COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A-078/CENIPA/2016

OCCURRENCE:	**SERIOUS INCIDENT**
AIRCRAFT:	**PR-YCB**
MODEL:	**AS 350 B2**
DATE:	**25APR2016**

NOTICE

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

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

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

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

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

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

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

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

SYNOPSIS

This is the Final Report of the 25APR2016 accident with the AS 350 B2 aircraft, registration PR-YCB. The accident was classified as “[LOC-I] Loss of Control in Flight”.

Soon after leaving the ground, before the hovering flight, the helicopter tilted to the right and turned 90º to the left, rolling in its longitudinal axis and turning over to the right.

The blades of the main rotor collided against the ground and the tail cone sectioned.

The aircraft had substantial damage.

The occupants were unharmed and there was no damage to third parties.

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

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GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ADE	Aircraft Registration Category of the State Direct Administration
ANAC	(Brazil's) National Civil Aviation Agency
BEA	Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile
BOA-CBMSC	Air Operations Battalion of the Santa Catarina Military Fire Brigade
CA	Airworthiness Certificate
CENIPA	Aeronautical Accident Investigation and Prevention Center
CG	Center of Gravity
CIV	Pilot's Flight Logbook
CMA	Aeronautical Medical Certificate
EACAR	Escola de Aviação de Asas Rotativas
EASA	European Aviation Safety Agency
H350	H350 Helicopter Type Rating (which included the AS 350 B2 model)
HMNC	Helicopter - Conventional Single-Engine Class Rating
HMNT	Helicopter - Turbine Single-Engine Class Rating
ICAO	International Civil Aviation Organization
IGE	In Ground Effect
INVH	Flight Instructor Rating - Helicopter
LTE	Loss of Tail Rotor Effectiveness
MCA	Aeronautics Command Manual
METAR	Aviation Routine Weather Report
NTSB	National Transportation Safety Board
PCH	Commercial Pilot License - Helicopter
PPH	Private Pilot License - Helicopter
PTO	Operational Training Program
SBBI	ICAO location designator – Bacacheri Aerodrome, PR
SERIPA V	Fifth Regional Aeronautical Accident Investigation and Prevention Service
SIPAER	Aeronautical Accident Investigation and Prevention System
SISY	ICAO location designator – Piraquara Aerodrome, PR
UTC	Universal Time Coordinated
VFR	Visual Flight Rules

1. FACTUAL INFORMATION.

Aircraft	**Model:** AS 350 B2 **Registration:** PR-YCB **Manufacturer:** HELIBRAS	**Operator:** Fund for Improvement of the Santa Catarina's Military Fire Brigade
Occurrence	**Date/time:** 25APR2016 -1358 UTC **Location:** Piraquara Aerodrome (SISY) **Lat.** 25º27'41"S **Long.** 049º06'10 **Municipality – State:** Piraquara - PR	**Type(s):** "Loss of Control in-Flight" **Subtype(s):** NIL

1.1 History of the flight.

The aircraft took off from the Piraquara Aerodrome - PR (SISY), to the Bacacheri Aerodrome - PR (SBBI), at 1358 (UTC), with two pilots and one passenger on board, in order to carry out a transfer flight and, also perform the basic adaptation instruction, with two pilots and one passenger on board.

Shortly after leaving the ground, before stabilizing in a hovering flight, the helicopter tilted to the right and turned 90º to the left, rolling its nose around its longitudinal axis and flipping to the right.

The aircraft had substantial damage.

The two crewmembers and the passenger were unharmed.

1.2 Injuries to persons.

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

1.3 Damage to the aircraft.

Sectioning of the tail cone and its transmission, breaking of the main rotor blades and breaking of the right windshield.

1.4 Other damage.

Nil.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Hours Flown		
	Pilot	Student
Total	820:00	88:20
Total in the last 30 days	05:45	04:45
Total in the last 24 hours	02:00	02:00
In this type of aircraft	600:00	41:45
In this type in the last 30 days	05:45	04:45
In this type in the last 24 hours	02:00	02:00

N.B.: The Data on flown hours were obtained from the Pilots' Flight Logbook.

1.5.2 Personnel training.

The pilot took the Private Pilot course - Helicopter (PPH) at the *Escola de Aviação Asas Rotativas* (EACAR), in Piraquara - PR, 2010.

The student took the Private Pilot course - Helicopter (PPH) at the *Escola de Aviação Civil Hórus* Ltd, in Joinville - SC, 2015.

1.5.3 Category of licenses and validity of certificates.

The pilot had the Commercial Pilot License - Helicopter (PCH) and had valid H350 type Rating (which included the AS 350 B2 model), Helicopter - Turbine Single-Engine Class Rating (HMNT) and Flight Instructor Rating - Helicopter (INVH).

The student had the Private Pilot License - Helicopter (PPH) and had valid R22 type Rating and Helicopter - Conventional Single-Engine Class Rating.

1.5.4 Qualification and flight experience.

The pilot was qualified and had experience on this kind of flight.

The student was not qualified in this kind of aircraft.

1.5.5 Validity of medical certificate.

The pilots had valid Aeronautical Medical Certificates (CMA).

1.6 Aircraft information.

The aircraft, serial number 4898, was manufactured by Helibras in 2010 and was registered in the State Direct Administration category (ADE).

The aircraft had valid Airworthiness Certificate (CA).

The airframe and engines logbooks records were outdated because the computations of the hours flown in the month of March 2016 had not yet been performed.

It was also not duly clarified how the operator controlled the number of cycles of the aircraft and the engine.

The last inspection of the aircraft, the "5400 hours/72 months type", was performed on 09MAR2016 by the HELISUL shop Ltd, in Curitiba - PR, having flown 24 hours and 40 minutes after the inspection.

In this inspection, the original model (BA) was converted to the current model (B2).

1.7 Meteorological information.

The METAR of the localities closest to SISY, Curitiba and Bacacheri were, respectively:

METAR SBCT 251400Z 31009G21KT CAVOK 28/15 Q1012;

METAR SBBI 251400Z 33014G25KT 9999 FEW025 SCT100 28/15 Q1012

Although the weather conditions in SISY were favorable for the visual flight, the wind direction was estimated to be 330° (sector NO), possibly with intensity of 14kt and gusts up to 25kt.

1.8 Aids to navigation.

Nil.

1.9 Communications.

Nil.

1.10 Aerodrome information.

The Aerodrome was private, administered by the Graciosa Aerodrome Aviation Club, and operated under visual flight rules (VFR) at daytime.

The runway was made of asphalt, with thresholds 09/27, dimensions of 450m x 18m, with elevation of 3,212 feet.

The aircraft was taking off from the lawn parking "spot", located in front of the *Escola de Aviação Asas Rotativas* (EACAR) hangar.

1.11 Flight recorders.

Neither required nor installed.

1.12 Wreckage and impact information.

The impact of the main rotor blades occurred against grassy terrain at a 45º angle and the aircraft rotated 90º from the left until its full stop.

The wreckage (sectioned tail cone, bent main rotor blades and broken right windshield) were distributed radially in a fan position.

Figure 1 - Overview of the aircraft after the accident.

1.13 Medical and pathological information.

1.13.1 Medical aspects.

Not Investigated.

1.13.2 Ergonomic information.

Nil.

1.13.3 Psychological aspects.

Not Investigated.

1.14 Fire.

There was no evidence of fire in flight or after impact.

1.15 Survival aspects.

Nil.

1.16 Tests and research.

Due to the possibility of a failure in the operation of the cyclic control assembly, a technical analysis of the entire flight control system of the aircraft was performed by a

team consisting of a technical support representative from HELIBRAS, a maintenance investigator from Fifth Regional Aeronautical Accident Investigation and Prevention Service (SERIPA V) and four mechanics from a maintenance shop approved for the model.

The team concluded that the entire flight control system had normal operation before the occurrence.

The Technical Report - 008/2016 Model AS 350 B2, PR-YCB, 17MAY2016, from HELIBRAS, reported that the cyclic, collective and directional control chain (pedals) has been verified throughout its command extension and noted that they could be moved normally. Finally, in item 3 of the report, he concluded that no anomaly was detected in the controls and the observed damages occurred due to the action and reaction of the impact of the main blades against the ground and due to the flip over of the aircraft.

Therefore, no abnormality was found in the aircraft's flight control system.

1.17 Organizational and management information.

The pilot, who was the Commander of the Battalion, was concerned about the activities scheduled for that day, as he had to travel to Bacacheri Airport (SBBI) where he would perform an aircraft maintenance service in the HELISUL shop and return to his operational base in SBFL.

1.18 Operational information.

The aircraft had enough fuel to make the flight and was available for maintenance. The weight of the aircraft at the time of the accident, according to the survey done in the field investigation, was of 1,798kg.

The aircraft was within the weight and balance limits specified by the manufacturer. However, due to the positioning of the passenger in the right rear seat, the CG had a small displacement in the longitudinal and lateral axes (front and right, respectively).

The AS 350 B2 main rotor blades (R / P) rotated clockwise. The transmission of power from the engine to the R/P generated a force called Torque (Tq). This force (Tq) had an anti-clockwise direction and caused a tendency for the entire fuselage to rotate in the direction opposite to the rotation of the main rotor.

Torque must be controlled, so that the helicopter flight develops normally. Tq is controlled by the tail rotor (R/C). The tail rotor generates a force called Traction (T) that opposes the Tq and allows directional control of the aircraft (about the vertical axis). When spinning and generating the T, the R/C produces an air mat known as downwash. These forces are illustrated in Figure 2.

The estimated wind in the Aerodrome came predominantly from the direction 330º (NO). However, the aircraft was positioned with the nose steered in the 195° (SO) magnetic direction. In this condition, the helicopter was subjected to a tail wind component, as shown in Figure 2.

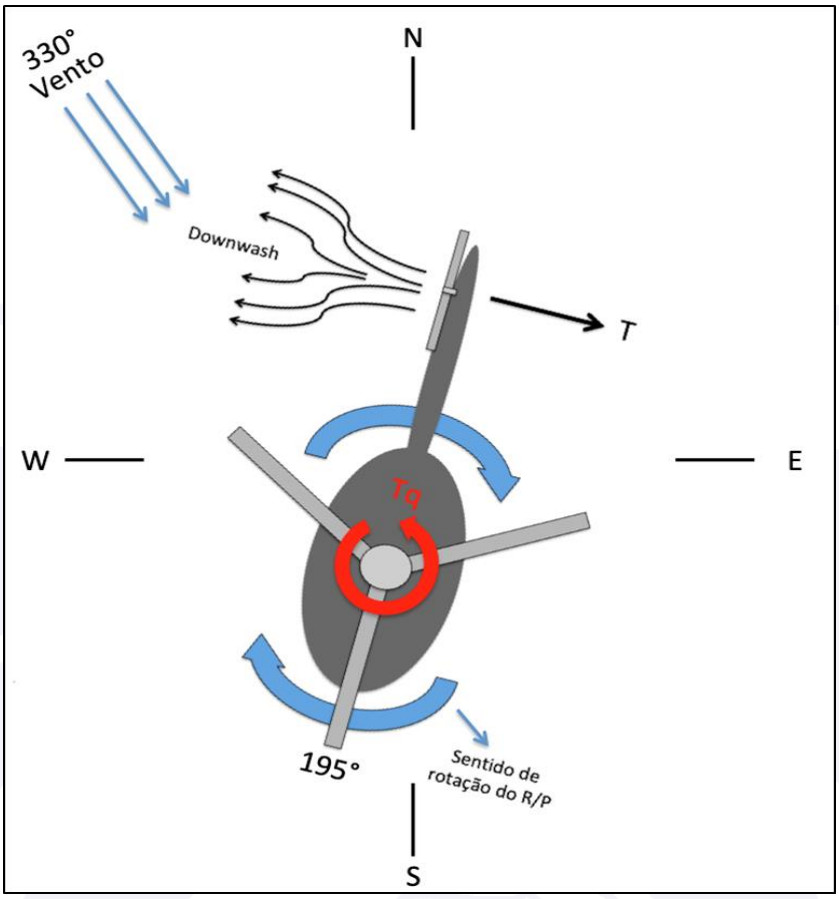

Figure 2 - Diagram of the positioning of the helicopter at take-off.

The engine was started normally.

With the rotors spinning, the pilot worked on the controls and started the vertical take-off. This maneuver consisted in withdrawing the aircraft from the ground in a vertical trajectory and establishing a hovering flight within the ground effect, 5ft high in relation to the ground.

The accident happened during the vertical take-off and, it seems, the commander was in command of the helicopter.

Section "E" - Flight Maneuvers, item 2 - Vertical Take-off within the Solo Effect - of the AS 350 B2 Operational Training Program (PTO) for BOA-CBMSC Pilots, of 20FEB2015, highlighted:

> … in this type of take-off, the pilot must note the movement trends of the aircraft and operate on the pedals to correct the heading variations.

The program also warned that it would be normal to start the maneuver with the right foot pedal mildly applied and that there should be a cyclical command action to keep the vertical trajectory in relation to the take-off point. When leaving the ground, the aircraft would keep a slightly tilted attitude to the right.

Sub-item 2.5 - Observations - also from Section "E", further warned that, normally, the aircraft would have a slight slope to the right at take-off due to its construction; however, this trend would vary according to the weight of take-off, the Center of Gravity (CG) and the direction and intensity of the wind.

According to the PTO, it would be important for the pilot to choose external visual references at the front and at the sides (45º on the left and 45º on the right), in order to maintain the position of the aircraft.

The program also defined as 15kt the wind limitation in ground maneuvers, such as vertical landing and take-off, turns and square exercises.

The HELIBRAS THP AS 350 B2 Pilot Instruction Manual, Rev. of SEPT 2007, in Section 4 - Normal Procedures, item 4.10 - Operations in Extreme Weather, quoted:

> … in operation with strong wind, the helicopter must be parked heading the wind and, in the starting procedure, the cyclic must be taken slightly towards the wind, when the rotor begins to rotate.

Section 3 of the Aircraft Manual, in the Emergency Procedures, item 3.4 Tail Rotor Failures, commented:

> ... on complete loss of tail rotor efficiency, the helicopter will take a left turn with rotational speed depending on the amount of power and the forward speed set at the time of the failure.

The same Manual also directed that:

> ... occurring such problem in the hovering IGE (in ground effect, height between 5ft and 10ft), one must land immediately, completely withdrawing the flow lever (FFCL) and using the collective pitch only to try to cushion the touch.

According to the Aeronautics Command Manual 3-6 (MCA 3-6), the loss of tail rotor effectiveness (LTE) is a critical aerodynamic phenomenon occurring at low speed. This phenomenon does not cease on its own and, if not corrected on a timely basis, may cause loss of control of the aircraft.

Aviation related organizations around the world such as the ICAO, the CENIPA, the NTSB, the EASA and the BEA constantly issue publications warning of the risks associated with the LTE and its consequences on helicopter flight. These publications usually bring in their content recovery techniques and prevention measures to avoid the appearance of this aerodynamic phenomenon. The Operator's manual also alerted to the possibility of the LTE in the AS 350 B2.

In general terms, pilot techniques associated with the recovery of an LTE condition consist of:

- down the collective control lever to lower the torque;
- applying pedal contrary to the direction of unwanted yaw, in order to reduce the ratio of rotation about the vertical axis; and
- take the cyclic ahead, in order to gain speed and allow the vertical stabilizer to assist in directional control.

An aerodrome security camera recorded images of the entire sequence of events that preceded the crash.

The recorded images showed that the left ski of the aircraft left the ground before the right ski, generating a slope to the right. In addition, the images showed that the nose of the helicopter started a left turn (right tail), as shown in Figures 3, 4, 5 and 6.

Figure 3 - Sequence of vertical take-off events.

Figure 4 - Sequence of vertical take-off events.

Figure 5 - Sequence of vertical take-off events.

Figure 6 - Sequence of vertical take-off events.

Figure 7 shows the instant when the right ski left the ground. At that time, the aircraft was tilted to the right and turned nose to the left (right tail).

Figure 7 - Sequence of vertical take-off events.

From that moment on, the right tilt and the nose turn to the left intensified, as shown in Figures 8 and 9.

Figure 8 - Sequence of vertical take-off events.

Figure 9 - Sequence of vertical take-off events.

In Figures 10, 11, 12 and 13 it is observed that the blades of the main rotor collided against the lawned ground.

Figure 10 - Sequence of vertical take-off events.

Figure 11 - Sequence of vertical take-off events.

Figure 12 - Sequence of vertical take-off events.

Figure 13 - Sequence of vertical take-off events.

By placing the photos side by side, it is possible to more clearly visualize the take-off dynamics that culminated in the accident (Figure 14).

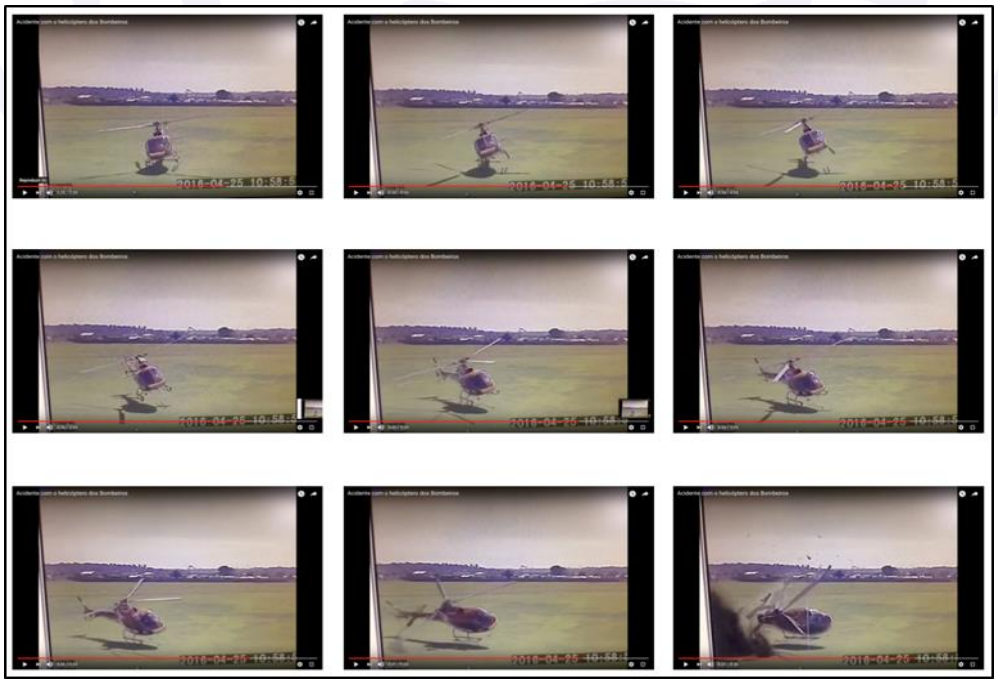

Figure 14 - Photos of the sequence of vertical take-off events arranged side by side.

The copilot was in the position of a trainee, in basic adaptation to the AS 350 B2 helicopter, awaiting for the beginning of the instruction of the Practical Initial Training Phases of the "Operational Training Program" (PTO) of the BOA-CBMSC.

At this stage, the student only fulfilled the role of copilot, in which he performed primarily functions on the left seat, not necessarily associated with the aircraft piloting.

The commander on his own initiative could give the release of the commands of the aircraft to the copilot, but he was not required to do so, since he should analyze the various safety conditions and the progress of the copilot in the operations.

The participation of the copilot on these flights was not instructional but merely a follow-up, like a trainee.

After 6 months in this occurrences follow-up stage as a co-pilot, the student started the "ALFA" Phase of the "Technical Ascention and Training Program for Helicopter Pilots" (PAT), aiming at the initial practical training in Type AS 350 B2.

1.19 Additional information.

Nil.

1.20 Useful or effective investigation techniques.

Nil.

2. ANALYSIS.

Due to the possibility of a failure in the operation of the cyclic control unit, it was performed a technical analysis of the aircraft's entire flight control system, in which it was concluded that the aircraft was in good conditions and had normal operation before the occurrence.

Thus, the Investigation Committee turned their attention to the operational conditions at the time of the occurrence, which could have contributed to the outcome of that accident.

The accident happened during the vertical take-off, a maneuver that consists of removing the aircraft from the ground in a vertical trajectory and establish a hovering flight inside the ground effect, 5ft high.

Publications of the Operator’s Training Program emphasized that the pilot should be aware of aircraft tendencies during vertical take-off and command commands to correct variations.

A helicopter with the aerodynamic characteristics of the AS 350 B2 has a tendency to nose up, tilt to the right and yaw to the left (right tail) during vertical take-offs.

As far as the pilot acts to raise the collective command lever, these tendencies are amplified and must be corrected.

To correct these variations, the pilot has to act on the cyclic command left and forward and must apply right pedal. If he does not do it properly, the aircraft tends to roll to the right, pitch up and turn nose to the left.

These tendencies experienced by the pilot when performing a vertical take-off are perceptible and, under normal operating conditions, are corrected with little amplitude of commands. However, under marginal operating conditions, these movements are amplified, as well as the range of command required to correct them.

Takeoff weight, operating altitude, ambient temperature, wind direction and intensity, and CG position may be considered conditions that affect the performance of a helicopter.

In these circumstances, the pilot's abilities are more required to maintain control of the helicopter.

Although the weather conditions at SISY were favorable for the visual flight, the wind at the time of take-off required extra care.

The prevailing wind estimated at the aerodrome was from the direction 330º (NO), with intensity of 14kt and gusts up to 25kt. However, the aircraft was positioned with the nose steered in the 195° (SO) magnetic direction. In this situation, the helicopter was subjected to a tail wind component, as shown in Figure 2.

The Operator's manuals instructed that, operating in strong wind conditions, the helicopter should be parked heading with the wind. Therefore, the operation of the aircraft in the conditions of wind and positioning presented at the date of the accident contradicted the guidelines contained in the operating manuals.

The incidence of tailwinds in helicopters compromises the performance of the tail rotor and, consequently, the directional control of the aircraft. For this reason, helicopter tailwind maneuvers must be avoided and, if necessary, must comply with the limits established by the aircraft manufacturer.

It is important to note that, even within the limits specified by the manufacturer, maneuvers with tailwinds will normally require more of the pilot to keep control of the aircraft. When operating under these conditions, the pilot must be aware of the aircraft's behavior and the amplitude of the flight commands.

In addition to influencing the maneuverability of the helicopter, tailwinds may also contribute to the emergence of an aerodynamic effect known as the LTE.

The loss of effectiveness in the tail rotor is a critical aerodynamic phenomenon that occurs at low speed and does not cease on its own. This means that the pilot must recognize an LTE and act correctly on the aircraft's commands to avoid losing control of the aircraft.

Images recorded by an aerodrome safety camera showed that the aircraft initially behaved aerodynamically as expected for a vertical take-off. However, the trends showed a marked amplitude during the maneuver.

The sequence of images in Figure 14 shows that the left ski left the ground before the right ski and that the aircraft tilted to the right. This behavior was expected for the helicopter model in question, by design characteristics of the aircraft. However, the tendency to lean to the right may have been greater in the accident flight because of the CG position (front and right).

It was also noted that the helicopter nose yawed to the left (right tail). This behavior is due to the increase in Torque (Tq) from the power transmission to the main rotor. Each time the pilot moves the collective control lever up, Tq increases. The response of the aircraft manifests itself in a tendency for the entire fuselage to rotate in the direction opposite to the direction of the main rotor blades rotation. In the case of AS 350 B2, the reaction to torque causes the nose to tend to yaw to the left.

To correct this tendency, the pilot must apply right pedal. However, in a scenario of strong tailwind components (14kt with gusts up to 25kt), the performance of the tail rotor can be compromised, hampering the pilot's work. Under the conditions presented, it is possible that, even applying the full right pedal, the aircraft would continue to yaw with its nose to the left.

At one point, the right ski also came off the ground. Without any part in contact with the floor, the aircraft moved sideways to the right, by virtue of its inclination and yaw.

However, the helicopter did not start a continuous nose-left turn. This fact may suggest that there was still some directional control, thus ruling out the incidence of the LTE.

Then the aircraft returned to touch the ground with the right ski. At the moment of the touch, the aircraft had a slightly pitch up attitude, a considerable slope to the right, slight lateral displacement to the right and a large amplitude yaw to the left (Figure 8).

Touching the ground, under these conditions, it created a pivot point and intensified inclination and yaw tendencies. From that moment on, the helicopter began to tilt and to guide more and more until the shock of the blades of the main rotor against the terrain occurred.

It was not possible to determine what type of performance the pilot had in the controls by analyzing the recordings obtained.

However, it is possible that the conditions prevailing at the time of the accident have compromised the performance of the tail rotor and made it difficult to perform the vertical take-off and hovering maneuver.

The presence of the tail wind caused the aircraft to exhibit amplified aerodynamic tendencies during the maneuver. These trends associated with the pilot's performance on the aircraft's controls led the helicopter to the lateral tilt condition that culminated in the shock of the main rotor blades against the ground.

In addition to the considerations regarding aerodynamic effects and wind incidence on the aircraft, it was found that the time urgency may have led the pilot to not carefully consider the adverse weather conditions in SISY (strong wind with estimated gusts up to 25kt), because there was concern about the activities that still had to be performed that day.

Therefore, it was found that the operating procedures contained in the AS 350 B2 operating manual and guidelines for tail-wind operation were not carefully followed.

Failure to comply with the planned procedures resulted in a critical condition for the take-off, without the risks present in that context being previously identified and properly managed. This attitude contributed to the occurrence in question.

3. CONCLUSIONS.

3.1 Facts.

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

b) the pilot had valid H350 type Rating (which included the AS 350 B2 model), Helicopter Turbine Single-Engine Class Rating (HMNT) and Flight Instructor – Helicopter Rating (INVH);

c) the pilot was qualified and had experience to perform the flight;

d) the copilot did not have qualification to fly the H350 aircraft;

e) the aircraft had valid Airworthiness Certificate (CA);

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

g) the airframe and engine logbooks records were outdated;

h) the weather conditions in SISY were favorable for the visual flight;

i) there was a strong wind blowing at the time of take-off with estimated wind gusts up to 25kt, coming from the right rear sector of the aircraft;

j) when leaving the ground to start the take-off, before establishing a hovering, a tilting movement to the right and a nose-to-left yaw started;

k) the yaw to the left was accentuated;

l) the right ski left the ground and the aircraft moved sideways to the right;

m) the right ski returned to touch the ground and the inclination and yaw of the aircraft increased;

n) there was a collision of the main rotor blades against the ground;

o) there was the sectioning of the tail cone, the main rotor blades were bent and damaged, and the right windshield was completely broken;

p) no abnormality was observed in the cyclic, collective and pedal chain of the aircraft, according to technical report;

q) the aircraft had substantial damage; and

r) the three occupants were unharmed.

3.2 Contributing factors.

- **Handling of aircraft flight controls - undetermined.**

It is probable that there was a lack of anticipation in the application of the controls to compensate the effect of the wind on the aircraft and the slight displacement of the CG to the right.

- **Attitude - a contributor.**

The decision to perform the vertical take-off in unfavorable conditions, despite the guidelines expressed in the aircraft manual, denoted an unfavorable attitude to flight safety. The failure to comply with the proposed procedures led to an inadequate management of the risks involved in the operation, which contributed to the occurrence in question.

- **Piloting judgement - a contributor.**

The pilot thought that he could takeoff with the weather conditions (direction and wind intensity) without complying with the recommendation to takeoff headed with the wind, which contributed to the occurrence in question.

- **Other - Self-imposed pressure - undetermined.**

The concern with completing other activities on the day of the occurrence and the time constraint may have generated in the pilot a self-imposed pressure condition, which may have impaired its decision-making, leading to an inadequate assessment of the adverse conditions present in the context.

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

The decision to carry out the vertical take-off despite the unfavorable conditions present in the context denoted an inadequate evaluation of the risks involved in the operation, which contributed to the occurrence.

4. SAFETY RECOMMENDATION.

A measure of preventative/corrective nature issued by a SIPAER Investigation Authority or by a SIPAER-Link within respective area of jurisdiction, aimed at eliminating or mitigating the risk brought about by either a latent condition or an active failure. It results from the investigation of an aeronautical occurrence or from a preventative action, and shall never be used for purposes of blame presumption or apportion of civil, criminal, or administrative liability.

In consonance with the Law n°7565/1986, recommendations are made solely for the benefit of the air activity operational safety, and shall be treated as established in the NSCA 3-13

"Protocols for the Investigation of Civil Aviation Aeronautical Occurrences conducted by the Brazilian State".

Recommendations issued at the publication of this report:

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

A-078/CENIPA/2016 - 01 **Issued on 05/16/2019**

Act in conjunction with the Air Operations Battalion of the Santa Catarina Military Fire Brigade (BOA / CBMSC), in order to include in its Operational Training Program (PTO) for AS 350 B2 pilots the recommendations contained in the THP Instruction Manual AS 350 B2 from HELIBRAS, Rev. 2007, Section 4 - Normal Procedures, item 4.10 - Operations in Extreme Weather Conditions, regarding the operation with strong wind.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

On 26APR2016, a meeting was held at EACAR's premises in Piraquara-PR, between the members of the Investigation Team and the Commander of the Air Operations Battalion of the CBMSC. Although the contributing factors of the occurrence were still unclear at that time, special procedures and precautions during a vertical take-off on the AS 350 B2 helicopter were commented and the following issues were dealt with: "IGE", "LTE", "Vortex" and "rollover" flying. Some preventive measures related to this accident were discussed as well.

On May 16th, 2019.

ANNEX A

COMMENTS BY THE BEA ON DRAFT FINAL REPORT

Below, there is a list of all the comments forwarded by the Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile (BEA) on PR-YCB Draft Final Report.

Comments	Chapter	Page	Text to be corrected (first ... last word)	Text Proposed by BEA/ Argumentation	CENIPA´s comment
1.	**1**	6	"Model AS350B2l	AH/Helibras proposes to replace by "Model: AS350B2"	Modified to AS 350 B2 in accordance with the Airworthiness Certificate issued by ANAC.
2.	**1.18**	9 and 10	"The HELIBRAS THP...the rotor begins to rotate."	AH/Helibras proposes to replace by "The AS350B2 VEMD flight manual in Section 4 – Normal Procedures, item 4.3 – Engine starting, quoted: ...in strong wind apply little cyclic into wind."	The manual quoted in the Report refers to the latest Portuguese version available in the HELIBRAS collection, the manufacturer's official representative in Brazil, at the time of the accident. For this reason, it was taken as the source of consultation by the IIC. The contents of the mentioned manual and the suggested manual are not conflicting.
3.	**1.18**	10	"The SAFETY CONSIDERATIONS...the torque of the rotor main"	AH/Helibras requires to remove this sentence. See explanation below.	Accepted
4.	**2**	11	"As the helicopter...Loss of Tail Rotor Effectiveness (LTE)."	AH/Helibras requires to remove this sentence which is not exact. Hovering with wind from any direction has been substantiated over the entire flight envelope up to winds of 17 kt, although this is not to be taken as a limit. For example hover at sea level at maximum weight, for all CG locations, has been substantiated at 30 kt. (See AS350B2 Flight manual, Section 5, §2.2, "wind envelope in hover"). For information, the §2.2 has been forgotten in the AS350B2 VEMD Flight manual but will be introduced in the next	The LTE text extracted from the "SAFETY CONSIDERATIONS" publication of the European Helicopter Safety Team (EHEST), chapter 3 - Loss of Tail Rotor Effectiveness (LTE), was removed, once the possibility of the LTE in this accident was reconsidered. However, the Team has decided to introduce, for the purposes of didactic, the LTE explanation of the MCA 3-6. It is emphasized in the analysis that the possibility of the LTE is discarded.

				revision.	
Comments	**Chapter**	Page	Text to be corrected (first ... last word)	Text Proposed by BEA/ Argumentation	CENIPA´s comment
5.	**2**	11	"It is possible to state from...With no further possibility of controlling the flight"	AH/Helibras requires to remove this sentence which is not exact. Hovering with wind from any direction has been substantiated over the entire flight envelope up to winds of 17 kt, although this is not to be taken as a limit. For example hover at sea level at maximum weight, for all CG locations, has been substantiated at 30 kt. (See AS350B2 Flight manual, Section 5, §2.2, "wind envelope in hover"). For information, the §2.2 has been forgotten in the AS350B2 VEMD Flight manual but will be introduced in the next revision.	Accepted.
6.	**4**	13	"Acting in conjunction…..regarding operation with strong wind."	AH/Helibras proposes to replace by "Acting in conjunction with the Air Operations Battalion of the Santa Catarina Military Fire Brigade (BOA / CBMSC), in order to include in its Operational Training Program (PTO) for AS-350B2 pilots the recommendations contained in the Flight Manual AS-350B2 VEMD, Section 4 - Normal Procedures, item 4.3 - Engine starting, regarding the operation with strong wind."	The manual quoted in the Report refers to the latest Portuguese version available in the HELIBRAS collection, the manufacturer's official representative in Brazil, at the time of the accident. For this reason, it was taken as the source of consultation by the IIC. The contents of the mentioned manual and the suggested manual are not conflicting.

Comments	Chapter	Line nº	Text to be corrected (first ... last word)	Text Proposed by BEA/ Argumentation	CENIPA´s comment
7.	**General**			For AH, the term "LTE" as described by EHEST should not be used because too confused and should be replaced by "unanticipated yaw". The phenomenon described by the CENIPA can theoretically occur but with a very specific wind condition and on very limited angular range. In such case, the effect would be only a simple yaw jerk of the aircraft but never a complete loss of the tail rotor effectiveness/performance. Indeed, this simple jerk of the aircraft leads to exit the phenomenon. AH flight test pilot and aerodynamic specialist declared that the accident conditions were not favourable for the phenomenon (wind speed too low and wind direction not compatible). Moreover, no jerk was observed on the video. The sequence observed on the video is first the lack of the pilot to maintain the aircraft roll during the take-off (and to counter act the aircraft roll because the main rotor disk remains perpendicular to the mast). And second, the lack of the pilot to apply pedals in relation with the application of the collective stick which is applied to take off in order to avoid the dynamic roll-over.	Comments were accepted and any reference to LTE in the RF remained only as didactic. The analysis discards the occurrence of this phenomenon in the occurrence.