COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A - 117/CENIPA/2019

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PR-EAM**
MODEL:	**AS350B3**
DATE:	**07AUG2019**

NOTICE

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

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

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

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

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

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

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

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

SYNOPSIS

This is the Final Report of the 07AUG2019 accident with the AS 350 B3 aircraft model, registration PR-EAM. The accident was classified as “[LOC-I] Loss of Control in Flight”.

During the take-off, shortly after leaving the ground, the aircraft started turning to the left. The crewmembers could not control the helicopter and there was an acceleration of the spin and height gain. The aircraft performed a hard landing 10 m ahead of the take-off point.

The aircraft had substantial damage.

All 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

ADE	Aircraft Registration Category – Direct State Administration
ANAC	Brazil's National Civil Aviation Agency
BEA	*Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile*
CA	Airworthiness Certificate
CAVOK	Ceiling and Visibility OK
CBMAM	Military Fire Department of the Amazonas State
CBSAR	Air Rescue Fire Command
CCTV	Closed-Circuit Television
CENIPA	Aeronautical Accident Investigation and Prevention Center
CIAC	Civil Aviation Instruction Centers
CMA	Aeronautical Medical Certificate
CNPAA	National Aeronautical Accidents Prevention Committee
CNT	National Training Committee
CRM	Crew Resource Management
CTOP	Operational Crew Course
DDN	Left Pedal Position
DIOA	Air Operations Integrated Department
FAA	Federal Aviation Administration
FAP	Pilot`s Evaluation Form
FLIR	Forward-Looking Infrared
GOA	Air Operations Group
GRAER	Air Patrol Group
GSO	Safety Manager
HMNC	Conventional Single-Engine Helicopter Rating
HMNT	Single-Turbo Helicopter Rating
IAM	Annual Maintenance Inspection
IIC	Investigator In Charge
METAR	Meteorological Aerodrome Report
MGSO	Safety Management Manual
MIV	Flight Instructor's Manual
MOP	Operations Manual
NSCA	Aeronautics Command System Standard
NTSB	National Transportation Safety Board (USA)
PCAM	Amazonas State Civil Police
PCH	Commercial Pilot License – Helicopter
PF	Pilot Flying
PIC	Pilot in Command

PM	Pilot monitoring
PMAM	Amazon State Military Police
PPH	Private Pilot License – Helicopter
PTO	Operational Training Program
RBAC	Brazilian Civil Aviation Regulation
RBHA	Brazilian Aeronautical Certification Regulation
SAFO	Safety Alert for Operators
SBEG	ICAO Location Designator - Eduardo Gomes International Aerodrome, Manaus - AM
SERIPA VII	Seventh Regional Aeronautical Accident Investigation and Prevention Service
SGSO	Safety Management System
SIC	Second in Command
SIPAER	Aeronautical Accident Investigation and Prevention System
SOP	Standard Operational Procedures
SSP-AM	Amazon State Public Security Secretariat
SWFN	ICAO Location Designator – Flores Aerodrome, Manaus - AM
UAP	Public Air Unit
UTC	Universal Time Coordinated
VFR	Visual Flight Rules

1. FACTUAL INFORMATION.

Aircraft	**Model:** AS 350 B3 **Registration:** PR-EAM **Manufacturer:** HELIBRAS	**Operator:** Amazon State Public Security Secretariat
Occurrence	**Date/time:** 07AUG2019 - 1410 UTC **Location:** Flores Aerodrome – SWFN **Lat.** 03°04'22"S **Long.** 060°01'16"W **Municipality – State:** Manaus – AM	**Type(s):** "[LOC-I] Loss of Control in Flight" **Subtype(s):** NIL

1.1 History of the flight.

The aircraft took off from the Flores Aerodrome (SWFN), Manaus - AM, from a helicopter landing and parking spot, located in front of the UAP hangar, at about 1410 (UTC), to carry out a police mission, with the overflight of the city of Manaus, with two pilots, two tactical air operators and two passengers on board.

As the aircraft was leaving the ground, he started turning to the left. The crew could not control it and there was an acceleration of the spin and height gain.

The aircraft landed abruptly, about 10 m ahead of the take-off point.

The main and tail rotor blade did not touch the ground, but the helicopter showed damage to its structure.

The aircraft had substantial damage.

All occupants left unharmed.

1.2 Injuries to persons.

Injuries	Crew	Passengers	Others
Fatal	-	-	-
Serious	-	-	-
Minor	-	-	-
None	4	2	-

1.3 Damage to the aircraft.

The aircraft had substantial damage to the tail cone and horizontal stabilizer, as well as light damage to the skis and tail rotor (Figure 1).

Figure 1 - Damage to the aircraft tail cone (seen from the right side).

1.4 Other damage.

None.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Flight Hours		
	PIC	SIC
Total	550:00	418:10
Total in the last 30 days	06:40	06:26
Total in the last 24 hours	00:30	00:20
In this type of aircraft	44:20	113:00
In this type in the last 30 days	06:40	06:25
In this type in the last 24 hours	00:30	00:20

N.B.: the data related to the flown hours were obtained through the information provided by the pilots.

1.5.2 Personnel training.

The PIC took the PPH course at the EDRA *Aeronáutica*, in Ipeúna - SP, in 2010.

The SIC took the PPH course at the EDRA *Aeronáutica,* in Ipeúna - SP, in 2012.

1.5.3 Category of licenses and validity of certificates.

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

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

1.5.4 Qualification and flight experience.

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

The PIC was 48 years old, he joined the UAP after completing his PPH and PCH training at the EDRA *Aeronáutica* School. In the unit, he flew the helicopter S300 (Schweizer 300) and the AS350 (Esquilo).

In mid-2019, he began training to serve as commander of the AS350 aircraft, completing the training the week before the accident.

From the FAP, there were no reports about difficulties that could have contributed to the occurrence.

The SIC was 44 years old, he joined the UAP after completing his PPH and PCH training at the EDRA *Aeronáutica* school. In the unit, he flew the S300 helicopter (Schweizer 300), having about 132 hours of flight time in this model, and in the AS350 aircraft, which he had last flown in the morning of the occurrence day, but without effectively acting on the controls of the aircraft. He had 113 hours and was in the training phase for becoming a commander.

In the same way as the PIC, in the analysis carried out in the FAP, no reports of difficulties that could have contributed to the accident were observed.

It was observed that the pilots were qualified and had experience in the type of flight. However, they had little experience in the aircraft model.

Regarding the flight of the occurrence, this was the second time that the PIC assumed this role. The first had been on the flight carried out by the same crew, that same day, early in the morning.

On the second flight of the day, the PIC, who occupied the chair on the right, performed the PM function, that is, he was not acting on the flight controls, so the SIC, which occupied the chair on the left, performed the role of PF, that is, he was the one who was effectively piloting the helicopter.

1.5.5 Validity of medical certificate.

The pilots had valid CMAs.

1.6 Aircraft information.

The aircraft, serial number 4771, was manufactured by HELIBRAS in 2009 and was registered in the ADE category.

The aircraft had valid a CA.

The airframe and engine logbook records were updated.

The last inspection of the aircraft, the “7D, 30H” type, was carried out on 26JUL2019 by the maintenance organization J.V.C. AEROTAXI, in Manaus - AM, with 6 hours and 25 minutes flown after the inspection.

The last inspections of the aircraft, the “IAM, 600H” types, were carried out on 30OCT2018 by the maintenance organization J.V.C. AEROTAXI, in Manaus - AM, with 125 hours and 20 minutes flown after the inspection.

The aircraft was within the weight and balance limits specified by the manufacturer. However, as verified, the weight table used to perform the weight and balance calculations belonged to another aircraft of the operator.

The last weighing used in the weight and balance chart presented was dated 02NOV2009, however, in 2014, equipment was installed for a police operation, called FLIR.

After the installation of this equipment, no new weighing was performed, nor was the new moment calculated, since the FLIR changed the aircraft's weight and center of gravity parameters. However, without extrapolating, on that occasion, the limits prevised in the manual.

1.7 Meteorological information.

The conditions were favorable for the visual flight.

The METAR from SBEG Aerodrome, about 3 NM away from the accident site, provided the following information:

METAR SBEG 071400Z 32004KT CAVOK 27/22 Q1018=

1.8 Aids to navigation.

Nil.

1.9 Communications.

Nil.

1.10 Aerodrome information.

The Aerodrome was public, managed by the Amazonas Aeroclub, and operated under VFR, during the day.

The runway was made of asphalt, with thresholds 11/29, dimensions of 799 x 30 m, with an elevation of 203 ft.

No factors affecting the Aerodrome infrastructure that could have contributed to the accident were observed.

1.11 Flight recorders.

Neither required nor installed.

1.12 Wreckage and impact information.

According to the images of a CCTV, it was possible to verify that the take-off took place at 14:13:20 (UTC). At that moment, before the aircraft left the ground, there was a left turn, causing the skis to drag on the ground (Figure 2).

Figure 2 - Moment when the aircraft starts the take-off.

After leaving the ground, the aircraft continued to turn to the left while it began to gain height and accelerate the turn. At 14:13:25 (UTC), when reaching about 90º of turn and about 3m high, there was a sudden acceleration of the turn and the aircraft tilted laterally (Figure 3).

Figure 3 - First 90º turn to the left and loss of control.

Two seconds later, at 14:13:27 (UTC), the aircraft completed the first 360º turn to the left, about the take-off position (Figure 4).

Figure 4 - First complete turn to the left (360º).

Then, the aircraft continued the left turn and quickly lost height, when at 14:13:28 (UTC) the impact with the ground occurred in a pitch up attitude of approximately 10º. At that moment, the tail of the aircraft and the rear portion of the skis collided (Figure 5).

Figure 5 - Touching the ground in a pitch-up attitude.

The aircraft continued the turn, however in deceleration, lowered the nose to about 10º pitch, continued the turn supported on the front part of the skis, but without leaving the ground, and completed another 270º turn. The stop took place at 14:13:32 (UTC), with the helicopter displaced about 10 m from the initial position (Figure 6).

Figure 6 - Final position of the aircraft, in which number 1 refers to the initial position (take-off) and number 5 refers to the final position.

1.13 Medical and pathological information.

1.13.1 Medical aspects.

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

1.13.2 Ergonomic information.

Nil.

1.13.3 Psychological aspects.

The PIC and the SIC had a friendly relationship beyond the work environment, but they had never flown together on the AS350 Esquilo aircraft until the day of the accident. They had already operated together only on the R44 Robinson aircraft, which was operated exclusively by the Civil Police, before the creation of the DIOA.

The PIC claimed to have a cautious operating profile, nothing bold, and that, lately, he was “calmer” when there was no flight. The last CRM training had been carried out about three years before the accident.

A week before the occurrence, the PIC was promoted to commander on the AS350 aircraft after meeting the schedule established by the PTO. This was his second flight in the role of PIC.

The SIC stated that he was extremely methodical and that he chose not to renew the HMNC Rating, required to operate the R44 Robinson aircraft due to differences in procedures in relation to the Esquilo aircraft.

The right-hand aircrew member had been in the role since 2009, but only completed the CTOP in 2012 when crewmembers were required to complete this course. In addition to performing the role of patrolman, the aircrew member guided the pilot in operations in a restricted area and carried out the safety briefing to eventual passengers. The crew's roster was 24 hours, and it was not necessary to sleep on the base.

The aircrew members were military police officers or firefighters who carried out training in public security institutions in other states.

According to reports, the training that was included in the daily routine of the organization, provided exercises in flight, on the ground, and in the water, however, the performance sheets were not available.

1.14 Fire.

There was no fire.

1.15 Survival aspects.

The right-hand aircrew member was seated on the cabin floor, also known as a “bottom structure”, and used only the restrain tether, without using the lap seat belt.

The left-hand aircrew member was used to flying standing in the doorway, with his feet on the ski. With the speed of the spin, he was thrown out of the aircraft, hanging next to the PIC door by the restrain tether, until it came to a complete stop.

1.16 Tests and research.

The aircraft underwent a series of checks related to the correct functioning of the hydraulic system and flight controls. The examinations took place in the operator's hangar, with the presence of specialists from the aircraft manufacturer, representatives of the operator, and the company responsible for maintenance.

Verification of the tail gearbox, tail rotor head, and tail rotor blades confirmed that these assemblies were in good condition and operating correctly at the time of the accident.

The complete tail rotor control package, pedals, and tail rotor blades were verified, and it was possible to confirm that these systems were operating as specified in the manufacturer's manuals.

Analyzing the tail rotor driveshaft, no damage was observed that could have occurred before the accident and could have compromised its proper functioning, demonstrating that it was operational, even with the damage observed in the tail cone structure.

During the examination of the tail rotor, contact marks were observed between the counterweights of the tail rotor blades (Figure 7) and the end of the rotating control plate (Figure 8).

Figure 7 - Approximate view of the mark left on the counterweight, due to contact with the rotating control plate.

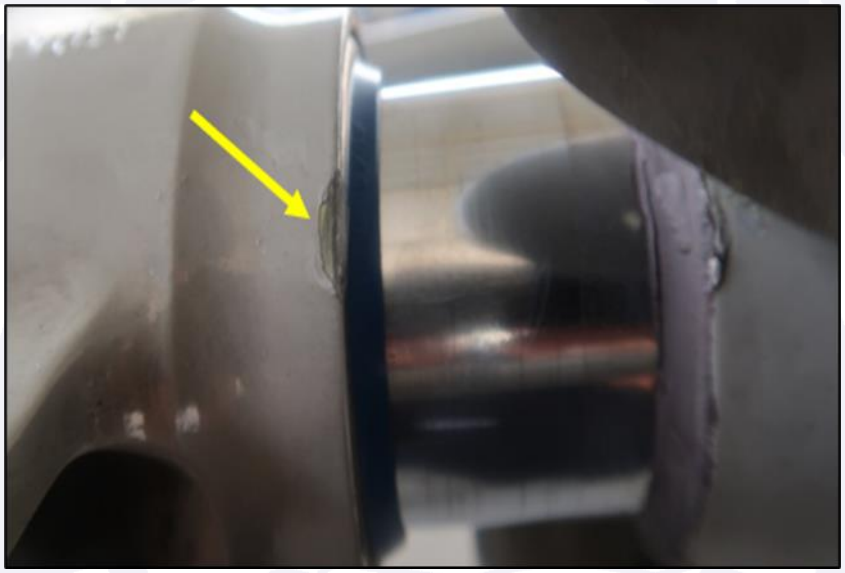


Figure 8 - Mark observed on the rotating control plate, caused by the contact of the tail rotor blade counterweight.

In order to make contact between the counterweight and the rotating plates possible, the left pedal should be applied to the end of its stop, since, in this condition, the rotating plate was in the position closest to the counterweights (Figure 9).

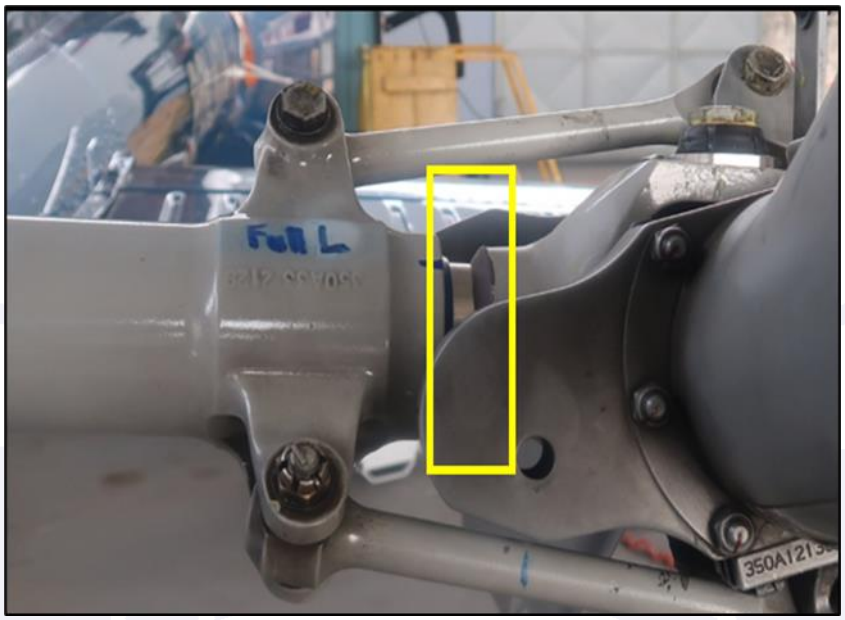


Figure 9 - Distance between the tail rotor blade counterweight and the rotating plate with the left pedal in the end-of-stroke position.

With the pedal applied to its left stop, there was an excessive increase in the turning speed and, consequently, the flapping effect, which made it possible for the counterweights to come into contact with the rotating plate.

It is noteworthy that, when the right pedal is applied to its stop, the distance between the tail rotor blade counterweight and the rotating control plate does not allow contact between these parts (Figure 10).

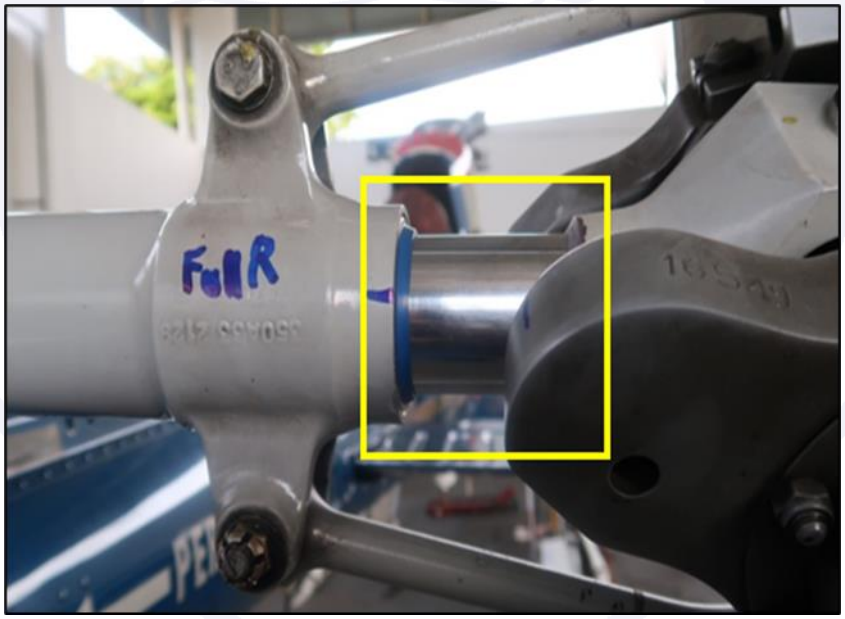


Figure 10 - Distance between the tail rotor blade counterweight and the rotating plate with the right pedal in the end-of-stroke position.

1.17 Organizational and management information.

The DIOA was created on 13JUL2018, through Law No. 4624, with the purpose of planning, coordinating, executing, and controlling all Public Security and Civil Defense aerial activities managed by the SSP-AM.

With this, the former air groups - GOA of the PCAM, CBSAR of the CBMAM, and GRAER of the PMAM - ended their air activities, maintaining only administrative functions within their institutions of origin.

The UAP had in its membership, members of the Public Security Forces of the Amazonas, namely: Amazonas Military Police, Amazonas Military Fire Department, and Amazonas Civil Police. At the time of the accident, it had 29 members, being 16 pilots, 9 aircrew members, and 4 mechanics. Many of these members also performed administrative functions in the organization, but on the day they were scheduled as crewmembers, they were exclusively at the disposal of air operations.

At the time of the accident, the UAP had been in operation for a year, and, unlike the GRAER, those who were assigned to the Integrated Department only performed aerial activities. In the interviews carried out, it was noticeable that some members considered the integration of air operations by the Military Police, Civil Police, and Fire Department to be positive and reported improvements in terms of flight safety.

Regarding air resources, the unit was equipped with two AS350 Esquilo helicopters, a Schweizer S300 helicopter, and an experimental amphibious aircraft model Super Petrel.

Aircraft maintenance was performed at a maintenance company located in front of the UAP hangar, which had autonomy in relation to the execution of these services.

At the time, an initial training program was not formally implemented, and pilots and mechanics from the formerly isolated units of the PMAM, the CBMAM, and the PCAM had carried out their basic training at the CIAC on their own.

According to the pilots and aircraft operators, the UAP did not have a formally implemented Training Program, a MOP, or SOP. This finding was also observed in the last Operational Safety Inspection, carried out after the creation of the DIOA by the GSO of the UAP.

According to information collected in the interviews, the recycling of tactical aircrews used to be performed by the more experienced crew.

Police air operations often took place within the “dead man's curve”, that is, in an area of the helicopter's performance graph where, in the event of an engine failure, the aircraft would not have sufficient height/speed to make an emergency landing in safety.

From the documentation used for training, it was found that there were outdated requirements and documents, such as the Organization's Internal Regulations, which established the criteria for operational elevation.

Such criteria were based on the requirements of Subpart K of the RBHA No. 91 - General Operating Rules for Civil Aircraft, in force on the date of the occurrence, which was replaced by the RBAC No. 90 - Requirements for Special Public Aviation Operations, approved by the ANAC through Resolution No. 512, of 12APR2019.

This Resolution, in addition to approving the RBAC 90, defined deadlines for the adaptation of the UAP to the new requirements, such as the implementation of a MOP, implementation of SOP, an adaptation of the PTO, among other measures.

At the time of the occurrence, the UAP was operating in accordance with Subpart K of the RBHA 91, however, in transition to the requirements set out in the RBAC 90.

1.18 Operational information.

The purpose of the flight was to perform a police observation overflight. Two tactical aircrew members and two passengers were on board.

The pilots reported having performed the pre-flight together with the mechanic and after everyone had boarded, the aircraft systems were checked, the take-off checklist and contact with the ATC was carried out.

The PIC reported that, during the take-off, he was surprised by a rapid turn of the aircraft to the left. Then there was the loss of lift and the impact on the ground. In an interview, it was possible to verify that the two acted at the same time in the controls, initially in an attempt to stop the spin and, later, to avoid the sudden landing, without any verbal communication between them.

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

The AS350 helicopter was equipped with a main rotor and a tail rotor (anti-torque device). The main rotor had a clockwise rotation, generating a torque effect in the opposite direction.

For this reason, during the take-off in the AS350, the pilot needed to apply the right pedal, seeking to cancel the effect of the torque caused by the increase in power in the main rotor. As informed in the interviews, it was normal to start the take-off with the right pedal slightly applied.

The S300 helicopter, which was manufactured by Schweizer Aircraft, had the main rotor and a tail rotor in the same configuration as the AS350. However, the main rotor of the S300 had a counterclockwise rotation, generating a torque effect to the right.

Thus, during take-off on the S300, the pilot should start the procedure with the left pedal slightly applied, the opposite procedure to what was expected for the AS350.

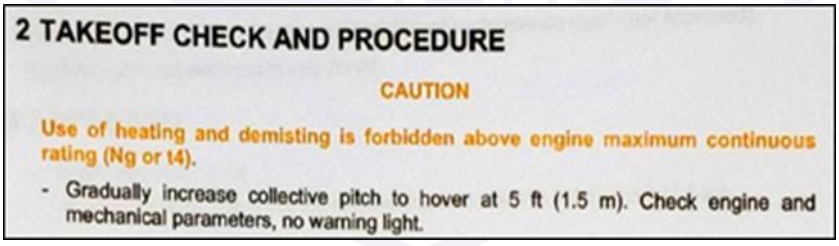
On the day of the accident, the crew had already carried out a morning flight on the AS350, which was conducted by the PIC and was uneventful.

For the second flight of the day, the SIC was at the controls and started a vertical take-off, a procedure that consisted of gaining about 1.5 m in height, without moving, that is, maintaining the position to then continue the climb until clear the obstacles present and proceed with the movement.

As made available by the operator, a document called “Training Manual” was used for training purposes, provided by the aircraft manufacturer and which contained the following information in item 4.4.2 “Check and take-off procedure”:

> Gradually increase collective pitch to hover at 5 ft. Check the mechanical and engine controls instruments, with the lights on the alarm panel off.

This procedure was available onboard the aircraft in the flight manual, which had in section 4.4 - Takeoff, the following information (Figure 11):



2 TAKEOFF CHECK AND PROCEDURE

CAUTION

Use of heating and demisting is forbidden above engine maximum continuous rating (Ng or t4).

- Gradually increase collective pitch to hover at 5 ft (1.5 m). Check engine and mechanical parameters, no warning light.

Figure 11 - Extract from the flight manual - Section 4.4 - Takeoff.

Also, the operation manual used by the operator, called "Pilot's Manual", which was used for standardization and description of the maneuvers, in item 3.5 "Vertical take-off", described the following information:

> (1) Apply the collective smoothly and continuously, with the aim of placing the light helicopter on the skis.

(2) Apply pedal command to correct heading variations, still light on skis.

(3) Use the cyclic command to correct the variations of the horizontal plane, still light on the skis.

(4) Mark a visual reference to the front of the helicopter and apply the collective continuously.

(5) To keep the helicopter vertical to the point, during take-off, we will feel that it is tilted slightly to the right.

(6) Once the helicopter leaves the ground, small and smooth corrections of:

• Cyclic - to avoid shifting.

• Pedal - to maintain the heading.

• Collective - to maintain a height of 5 ft (1.5 meters).

It was verified in the images that, soon after the aircraft was removed from the ground, there was no hover check as defined in the operating manuals and that the aircraft continued to turn to the left and gained height, up to about three meters, when it occurred the loss of control.

The PIC reported that, as soon as he noticed the sudden yaw, he tried to regain control and land the aircraft, however, he felt the commands “hard”. The PIC, who was not maneuvering the aircraft, when trying to regain control, did not inform the SIC of this action.

The MIV, prepared by the CNPAA, through its CNT in 2016, on page 54, addressed the positive handover of commands as follows form:

> Still on the positive handover of commands, one should never have doubts about who is controlling the aircraft. If there is, the instructor must take over the commands and inform what he is doing, until the doubt is fully resolved (“I HAVE CONTROL” versus “YOU HAVE CONTROL”).
>
> The instructor must always be prepared to take over command of the aircraft at any time. Therefore, it is important to point out to students in the briefing that joint action in commands, with the aim of teaching, can happen naturally. However, “I HAVE CONTROL” means to clear the actuation in the commands in all amplitude.

Upon request to the manufacturer, a computer simulation was performed, based on the information collected at the time of the occurrence and the flight dynamics, captured by the operator's CCTV system, to verify if it would be possible to estimate, through calculations, the position of the tail rotor control pedal, necessary to reproduce the same turning speed observed on the day of the occurrence.

For this simulation, the same parameters of the day of the accident were used, namely: take-off weight of 2,171 kg, altitude of 30 ft, the external temperature of 30ºC, and no wind.

Based on these data and using as a reference the portion of the video where the aircraft performed a 360º turn in about 4.5 seconds, it was possible to estimate the necessary position of the tail rotor command (pedal) for the observed turn.

Initially, in order to maintain a hovering flight, given the aircraft's weight and weather conditions at that time, it would be necessary to apply approximately 66% of the right pedal.

With the right pedal applied at 66%, simulations of application of the left pedal were then performed every half second, with each simulation varying the intensity of this command, from 10% to 50% of the left pedal.

This methodology was necessary so that it was possible to understand the effect of the new command input on the helicopter's heading and turning speed, depending on the speed at which the new command was applied, generating the graph in Figure 12, below:

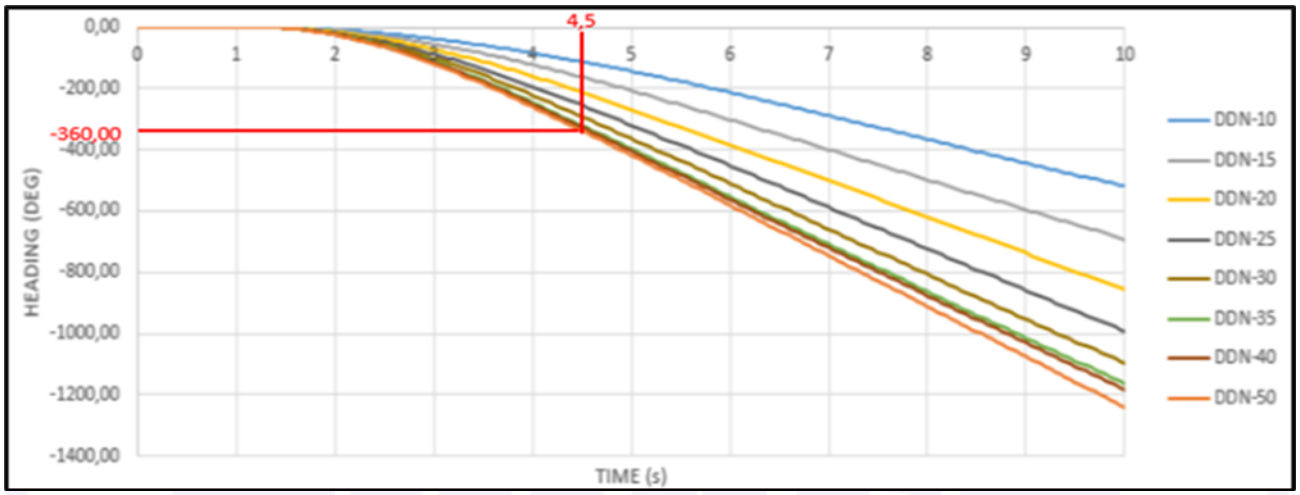


Figure 12 - Effect of left pedal application speed on aircraft heading variation as a function of time. Note that the DDN-50 Curve reaches a 360º turn in 4.5 seconds.

Considering the “DDN-50” curve (application in increments of 50% of the left pedal every half second) it is observed that in approximately 4.5 seconds the aircraft heading DEG is close to 360º.

In this context, the Instruction Manual presented by the operator had the following limitation:

> In hovering, avoid fast turns and more than a complete turn in less than 6 seconds.

Still, from the CCTV footage, it was possible to verify that the aircraft performed a complete turn in 4.5 seconds, counted from the moment of loss of control, which started when the aircraft was already 90º out of phase to the left of the take-off heading.

1.19 Additional information.

The take-off without performing the hover check was a decisive factor in occurrences, such as, for example, the accident that occurred on 03JUL2015 in the city of Frisco, Colorado - USA, with an aircraft similar to the PR-EAM.

On that occasion, as stated in the Final Report NTSB/AAR-17/01, issued by the NTSB, the crewmember possibly forgot to activate the hydraulic system and performed a direct take-off, without carrying out the hover check, as explicit in the operating manual.

Shortly after the take-off, the aircraft started to turn to the left and gained height until it lost control, with a subsequent violent collision with the ground and post-impact fire. Two crewmembers suffered serious injuries and the pilot died.

As a result of this accident, Airbus Helicopter, the aircraft manufacturer, issued the Safety Information Notice No. 2992-S-00, dated 21JAN2016, to remind pilots of best practices in order to ensure a safe take-off. These practices included the following, as freely translated by the Investigation Team:

> Make sure that normal loads are being felt on the flight controls (cyclic, collective, and pedals);
>
> Check if the switch positions and cabin configuration (warning and caution lights off) are correct for the phase of flight; and
>
> Perform a hover flight at approximately 5 ft and confirm normal aircraft behavior.

Also, the FAA issued, on 15NOV2016, the SAFO 16016 - Helicopter stabilized hover checks before departure.

In this bulletin, the FAA reported that, in several investigations of accidents that occurred with helicopters, the recurrence of take-off was observed without the pilots carrying

out a hover check. The alert recommended that pilots always perform a hover check before take-off, except in cases where operational conditions do not allow it.

It was also recommended the take-off be aborted if, “during the initial application of power with the collective, the aircraft was not stabilized”.

1.20 Useful or effective investigation techniques.

The use of the flight mechanics simulation, performed by the manufacturer, served to support the information obtained through the CCTV footage, providing a theoretical foundation for the aerodynamic reaction of the aircraft in the event of a sudden application of the left pedal until the end-of-stroke.

This analysis served to corroborate the marks observed in the counterweights of the tail rotor blades and the rotating plate, which were caused by the phenomenon known as tail rotor flapping.

2. ANALYSIS.

It was a police flight. The SIC, in the Pilot Flying role, was at the controls and started a vertical take-off. The PIC, in the role of Pilot Monitoring, followed the operation at that time.

As soon as the aircraft became “light on skis”, there was a yaw movement to the left, with the skid still on the ground. The movement continued as the helicopter climbed.

After turning 90º to the left, with three meters high, the turn increased in speed. At that moment, the PIC started to act in the flight controls. However, there was no communication about this procedure with the SIC.

Thus, it was concluded that both began to act simultaneously, as there was no positive handover of commands, which impaired the crew's ability to react adequately to that emergency, causing the loss of control in flight.

As stated in the MIV, there should be no doubt about who was at the controls of the aircraft, and there should not be simultaneous action.

The contact marks between the rotating control plate and the counterweights of the tail rotor blades indicated that the aerodynamic phenomenon known as flapping occurred, caused by the application of the left pedal command until close to the end of its course, which resulted in a tailspin at a rate greater than 60° per second. These findings were corroborated by the CCTV footage obtained and through the aerodynamic simulations performed by the manufacturer, which considered the conditions at the time of the occurrence.

The aircraft's hydraulic and flight control system was tested and found to be functional, even with the damage observed after the occurrence, and the failure of these components was ruled out by the Investigation Team.

Thus, the Investigation Team raised the hypothesis that the SIC had mistakenly applied the left pedal during the take-off and, as the spin increased, in an attempt to stop the movement, he applied more left pedal until the end of the stroke causing loss of control and contact of the counterweights of the tail rotor blades with the rotating control plate.

This misapplication of the pedal possibly occurred due to the pilot's confusion, due to the mental model he had for operating the S300 helicopter, which required the application of the left pedal to cancel the effect of the main rotor torque, which rotated in the opposite direction to the AS350.

The incorrect application of the pedal could have been noticed by the crew if the hovering check procedure had been performed, which could have made it possible to reduce the observed damage. This non-observance of procedures denoted inadequate supervision

by the organization, low adherence to rules and procedures, as well as a shared informal culture.

The failure to execute the hover check had already been detected previously and was a contributing factor in other occurrences, such as the accident on 03JUL2015 in the city of Frisco, Colorado - USA.

There was no formal training provision and the UAP also did not have an SOP in place at the time. This fact reflected the informality of the institution's organizational culture, which still lacked a doctrine of operation.

It is noteworthy that both crewmembers had little experience in the aircraft model.

Still, in relation to the PIC's little experience, it is possible that its operational capacity to manage the abnormal condition presented was below what was required at that time.

The interference of the PIC in the piloting, without there being a positive handover of commands, denoted an inefficiency in the use of the human resources available for the operation of the aircraft, due to inadequate management of the tasks assigned to each crewmember.

In this sense, the absence of participation in a formal and periodic training program and the lack of monitoring of the pilots' operational proficiency favored inappropriate actions both for the incorrect application of the pedal and for the simultaneous action on the commands and suppression of procedures prevised in the manual.

3. CONCLUSIONS.

3.1 Facts.

a) the pilots had valid CMAs;

b) the pilots had valid HMNT Ratings;

c) the pilots were qualified and had experience in the type of flight, however, they had little experience in the aircraft model;

d) the aircraft had a valid CA;

e) although the weight and balance sheet presented refers to the operator's other aircraft, 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) the take-off check procedure was not followed;

i) the hover check was not carried out;

j) there was contact between the rotating plate and the tail rotor blades counterweights;

k) the aircraft performed a complete turn in 4.5 seconds;

l) the helicopter landed abruptly;

m) the aircraft had substantial damage; and

n) all occupants left unharmed.

3.2 Contributing factors.

- **Control skills – a contributor.**

The application of the left pedal to the end of the stroke caused the aircraft to perform an uncontrolled turn to the left, completing 360º in 4.5 seconds. As there was no positive

handover of commands, there was a simultaneous and uncoordinated operation of the flight controls, which caused the loss of control in flight and, consequently, a hard landing.

- **Training – a contributor.**

There was no formal provision for the participation of pilots in training programs and continued training, which made it impossible to maintain the knowledge, skills, and attitudes necessary for effective performance in flight.

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

The PIC's attempt to take over the flight controls without communicating to the PF demonstrated poor cabin coordination and made it impossible to regain control of the aircraft.

- **Organizational culture – a contributor.**

The organizational culture proved to be fragile, since there was no appreciation of training on the part of the managers and members of the UAP, allowing an environment of low adherence to what was foreseen in the operation manuals.

- **Memory – undetermined.**

It is possible that the PF, for reasons beyond his control, confused the application of the flight controls, due to previous experience in the S300 (Schweizer) aircraft, which may have contributed to the incorrect application of the left pedal.

- **Insufficient pilot's experience – a contributor.**

Although the crew had the required experience for the flight, they had little experience in the aircraft model.

The procedural failures observed showed that the total experience of both allowed the operation to go beyond what was foreseen in the operating manuals, as well as contributed to the failures observed in the cabin coordination.

- **Organizational processes – undetermined.**

The lack of formal processes established concerning organizational supervision regarding the adherence to rules and procedures by the crewmembers may have contributed to the flight being performed on the margin of what was foreseen in the operating manuals.

- **Managerial oversight – a contributor.**

As noted in the documentation presented, there was no adequate management supervision over the operations, which took place without proper supervision by the organization, allowing procedures prevised in the flight manual to not be complied with.

4. SAFETY RECOMMENDATION.

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

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

Recommendations issued at the publication of this report:

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

A-117/CENIPA/2019 - 01 Issued on 05/27/2022

Disseminate the lessons learned in the present investigation to the DIOA of the SSP-AM, in order to encourage that operator to implement a cultural change in the organization, focusing on raising the collective perception of the need for faithful compliance with the standards and procedures defined in the unit's manuals, as well as the effective management of the risk inherent to public security aviation operations.

A-117/CENIPA/2019 - 02 Issued on 05/27/2022

Work with the DIOA of the SSP-AM, in order to certify that the operator has approved, implemented, and continuously keeps adequate to its reality, an MGSO, a MOP, as well as the SOP, by current regulations.

A-117/CENIPA/2019 - 03 Issued on 05/27/2022

Analyze the Training Program approved by the DIOA of the SSP-AM, in order to certify that operator addressed it in its initial and periodic training programs, in the flight and ground curricula, the main differences between the aircraft models operated, especially concerning the difference in the application of the anti-torque command (pedal), between the S300 and the AS350 models.

A-117/CENIPA/2019 - 04 Issued on 05/27/2022

Work with the other PAUs operating the AS350 model, to make sure that the operational procedures provided for in Safety Information Notice No. 2992-S-00, notably the hover check, are included in the SOP and are effectively being carried out by its crewmembers.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

None.

On May 27th, 2022.