COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
IG - 111/CENIPA/2020

OCCURRENCE:	**SERIOUS INCIDENT**
AIRCRAFT:	**PP-MRA**
MODEL:	**AS 350 B3**
DATE:	**13SEPT2020**

NOTICE

According to 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 investigation and prevention activities of aeronautical accidents.

The elaboration of this Final Report was conducted by taking into account the contributing factors and hypotheses raised. Therefore, the report is a technical document reflecting 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 under 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, using this report for any purpose other than 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 13SEPT202 serious incident with the AS 350 B3 aircraft model, registration PP-MRA. The serious incident was classified as “[LOC-I] Loss of Control in Flight”.

During the air taxiing, after returning from a local flight when performing a 90º turn to the left to enter a taxiway, there was a loss of control of the aircraft, which made a turn of approximately 540º. Then, the control of the helicopter was re-established.

There was no damage to the aircraft.

The five occupants 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
ADE	State Direct Administration Aircraft Registration Category
ANAC	Brazil's National Civil Aviation Agency
BEA	Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile
CA	Airworthiness Certificate
CAESP-AL	Special Air Head of the Alagoas Public Security
CENIPA	Aeronautical Accident Investigation and Prevention Center
CMA	Aeronautical Medical Certificate
DB	Flight Logbook
DIVOP	Operational Disclosure
EHST	European Helicopter Safety Team
FAA	Federal Aviation Administration
HMNT	Single-Engine Turbine Rating - Helicopter
IPEV	Institute for Research and Flight Testing
IS	Supplementary Instruction
LTE	Loss of Tail Rotor Effectiveness
NSCA	Aeronautics Command System Standard
NTSB	National Transportation Safety Board (USA)
OM	Maintenance Organization
PCH	Commercial Pilot License – Helicopter
PF	Pilot Flying
PIC	Pilot in Command
PM	Pilot Monitoring
PMD	Maximum Takeoff Weight
PPH	Private Pilot License – Helicopter
PTO	Operational Training Program
RBAC	Brazilian Civil Aviation Regulation
SERIPA II	Second 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
SNAL	ICAO Location Designator – Arapiraca Aerodrome - AL
SOP	Standard Operating Procedures
SSP	State Secretariat for Public Security
UAP	Public Air Unit

UTC	Universal Time Coordinated
VFR	Visual Flight Rules

1. FACTUAL INFORMATION.

Aircraft	**Model:** AS 350 B3 **Registration:** PP-MRA **Manufacturer:** HELIBRAS	**Operator:** State Secretariat for Public Security – SSP
Occurrence	**Date/Time:** 13SEPT2020 - 1640 UTC **Location:** Arapiraca Aerodrome (SNAL) **Lat.** 09°46’35” S **Long.** 036°37’50” W **Municipality – State:** Arapiraca – AL	**Type(s):** “[LOC-I] Loss of Control in Flight” **Subtype(s):** NIL

1.1 History of the flight.

The aircraft took off from the Arapiraca Aerodrome (SNAL) - AL at about 1615 (UTC) for a local flight to perform aerial patrol with two pilots and three other police officers on board.

On the way back, during air taxiing, when performing a 90º turn to the left to enter the taxiway that gave access to the apron, there was a loss of control of the aircraft, which made a turn of approximately 540º to the left.

Then, control of the aircraft was re-established, and the pilot performed a go-around procedure, entering the SNAL traffic circuit, where the landing was uneventful.

Figure 1 – The PP-MRA helicopter at the SNAL maneuvering apron.

The aircraft was not damaged.

The pilots and passengers left unharmed.

1.2 Injuries to persons.

Injuries	Crew	Passengers	Others
Fatal	-	-	-
Serious	-	-	-
Minor	-	-	-
None	2	3	-

1.3 Damage to the aircraft.

None.

1.4 Other damage.

None.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Flight Hours		
	PIC	SIC
Total	2.176:55	496:25
Total in the last 30 days	06:30	26:35
Total in the last 24 hours	04:00	04:00
In this type of aircraft	1.893:00	54:50
In this type in the last 30 days	06:30	26:35
In this type in the last 24 hours	04:00	04:00

N.B.: The data relating to the flown hours were obtained through interviews with the pilots.

1.5.2 Personnel training.

The PIC took the PPH course, at Edra *Aeronáutica*, in Ipeúna - SP, in 2003.

The SIC took the PPH course, at Scoda *Aeronáutica*, in Ipeúna - SP, in 2016.

1.5.3 Category of licenses and validity of certificates.

The pilots had a PCH License and valid HMNT Rating.

1.5.4 Qualification and flight experience.

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

The RBAC nº 61, which provided for Licenses, Ratings, and Certificates for Pilots, established that:

> 61.21 Recent Experience
>
> (a) Notwithstanding the time limits outlined in section 61.19 of these Regulations, no pilot may act as pilot-in-command or second-in-command of an aircraft unless within the preceding ninety (90) days he has performed:
>
> (1) for daytime flight operations: at least 3 (three) takeoffs and 3 (three) landings in visual flight conditions, during which you have effectively operated the controls of the aircraft of the same category, class, and model or type, as required; and
>
> [...]

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) 3250, was manufactured by HELIBRAS in 2000 and was registered in the ADE Category.

The aircraft CA was valid.

The airframe and engine logbook records were updated.

On the date of the occurrence, the aircraft had 4.824 hours and 35 minutes total.

The last inspection, the "100H/10H/1MONTH/7DAYS" type, was carried out on 03SEPT2020 by the OM Henrimar *Helicópteros* (COM nº 1110-32/ANAC), in Maceió - AL, with the aircraft having 15 hours and 35 minutes flown after 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 a flight with power would result in yaw to the left and that the speed of the spin would depend on the power and speed 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.

1.7 Meteorological information.

The weather conditions were favorable for the flight to take place.

The wind at the site had, respectively, an estimated direction and speed of 120º and 15 kt.

1.8 Aids to navigation.

Nil.

1.9 Communications.

Nil.

1.10 Aerodrome information.

The Aerodrome was public, managed by the Alagoas Department of Roads and Highways, and operated under Visual Flight Rules (VFR), day and night.

The runway was made of asphalt, with 10/28 thresholds, dimensions of 930 x 18 m, and an elevation of 886 ft.

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.

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

1.13.2 Ergonomic information.

Nil.

1.13.3 Psychological aspects.

The PIC was part of the CAESP-AL's pilot staff. He was 52 years old and an Alagoas Civil Police Officer.

This flight was a routine operational activity, with an overflight of the region and an approximate time of 20 minutes.

The flight was performed with the PIC occupying the left seat and exercising the role of PM. The SIC was in the right seat, acting as the PF.

On the way back, when entering the final approach to land on SNAL, the pilots' roles were switched, and the aircraft started to be operated by the PIC.

The PIC reported that he had not operated the aircraft from the left seat for some time without specifying the exact period. He added that this aspect could have influenced the loss of control of the aircraft.

Moreover, he pointed out that he had established communication with the pilot of another aircraft during the approach phase for landing. He had difficulties in clearly defining how he acted on the pedals during the critical phase of the flight, and he requested help from the SIC to reestablish control of the aircraft.

During the interview, the PIC showed overconfidence when he reported that he would be able to maintain control, even by executing a sharp left turn, without decelerating. It was also identified that the PIC's behavior may have been influenced by the intention to show the SIC his operational capability.

Another factor observed was associated with inattention since the PIC shared the helicopter operation and had bilateral contact with the pilot of another aircraft moments before the serious incident.

The SIC was a Civil Police Officer from the State of Alagoas. He was 43 years old and a member of the CAESP-AL pilots' staff.

He was in a career phase in which he was accumulating experience, aiming for operational progression since the legislation established a mark of 500 flight hours to occupy the position of commander in police operations.

During the interview, he reported that, although he had tried to help the PIC to stabilize the aircraft, he did not remember if, at that moment, he acted on the pedals.

1.14 Fire.

There was no fire.

1.15 Survival aspects.

The pilots and passengers abandoned the aircraft by their own means.

1.16 Tests and research.

The aircraft's engine was operational and developing power at the time of the serious incident, and all systems were working properly.

1.17 Organizational and management information.

The SSP/CAESP-AL, the operator of the helicopter involved in this serious incident, operated under the rules established by the RBAC No. 90, which provided the requirements for Special Operations in Public Aviation, and was treated by that legislation as a UAP.

Created to provide administrative and operational support to preventive, ostensive, and repressive air policing, the UAP also operated in aerial medical rescue and transport as well as in civil defense actions carried out by the agencies belonging to the Alagoas Social Defense System.

At the time of the occurrence, CAESP operated from its headquarters, located in Maceió - AL, and had a detached base at the Arapiraca Aerodrome - AL.

The institution's staff was composed of members of the Military Fire Department and the Civil and Military Police of the State of Alagoas.

The organization had an internal structure focused on runway maintenance services supervision, including daily pre-flight and post-flight procedures and in-flight checks.

The Operational Training and compliance with the PTO were the responsibility of the operations sector.

There was an Operational Safety Management structure implemented in the organization.

1.18 Operational information.

The aircraft was within the weight and balance limits specified by the manufacturer at the time of the occurrence.

It was an aerial patrol flight conducted by CAESP-AL.

The police operation took place under the rules of the RBAC No. 90, namely:

> 90.5 Attributions of air units of public agencies and entities
>
> (a) Special public aviation operations carried out by public agencies and entities shall be restricted to their attributions provided by law.
>
> (b) The attributions of public agencies and entities covered by this Regulation are:
>
> (1) public security air operations: intended for the preservation of public order, the security of people and property, protection of the environment, and civil defense actions as established in art. 144 of the Constitution of the Federative Republic of Brazil;
>
> [...]

On the day of the occurrence, the pilots performed two local flights on the same aircraft, totaling 1 hour and 24 minutes.

The PIC and SIC reported that in the 90 days before this serious incident, they had flown, respectively, 33 hours and 55 minutes and 29 hours and 25 minutes, in the AS 350 B3 model aircraft, having both performed at least 3 (three) takeoffs and 3 (three) landings during the day, effectively operating the aircraft controls, thus complying with the provisions of section 61.21 of the RBAC 61.

The most experienced pilot, who acted as PIC, had approximately 2,177 total flight hours, of which 1.893 hours were on the aircraft model involved in the occurrence, while the SIC had approximately 496 total flight hours, of which 55 hours were performed on the model in question.

To be promoted and be able to act as Pilot in Command, the SIC had the objective of reaching the 500 flight hours mark, according to the requirement established in section 90.23 of the RBAC 90:

> 90.23 Requirements for exercising the role of pilot-in-command:
>
> (a) These are minimum requirements for exercising the role of pilot-in-command at the UAP
>
> [...]

> (6) having 500 (five hundred) total flight hours in the category of aircraft in which they will perform the respective function or 300 (three hundred) total flight hours in the case of a single-engine piston aircraft under VFR;
>
> (7) having the minimum experience (number of flight hours) in public aviation special operations, as established by the UAP in the MOP;
>
> [...]

Before the take-off, the pre-flight items were carried out under the provisions of the aircraft's operating manual. In the flight preparations phase, the pilots adjusted the positioning of the seats, considering the reach and amplitude of the pedals, and collective and cyclic commands.

During the investigation, it was found that the adjustment of the left seat, a position occupied by the PIC throughout the flight, allowed his full authority over the flight controls (cyclic, collective, and pedals).

The aerial patrol flight was conducted at approximately 500 ft above sea level and was uneventful.

In the aircraft's Logbook, on page 00004, referring to the date of the occurrence, there was a record that the pilot who occupied the left seat performed the PIC function, and the one who occupied the right seat performed the SIC function.

The PIC acted as PM from the take-off until the approach for landing.

On the way back, close to landing at threshold 10, the pilots alternated their actions in the commands, with the PIC taking over the commands (PF).

Section 90.3 of the RBAC No. 90 established the following definitions for PM and PF:

> (63) pilot monitoring: pilot-in-command or second-in-command in the effective monitoring of the phases of the flight, which performs auxiliary functions to the pilot flying, according to the UAP`s SOP.
>
> (64) pilot flying: pilot-in-command or second-in-command in effective control of the aircraft, either manually or through the use of automation, according to the UAP`s SOP.

The PIC reported to the SIPAER investigators that he maintained the speed of 60 kt on the final straight until the crossing of the threshold, adding that the wind direction in SNAL was approximately 120º, with an intensity of 15 kt.

The images obtained by a camera installed at the Aerodrome show the sequence of events that elapsed between the approach of the PP-MRA for landing and the restoration of control.

The approach was carried out to threshold 10 of SNAL. Subsequently, the helicopter taxied over the runway, reducing speed (Figures 3 and 4).

Figure 3 - Point 1, air taxiing over the runway.

Figure 4 - Point 2, left turn.

The loss of control occurred at the end of the 90º turn to the left when entering the taxiway that gave access to the apron (Figures 5 and 6).

Figure 5 - Point 3, air taxiing over the taxiway.

Figure 6 - Point 4, beginning of the loss of control.

After making one turn and a half to the left, approximately 540°, control of the aircraft was reestablished (Figures 7, 8, 9, and 10).

Figure 7 - Point 5, another record of the loss of control of the aircraft.

Figure 8 - Point 6, final moments of the loss of control of the aircraft.

Figure 9 - Point 7, restoration of aircraft`s control.

Figure 10 - Point 8, controlled aircraft.

Then, the PIC decided to perform a go-around procedure to carry out a visual traffic circuit, which culminated in the final landing.

The dynamics of this serious incident can be visualized and understood from the sketch shown in Figure 11.

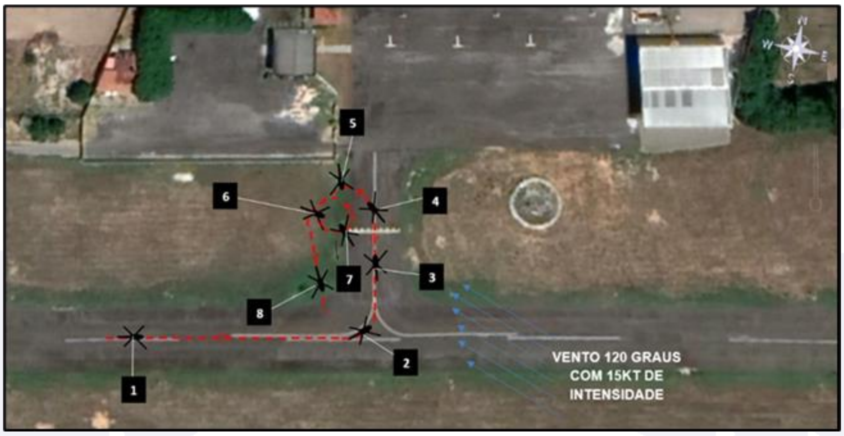

Figure 11 - Sketch of the serious incident.

- Point 1: air taxiing over the runway aiming at landing;
- Point 2: start turning left, to enter the taxiway;
- Point 3: air taxiing over the taxiway;
- Point 4: the beginning of the loss of control;
- Points 5 and 6: sequence of loss of control in-flight;
- Point 7: Restoration of aircraft control; and
- Point 8: aircraft returning to the runway, controlled.

- The CAESP-AL PTO, section C, page 09, of 09APR2020, Revision 02, contemplated procedures for the prevention of Loss of Tail Rotor Effectiveness (LTE).

On the subject, section 90.173 of Subpart M of RBAC No. 90, Requirements for Public Aviation Special 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.

1.19 Additional information.

Advisory Circular (AC) No. 90-95 - Unexpected Right Turn in Helicopters.

On 26DEC1995, the AC No. 90-95, published by the FAA, described the LTE as a critical, low-speed aerodynamic phenomenon that can result in unexpected yaw and, if not properly corrected, can lead to loss of aircraft control. LTE is not related to maintenance problems and can vary in helicopters with only one main rotor at speeds below 30 kt.

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

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

The AC further detailed another characteristic of helicopters, known as weathercock stability. By construction, helicopters have a smaller lateral area ahead of the center of gravity than the lateral area behind it, generating positive directional stability in the flight ahead. This characteristic 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, the publication continued, tailwinds of 120º to 240º cause a large workload for the pilot. The most significant characteristic of tailwinds is that they cause the pre-existing yaw ratio to accelerate. Even a smooth yaw ratio can be abruptly accelerated if the pilot does not counteract this tendency by applying the pedal opposite to the yaw from the moment the wind hits the tailwind quadrant (from 120º to 240º).

In this way, the AC emphasized that a correct and timely response by the pilot to an unexpected yaw would be critical. Unexpected yaw is usually correctable if the counter-turn pedal is applied immediately. If the response is incorrect or slow, the yaw rate can rapidly increase to a point where recovery will not be possible.

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

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

The following factors contribute to the occurrence of the loss of tail rotor effectiveness (LTE):

- high weight;
- low speed ahead;
- left turn (for aircraft with clockwise rotating main rotors);
- crosswind;
- tailwind; and
- rapid power fluctuations.

DIVOP nº 001/2018.

Due to an accident that occurred with an AS 350 B3 helicopter, the CENIPA published a DIVOP, which dealt with LTE.

On the subject, the DIVOP reported that loss of tail rotor effectiveness is a critical aerodynamic phenomenon that is characterized by a sudden, unexpected yaw around the helicopter's vertical axis. Such a phenomenon does not cease without correct pilot intervention and can cause the loss of control of the aircraft.

According to the DIVOP, the LTE 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, usually less than 30 kt.

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

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

(a) the variable, swirling airflow from the main rotor blades, particularly in high-power configurations;

b) the environmental conditions;

c) low translational speed operations (below 30 kt);

d) operations at high altitudes and weight close to PMD;

e) operations close to large buildings or large natural obstacles, which may cause turbulence; and

f) the intensity and direction of the relative wind.

The DIVOP also warned that typical operations such as power grid inspections, electromagnetic surveys, rescue, and air ambulance services, police operations, aerial reporting, and filming services had a higher possibility of LTE occurrence phenomena.

Technical Opinion No. 001/IPEV/2021.

In Technical Opinion nº 001/IPEV/2021, prepared to subsidize this investigation, the IPEV recorded that all helicopters in the single-rotor configuration, with tail rotor, are susceptible to unexpected yaw at low speed. Depending primarily on the wind condition (intensity and direction), among other factors. For this helicopter, with clockwise rotation of the main rotor, when viewed from above (observed from the top perspective), the consequent unexpected yaw would be the one with the nose to the left, as observed in this serious incident.

The document recorded that LTE or unexpected yaw is a critical aerodynamic phenomenon characterized by a sudden and unexpected 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.

In this sense, the Technical Opinion elaborated some considerations, namely:

- LTE due to main rotor disk vortex interference.

> 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 12, letter “A”). As a result, the tail rotor can operate in an extremely turbulent environment, producing a reduction in thrust as it enters the vortex area of the main rotor disk.
>
> 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). It requires the 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. That may surprise the pilot since the pedal input appears not to match the response of the aircraft with a 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 yaw control.

- LTE due to tailwind interference on the tail rotor.

Tailwinds of 120º to 240º typically cause an increase in pilot workload (Figure 12, 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 in controlling the desired yaw rate can initiate an accelerated turn on the vertical axis.

- LTE due to state interference from tail rotor vortex rings.

Relative winds of 30° to 150° (right sector) can cause the tail rotor vortex ring state to develop (Figure 12, letter B). Since the tail rotor drives the airflow from left to right (aircraft upper 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 a right side wind due to the pilot's 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 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.

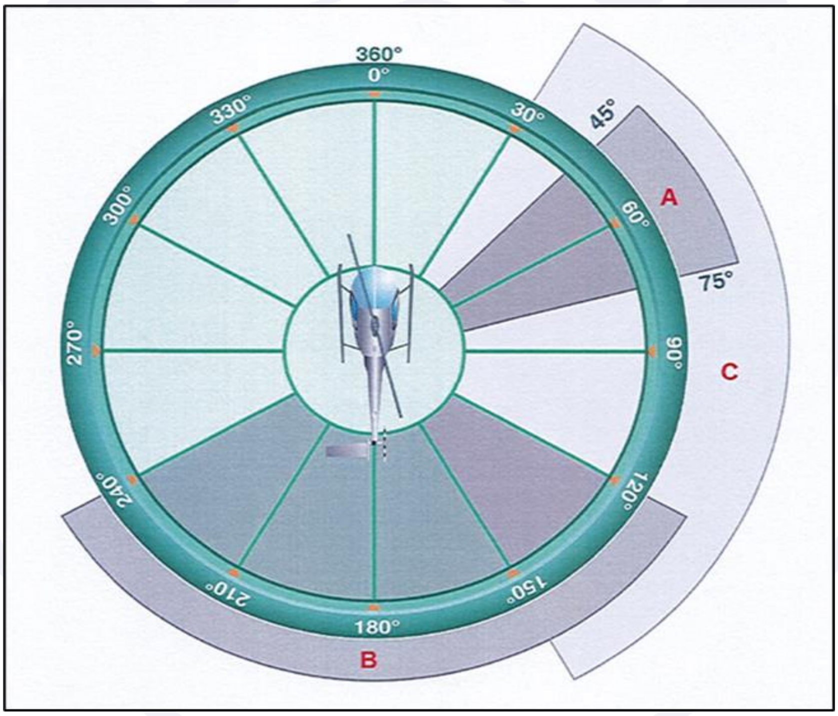

Figure 12 - LTE for helicopter with clockwise Main Rotor.
Source: CENIPA, 2018 apud NTSB, 2017.

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

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

C. Region C: Tail rotor vortex ring interference (relative wind between 30° and 150°).

- Tail rotor aerodynamic interference.

In flights with effective translational speed ahead (typically above 30 kt), there is key participation of the tail rotor, the aerodynamic moment on the fuselage, and the lateral forces on the vertical drift as contributing factors to the sum of all portions of the moments providing to yaw (also known as the girouette effect). In low-speed flight, however, it is important to emphasize the primary influence of the tail rotor for yaw motion.

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 relative to the ground, for example, the pilot maintains a certain azimuth through a footswitch input, adjusting the pitch and angle of attack of the tail rotor blades to produce a desired pull.

Like the main rotor, the effectiveness of a tail rotor is related to a relatively undisturbed air mass flow 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 at which the air passes the rotor disc blades is modified and 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 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 a loss of effective control in the yaw plan (LTE).

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

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

a) main rotor vortices developing at the tips of the main rotor blades, interfering with the flow of air entering the tail rotor assembly;

b) 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;

c) 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;

d) turbulence and other natural phenomena that affect the flow of air around the tail rotor;

e) high power adjustments, hence large pitch angle of the main rotor blades, inducing considerable downwash of the main rotor blades, providing more turbulence than when the helicopter is in a low power condition; and

f) low speeds with changes in translational lift. Varying the direction and speed of the airflow around the tail rotor.

- Improper application of pedal command.

As previously mentioned, the unexpected 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 unexpected yaw occurs, a quick corrective response is required to prevent the rate of turn from increasing too much. At first, using the pedal against the yaw may not be effective. Such a feature can lead to improper application of the pedal command, as the pilot may suspect that the opposite pedal was not effective in containing the rate of turn. However, the ability of the tail rotor to counterbalance the main rotor torque remains unchanged, which would be equivalent to saying that there is no loss of tail rotor efficiency but the rather inadequate application of commands.

On this, on 07MAR2019, Airbus Helicopters published a SIN 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 (the main rotor rotating clockwise), commonly referred to as LTE.

The document reported that unanticipated 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, does not guarantee that the yaw will decrease immediately, leads the pilot to suspect that the effectiveness of the tail rotor is compromised, when, in fact, the ability to of available tail rotor thrust remains unchanged.

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

Therefore, understanding what unexpected yaw is, is important to avoid it, especially since it is a contributing factor in some accidents.

In this regard, Safety Information Notice No. 3297-S-00 provided detailed information about:

- when the situation could arise;
- why the tail rotor might seem ineffective; and
- how to react to maintain or regain full control of the equipment.

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

The publication also highlighted that only the immediate application of the right pedal in all its amplitude and promptly 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 has no effect on the 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 an unexpected yaw that 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 limited application of the pedal.

During spin caused by an unexpected yaw, 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 pitch of the tail rotor.

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

Therefore, the SIN recommended the following actions:

- take special care when the wind comes from the right side of 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 to respond to an unexpected and abrupt yaw;

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

- if an unexpected yaw occurs, react immediately and with great amplitude, using the pedal opposite to the turn direction. 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 has stopped.

For the description of the phenomenon, a constant graph was used in the Safety Information Notice N° 3297-S-00, which approached the pedal position turn, as a function of the relative wind incidence direction of the helicopter, in a stabilized condition of hovering. For each combination of weight, altitude, temperature, and wind speed there was a corresponding turn (Figure 13).

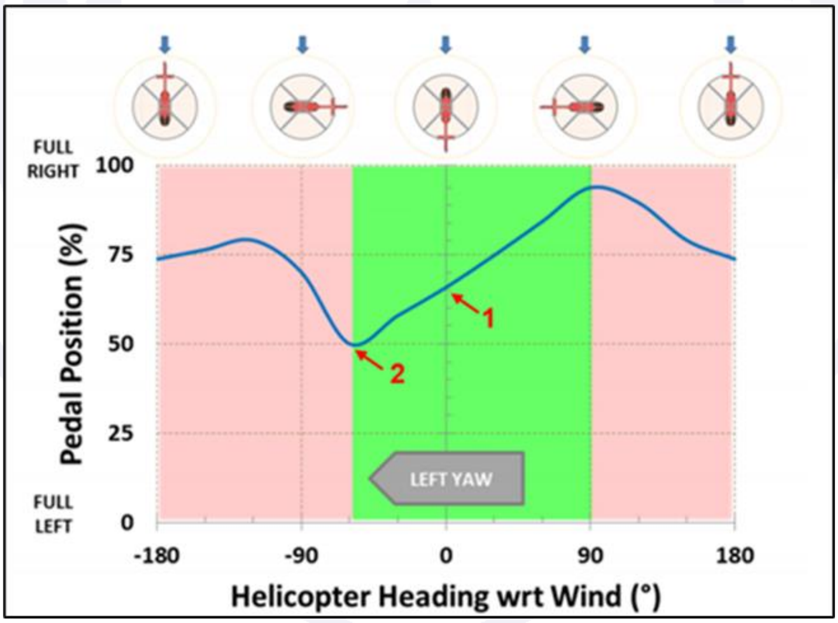

Figure 13 - Stabilized pedal position as a function of the relative wind.
Source: Airbus Helicopters.

Regarding a helicopter with clockwise rotation of the main rotor, maintaining a hover with a relative wind of 0° (number 1 in Figure 13, wind aligned with the helicopter's heading) requires the application of about 65% pedal, i.e., with pedal a little closer to the right pedal stop (upper part of the graph) than to the left pedal stop (lower part of the graph).

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

If the pedal control is set to a position above the turn, the helicopter will produce a differential in tail rotor pull relative to the pull required to maintain the heading, yawing to the right. Conversely, 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 13 corresponds to the wind direction range in which the helicopter is stable in yaw. In this interval, if there is a gust of wind changing the helicopter's heading from 0° to -10° without any pedal command input (x-axis to the left with no variation in the y-axis), the pedal percentage will sit in a position above the turn (helicopter from North heading to 350° heading. It is equivalent to a helicopter heading -10° relative to the wind direction while maintaining the pedal position that existed with relative wind heading of 0°). In response (right pedal above that required for this new position), the helicopter swerves to the right until it crosses the turn in a stabilized position for the selected pedal position, which happens at an initial 0° heading. Therefore, when moving away from the stabilized position, a return movement to this position is generated.

The red area in Figure 13 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 tailwind regions is often recognized by helicopter pilots, creating increased workload for yaw control, especially at low speeds when vertical drifts and, the fuselage have little influence on heading hold.

The lower limit of the stable range (helicopter heading of about -60° concerning wind direction) is indicated as number 2 in Figure 13. From this point (-60°), the helicopter's relative heading decrease is linked to the unstable yaw region (left red area of the graph). At this inflection point (number 2 in Figure 13), when a left pedal is applied (from 50% pedal position to 45%), the pedal position lies below the lowest point of the pedal turn. This means that a nose turn to the left will occur without, however, reaching a stabilized point of relative heading.

Unless the right pedal is actuated, the aircraft will not cease the nose turn to the left. Building on this example, by maintaining the pedal position at 45% as the helicopter turns (rotates around its Z axis), the turn ratio is dramatically increased as the difference between the stabilized pedal position and the applied command increases (distance between the 45% pedal position and the turn). In other words, the longer the delay to correct the maneuver through the right pedal, the greater the acceleration in yaw, which defines unexpected yaw (an increase in the yaw ratio in an uncommanded way, 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 an EADS Company published SIN No. 2335-S-00 which, among other topics, addressed the issue of 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.

SIN No. 2335-S-00 highlighted 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, 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 SIN considered the LTE as insufficient tail rotor thrust associated with an insufficient margin of control, as this can lead to unexpected rapid yaw speed. This yaw speed cannot naturally decrease, and in the absence of correction, it can cause the helicopter to lose control.

The publication went on to say that an LTE is more likely to occur when the critical yaw pedal is near its end-of-travel position.

The yaw pedal that is considered critical is the right pedal for the main rotor turning clockwise and the left pedal for a rotor turning counterclockwise.

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;

- high power regulation demands a yaw pedal position close to the end of the travel;

- unfavorable wind conditions increase the thrust requirement of the tail rotor; and

- turbulent wind conditions require significant and fast yaw and collective controls;

The document directed that to avoid an LTE, during flight preparation, pilots should consider the aircraft's flight manual, more especially regarding performances as a function of critical wind azimuths, the density altitude at which they fly, the gross weight at helicopter takeoff, and flight characteristics.

During the flight, pilots should always be aware of wind conditions and the available tail rotor thrust margin, which is represented by the critical pedal position.

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

- unfavorable winds at low speed;

- unexpected yaw;

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

- low-speed flight in turbulent wind conditions.

The SIN went on to state that pilots should be aware that if they enter a flight regime in which a condition or a combination of them occurs, they may enter an LTE situation. They should be able to recognize its onset and immediately begin positive control recovery actions.

Thus, control recovery actions vary depending on the circumstances. If height permits, increase speed ahead without increasing power (if possible by reducing it). This should resolve the unexpected spin.

Therefore, as these actions can entail considerable altitude loss, pilots are recommended to identify them clearly before performing the operations mentioned above.

The document was finalized indicating the following actions to exit an LTE:

- fully press the pedal opposite the direction of the turn;

- adopt a throttle attitude to increase speed ahead; and

- if altitude permits, reduce power.

1.20 Useful or effective investigation techniques.

Nil.

2. ANALYSIS.

It was a local flight to perform aerial patrol in the region, with two pilots and three other police officers on board.

The flight in question, a public security air operation, was under the requirements established in the RBAC #90.

The pilots were qualified and experienced in the type of flight. The mission was executed with the PIC in the left seat, acting as Pilot Monitoring (PM). The SIC occupied the right seat, as Pilot Flying (PF).

Although the documentation submitted by the CAESP-AL showed that the PIC had performed other flights in the last 90 days, in aircraft of the same model, it was not possible to determine whether he operated in command of a helicopter (Pilot Flying), making landings and takeoffs, using the left seat.

On the way back, near the entrance of visual traffic for landing at SNAL, the pilots' roles were reversed, and the PIC now operated the aircraft.

During the taxiing, while making a 90º turn to the left to enter the taxiway leading to the maneuvering area, there was an unexpected yaw to the left, associated with loss of control of the helicopter, which made one and a half turns to the left (approximately 540°). Control of the aircraft was reestablished when it was at about 180° to the maneuvering yard. The aircraft then reentered a new traffic circle. The landing at SNAL was uneventful.

The weather conditions were favorable for the flight. The wind at the site had an estimated direction and speed of 120º and 15 kt respectively.

The video of the occurrence showed an air taxiing speed acceleration after the left turn, already on the taxiway, followed by a deceleration just before the unexpected yaw.

Observing the facts and evidence present in this occurrence it is inferred that the phenomenon known as unexpected yaw has occurred, considering that no evidence of the contribution of aircraft systems to the occurrence under analysis was found.

In this respect, Safety Information Notice No. 3297-S-00 recorded that unexpected yaw is a flight characteristic to which all single-rotor helicopter types (regardless of anti-torque design) may be susceptible at low speed, generally depending on the wind direction and strength in relation to the helicopter. Yaw is rapid and most often occurs in the opposite direction of rotation of the main rotor blades (i.e., yaw to the left where the blades rotate clockwise).

According to the Advisory Circular (AC) No. 90-95, any maneuver that requires the pilot to operate in a high-power, low-speed environment with crosswinds or tailwinds creates conditions that may propitiate unexpected yaw to the right or left, depending on the direction of the main rotor rotation.

About this, the CENIPA's DIVOP 001/2018 warned that unexpected yaw is a critical aerodynamic phenomenon characterized by sudden and unexpected yaw around the vertical axis of the helicopter. Such a phenomenon does not cease without correct pilot intervention and can cause the loss of control of the aircraft. The phenomenon is not related to equipment or maintenance failures and can occur at low speeds, usually less than 30 kt.

It is important to note that, in this condition, the tail rotor does not stall but becomes inefficient and does not produce the necessary traction to prevent yaw if corrective actions are not in a timely adopted. Thus, as Safety Information Notice No. 3297-S-00 correctly pointed out, only the immediate application of the right pedal to its full amplitude will be able to counter the yaw and allow the pilot to identify whether he is experiencing unexpected yaw or total loss of tail rotor thrust due to malfunction.

Given the recovery to a stabilized controllability condition after the yaw, any mechanical failure was ruled out in this serious incident.

From the data collected during the investigation, such as wind conditions, weight and balance of the aircraft, video made available by the operator, and the non-identification of mechanical failure, it was possible to specify, in accordance with what was exposed in the Technical Report 001/IPEV/2021, the following two factors that may have contributed to the momentary loss of control of the helicopter:

(a) aerodynamic interference with the tail rotor; and

(b) Inadequate application of pedal control.

1st hypothesis - Aerodynamic interference in the tail rotor.

In this hypothesis, it was considered that there was a disturbance in the tail rotor airflow, and the tail rotor failed to provide the necessary force to balance the torque coming from the main rotor, occurring an uncommanded change in the yaw axis.

Some conditions present contributed to the unexpected yaw, such as tailspin from the right to enter the taxiway, with right and tailwinds (Figure 12), and high gross weight with a speed ahead of less than 30 kt.

The rapid power variations performed (acceleration and deceleration during taxiway) interfered with translational lift, resulting in increased power demand and, consequently, the increased anti-torque force needed to keep the flight stabilized. As there was not enough force, the resulting imbalance led to the phenomenon described as a loss of effective control in the yaw plan.

2nd hypothesis - Inadequate application of pedal control.

This hypothesis is directly related to the pilot's commands.

During the air taxi, there was a speed acceleration, already in the taxiway, followed by a deceleration just before the inadvertent yaw.

The variations in speed were accompanied by longitudinal variations in cyclic command (pitch down and pitch up), which were followed by variations in the collective command to maintain height relative to the ground. In turn, wide variations in the collective command required compensations in the pedal command for maintaining heading.

This dynamic, characterized by successive variations in the cyclic, collective, and pedal commands, demanded a great deal of work from the pilot to the taxi. The moment that preceded the inadvertent turn coincided with the critical region of wind incidence, with gusts close to the inflection point of the stable area in yaw to the unstable area (Figure 13).

This situation induced a flight with low predictability about the ideal pedal position for heading maintenance. The delay in correcting any inaccurate commands was sufficient for the yaw acceleration until reaching high spin ratios and may even have reached the condition in which the tail rotor traction became insufficient to stop the fast yaw.

Such a hypothesis was entirely linked to the pilot's commands (inputs), unrelated to the phenomena of unexpected yaw or LTE when wind or main rotor runoff affects the tail rotor's ability to generate traction.

Although the two hypotheses have been treated separately for ease of understanding, their concomitant occurrence is also admissible.

Regarding the hypotheses above, it was observed that, for the occurrence of the unexpected left yaw, the PF may have failed to adequately consider, among others, the following aspects:

- making turns contrary to the anti-torque effect in operations with speeds below 30 kt, whenever possible;

- tailwind and crosswind when operating at speeds below 30 kt;

- wide and fast yaw and collective controls at speeds below 30 kt; and

- Pedal amplitude used to counteract main rotor torque, keeping in mind that if the pedal course was close to the stop, it would not be possible to counteract an unexpected yaw.

However, the crew took effective measures to regain control of the helicopter after the unexpected left yaw, as described in Helibras Safety Information Notice No. 2335-S-00 of 2011, as well as in Safety Information Notice No. 3297-S-00, prepared by Airbus Helicopters on 03JUL2019.

It was not possible to identify whether there was a conflict between the pilots in the application of flight commands at the critical moment of the flight.

The PIC reported that he had not operated the aircraft from the left seat for some time without specifying the exact period. He added that this aspect could have influenced the loss of control of the aircraft.

In addition, he pointed out that he established communication with the pilot of another aircraft during the approach phase for landing and reported that he had difficulty in clearly defining how he acted on the pedals during the critical phase of the flight. He requested help from the other pilot to reestablish control of the aircraft. Thus, it is possible that the PIC experienced a downgrade in the attention process and the warning system, reducing the possibility of a quick and accurate response to the first signs of the unexpected yaw.

During the interview, the PIC stated that he could perform the air taxi maneuver over the runway with the aircraft developing speed above desirable and that he would be able to maintain control, even by executing a sharp left turn without decelerating. Based on this statement, it is possible to infer that the pilot was overconfident, increasing the potential undesired consequences of a maneuver that could lead to loss of control due to conditions favorable to unexpected yaw.

It was also identified that the PIC's behavior may have been influenced by the intention of showing the other pilot his operational capability.

3. CONCLUSIONS.

3.1 Facts.

a) the pilots had valid CMA`s;

b) the pilots had valid HMNT Ratings;

c) the pilots were qualified and had experience in the type of 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) the weather conditions were favorable for the flight;

h) it was a police patrol flight, with two pilots and three other police officers on board;

i) on the way back, during the taxi when performing a 90º turn to the left to enter the taxiway that gave access to the apron, there was a loss of control of the aircraft;

j) there was an acceleration of the air taxi speed, after the left turn, already on the taxiway;

k) the aircraft performed a left turn of approximately 540°;

l) control was reestablished when the aircraft moved approximately 180º in relation to the apron;

m) after performing a go-around procedure, the PIC entered the SNAL traffic circuit, proceeding to land;

n) the landing was carried out safely;

o) the aircraft was not damaged; and

p) all occupants left unharmed.

3.2 Contributing factors.

- **Control skills – a contributor.**

The unexpected yaw, such as the one that happened in this occurrence, could have been avoided if the pedal opposite to the spin, in this case, the right pedal, was applied immediately and in its full amplitude, substantially increasing the pitch of the tail rotor in the first moments of the yaw.

During the air taxi, there was an acceleration in speed, already on the taxiway, followed by a deceleration just before the unexpected yaw.

The variations in speed were accompanied by longitudinal variations in cyclic command (pitch down and pitch up), followed by variations in the collective command to maintain height relative to the ground. In turn, wide variations in the collective command required compensations in the pedal command for maintaining heading.

This dynamic, characterized by successive variations in the cyclic, collective, and pedal commands, required a great workload from the pilot to perform the taxi.

- **Attention – undetermined.**

It is possible that, as a result of inattention and the downgrading of the warning system, the possibility of a quick and accurate response to the first signs of sudden yaw was reduced due to the PIC's dialogue with the pilot of another aircraft.

- **Attitude – undetermined.**

It is possible that the failure in the aircraft operation was associated with the PIC's overconfidence, believing that he would maintain control of the aircraft performing the maneuver at a speed above the desired, and by the possible intention to show the other pilot his operational capabilities.

- **Training – undetermined.**

The PIC reported that he had not operated the aircraft from the left seat for some time, which may have contributed to the inadequate performance and insufficient throughput in the context of the operation.

- **Crew Resource Management – undetermined.**

The transfer of command between the pilots moments before landing, without proper coordination, may have impacted the management of tasks related to each pilot in the conduct of the flight since the PIC continued to maintain bilateral contact with another aircraft.

- **Piloting judgment – a contributor.**

When deciding to perform the aerial taxiing maneuver on the runway with the aircraft developing speed above the recommended and below 30 kt, also with longitudinal variations of cyclic command (pitch down and pitch up), followed by variations of collective command to maintain height above the ground, the pilot failed to adequately assess the risk conditions that were present, including the variables that contributed to the occurrence of unexpected yaw.

- **Perception – a contributor.**

The PIC had difficulties in his ability to recognize and understand the characteristic signs that the helicopter was starting an unexpected and uncommanded yaw.

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 Brazil's National Civil Aviation Agency (ANAC):

IG-111/CENIPA/2020 - 01 **Issued on 03/23/2023**

Disseminate the lessons learned in the present investigation to the Alagoas State Secretariat for Public Security and to the other Public Air Units that operate according to the rules of the RBAC 90, to complement the guidelines contained in the training programs, in particular on the need to recognize the first signs and the field actions to be taken to recover from unexpected yaw.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

None.

On March 23th, 2023.