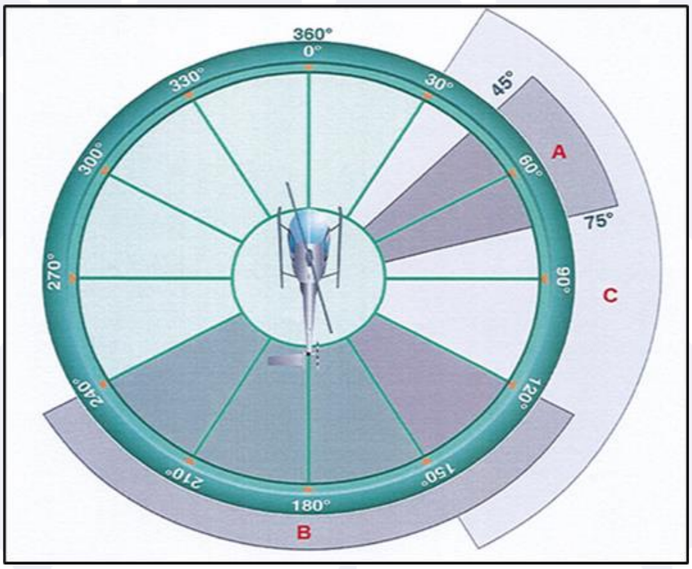

Figure 10 - LTE for helicopter with Clockwise Direction of the Main Rotor. Source: CENIPA, 2018 apud NTSB, 2017.

Region A: Main rotor disk vortex interference towards the tail rotor (relative wind between 45° to 75°);

Region B: Tailwind interference on the tail rotor (relative wind between 120° to 240°); and

Region C: Interference from tail rotor vortex rings (relative wind between 30° to 150°).

LTE due to tail rotor vortex ring state interference.

Relative winds of 30° to 150° (right sector) can cause the tail rotor vortex ring state to develop (Figure 10, letter "C"). Since the tail rotor drives the airflow from left to right (aircraft overhead view), right sector crosswinds oppose this air mass movement imposed by the tail rotor. Thus, conditions can develop for the formation of the state of vortex rings, causing a non-uniform and unstable flow in the tail rotor, with consequent oscillation of the traction of this rotor and deviations in the yaw of the helicopter.

Thus, it is commonly observed that rapid and continuous pedal commands are required from the pilot during a hover with the right-side wind due to the need to compensate for the constant variations in tail rotor traction.

However, it is noted that even with a high pedal workload resulting from the state of the tail rotor vortex rings, helicopters are routinely operated with winds in this region. In this regard, the FAA suggests that an LTE occurs only when there is a delay in the pilot's response to control the rate of yaw increase.

Aerodynamic interference in the tail rotor.

In flights with effective forward translational speed (typically above 30 kt), the tail rotor, the aerodynamic moment on the fuselage and the lateral forces on the vertical drift play a large role as contributing factors to the sum of all the moments portions that contribute to yaw (also known as the *girouette* effect). However, in low-speed flights, it is important to emphasize the primary influence of the tail rotor for yaw movement.

For a given main rotor torque setting, there is an exact amount of tail rotor pull required to prevent the helicopter from yawing left or right. In a hover over the ground, for example, the pilot maintains a certain azimuth through a command (input) on the pedal, adjusting the pitch and angle of attack of the tail rotor blades to produce the desired traction.

Like the main rotor, the effectiveness of the tail rotor is related to a relatively undisturbed mass flow of air to provide constant traction (anti-torque force). On the other hand, when the airflow through a rotor is modified or becomes turbulent, the angle or speed with which the air passes through the rotor disk blades changes, which can produce changes in the traction of the rotor in question.

When there is a disturbance in the tail rotor airflow and the tail rotor is not able to provide the force necessary to balance the torque coming from the main rotor, an uncommanded change in the yaw axis is possible. The resulting imbalance can lead to a sudden swerve and loss of effective control on the directional axis.

The LTE is not related to material failure and can occur on any conventional helicopter flying at speeds less than 30 kt. In addition, it is not necessarily related to a deficiency in the margin of control, which is a certification requirement (Title14 Code of Federal Regulations Part 27.143) and the reason why the critical wind envelope is included in the aircraft flight manual. (Critical Relative Winds Azimuths). In addition, although it does not produce the traction needed to prevent yaw, the tail rotor does not stall.

Tail rotor thrust can be affected by many external factors. The main factors contributing to the LTE are:

- main rotor vortices developing at the tips of the main rotor blades, interfering with the airflow entering the tail rotor assembly;

- tailwinds, with side winds from the right, causing a high workload for the pilot. This factor is also referred to in English as weathercock stability, due to wind action on vertical drift and the fuselage;

- state of tail rotor vortex rings, which originates with the relative lateral wind being sucked in by the tail rotor itself, producing tail rotor traction oscillation, due to non-uniform and unstable airflow;

- turbulence and other natural phenomena that affect the airflow around the tail rotor;

- high power adjustments, that is, of large pitch angle of the main rotor blades, inducing considerable downward airflow of the main rotor blades, providing more turbulence than when the helicopter is in a low power condition; and

- low speeds with changes in the translational lift, varying the direction and speed of the airflow around the tail rotor.

Improper application of pedal command.

As mentioned earlier, the inadvertent yaw, typical of conventional helicopters at low speed and in certain wind conditions relative to the helicopter, was initially described in the 1980s as “loss of tail rotor efficiency – LTE”. In these flight conditions, the tail rotor remains in full operation and without material failures.

Once the unintended yaw happens, a quick corrective response is needed to prevent the turning rate from increasing too much. At first, using the pedal against the yaw may not be effective. Such a characteristic can cause an inadequate application of the pedal command, since the pilot may suspect that the opposite pedal was not effective to contain the rate of turn. However, the ability of the tail rotor to counterbalance the torque of the main rotor remains unchanged, which would be equivalent to saying that there is no loss of tail rotor efficiency, but the inadequate application of commands.

On 07MAR2019, AIRBUS HELICOPTERS published Safety Information Notice No. 3297-S-00 - Unintended left yaw (the main rotor rotating clockwise), commonly referred to as LTE, in which it addressed, from another point of view, the inadvertent turn to the left of a helicopter, whose main rotor rotated clockwise.

The document reported that unintended 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.

Unintended yaw can be rapid and most often occurs in the opposite rotation direction 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 of 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.

Therefore, understanding what an inadvertent swerve is, it`s important to avoid it, mainly because it is a contributing factor to some accidents.

In this regard, Safety Information Notice No. 3297-S-00 provided detailed information on when the situation could arise, why the tail rotor might appear 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 a total loss of tail rotor thrust (for example, as would be the case after the tail rotor drive rupture). The symptom (intense inadvertent left yaw) is similar and the short-term response to a late and ineffective pedal command is close to zero for both cases.

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

If the full use of the right pedal has no effect on the yaw after a timely correction, 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 an inadvertent yaw, which requires staying well away from the ground and obstacles until a full recovery is achieved.

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

During an unintended 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 counteracted by substantially increasing the pitch of the tail rotor.

The only early signal the pilot can receive of a possible loss of control is the initiation of an unintended yaw.

Therefore, the Safety Information Notice recommended some 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 an inadvertent, abrupt yaw;

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

- if an inadvertent yaw occurs, react immediately and with great amplitude, using the pedal opposite to 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 11).

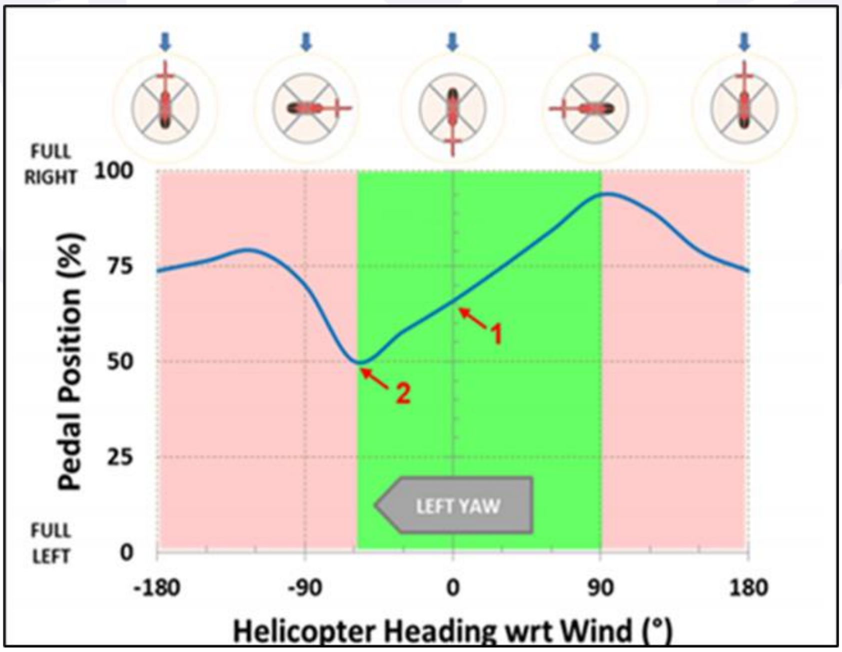

Figure 11 - Stabilized Pedal Position as a Function of Relative Wind. Source: Airbus Helicopters.

Concerning a helicopter with clockwise rotation of the main rotor, maintaining a hover with a relative wind of 0° (figure 11 in Figure 11, wind aligned with the helicopter's heading) requires the application of about 65% of the pedal, that is, with the pedal slightly closer to the right pedal stop (top of the graph) than the left pedal 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 over 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.

Furthermore, the green area in Figure 11 corresponds to the range of wind direction in which the helicopter is stable in yaw. 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 11 represents a region 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 11. 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 11), 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, however, 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 inadvertent yaw (uncommanded increase in turning ratio, which does not reduce on its own).

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

On 07FEB2011, Eurocopter and EADS Company published Safety Information Notice No. 2335-S-00 which, among other topics, addressed the issue of LTE. The document was based on the booklet of 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.

Safety Information Notice No. 2335-S-00 noted that in a single main rotor helicopter, one of the main functions of the tail rotor thrust was to control the helicopter's heading. If the tail rotor thrust is insufficient, unintended, 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 the LTE to be insufficient tail rotor thrust associated with an insufficient margin of control, as this can lead to uncontrolled rapid yaw speed. This speed cannot naturally decrease, and, in the absence of correction, it can cause the helicopter to lose control.

The publication goes on to say 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 generally occurs at a low forward speed, typically less than 30 kt, 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 the thrust of the tail rotor; and

- turbulent wind conditions require 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 fly, the gross weight at takeoff 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:

- conditions of unfavorable winds at low speed;

- unintended yaw;

- important and fast yaw, and collective commands at low speed; and

- low-speed flight in turbulent wind conditions.

The Safety Information Notice emphasizes 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 must be able to recognize its onset and begin immediately 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).

Therefore, as these actions can imply 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 an acceleration attitude to increase the forward speed; and

- if altitude allows, reduce power.

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

On the subject, on 12APR2019, section 90.173 of Subpart M of the RBAC No. 90, 'Requirements for Special Public Aviation Operations', established that the LTE concepts 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 local shooting training flight on board with five crewmembers; two pilots and three shooters, all military personnel from the PMMG.

In the sixth circuit of the training, during the performance of a sharp turn to the left, at low speed, about 20 kt, with approximately 150 ft of height, the aircraft started a series of uncontrolled turns, losing height, until its collision with the ground in a forest region. The PP-MMG was completely destroyed due to the fire that started after the impact.

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

Despite not having contributed to the accident, the airframe and engine logbook records were outdated.

It was found that the conditions were favorable for visual flight with visibility above 10 km. The temperature was 28°C and the wind had a direction of 070° with an intensity of 7 kt.

To establish the contributing factors that led to the loss of control of the aircraft, the following points were considered: interviews with the crew; wreckage analysis; information presented by the manufacturer, publications, research, Technical Opinion, and studies carried out.

The analysis of the wreckage showed that the PP-MMG had normal functioning of its systems.

The main rotor blades and tail rotor collided with vegetation before touching the ground. The impact caused the main rotor blades, skis, and main transmission to break.

Examinations of the engine revealed that all damage was probably due to the impact on the ground and the fire that followed.

Therefore, it was concluded that the engine had a normal operation and developed high power in the moments that preceded the collision of the aircraft, thus eliminating the influence of this component as a contributing factor to the occurrence.

Likewise, examinations of the tail rotor assembly confirmed the system's operability with the presence of rotation and torque in the tail rotor blades at the time of the accident.

The PIC and SIC confirmed that the cyclic and collective control were operating normally before the aircraft lost control.

That said, there was no contribution from aspects related to maintenance or premature failure of any material component of the aircraft systems.

In this sense, the operational aspects of the flight that resulted in the accident in question were analyzed.

The aircraft was within the weight and balance limits specified by the manufacturer, operating with a total weight of 1.842 kg at the time of the occurrence.

Initially, it is important to highlight that, according to the height and speed data obtained in the investigation, it was concluded, based on the height/velocity envelope, that the PP-MMG operated out of the stipulated parameters to guarantee a safe landing in autorotation in the event of an engine failure.

The aircraft was carrying out an onboard fire training and operational training flight for PMMG military snipers. However, the unit did not have an established procedure for this type of training, which may have contributed to the fact that pilots flew in the traffic circuit at a speed lower than necessary to guarantee the safety of the operation.

Only on 12APR2019, with the publication of the RBAC No. 90 entitled “Requirements for Special Public Aviation Operations”, the necessary training requirements for tactical air operators of Public Air Units were established in Subpart N.

Also, according to reports, at the end of the sixth circuit, the PIC transferred the aircraft command to the SIC during a left turn, at low speed, without the helicopter being stabilized.

After this transfer, the aircraft initiated an inadvertent left yaw, losing height until impact with the ground. Such action revealed inadequate coordination between the pilots, impacting the management of tasks related to each crewmember in the conduct of the flight.

According to the PIC, upon noticing the loss of control, he took over the controls of the aircraft, as recommended by the Doctrine Section of the unit, in the event of an adverse situation. However, this action did not contribute to the stabilization of the helicopter, which continued in an uncontrolled turn to the left, losing height until it collided with the ground. The act of transferring the controls of the aircraft, in this situation, implied a delayed response in the actuation of the pedal, at a critical moment of the flight.

In this regard, the various publications that addressed accidents related to the loss of control of a helicopter, resulting from unintended and uncommanded yaw, were unanimous in stating that the response of the commands in the situation experienced should be incisive and immediate, which did not happen in this accident.

An unintended yaw or LTE tends to be fast and most often occurs in the opposite direction of rotation of the main rotor blades (i.e., left yaw where the blades rotate clockwise), as was the case with the model of the helicopter of this accident.

Although there are some conceptual interpretations about the taxonomy to be used in this type of event (LTE or inadvertent yaw), it is important to note that, in general, all types of single rotor helicopters, regardless of the direction of the main rotor rotation may be susceptible to the phenomenon of unintended yaw, especially in a curved flight profile, at low speed and with a tailwind.

In this regard, Safety Information Notice No. 2335-S-00 noted that the yaw pedal that is considered critical is the right pedal for a clockwise rotating main rotor and the left pedal for a counterclockwise rotating rotor.

In flights with effective forward translational speed (typically above 30 kt), the tail rotor, the aerodynamic moment on the fuselage and the lateral forces on the vertical drift play a large role as contributing factors to the sum of all the moments portions that contribute to yaw (also known as the girouette effect). However, in flights at low speeds, such as what happened in this accident, it is important to emphasize the primary influence of the tail rotor for yaw movement.

For a given main rotor torque setting, there is an exact amount of tail rotor pull required to prevent the helicopter from yawing left or right.

When there is a disturbance in the tail rotor airflow and the tail rotor is unable to provide the force necessary to balance the torque coming from the main rotor, an uncommanded change in the yaw axis is possible. The resulting imbalance can lead to unintended yaw or LTE.

Thus, observing the flight profile, it was inferred that some factors that were present in the operation of the PP-MMG, in the moments before the accident, created a favorable environment to succeed in the unforeseen turn to the left, namely:

- speed lower than 30 kt;

- tailwind between 120º to 240º typically causes an increase in pilot workload. Given the influence of relative wind on the fuselage and vertical drift, the tailwinds acted as an accelerator on the yaw rate, requiring corrective pedal action to counter the aircraft's tendency to align with the wind. A delay in this correction or in controlling the desired yaw rate contributed to the initiation of an accelerated turn on the vertical axis; and

- the relative winds of 30° to 150° (right sector) can cause the tail rotor vortex ring state to develop. Thus, conditions can develop for the formation of the state of vortex rings, causing a non-uniform and unstable flow in the tail rotor, with consequent oscillation of the traction of this rotor and deviations in the yaw of the helicopter.

Therefore, the inadvertent swerve, like the one that happened in this accident, could, initially, have been avoided, if the circuit had been carried out with speeds above 30 kt.

In the same way, the inadvertent yaw phenomenon could have been reversed if the pedal opposite to the spin, in this case, the right pedal, was applied immediately, at the first signs of the spin and, in its full amplitude, by substantially increasing the pitch of the tail rotor. Reducing the power and pitch of the helicopter were also recommended actions.

However, the fact that the PIC transferred the command of the aircraft, in a non-stabilized condition, with low speed, and in a turn, and had untimely reassumed the controls, after the beginning of the yaw, contributed decisively to the adoption of a response delay in the controls of the aircraft, making it impossible to regain control of the helicopter.

3. CONCLUSIONS.

3.1 Facts.

a) the pilots had valid CMAs;

b) the pilots were qualified and had experience in the type of flight;

c) the PIC had a PCH License and a valid HMNT Rating;

d) the SIC had a PPH License and valid HMNC and HMNT Ratings;

e) the aircraft had a valid CA;

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

g) the airframe and engine logbook records were outdated;

h) the weather conditions were favorable for the flight;

i) the organization did not have an established procedure for this type of on-board shooting training;

j) while performing a left turn, an unintended yaw occurred which caused the helicopter to lose control;

k) the helicopter lost height and spun out of control until it hit the ground;

l) there was no contribution from aspects related to maintenance or premature failure of any material component of the aircraft systems;

m) aircraft systems were operating normally;

n) the aircraft was destroyed;

o) the PIC and the SIC suffered minor injuries;

p) one shooter left unharmed; and

q) two shooters suffered serious injuries.

3.2 Contributing factors.

- **Control skills – a contributor.**

The unintended yaw, such as the one that occurred in this accident, could have been reversed if the pedal opposite to the turn, in this case, the right pedal, was applied immediately and, in all its amplitude, in the first moments of the yaw.

- **Training – undetermined.**

The fact that the organization did not have an established procedure for onboard fire training may have contributed to pilots flying in the traffic circuit at a speed lower than necessary to guarantee the safety of the operation in case of in-flight engine failure.

- **Crew Resource Management – a contributor.**

The successive transfers of command between the pilots revealed inadequate coordination between the crewmembers, impacting the management of tasks related to each pilot in the conduct of the flight.

- **Perception – a contributor.**

It was difficult for the crewmembers to recognize and understand the characteristic signs that the helicopter was starting an inadvertent and uncommanded yaw.

- **Support systems – undetermined.**

The unit did not have an established procedure for the type of training carried out, which may have contributed to the fact that the pilots flew in the traffic circuit at a speed lower than necessary to guarantee the safety of the operation in the event of an in-flight engine failure.

4. SAFETY RECOMMENDATION.

A proposal of an accident investigation authority based on information derived from an investigation made intending to prevent 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 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):

A-065/CENIPA/2019 - 01 **Issued on 12/05/2022**

Work with the Minas Gerais` Btl Rpaer, to verify that the control of risks inherent to specialized training, especially low-altitude tactical flights and onboard fire, are within the NADSO defined by that UAP, as prevised in the RBAC No. 90.

A-065/CENIPA/2019 - 02 **Issued on 12/05/2022**

Disseminate the lessons learned in the present investigation to the Public Air Units that operate according to the rules of the RBAC 90, in order to complement the guidelines contained in the training programs, especially on the need to recognize the first signs and the field actions to be taken for recovery from an unintended turn.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

An online lecture was held by the SERIPA III, addressing the topic of LTE / unintended yaw for all Public Air Units in its area of jurisdiction.

On December 5th, 2022.