COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
IG-063/CENIPA/2020

OCCURRENCE:	**SERIOUS INCIDENT**
AIRCRAFT:	**PR-SCL**
MODEL:	**AS 350 B2**
DATE:	**11MAI2020**

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 considering the contributing factors and hypotheses raised. The report is, therefore, a technical document which reflects the result obtained by SIPAER regarding the circumstances that contributed or may have contributed to triggering this occurrence.

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

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

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

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

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

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

N.B.: This English version of the report has been written and published by the CENIPA with the intention of making it easier to be read by English speaking people. Considering 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 Final Report refers to the serious incident involving the AS 350 B2 aircraft, registration PR-SCL, on 11 May 2020. The occurrence was typified as "[UIMC] IMC unintentional" and "[AMAN] Abrupt Maneuver".

While flying en route, the aircraft entered Instrument Meteorological Conditions (IMC). The pilot commanded an abrupt maneuver to get out of such condition.

During the maneuver, the main rotor RPM exceeded the limits specified by the manufacturer.

The aircraft sustained minor damage.

The crew was not injured.

Being France the State of the Aircraft Design, an Accredited Representative of the *Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile* (BEA) was designated for participation in the investigation.

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GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ADE	Category of registration for aircraft under direct state-administration
ANAC	Brazil's National Civil Aviation Agency
BEA	*Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile* (France)
CA	Airworthiness Certificate
CENIPA	Brazil's Aeronautical Accidents Investigation and Prevention Center
CIV	Pilot Logbook
CMA	Aeronautical Medical Certificate
CRM	Crew Resource Management
ELT	Emergency Locator Transmitter
FL	Flight Level
GRAESP/PA	State of Pará's Public Security Air Operations Group
HMNT	Single-Engine Turbine Helicopter Class Rating
ICA	Command of Aeronautics' Instruction
IFR	Instrument Flight Rules
IFRH	IFR Flight Rating (Helicopter Category)
IMC	Instrument Meteorological Conditions
NR	Main-Rotor Rotational Speed
OEE	Special-Equipment Operator
PCH	Commercial Pilot License (Helicopter Category)
PF	Pilot Flying
PIC	Pilot in Command
PPH	Private Pilot License (Helicopter Category)
PTO	Operational-Training Program
RBAC	Brazilian Civil Aviation Regulation
RPM	Revolutions per minute
SBBE	ICAO location designator - *Aeródromo Internacional Val de Cans - Júlio Cezar Ribeiro*, *Belém,* State of *Pará*
SIC	Second in Command
SIGWX	Significant Weather Chart
SNVS	ICAO location designator - *Aeródromo de Breves*, state of *Pará*
UTC	Universal Time Coordinated
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions

1. FACTUAL INFORMATION.

Aircraft	**Model:** AS 350 B2 **Registration:** PR-SCL **Manufacturer:** HELIBRAS	**Operator:** Sec. de Estado de Seg. Pub. Def. Soc. do Pará
Occurrence	**Date/time**: 11MAI2020 - 12:05 UTC **Location:** Route between *Belém* and *Breves*, state of *Pará.* **Lat.** 01°31'30"S **Long.** 049°48'14" W **Municipality – State:** *Breves – Pará*	**Type(s):** [UIMC] Unintended flight in IMC [AMAN] Abrupt maneuvre

1.1. History of the flight.

At 11:19 UTC, the aircraft took off from SBBE (*Val de Cans - Júlio Cezar Ribeiro* International Aerodrome, *Belém*, *Pará*) bound for SNVS (*Breves* Aerodrome, *Pará*) on a personnel transport flight, with two pilots, one Special-Equipment Operator (SSO), and one passenger on board.

While flying VFR en route, the helicopter entered instrument meteorological conditions above a layer of clouds. At approximately 12:05 UTC, while attempting to regain visual meteorological conditions, the aircraft performed an abrupt maneuver with a descending right turn.

During the maneuver, the main rotor speed reached 493 RPM. There was high vibration, and the Emergency Locator Transmitter automatically activated.

After stabilizing the flight conditions, the helicopter proceeded to the destination.

The aircraft sustained slight damage. The three crewmembers and the passenger did not suffer injuries.

1.2. Injuries to persons.

Injuries	Crew	Passengers	Others
Fatal	-	-	-
Serious	-	-	-
Minor	-	-	-
None	3	1	-

1.3. Damage to the aircraft.

The visible damage was limited to detachment of the seals from the three main-rotor blades frequency adapters (Figure 1).

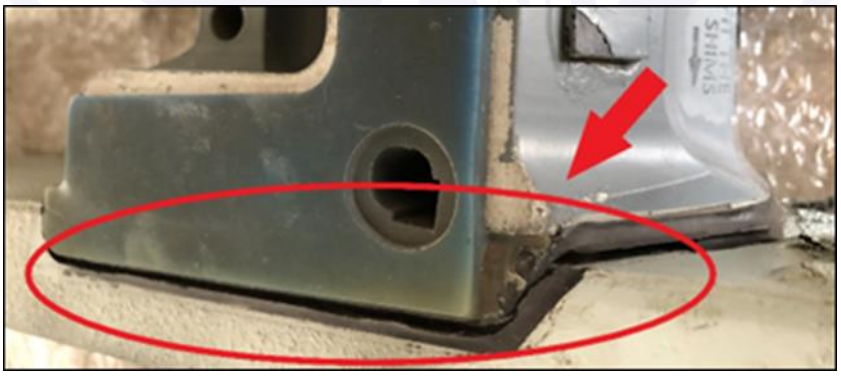

Figure 1 – Detachment of the frequency-adapter sealant.

Due to the overspeed condition event (493 RPM), the maintenance staff removed the main- and tail-rotor blades, and sent them to the manufacturer for analysis and repair.

It was necessary to discard some of the components described in the AS350 05-53-00-601 Maintenance Manual, page 603, version 2019.09.26, as determined by the manual.

1.4. Other damage.

NIL.

1.5. Personnel information.

1.5.1. Crew's flight experience.

Flight Experience		
	PIC	SIC
Total	1.075:40	146:00
Total in the last 30 days	04:10	05:00
Total in the last 24 hours	01:10	01:10
In this type of aircraft	819:20	05:00
In this type in the last 30 days	04:10	05:00
In this type in the last 24 hours	01:10	01:10

NB.: Source of information related to the crew's flying-time: pilots' Logbooks (CIV).

1.5.2. Personnel training.

The Pilot-in-Command (PIC) did the PPH course (Private Pilot – Helicopter) in 2006, at *EDRA Aeronáutica*, in *Ipeúna*, state of *São Paulo*.

The pilot Second-in-Command (SIC) did the PPH course in 2019, at *EACAR - Escola de Aviação Civil*, in *Piraquara*, state of *Paraná*.

1.5.3. Category of licenses and validity of certificates.

The PIC held a PCH license (Commercial Pilot – Helicopter) and a valid HMNT rating (Single-Engine Turbine Helicopter).

The SIC held a PPH license (Private Pilot – Helicopter) and a valid HMNT rating.

Neither pilot had an IFRH rating (IFR Flight Pilot – Helicopter).

1.5.4. Qualification and flight experience.

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

1.5.5. Validity of medical certificate.

The pilots held valid Aeronautical Medical Certificates (CMA).

1.6. Aircraft information.

The serial number 7792 aircraft was manufactured by HELIBRAS in 2014, and was registered in the Direct State-Administration Registration Category.

The Certificate of Airworthiness (CA) was valid.

The airframe and engine logbooks were up-to-date.

The last inspection of the aircraft (type "10 hours / 7 days") was performed on 10 May 2020 by the GRAESP/PA (State of *Pará's* Public Security Air Operations Group) in *Belem*, *Pará*. The aircraft flew 1 hour and 10 minutes after the inspection.

The last comprehensive inspection of the aircraft (type "150 hours") was performed on 23 March 2020 by the *HELISUL* maintenance organization, in *Belém*, *Pará*. The aircraft flew 6 hours and 20 minutes after that comprehensive inspection.

The AS 350 Maintenance Manual established the following actions for operation incidents involving rotor overspeed (Figure 2).

SPEED rpm	CHECK	REMOVE	DISCARD
470 rpm < overspeed ≤ 500 rpm	- Do the operations planned for a rate between 450 and 470 rpm.	- Rear rotor blades or approved repair shop return for: Appearance and tap test of bonding areas (64-10-00-601). Straightness check 3 mm (.118 in.) max. Binding adherence check using ultrasound for the rotors PRE MOD 075595 Inspection of the blade (64-10-00-602) section Check with disassembly. See NOTE below. - Main rotor blades Factory return for: Appearance and tap test of bonding areas (62-10-10-601). Measurement of the dragwise blade deflection (62-10-00-604) Transfer to the dynamic bench for identification of the adjustment parameters.	- STARFLEX star. - Blade attachment pins. - Sleeve flanges (P/N 350A31-1831-06) and (P/N 350A31-1831-07) (Glass flanges) or (P/N 350A31-1850-02) and (P/N 350A31-1850-03) (Carbon flanges).
500 rpm < overspeed			- Main and rear rotor blades.

Figure 2 - Extract from the AS350 - 05-53-00-601 Maintenance Manual, page 603, 2019.09.26

1.7. Meteorological information.

At the time of the occurrence, no weather information was available for SNVS.

As for the region where the flight was taking place, the Significant Weather Chart (SIGWX) generated on 11 May 2020 at 12:00 UTC (valid until 12 May 2020 at 12:00 UTC) showed 5 to 7 oktas of Cumulus and Stratocumulus clouds with base at 1,700 ft and tops at flight level 080.

There was also information that to the north of the route, there were 5 to 7 oktas of Stratus and Stratocumulus clouds with base at 700 ft and tops at FL030.

1.8. Aids to navigation.

NIL.

1.9. Communications.

NIL.

1.10. Aerodrome information.

The occurrence was outside of aerodrome area.

1.11. Flight recorders.

Neither required nor installed.

1.12. Wreckage and impact information.

NIL.

1.13. Medical and pathological information.

1.13.1. Medical aspects.

NIL.

1.13.2. Ergonomic information.

NIL.

1.13.3. Psychological aspects.

The PIC had been a member of the Fire Department for 28 years, 13 of which working at the GRAESP/PA. At the time of the occurrence, he was the operations coordinator of the organization.

According to information, the PIC was a discrete, reserved professional who interacted in a friendly way with the other members of the group. He was regarded as someone who worked with satisfaction and dedication, persisting in the pursuit of his personal and professional goals.

However, there were reports indicating that the PIC presented a somewhat bolder profile as far flight maneuvers were concerned, and there were situations in which his technical-operational judgment was considered inadequate.

According to information gathered, the pilots had rested prior to conducting the flight, and no malaise was reported the day before the event.

The reports gathered indicated a strong commitment of the crewmembers in relation to the accomplishment of the mission, which had the purpose of supporting actions in the fight against the Coronavirus pandemic.

The SIC related experiencing spatial disorientation during the maneuver performed by the PIC, and the aircraft crossed the layer with a highly pitched-down attitude.

According to reports, the PIC decided to descend and cross the cloud layer without coordination or communication with the other crewmembers. There was some discomfort onboard regarding the abrupt change of the flight profile due to the conditions under which the maneuver took place.

It was also informed that, due to possible abnormalities in the collective control resulting from an overspeed condition of the main rotor, the SIC had suggested, several times, to land for a check of the aircraft operating conditions. However, the decision to proceed for a landing at the destination (SNVS) was made unilaterally by the PIC.

According to accounts, there was an appropriate culture in terms of training and flight safety in the Air Operations Group. Notwithstanding, there were reports that the crossing of cloud layers from above was common in operations.

There was no briefing for the mission of the occurrence, according to information.

Considering the data obtained, the pace of work in the Group was generally deemed adequate. However, in some managerial spheres, there was a greater accumulation of activities.

In the case at hand, although such condition was not associated with fatigue, the PIC, besides being an operational crewmember, accumulated two administrative functions.

1.14. Fire.

There was no fire.

1.15. Survival aspects.

NIL.

1.16. Tests and research.

After landing, there was verification that the seals of the main rotor blades' frequency-adapters had detached.

According to the Letter 05-53-00-601 of the AS 350 B2 Maintenance Manual, the rotational speed reached by the main rotor (493 RPM) required the discard of some items of the rotating system, as well as the sending of the main- and tail-rotor blades for analysis by the manufacturer.

The same letter specified that the Main Rotor rotational speed (NR) limit for the discard of all blades was 500 RPM.

1.17. Organizational and management information.

The GRAESP/PA, operator of the helicopter involved in the serious incident, operated in accordance with the rules established in the Brazilian Civil Aviation Regulation no. 90 (RBAC-90). Its staff was composed of members coming from the Military Fire Department, from the Civil and Military Police of the State of *Pará*, as well as of other collaborators linked to the government of the state.

The organization had an internal structure designed to implement the state's public security and civil defense policies by means of air actions and operations, with the objective of promoting the integration and optimization of the aviation resources available in the State's Public Security and Social Defense System, in order to guarantee the execution of the missions pertaining to each institution.

The periodic inspections and more complex maintenance services for the benefit of the PR-SCL aircraft were performed by a specialized workshop certified by the ANAC (Brazil's National Civil Aviation Agency).

The operational training processes were the responsibility of the operations sector. The Operational Training Program (PTO) was valid.

It is worth mentioning that the PTO accepted by ANAC dated back to 03 December 2015, and that it had been produced before the RBAC-90 was in force.

Neither dissatisfactions nor complaints were noticeable in relation to the workload, division of tasks, and work schedules in the organizational context.

The information gathered at the time of the occurrence indicated an average workload accumulation in some managerial positions, leading to an increased centralization of the activities. However, there were no reports of crew fatigue.

1.18. Operational information.

The occurrence flight had the purpose of transporting personnel under the rules established in RBAC-90, Amendment 00 - "Special Public Aviation Operations".

The crewmembers were familiar with the route, and operated in that region on a regular basis.

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

The mission comprised a flight between SBBE and SNVS (Figure 3), in support of actions against the COVID-19 pandemic.

Figure 3 - Aircraft trajectory. Source: Adapted from Google Earth.

The aim of the flight was to transport an oxygen-technician to the field hospital in the city of *Breves*, *Pará*.

The pilots were not qualified to fly in instrument meteorological conditions, nor was the aircraft approved for IFR operations.

The SIC was the Pilot Flying (PF) from the takeoff in SBBE until approximately 30 minutes before landing in SNVS. At some point of the flight, the crew encountered an area of scattered clouds with base at 700 ft.

After coordination with another aircraft which was flying a few minutes ahead of them, and that had reported significant cloud formation at *Breves*, a decision was made to climb in order to avoid those clouds.

Thus, under the guidance of the PIC, the SIC started flying above that layer. The aircraft climbed and remained between 1,000 and 2,000 ft in uncontrolled airspace. After some time flying in those conditions, visual references with the ground diminished.

At a given moment, the PIC took over the controls and decided to go down in order to cross the cloud layer. According to reports, this maneuver had no previous coordination, much to the surprise of the other crewmembers.

According to reports, the PIC looked for an opening in the layer and started a "dive", at a speed of 120 kt. During the descent, the aircraft initiated a right turn in order to remain within that opening. Under such conditions, the visual references were lost, the speed diminished, and the main rotor rotational speed reached 493 RPM. In addition, the aircraft sustained high vibration, and the ELT automatically activated.

After exiting the cloud layer, the aircraft was in a pitch-down attitude. In addition, reports said that the helicopter seemed as if it was being "pushed hard" during the descent.

According to reports, after the NR overspeed and stabilization of the flight, the aircraft's collective control position had visibly changed in relation to the usual for the same flight condition.

Because of that, the SIC had suggested, several times, to perform a precautionary landing. However, the PIC unilaterally decided to proceed to the destination aerodrome.

1.19. Additional information.

The study of helicopter aerodynamics shows that a rotary-wing aircraft flies on the same basic principles of a conventional airplane. The aerodynamic forces for keeping a helicopter in flight are produced at the top of the main rotor as air passes over its blades. The rotor blade, or wing, is the structure that makes flying possible through displacement of the air to keep the helicopter in the air.

The *chord* of a blade is the straight line connecting the blade’s trailing edge to its leading edge.

The *relative wind* is the result of the airfoil moving through the air, while the *angle of attack* is the one formed between the chord of the profile and the relative wind.

In a helicopter, several factors can influence the angle of attack. The pilot controls some of the movements, and other ones occur automatically due to the rotor system. The pilot can control the angle of attack by means of the cyclic and collective flight controls. Whenever the helicopter comes out of a stationary flight, this angle changes constantly, as the blades spin in their cycle along the rotor disk.

Drag, in turn, is the component that counteracts the movement of the airfoil. Typically, when the angle of attack increases, the drag also increases.

The flight controls comprise, among others, the *collective* and *cyclic* control systems.

The cyclic control actuates on the pitch of the blades by changing the angle in different proportions around the main rotor disk. This difference in blade-angle on the disk causes the aircraft to travel according to the movement performed (forward, aft, or sideways).

The collective control actuates in such a way that all the blades change their angle at the same time and in equal proportions, something which results in more or less lift and, therefore, more or less drag on the blades.

In helicopters with turbine engines, control of the throttle is also in the collective, but the rotor RPM is controlled by means of automatic compensators (governor) installed in the fuel controller. When the collective control is applied upwards, there is an increase in blade-pitch, which causes greater drag and, as a consequence, a greater demand for engine power to maintain the rotor rotation. If the collective is moved down, the pitch is reduced, and the propeller will be less required for the task.

The main gearbox receives the motion coming from the engine by means of a shaft attached to it (or shafts, when the helicopter is a twin-engine). It transforms the horizontal motion from the engine into vertical motion for the main rotor.

The transmission reduces the engine's output speed to an optimum speed for better traction of the main rotor. Installed there, is the free wheel, which is the component responsible for providing autorotation.

The autorotation is characterized by the decoupling of the main transmission from the engine in case of propeller failure, allowing the pilot to maneuver the helicopter with the resources available for flying back to the ground.

This condition is achieved by taking advantage of the inertia of the rotor, which is kept spinning by the air which flows from bottom to top in autorotation.

Thus, during autorotation, the upward flow of the air through the rotor maintains the NR.

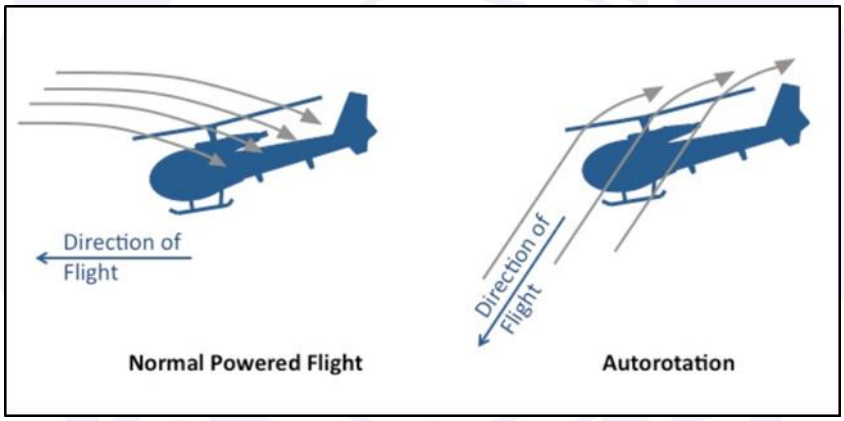

Figure 4 - Illustration of the airflow on the main rotor in normal and autorotation flight.
Source: Autorotation. Available at https://www.skybrary.aero/articles/autorotation.

It is worth remembering that when passing from normal flight to autorotation, it is necessary to lower the collective control to bring the main rotor blades to the minimum flight pitch, and ensure that it keeps spinning with adequate RPM (green band), with a speed of approximately 65 kt for the AS 350 B2.

If one adds a turn to such maneuver, the rate of descent increases because the portion of the rotor disk area that opposes the descent motion decreases.

In addition, the NR will tend to increase during turns, due to the increased load on the blades (G-force), and the pilot may need to use small increments of the collective pitch to keep it within the limits specified by the manufacturer[1].

In such situation, the wind induced by the downward travel will also tend to increase

1 Source: adapted from *Autorotation*. Available at https://www.skybrary.aero/articles/autorotation. Access on 28 OCT 2022.

the main rotor speed.

Flare is a maneuver generally used for landing, in which the speed and rate of descent are reduced, placing the helicopter in a nose-up attitude (cyclic backward)[2].

In summary, in rotary-wing aircraft, recovery from a dive (a maneuver to reduce speed and rate of descent) with application of the cyclic control backward, and collective control downward, can generate NR overspeed.

As for the requirements for conducting a flight under VFR, the Command of Aeronautics' Instruction no. 100-4 (ICA 100-4), - "Special Air Traffic Rules and Procedures for Helicopters", in its paragraphs 3.1.2 and 3.1.3, specifies the following:

> [...]
>
> 3.1.2 Outside controlled airspace, above 3,000 feet altitude or 1,000 feet altitude above ground level, whichever results greater, a helicopter VFR flight shall take place only when, simultaneously and continuously, the following conditions can be met:
>
> (a) remain in flight visibility conditions equal to or greater than 3,000 m;
>
> (b) remain at least 1,500 m horizontally and 500 ft vertically from clouds or any other meteorological formation of equivalent opacity; and
>
> (c) maintain reference with ground or water so that weather formations, below the flight level, do not obstruct more than half of the pilot's area of vision.
>
> 3.1.3 Outside controlled airspace, below 3,000 feet altitude or 1,000 feet above the ground, whichever results greater, a helicopter VFR flight shall take place only when, simultaneously and continuously, the following conditions can be met:
>
> (a) remain in conditions of flight visibility equal to or greater than 1,000 m, provided that the flight speed is sufficient to be seen and avoided by traffic or any obstacle in sufficient time to prevent a collision; and
>
> (b) stay clear of clouds and maintain reference to ground or water.

1.20. Useful or effective investigation techniques.

NIL.

2. ANALYSIS.

It was a flight for transporting personnel between SBBE and SNVS, conducted under the rules established in the RBAC-90.

The flight was under appropriate weather conditions until the moment that the cloudiness along the route intensified, and the PIC instructed the SIC (who was the Pilot Flying) to gain height and keep the helicopter above the cloud layer.

In that context, the flight continued, and the maintenance of visual contact with the ground was becoming impractical. The search for meteorological information on the pertinent database showed the existence of a cloud cover obstructing between 5 and 7 oktas of the sky.

According to accounts, despite being over a layer of clouds obstructing the sight of most of the ground directly below, the flight was progressing normally until the moment that the aircraft was unexpectedly put on a right turn with a downward trajectory. The aircraft ended up crossing the cloud cover, and finished the maneuver in a pitch-down flight trajectory at a pronounced angle before being stabilized.

Upon examining the helicopter flight theory, one inferred that, in order to initiate that maneuver, it was necessary to lower the collective control to its full amplitude, which possibly

[2] Source: adapted from Autorotation. Available at https://www.skybrary.aero/articles/autorotation. Access on 28 OCT 2022.

resulted in decoupling the engine from the main drive (autorotation with power), and to apply the cyclic control to the right, in the same direction of the main rotor rotation.

Because the decoupling resulting from the pilot's input on the collective would permit the rotor to turn freely, while being accelerated by the aerodynamic forces produced during the "dive" (upward air-flow), and also because commanding a turn at that moment would aggravate the overspeed tendency, one concluded that the maneuver was the cause of the overspeed observed in the main-rotor.

The investigators, upon interpreting the expression used by the crewmembers when they said that the helicopter seemed to have been "pushed hard during the descent" as an indication that the aircraft was under a G-force action during the maneuver, concluded that an aggressive flare was conducted for leveling off the helicopter. Such an aggressive flare also contributed to the NR overspeed, as well as to the high levels of vibration reported.

After recovery from the abnormal attitude, the collective control position was different from the one it should be for the flight condition.

The altered position of the flight controls could be an indication of some damage to the main rotor collective pitch-control components. In the case of a rotary-wing aircraft, such alteration after an abrupt maneuver might be the result of an alteration or failure in parts of the rotary system, which one had to check before continuing the flight.

The evasive maneuver performed by the aircraft (to get out of the instrument meteorological conditions on top of the cloud layer) ended up triggering the main rotor overspeed, and caused discomfort to the other crewmembers, as well as possible damage to the main-rotor collective pitch-control components. Therefore, the investigation committee considered that the PIC exercised inappropriate judgment both in relation to the possible consequences of placing the helicopter in such an unusual flight attitude, and to his own ability of managing all the aircraft parameters during the maneuver to recover visual meteorological conditions.

The decision to proceed along the route without the visual references prescribed for VFR flights, as well as performing an abrupt maneuver without prior coordination, characterized actions that reflected difficulties in one's way of thinking, feeling, and reacting in that specific situation, revealing inappropriate postures, such as authoritarianism, excessive self-confidence, and impulsiveness.

The information that the PIC turned down a suggestion of performing a landing to check the aircraft after recovery of normal flight condition also indicated the adoption of a complacent attitude towards the alterations observed in the flight controls, which could escalate the consequences of the incident.

It is possible that, because of his experience of more than 13 years in aviation, and the fact that he was used to operating flights along that route, the PIC chose to proceed with the flight, corroborating the adoption of an attitude of overconfidence in his own performance.

The unilateral decision-making, without any previous coordination, showed lack of efficiency in the use of the human resources available for operation of the aircraft. Such inefficiency was characterized by the absence of the effective communication required for a proper management of the individual crewmembers' assigned tasks, which could help control the rotation of the main rotor and prevent the damage resulting from the maneuver performed.

Such fact, besides indicating weaknesses in the analysis of the situation, evidenced the lack of Crew Resource Management (CRM) principles, the application of which would foster better quality to the decision-making process and would allow the assessment of more appropriate alternatives to the management of the experienced condition.

Since their mission was to support actions in the war against the COVID-19 pandemic, it is possible that there was high motivation for the completion of the flight.

Therefore, it is possible that such motivation contributed to the decision to accept additional risks and proceed under adverse weather conditions, rather than the more conservative option of returning to SBBE within the parameters for a visual flight.

The reports that flying over cloud layers was a common practice in the Air Operations Group, a factor capable of influencing pilots into accepting unsafe operational conditions, could be an indication that the Group operations habitually failed to meet flight safety requirements and procedures in the accomplishment of public security missions. Such behavior suggests the existence of fragility in the group's culture, particularly in what refers to dealing with adverse weather conditions.

The possible existence of such culture in the work group could relate to inadequate supervision by the GRAESP/PA of the activities of execution at the operational level.

Finally, the conduct of the flight under IMC conditions by a pilot who did not have an IFR rating, with an aircraft not certified for that type of operation resulted in additional risks due to the difficulties in maintaining proper control of the equipment.

Under those conditions, the occurrence of spatial disorientation, inappropriate application of flight controls and/or incompliance of limits is common, but it is something that can be mitigated by adherence to the applicable flight standards and requirements.

3. CONCLUSIONS.

3.1. Findings.

a) the pilots had valid Medical Aeronautical Certificates (CMA);

b) the pilots had valid Single Engine Turbine Helicopter (HMNT) licenses. They did not have Instrument Flight Rules - Helicopter (IFRH) licenses;

c) the pilots were qualified and experienced for the flight;

d) the aircraft had a valid Certificate of Airworthiness (CA)

e) the aircraft was within weight and balance limits;

f) the airframe and engine logbooks were up to date;

g) during the flight, the crew encountered an area with scattered cloud formations, with base at 700 ft;

h) under the guidance of the PIC, the SIC started to fly above those clouds;

i) after some time flying in those conditions, references to the ground diminished ;

j) at a certain moment, the PIC took the controls and decided to descend and cross the cloud layer;

k) during the descent, a right turn was initiated, the visual references were lost, the speed decreased, the main rotor rotation reached 493 RPM, the aircraft showed high vibration, and the ELT automatically activated;

l) after exiting the cloud layer, the aircraft was in a very pitched down attitude;

m) it was reported that, after the NR was triggered and the flight stabilized, the position of the collective control was visibly different what was expected for that flight condition;

n) the helicopter proceeded to land at the destination;

o) the aircraft sustained minor damage; and

p) the crewmembers and passenger were not injured.

3.2. Contributing factors.

- **Attitude – a contributor.**

The decision to proceed en route without the visual references prescribed for VFR flights, and the making of an abrupt maneuver without previous coordination, characterized actions which reflected difficulties in one's way of thinking, feeling and reacting in that specific situation. Such mind frame led to inappropriate postures such as authoritarianism, overconfidence, impulsiveness, and disregard with operations, which ended up compromising the safety of the flight.

The information concerning refusal to accept a suggestion to perform a landing for a check of the aircraft after recovering a normal flight condition also indicated the adoption of a complacent attitude in relation to the alterations observed in the flight controls, something that could have aggravated the consequences of the incident.

- **Adverse meteorological conditions – undetermined.**

The search on the weather database, showing a cloud cover obstructing between 5 and 7 oktas of the sky, and crew accounts that maintaining visual contact with the ground was becoming more restricted as the flight proceeded, were an indication that flying under VFR, as per the requirements of the ICA 100-4, might not be feasible in that region.

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

The unilateral decision-making without prior coordination demonstrated inefficiency in the use of the human resources available for operation of the aircraft, characterized by the absence of effective the communication required for the proper management of the tasks assigned to each crewmember, which could help control the rotation of the main rotor and avoid damage resulting from the maneuver performed.

- **Work-group culture – undetermined.**

The reports that flying over cloud layers overhead was common practice in the air operations group were a factor that could influence pilots into accepting unsafe operating conditions. Such fact suggests that, in execution of public security missions, the operations habitually failed to meet the requirements and procedures designed to ensure flight safety, which might relate to a weakness in the group's culture, particularly with regard to facing adverse weather conditions.

- **Handling of aircraft flight controls – a contributor.**

Considering the accounts about the flight dynamic at the time of the main-rotor overspeed event, one concluded that the pilot created certain conditions that triggered the overspeed occurrence, by abruptly putting the aircraft on a downward trajectory during a turn, with the collective control in a down position, and subsequently performing a flare to reestablish level flight. Such combination of actions characterized his application of the flight controls as a contributing factor to this incident.

- **Piloting judgment – a contributor.**

Considering that the pilot's actions performed in order to get out of the instrument meteorological conditions (on top of the layer of clouds) triggered the main-rotor overspeed event. Besides, they caused discomfort to the crew, and damage to the components of the main-rotor rotary assembly. One's conclusion is that the PIC exercised inadequate judgment both in relation to the possible consequences of placing the helicopter in an unusual flight attitude and his ability to manage all the parameters while maneuvering the aircraft to reach visual meteorological conditions.

- **Motivation – undetermined.**

Since the mission was in support of actions against the COVID-19 pandemic, it is possible that a high motivation existed for the accomplishment of the flight.

This motivation may have contributed to the decision to accept additional risk and proceed under adverse weather conditions, rather than the more conservative option of returning to SBBE while meeting the parameters for visual flight.

- **Decision-making process – a contributor.**

The unilateral decision making, without previous coordination, besides indicating weaknesses in the analysis of the situation, evidenced the non-observance of CRM principles, whose application would provide a better quality to the decision making process and would allow the evaluation of more adequate alternatives to manage the experienced condition.

- **Managerial oversight – undetermined.**

The possible existence of a work-group culture related to crossing cloud layers from above might be an indication of inadequate supervision by the GRAESP/PA of the execution activities at the operational level.

4. SAFETY RECOMMENDATIONS

A proposal of an accident investigation authority based on information derived from an investigation, made with the intention of preventing accidents or incidents and which in no case has the purpose of creating a presumption of blame or liability for an accident or incident.

In consonance with the Law n°7565/1986, recommendations are made solely for the benefit of 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".

To Brazil's National Civil Aviation Agency (ANAC), it is recommended:

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Work with the *Grupamento Aéreo de Segurança Pública do Estado do Pará* (GRAESP/PA), so that the operator demonstrates that its managerial oversight mechanisms ensure faithful observance of practices essential to the maintenance of an adequate level of operational safety, particularly with regard to compliance with visual flight rules and application of Crew Resource Management (CRM) principles.

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Work with the Grupamento Aéreo de Segurança Pública do Estado do Pará (GRAESP/PA), so that the operator demonstrates that its Operational Training Program (PTO) meets the requirements set forth in the RBAC-90 in effect.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

A lecture was held at GRAESP/PA, addressing the topic of air operations in IMC conditions and inadvertent entry into IMC.

On August 15th, 2023.