COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT A-125/CENIPA/2020

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PR-MJZ**
MODEL:	**AS350 B2**
DATE:	**08OUT2020**

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 pertains to the October 8, 2020, accident involving the model AS350 B2 aircraft of registration marks PR-MJZ. The occurrence was typified as “[SCF-PP] Powerplant failure or malfunction.”

During the flight, the aircraft experienced a loss of main rotor RPM, prompting the pilot to perform a low-altitude autorotation and attempt a forced landing.

The aircraft sustained substantial damage.

The pilots suffered serious injuries, and one of them died days after the occurrence. The tactical operator sustained minor injuries.

Being France the State of Design/Manufacture of the aircraft and engine, an Accredited Representative from the *Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile* (BEA) was appointed for participation in the investigation of the accident.

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GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ADF	Public Aircraft Registry Category (Under Direct Federal Administration)
ANAC	Brazil’s National Civil Aviation Agency
BEA	French *Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile*
CA	Certificate of Airworthiness
CENIPA	Center for the Investigation and Prevention of Aeronautical Accidents
CIV	Digital Pilot-Logbook
CMA	Aeronautical Medical Certificate
CRM	Crew Resource Management
CTP	Main Gearbox
DECEA	Command of Aeronautics’ Department of Airspace Control
DFNSP	Department of the National Public Security Force
FAA	Federal Aviation Administration
FCU	Fuel Control Unit
FNSP	National Public Security Force
HMNT	Class Rating for Single-Engine Turbine Helicopters
ICA	Command of Aeronautics’ Instruction
INMET	Brazil’s National Institute of Meteorology
METAR	Routine Meteorological Aerodrome Report
MJSP	Brazil’s Ministry of Justice and Public Security
N1	Indication of the rotational speed of the low-pressure turbine and low-pressure compressor shaft.
N2	Indication of the rotational speed of the high-pressure turbine and high-pressure compressor shaft.
NR	Number of revolutions per minute (RPM) of the main rotor
NTSB	USA’s National Transportation Safety Board
PCH	Commercial Pilot License (Helicopter)
PF	Pilot Flying
PIC	Pilot in Command
PM	Pilot Monitoring
PPH	Private Pilot License (Helicopter)
RBAC	Brazilian Civil Aviation Regulation
RPM	Revolutions per minute
SACI	ANAC’s Civil Aviation Integrated Information System
SBCY	ICAO location designator - *Marechal Rondon* Aerodrome, *Cuiabá*, MT
SBCR	ICAO location designator - *Corumbá* Aerodrome, MS
SENASP	Brazil’s National Public Security Secretariat

SIC	Second in Command
SN	Serial number
SJQI	ICAO location designator - *Hotel Porto Jofre* Aerodrome, *Poconé*, MT
UTC	Coordinated Universal Time
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions

1. FACTUAL INFORMATION.

Aircraft	**Model:** AS350 B2 **Registration:** PR-MJZ **Manufacturer:** *Eurocopter France.*	**Operator:** *Ministério da Justiça e Secretaria Nacional de Segurança Pública*
Occurrence	**Date/time**: 08OUT2020 – 16:00 (UTC) **Location:** *Comunidade Santa Helena* **Lat.** 17°26'30"S **Long.** 056°49'37"W **Municipality – State:** *Corumbá – Mato Grosso do Sul*.	**Type(s):** [SCF-PP] Powerplant failure or malfunction

1.1. History of the flight.

At approximately 15:00 UTC, the aircraft departed from SBCR (Aerodrome of *Corumbá*, State of *Mato Grosso do Sul*), bound for SJQI (*Hotel Porto Jofre* Aerodrome, *Poconé*, State of *Mato Grosso*), in order to return to its operational base, with 2 pilots and 1 tactical operator on board.

At about 16:00 UTC, roughly five minutes before landing at the destination, the aircraft experienced a loss of main rotor RPM, prompting the pilot to perform a low-altitude autorotation and attempt a forced landing, which resulted in the aircraft colliding with the ground.

Figure 1 – Final position of the aircraft.

1.2. Injuries to persons.

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

1.3. Damage to the aircraft.

The aircraft sustained substantial damage to its whole structure. The skids, stabilizers, main transmission rotor, tail rotor, and tail boom were severed. The engine also sustained damage but remained attached to the aircraft. There was minor internal damage to the pilot's cockpit and to the passenger cabin.

1.4. Other damage.

NIL

1.5. Personnel information.

1.5.1. Crew's flight experience.

Hours Flown		
	PIC	SIC
Total	1,262:06	403:54
Total in the last 30 days	10:00	29:48
Total in the last 24 hours	07:54	02:42
In this type of aircraft	1,173:24	47:29
In this type in the last 30 days	10:00	29:48
In this type in the last 24 hours	07:54	02:42

Note: Flight hour's data obtained through the records of the pilots' CIV (Digital Pilot-Logbook), available in the ANAC's SACI (Civil Aviation Integrated Information System), as well as from aircraft documentation and information provided by official entities**.**

1.5.2. Personnel training.

The Pilot in Command (PIC) obtained his Private Pilot License – Helicopter (PPH) on August 9, 2010, and the Second in Command (SIC) obtained his PPH license on September 22, 2014.

1.5.3. Category of licenses and validity of certificates.

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

The SIC also held a PCH license, and his HMNT rating was valid.

1.5.4. Qualification and flight experience.

The PIC was a Special Agent with the Civil Police of the Federal District (PCDF) and, according to historical records from the PCDF's Air Operations Division (DOA), he had been operating AS350 aircraft since September 2010, having accumulated over 1,100 flight hours in this model.

On August 1, 2014, after meeting the requirements set forth in the DOA/PCDF Pilot Training and Specialization Plan, the Flight Board approved his technical and professional advancement to the role of Rotary-Wing Aircraft Commander.

On May 3, 2016, the PIC was assigned to the National Public Security Force (FNSP).

On July 7, 2016, the Operational Board of the Department of the National Public Security Force (DFNSP) recognized and validated the Rotary-Wing Aircraft Commander designation granted by the DOA/PCDF, granting him all the prerogatives of that role within the National Force.

Records indicated that the PIC had been operating the aircraft of registration marks PR-MJZ since February 2017.

Based on the occurrence aircraft's flight logbook, it was identified that the PIC had operated the referred aircraft daily for the three days prior to the accident, always in the role of Pilot in Command.

The SIC was an Inspector with the Civil Police of *Rio de Janeiro* and a member of the FNSP's pilot corps. He had approximately 403 total flight hours, of which 296 hours and 46 minutes were in the HMNT rating and 47 hours and 29 minutes in the specific model of the occurrence aircraft. The records from his Digital CIV indicated that he had been operating AS350 aircraft since at least December 2018 and the PR-MJZ helicopter since June 2019. He had greater experience in Bell 206 models.

The Tactical Operator, seated in the rear, had experience with the aircraft model and was a member of the *Rio de Janeiro* Military Police.

In accordance with the Brazilian Civil Aviation Regulation nº 61 (RBAC 61), Amendment nº 13 – Licenses, Ratings and Certificates for Pilots, section 61.21, the pilots met the recent experience requirements.

The pilots were qualified and experienced in the type of flight.

1.5.5. Validity of medical certificate.

The pilots held valid CMAs (Aeronautical Medical Certificates).

1.6. Aircraft information.

The Serial Number 4174 helicopter was manufactured by Eurocopter France in 2006. It was registered under the Public Aircraft Registration Category – under Direct Federal Administration (ADF), and was owned and operated by the Ministry of Justice and National Public Security Secretariat (MJSP).

The records of the airframe and engine logbooks were up to date.

The helicopter's Certificate of Airworthiness (CA) was valid.

The most recent inspection of the aircraft, a "7-day airframe" inspection, was carried out on October 7, 2020, by the maintenance organization *HELISUL Táxi Aéreo Ltda.* (COM 7901-01/ANAC), in *Poconé*, MT. The aircraft had accumulated 7 hours and 48 minutes of flight time since that inspection.

The latest comprehensive inspection had been performed on August 31, 2020, also by *HELISUL Táxi Aéreo Ltda.*, with the aircraft having logged 58 hours and 36 minutes of flight time after the said overhaul.

The maintenance services were considered periodic and appropriate.

It was identified that the anticipator of the Arriel 1D1 engine, SN 19076, had undergone maintenance (approximately 50 flight hours before the event), after the finding that the aircraft's main rotor rotational speed (NR) was slightly above the allowable tolerance. The aircraft's NR was reduced by 4 RPM (from 398 to 394 RPM), according to information provided by the aircraft manufacturer.

1.7. Meteorological information.

As reported by the aircraft occupants, the meteorological conditions were in general favorable for a visual flight. However, in certain areas, visibility was restricted, which significantly hindered the ability to maintain a constant altitude in order to remain under VMC.

It was not possible to determine the exact horizontal visibility at the time of the occurrence, as the nearest meteorological station was located over 100 NM from the accident site.

Thus, data were gathered from the following meteorological stations of the National Institute of Meteorology (INMET): *Corumbá* (A724), *Cuiabá* (A901), and *Sonora* (A761). These were the closest data sources, located approximately 104, 117, and 118 NM, respectively, from the accident site (Figures 2 and 3). In addition, aeronautical weather information was collected from the *Corumbá* and *Cuiabá* Aerodromes.

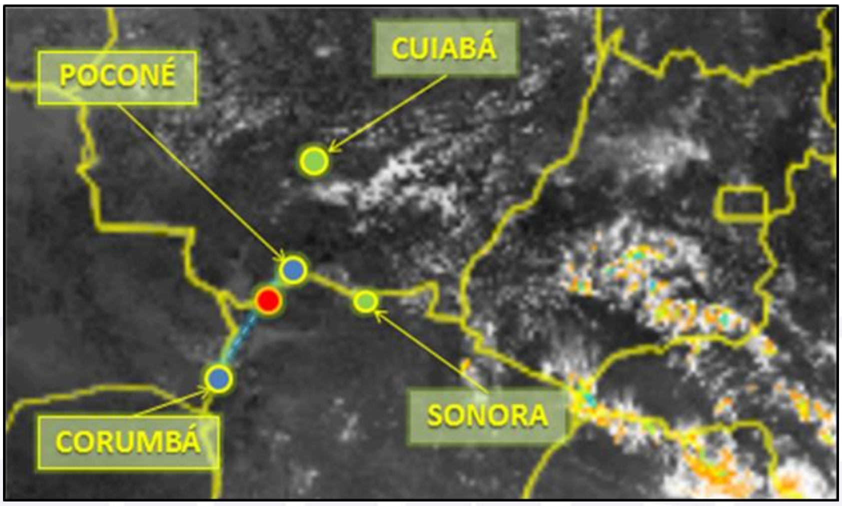

Figure 2 – Enhanced satellite image at 16:00 UTC.
In red, the location of the occurrence.
Source: adapted from https://redemet.decea.mil.br/.

Station	Wind direction (º)	Wind speed (kt)	Gusts (kt)	Temperature (°C)	Humidity (%)
Corumbá (A724)	274	3.5	14.5	40.1	21
Cuiabá (A901)	113	2.9	9.1	41.4	17
Sonora (A761)	278	8.7	15.1	37.6	22

Figure 3 – Table with weather conditions in the region of the occurrence at 16:00 UTC.
Source: https://mapas.inmet.gov.br/.

The Meteorological Aerodrome Reports (METAR) for SBCR (*Corumbá* Aerodrome, MS) and SBCY (*Marechal Rondon* Aerodrome, Cuiabá, MT) were available and contained the following information:

METAR SBCR 081500Z 32009KT 5000 FU NSC 39/17 Q1010=

METAR SBCR 081600Z 29009KT 260V320 4000 FU FEW035 40/17 Q1009=

METAR SBCY 081500Z 29005KT CAVOK 39/11 Q1012=

METAR SBCY 081600Z 23005KT CAVOK 40/10 Q1011=

The 15:00 UTC METAR from SBCR, corresponding to the takeoff time of the PR-MJZ helicopter, indicated marginal conditions for Visual Flight Rules (VFR), with visibility of 5,000 meters and the presence of smoke.

The 16:00 UTC METAR from the same location no longer supported VFR operations, with wind at 9 kt. and a variable direction from 260° to 320°, visibility of 4,000 meters, continued presence of smoke, few clouds at 3,500 ft., temperature of 40°C, and pressure at 1009 hPa.

At SBCY, approximately 117 NM from the accident site, the 15:00 UTC METAR reported conditions favorable for the flight, with wind at 5 kt. coming from 290°, visibility above 10 km, no cloud cover, a temperature of 39°C, and pressure at 1012 hPa. The 16:00 UTC METAR indicated wind at 5 kt. from 230°, visibility above 10 km, no cloud cover, a temperature of 40°C, and pressure at 1011 hPa.

The weather data gathered in the region indicated extremely low humidity, temperatures near 40°C, presence of wind, fire outbreaks, and smoke in the area – factors that contributed to reduced visibility. It was possible to confirm that, throughout the analyzed area – especially at the accident site – visibility was significantly reduced, as shown in photographic records taken shortly after the occurrence (Figure 4).

Figure 4 – Photograph taken moments after the occurrence, showing the reduced visibility prevailing at the accident site.

1.8. Aids to navigation.

NIL.

1.9. Communications.

NIL.

1.10. Aerodrome information.

The occurrence was off-aerodrome.

1.11. Flight recorders.

Not required and not installed.

1.12. Wreckage and impact information.

The wreckage was located 5.5 NM southwest of the intended landing site, SJQI, approximately 200 meters from the right bank of the *São Lourenço* River, in a rural area of the municipality of *Corumbá*, MS, in an open field, still within the State of *Mato Grosso do Sul* (Figure 5).

Figure 5 – Overview of the area.

According to the physical evidence at the crash site, the aircraft was in a nose-up attitude, with the skids laterally level – a condition consistent with ground impact involving little longitudinal displacement and a high rate of descent.

It was possible to verify that the skids contacted the ground simultaneously and level, and were severed due to material overload. The tail section of the aircraft was also severed, and its position – being located ahead of the main skid contact point – indicated a nose-up (tail-low) attitude at the time of collision with the ground.

The wreckage was concentrated near the initial point of impact, with a longitudinal dispersion of approximately 10 meters, a condition consistent with low forward speed.

The aircraft nosed over on its second ground contact, and the main rotor blades struck the terrain, with the aircraft coming to rest on its left side.

1.13. Medical and pathological information.

1.13.1. Medical aspects.

NIL.

1.13.2. Ergonomic information.

NIL.

1.13.3. Psychological aspects.

The investigation elements related to psychological aspects are consolidated in the factual data presented in item 1.18 (Operational Information). This approach was adopted because, in this occurrence, human and operational factors were intrinsically linked, and the psychological evidence emerged organically from the documented operational context. Therefore, keeping them integrated with the other facts contributes to a comprehensive understanding of the accident.

1.14. Fire.

No fire occurred.

1.15. Survival aspects.

After the occurrence, the occupants remained at the site for approximately four hours before rescue personnel arrived.

1.16. Tests and research.

The aircraft was removed from the accident site in parts due to the difficulty of access to the area. Examinations were conducted on the engine and other components. The engine examinations were carried out by the Investigation Committee and were accompanied by representatives of the FNSP and HELISUL.

The results of the engine power module examinations did not indicate any malfunction and confirmed that the engine was producing high power at the time the aircraft collided with the ground.

The oil and pneumatic line connections were properly torqued according to specifications, and no oil or air leaks were identified. The magnetic plugs of modules 1, 3, and 5, as well as the main oil filter, were examined and showed no metallic contamination or carbonization in their respective housings. The pre-obstruction indicator of the filter was in the resting (normal operating) position, thus unobstructed.

When examining the power output shaft coupling to the tail rotor, it was observed that all coupling blades had failed due to overload.

Figure 6 shows the power transmission shaft from the freewheel unit to the Main Gearbox (MGB). The damage observed exhibited characteristics consistent with disconnection while the engine was still running, resulting from the impact against the ground.

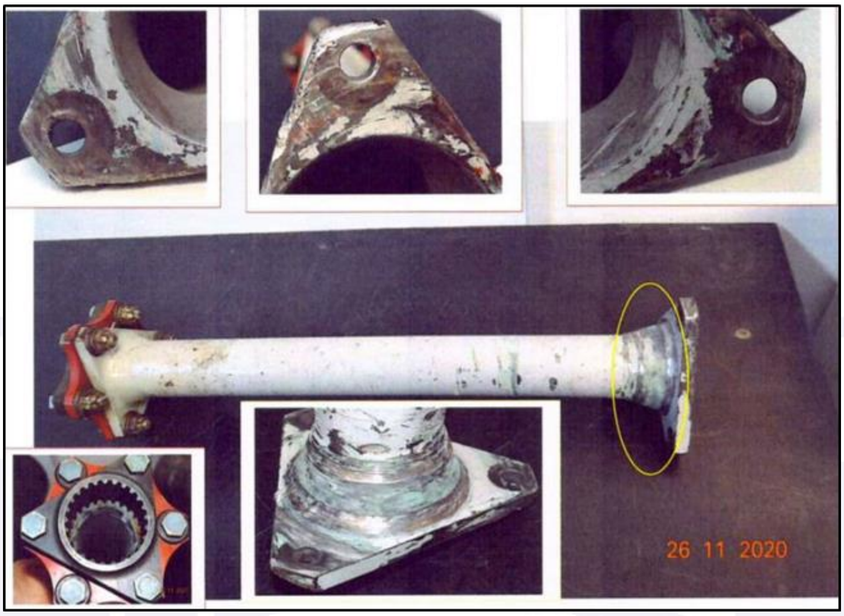

Figure 6 – View of the power output shaft from the freewheel to the Main Gearbox (MGB), showing scuff marks.

Significant quantities of metal shavings were identified on the impeller housing and diffuser walls, along with wear on the latter. Metal shavings were also observed on the first and second stages of the compressor turbine and in the exhaust duct, confirming that the engine was operating up to the moment of ground impact.

The most conclusive evidence of normal engine operation with power output was found in module 5. The misalignment observed between the input gear marks and the castellated nut of this module indicated that the engine was operating and that the systems being driven experienced abrupt stoppage at the time of the accident. This condition generated over-torque, causing the marks between the input pinion and the castellated nut to become misaligned.

According to the engine manufacturer, a 1.0 mm misalignment between the marks would require at least double the torque applied to the nut during engine assembly. These marks serve as a reference for identifying misalignment during normal engine operation. In this case, the misalignment measured 2.79 mm.

The (PN 0164548720 / SN 431M) Fuel Control Unit (FCU) was one of the engine components responsible for fuel management and for maintaining rotor speed within the normal operating range with increases or decreases in RPM (NR). The FCU behaved as expected during testing and was within its specifications, except for the NG STOP check.

It was not possible to recover a sufficient amount of residual fuel in the FCU to form a sample for contamination analysis.

The visual inspection of the FCU revealed signs of water contamination over its operational life evidenced by internal corrosion and pollution residues. These conditions altered the system's hydromechanical balance, increasing friction between components. Although the contamination prevented the performance of the NG STOP check – one of the standard tests for verifying optimal FCU functionality – its omission did not compromise the analysis of a possible connection between the component and the reported failure. One concluded that there was no correlation between the condition of the FCU and the main rotor RPM loss event.

According to retrieved information, the FCU had an operational limit of 3,600 hours or 10 years for that model. Records showed the FCU had approximately 1,600 hours since its last overhaul, performed in March 2014. Thus, it was confirmed that the FCU remained within both calendar and flight-hour limits.

Among the FCU's required tests was the "acceleration curve at 20°C", which verified fuel flow across the full spectrum of engine operating rates, from startup to maximum NG speed. Test points #4, #7, and #9 were found to be slightly above or below the tolerance range. According to observations, these discrepancies were not significant (Figure 7).

#	NG (rpm)	Inj. P (kPa)	P2-P0 (kPa)	Q (l/hr) metering valve only		Q (l/hr) with barostat		
						min.	max.	Recorded
1	950	200	0	30/36		30	36	33,8
2	1230	235	20			34,6	40,6	36,2
3	1760	250	40			39	45	40
4	2370	305	80			49	55	48,6
5	2580	335	100	54/60		54	60	55
6	2810	380	130			63	69	66
7	3250	510	200	83/90		83	90	90,2
8	3500	635	250			100	107,5	105,7
9	3725	825	300			121	128,5	128,3
10	3910	930	350			147	154	154,4
11	4050	1110	400	146/155		171,5	178,5	177,3
12	4305	1475	500			208,5	215	213,2
13	4540	1810	600	218/228		240	249	243,8
14	4780	2110	700			250	255	flow limitation
15	4850	2210	750			250	255	flow limitation

Table 01: acceleration curve table of results.

Figure 7 – Results of the acceleration curve test.

Considering the observed circumstances, a test was conducted to verify the maximum fuel flow of the FCU in manual mode. The two measurements obtained were 247.8 l/hr. and 244.8 l/hr., both within the manufacturer's acceptable range of 243 to 250 l/hr.

According to information from the manufacturer, every FCU had an NG limit to prevent the engine from exceeding operational parameters. This value was defined by a mechanical limit within the FCU. However, depending on the assembly and condition of the parts, the NG limit could also be reached under certain conditions and configurations specific to each FCU. A dedicated test was conducted, and the results are shown in Figure 8.

Test #	Fuel Temp (°C)	FCU power turbine shaft speed setting	FCU power turbine shaft speed range	FCU gas generator shaft speed measurement	FCU gas generator shaft speed range	Gap
1.1	20	3780	3714-3794	4872	4858-4864	+8rpm/+0.16%
1.2	50	3770	3714-3794	4796	4852-4858	-56rpm/-1.15%
1.3	20	3796	3714-3794	4799	4858-4864	-59rmp/-1.21%

Table 02: Tests 1.1 to 1.3 results.

Figure 8 – FCU Test Results

According to observations, Test 1.1 showed an insignificant inconsistency – common after some time in service – of 0.16% above the expected value.

Test 1.2 showed that the FCU did not reach its maximum NG STOP, with a result 1.15% below the expected value. The thermal compensator, which typically compensates for temperature increases by raising fuel flow, could have been the source of the discrepancy, although this hypothesis was not confirmed by complementary tests.

Test 1.3 showed that the maximum NG STOP did not change from 50°C to 20°C (remaining 1.20% below the expected value). The root cause of this behavior could not be identified.

In the sequence, a check of the fuel flow stability was conducted across various flow rates to assess regulation stability.

At 120 l/hr., a variation of 3.7 l/hr. was recorded; at 150 l/hr., a variation of 3.8 l/hr. was recorded – both within the allowable tolerance of 6 l/hr. At 209 l/hr., a variation of 6.8 l/hr. was recorded, exceeding the tolerance limit. According to manufacturer parameters, this discrepancy was not considered significant enough to cause instability detectable during engine operation, but it did confirm the inconsistency in fuel flow.

A test simulating 100% NG and a rapid load increase on the free turbine was also conducted to measure fuel flow and gas generator turbine (NG) speed variation. The response time was found to be within the test specification – less than 3.5 seconds.

The thermal compensator was removed and inspected. It showed damage on its non-functional surface, which did not affect regulation. No metallic particles were found inside the device, and all the damage was external.

Upon internal inspection, the barostatic device displayed a two-tone coloration, which could indicate it had remained stuck in one position for an undetermined period. The two-tone color pattern might suggest a temperature difference. For instance, according to tested temperatures, it could have locked in a 20°C position, limiting the maximum NG to a condition expected at 50°C. However, this locking behavior was not confirmed in the subsequent tests presented below.

The thermal compensator was replaced to isolate the discrepancy, and a new bench test was performed. The results are shown in Figure 9.

Test #	Fuel Temp (°C)	FCU power turbine shaft speed setting	FCU power turbine shaft speed range	FCU gas generator shaft speed measurement (NG stop)	FCU gas generator shaft speed range	Gap
2.1	20	3757	3714-3794	4885	4858-4864	+21rpm/+0.43%
2.2	50	3739	3714-3794	4875	4852-4858	+17rpm/+0.35%
2.3	20	3770	3714-3794	4813	4858-4864	-45rpm/-0.93%
3.1	20	3767	3714-3794	4825	4858-4864	-33rpm/-0.68%
3.2	50	3760	3714-3794	4825	4852-4858	-27rpm/-0.56%
3.3	20	3738	3714-3794	4832	4858-4864	-26rpm/-0.54%

Table 03: Tests 2.1 to 3.3 results.

Figure 9 – FCU Test Results with the New Thermal Compensator

The new test showed improved results, and a final confirmation (third test), using the original thermal compensator, reaffirmed the FCU's discrepancy at both 20°C and 50°C.

In the next phase of the examinations, upon checking the bench test filter, residues were identified and analyzed. When disassembling the FCU, corrosion and material contamination were observed in the internal NG chamber. The contamination contained iron oxide particles, likely resulting from the degradation of internal FCU components, possibly due to exposure to contaminated fuel during previous flights (Figures 10, 11, 12 and 13).

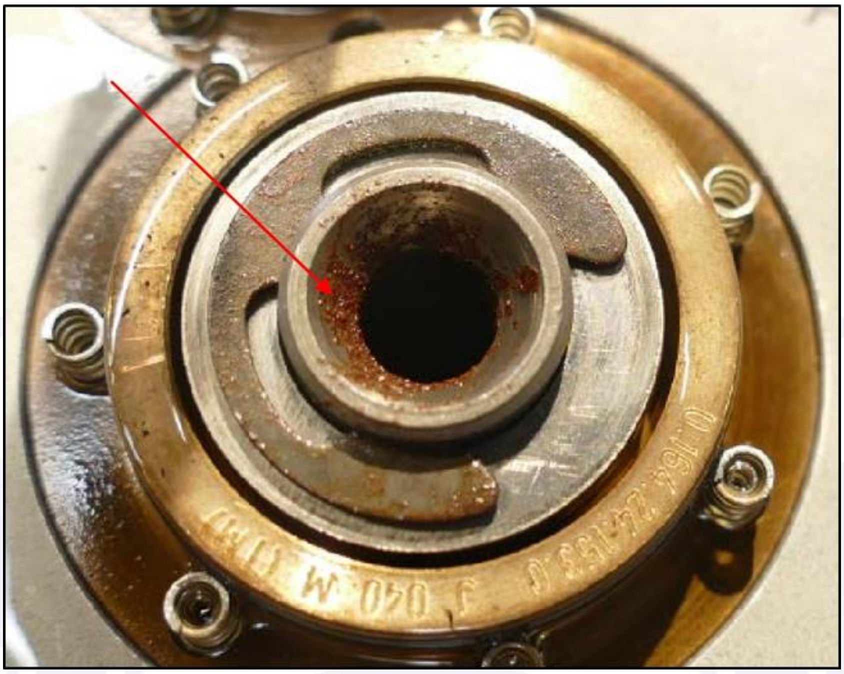

Figure 10 – Presence of corrosion and contamination on the edge of the FCU's NG chamber.

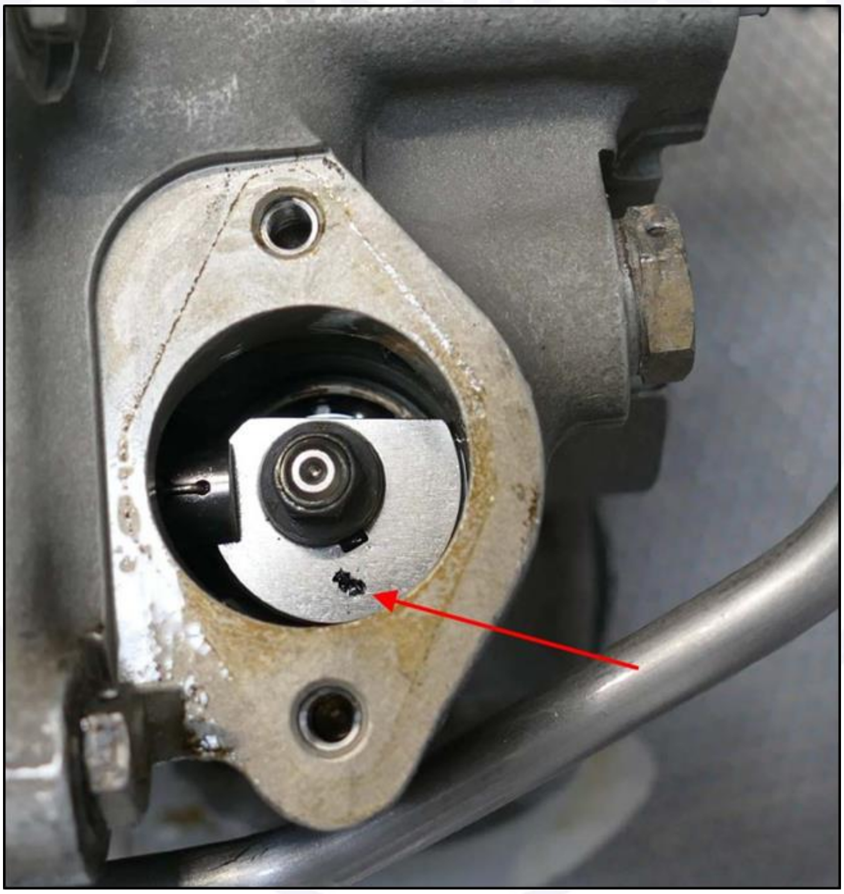

Figure 11 – Visible contamination in the anticipator chamber.

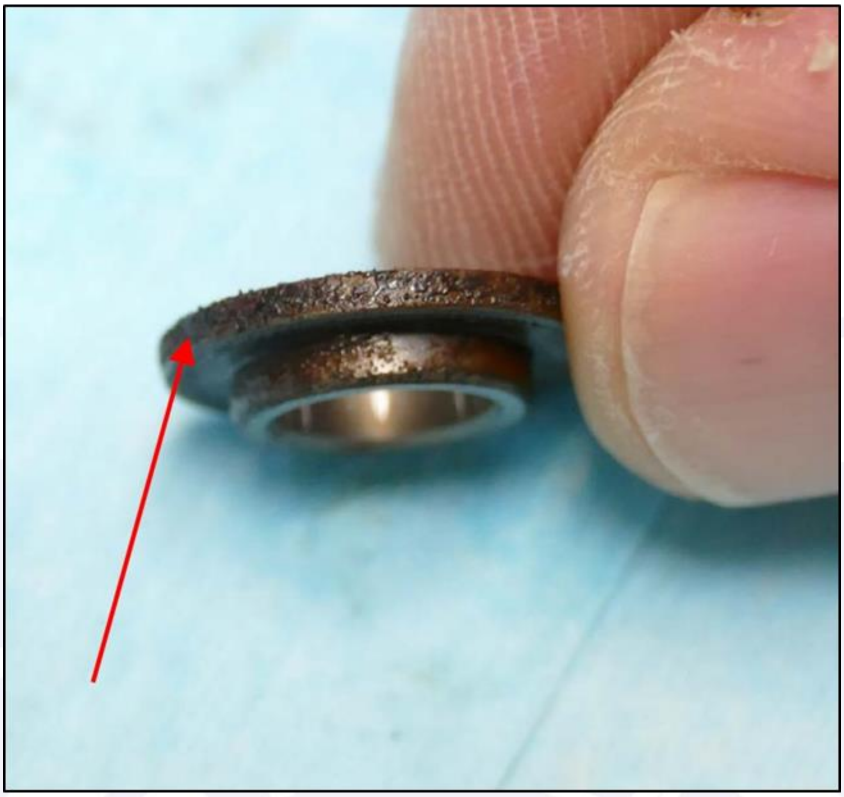

Figure 12 – Significant corrosion on the anticipator control spring seat.

Figure 13 – Detail of the partially clogged amplifier piston filter (internal FCU component). Highlighted in red as found, and in green as it should appear when unobstructed.

As some test results showed the NG STOP to be outside the tolerance range at 20°C and 50°C, the FCU was disassembled, and internal contamination was found. Although a rapid temperature change from 20°C to 50°C or from 50°C to 20°C in the fuel is not representative of normal engine operation, the bench test made it possible to detect that a quick variation in fuel temperature could affect the internal balance within the FCU.

This balance is a function of fuel temperature, but also of mechanical forces applied to internal components of the FCU that make up its hydromechanical regulation circuit. These forces were altered by mechanical wear, corrosion of internal parts, and contamination deposits, which could explain the inconsistencies in the NG STOP checks.

The bench test did not reveal any fuel flow instability or unexpected variation that could explain a rapid decrease in NR, as reported in the event circumstances.

According to the manufacturer, such a situation is similar to a temporary reduction in NTL speed (N2 or free turbine) due to a momentary increase in rotor load, followed by a control input in the cockpit pulling the collective lever. This action would prompt the FCU to adjust NTL by increasing fuel flow. As a result, the fuel flow to the metering unit would increase, restoring NTL speed to maintain it constant at 100%.

Based on the manufacturer's information, this behavior was consistent, considering that the engine's anticipator had undergone maintenance (approximately 50 flight hours prior to the event) after it was detected that the aircraft's NR was slightly above the allowable tolerance – suggesting that FCU contamination events might have been occurring previously.

Based on all tests and examinations performed, it was concluded that the engine was producing high power at the time of the aircraft collision with the ground.

Nonetheless, the Committee identified the presence of nonconformities that could result in powerplant malfunction, although these could not be conclusively linked to the NR drop observed by the pilots during the flight.

1.17. Organizational and management information.

The National Public Security Force (FNSP), established on November 29, 2004, through Decree nº 5,289, was a public security cooperation program coordinated by the National Secretariat of Public Security (SENASP) under the Ministry of Justice and Public Security (MJSP), headquartered in Brasília (DF).

To fulfill its inherent and specific duties related to Police Aviation, the Department of the National Public Security Force (DFNSP) established, on May 29, 2009, through Ordinance nº 05/DFNSP/SENASP/MJ, the Special Advisory for Police Aviation (AEAP).

The AEAP was later renamed as the Aviation Section (SAv) through Ordinance nº 011/2014/DFNSP/SENASP/MJ, which approved its internal regulations, whose main objectives were:

> Art. 1 – The SAv is an executive body of the DFNSP subordinated to the General Coordination of Operations (CGOp).
>
> Art. 2 – The Aviation Section (SAv) is tasked with advising the Director of the DFNSP on aviation-related matters and **managing the aerial assets assigned to the National Force (emphasis added)**.

The organizational structure of the SAv included the Chief, Deputy Chief, and Subsections for Administration, Operations, Training and Specialization, Operational Safety, and Maintenance.

Among the SAv's responsibilities were mission planning, aircraft control, and crew training in accordance with ANAC's regulatory requirements. Its pilots were officers from military police forces, military firefighters, or qualified civil police officers, holding valid licenses and having passed a selection process.

To fill positions within the SAv as Aircraft Commanders, candidates were required to have a minimum of 500 (five hundred) flight hours, as also provided for in RBAC 90, Amendment No. 00, section 90.23, item 6, in addition to completing the Command Advancement Program (PAC) and undergoing evaluation by the Operational Board.

Regarding this organizational aspect, qualified crewmembers approved through the SAv's selection process were mobilized from their institutions of origin and placed at the disposal of the National Force for a one-year term, renewable. These professionals were deployed in response to Public Security Operations as needed in a particular State of the Federation.

Given these characteristics, the SAv, subordinate to the CGOp of the DFNSP, operated as a Public Aerial Unit (UAP), in accordance with the requirements set forth in RBAC 90:

> 90.11 General criteria for designated management personnel
>
> (a) The UAP shall have qualified technical and administrative personnel with specific responsibilities to ensure the maintenance of the operational safety performance of said Unit.
>
> (b) The UAP shall have, at a minimum, the following management personnel:
>
> (1) a UAP manager, in accordance with section 90.35 of this Regulation;
>
> (2) a Safety Officer (GSO), in accordance with section 90.37 of this Regulation;
>
> (3) a chief of operations, in accordance with section 90.39 of this Regulation; and
>
> (4) a person responsible for the maintenance control of the UAP's aircraft, as defined by the UAP or in specific regulations.

It is important to note that prior to their mobilization to the FNSP, the PIC operated within the Public Aerial Unit (UAP) of the Civil Police of the Federal District, the SIC within the UAP of the Civil Police of *Rio de Janeiro*, and the Tactical Operator within the UAP of the Military Police of *Rio de Janeiro*.

On the date of the accident, the FNSP was conducting Operation *Pantanal II*. This was an aerial environmental protection operation aimed at exercising environmental police authority and implementing actions under the national environmental policy in accordance with the applicable environmental legislation. The crews were carrying out fire prevention and firefighting missions in the region between *Corumbá*, MS, and *Porto Jofre*, MT.

1.18. Operational information.

The flight was conducted by the National Public Security Force (FNSP) during Operation *Pantanal II*, in accordance with RBAC 90, Amendment nº 00, which establishes the Requirements for Special Public Aviation Operations.

The aircraft departed from SBCR with two pilots and one tactical operator on board, having SJQI as the final destination.

The PIC reported that he had flown the same route recently in support of Operation *Pantanal II*, including the day before the occurrence.

The PIC was seated on the right-hand side of the aircraft and acted as the Pilot Flying (PF). The SIC acted as the Pilot Monitoring (PM).

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

According to the pilots, up until the moment of the rotor RPM loss, the flight had progressed without any anomalies, just like the previous flights.

As reported by the pilots, in certain areas, visibility conditions were restrictive, which hindered the maintenance of visual flight at a constant altitude.

Due to reduced visibility, the flight was being conducted at an average altitude of 300 ft. above the terrain. The occupants stated they were approximately 200 ft. above ground level when they noticed the loss of rotor RPM.

Regarding Emergency Procedures, the AS350 B2 Flight Manual by HELIBRAS described the actions to be performed by the pilot in the event of various possible failures. The General Information section specified how to identify immediate actions (in bold) within the procedures, adding that depending on external environmental variables, the pilot might need to adapt to the situation based on their experience (Figure 14).

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MANUAL DE INSTRUÇÃO
AS 350 B2

3.1 GENERALIDADES

Os procedimentos de emergência descrevem as ações que o piloto precisa executar em relação às várias panes possíveis que podem ocorrer.
Entretanto, dependendo de algumas variáveis do ambiente externo, tal como o tipo de terreno sobrevoado, o piloto pode ter que adaptar-se à situação de acordo com sua experiência.

Para ajudar o piloto nesse processo de tomada de decisão, quatro recomendações são usadas:

- **POUSAR IMEDIATAMENTE**
  Autoexplicativo.
- **POUSAR ASSIM QUE POSSÍVEL**
  As condições de emergência são urgentes e é necessário pousar no local mais próximo onde se possa efetuar um pouso em segurança.
- **POUSAR ASSIM QUE PRATICÁVEL**
  As condições de emergência são menos urgentes e, a seu critério, o piloto pode prosseguir o voo até o local de pouso mais próximo, onde se possa obter a assistência apropriada.
- **PROSSEGUIR O VOO**
  PROSSEGUIR O VOO como planejado. Efetuar o reparo no destino conforme o Manual de Manutenção.

NOTA:
As ações imediatas que o piloto deve tomar estão em negrito.

Figure 14 – General Information on Emergency Procedures
Source: AS350 B2 Flight Manual – HELIBRAS

In the AS350 B2, the main rotor RPM (NR) operated within a normal range of 385 to 394 RPM during stabilized, powered flight.

This type of helicopter also featured an aural warning system that sounded a buzzer to alert the pilot when NR was outside safe operational limits. When NR dropped below 360 RPM, the pilot would hear a continuous tone. When NR exceeded 410 RPM, an intermittent tone would be heard.

Regarding the aural alerts, the manufacturer's manual specified the procedures to be followed upon detecting such warning tones (Figure 15).

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MANUAL DE INSTRUÇÃO
AS 350 B2

- **SOM CONTÍNUO**
  Dois sons contínuos podem ser ouvidos:
  - Quando a NR estiver abaixo de 360 rpm (som de 310 Hz).
  - Quando as limitações de decolagem são excedidas (som de 285 Hz):
    * Após um retardo de 1,5 segundos se a potência permanecer dentro das limitações de potências transitórias.
    * Imediatamente quando os limites transitórios de potência são ou possam ser excedidos durante um aumento rápido de potência.

  1. Passo coletivo........................ REDUZIR para manter a NR na faixa verde ou dentro das limitações de potência.
  2. Parâmetros do motor............ VERIFICAR.

- **SOM INTERMITENTE**
  Um som intermitente (de 310 Hz) é ouvido quando a NR estiver acima de 410 rpm:

  Passo coletivo........................... AUMENTAR para manter a NR na faixa verde.
  Aplicar o procedimento aplicável de acordo com a situação.

Figure 15 – Aural Warnings Related to NR.
Highlighted in red: actions to be taken.
Source: AS350 B2 Instruction Manual – HELIBRAS

The detailed procedure to be followed in the event of engine flameout during cruise flight described the autorotation procedure (Figure 16).

3.2 APAGAMENTO DO MOTOR

3.2.1 Em voo cruzeiro

PROCEDIMENTO DE AUTORROTAÇÃO SOBRE TERRA

1. **Passo coletivo** .... **REDUZIR.** para manter a NR na faixa verde.
2. **IAS** .... **AJUSTAR PARA 65 kt (120 km/h).**

- Se o reacendimento for impossível ou após perda do empuxo do rotor de cauda:

3. **Manete de vazão (FFCL)** .... **posição CORTADA.**
   Se o momento, a altura e as circunstâncias permitirem:
   - Válvula de corte de combustível.............................. **CORTAR.**
   - **[FUEL PUMP]** (ambas)............. **DESLIGAR.**
   - **[BATT]**...................................... **EMER SHED.**
4. Manobrar a aeronave para aproar o vento na aproximação final.

- Numa altura ≅ 70 ft (21 m):

5. Cíclico .... FLARE.

- A uma altura de 20/25 ft (6/8 m) e em atitude constante:

6. Passo coletivo................................. AUMENTAR GRADUALMENTE para reduzir a razão de descida e a velocidade à frente.
7. Cíclico .... Levemente À FRENTE para adotar uma atitude de pouso cabrada (< 10°).
8. Pedais... AJUSTAR para anular qualquer tendência de derrapagem lateral.
9. Passo coletivo................................. AUMENTAR para amortecer o toque com o solo.

- Após o toque

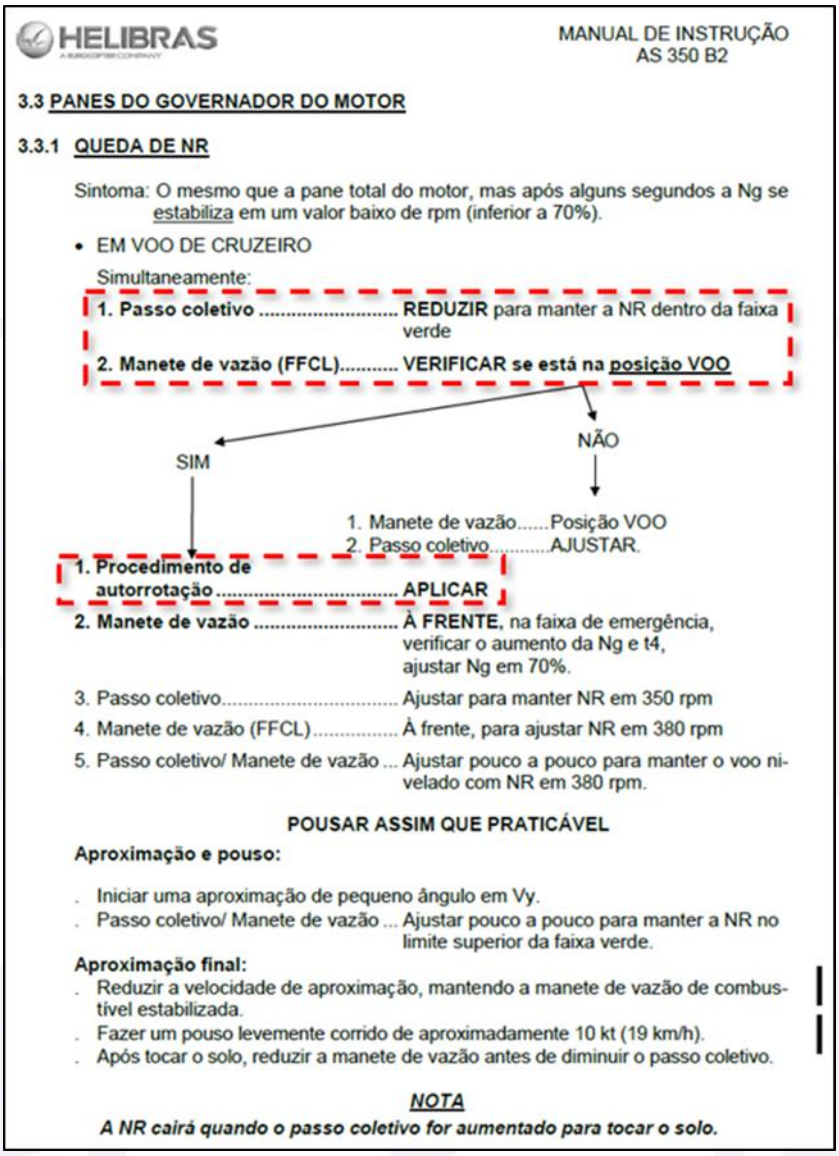
10. Cíclico, coletivo e pedais.............. AJUSTAR para controlar o pouso corrido.

- Após a aeronave ter parado

11. Passo coletivo............................... REDUZIR TOTALMENTE
12. Freio rotor .... APLICAR abaixo de 170 rpm do rotor.

Figure 16 – Engine Flameout in Cruise Flight
Source: AS350 B2 Instruction Manual – HELIBRAS

According to the manufacturer's manual, in Governor Failure situations, the drop in NR would exhibit the same behavior as in the event of a complete engine failure, but after a few seconds, Ng would stabilize. The autorotation procedure was also listed under the specific actions for engine governor failure, although there were additional actions to be taken (Figure 17).



HELIBRAS MANUAL DE INSTRUÇÃO AS 350 B2

3.3 PANES DO GOVERNADOR DO MOTOR

3.3.1 QUEDA DE NR

Sintoma: O mesmo que a pane total do motor, mas após alguns segundos a Ng se estabiliza em um valor baixo de rpm (inferior a 70%).

- EM VOO DE CRUZEIRO

Simultaneamente:

1. Passo coletivo .... REDUZIR para manter a NR dentro da faixa verde

2. Manete de vazão (FFCL).......... VERIFICAR se está na posição VOO

SIM

1. Procedimento de autorrotação .... APLICAR

2. Manete de vazão .... À FRENTE, na faixa de emergência, verificar o aumento da Ng e t4, ajustar Ng em 70%.

3. Passo coletivo................................ Ajustar para manter NR em 350 rpm

4. Manete de vazão (FFCL)................ À frente, para ajustar NR em 380 rpm

5. Passo coletivo/ Manete de vazão ... Ajustar pouco a pouco para manter o voo nivelado com NR em 380 rpm.

NÃO

1. Manete de vazão......Posição VOO
2. Passo coletivo...........AJUSTAR.

POUSAR ASSIM QUE PRATICÁVEL

Aproximação e pouso:

. Iniciar uma aproximação de pequeno ângulo em Vy.
. Passo coletivo/ Manete de vazão ... Ajustar pouco a pouco para manter a NR no limite superior da faixa verde.

Aproximação final:

. Reduzir a velocidade de aproximação, mantendo a manete de vazão de combustível estabilizada.
. Fazer um pouso levemente corrido de aproximadamente 10 kt (19 km/h).
. Após tocar o solo, reduzir a manete de vazão antes de diminuir o passo coletivo.

NOTA

A NR cairá quando o passo coletivo for aumentado para tocar o solo.

Figure 17 – Procedures for Engine Governor Failures
Source: AS350 B2 Instruction Manual – HELIBRAS

The PIC reported that, following the NR aural warning, the immediate action was to lower the collective control, and that he was unable to observe engine parameters such as oil temperature and pressure. The PIC also stated that the fuel flow lever was not moved to the emergency range, as prescribed in the manufacturer's manual in case of governor failure.

In interviews with the pilots, it was not possible to determine what led them to remain flying at low altitude under marginal weather conditions.

On this subject, the Federal Aviation Administration (FAA)[1] has noted that pilots frequently underestimate deteriorating visibility and continue flight relying on previous experience (familiarity with the route, location, and terrain) or in the hope that weather conditions will improve.

In Brazil, the Center for the Investigation and Prevention of Aeronautical Accident (CENIPA) has published several Final Reports[2] involving rotary-wing aviation in which pilots

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[1] *FAA Advisory Circular* 61-134 - *General Aviation Controlled Flight into Terrain Awareness.* Disponível em*:* *https://www.faa.gov/documentLibrary/media/Advisory_Circular/ac61-134.pdf*

[2] Final reports from CENIPA. Available at: https://sistema.cenipa.fab.mil.br/cenipa/paginas/relatorios/relatorios.php

chose to conduct VFR flight under marginal meteorological conditions for the intended type of operation, resulting in fatal accidents.

The National Transportation Safety Board (NTSB)[3] has also documented in several reports that the decision to continue VFR flight under degraded visibility conditions is one of the most common causes of fatal helicopter accidents.

Regarding VFR operations, it is worth noting that helicopter operations in Brazil are subject to the provisions of Command of Aeronautics' Instruction (ICA) 100-4 (2018) – "Special Air Traffic Rules and Procedures for Helicopters," published by the Department of Airspace Control (DECEA), which establishes the following:

> 3. VISUAL FLIGHT RULES
>
> 3.1 GENERAL CRITERIA
>
> 3.1.3 **Outside controlled airspace**, below 3,000 feet altitude or 1,000 feet above ground level, whichever is higher, helicopter VFR flights shall be conducted only when the following conditions can be met simultaneously and continuously:
>
> a) maintain visual flight conditions with visibility equal to or greater than 1,000 meters, provided the flight speed allows traffic or any obstacle to be seen and avoided with enough time to prevent a collision; and
>
> b) remain clear of clouds and maintain reference with the ground or water.
>
> 3.2 MINIMUM HEIGHTS FOR VFR FLIGHT
>
> 3.2.1 Except during takeoff and landing operations, or when authorized by the DECEA Regional Organization with jurisdiction over the intended area of operation, helicopter VFR flight shall not be conducted over cities, towns, populated areas, or gatherings of people in the open air at an altitude lower than 500 feet above the highest obstacle within a 600-meter radius around the aircraft.
>
> 3.2.2 In locations not mentioned in 3.2.1, **flight shall not be conducted at an altitude lower than the one that would allow a safe landing in the event of an emergency**, without endangering people or property on the surface.
>
> **NOTE: This altitude shall be at least 200 feet (emphasis added).**

According to the requirements of section 90.311 of RBAC 90, only during tactical low-altitude operations is it permitted to fly below the minimum altitudes established by RBAC 91 and by DECEA:

> 90.311 General Requirements
>
> (a) The initial requirement for low-altitude tactical operation is that the risk inherent to the operation—including the protection of aircraft, crew, mission personnel, passengers, and third parties—must be managed within the NADSO.
>
> (b) The aerial operations provided for in this Regulation shall preferably be conducted within the minimum altitude limits established by RBAC nº 91 and by DECEA, except during landing, takeoff, missed approach procedures, or when conducting the respective public aviation special operation.

Another important aspect related to this occurrence concerns the issuance of RBAC 90, through Resolution nº 512, dated April 11, 2019, published by ANAC, which established several transitional provisions, as detailed below:

> [...]
>
> Art. 2 – The following transitional provisions apply to RBAC nº 90, Amendment nº 00:
>
> I – UAPs, as defined in RBAC nº 90, operated by government agencies and public entities shall have until April 12, 2022, to comply with the provisions of Subpart B of RBAC nº 90;

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[3] *Continued VFR Flight into IMC- NTSB Safety Alert* SA-019. Available at: https://www.ntsb.gov/Advocacy/safety-alerts/Pages/safetyalerts.aspx

II – For UAPs created after April 12, 2019, the respective government agency or public entity shall have up to 48 (forty-eight) months from the formalization date of the UAP to comply with the provisions of Subpart B of RBAC nº 90, provided that operational safety risks are mitigated;

III – Examiners already credentialed as of the publication date of this Regulation must comply with the requirements of sections 90.47 and 90.49, as applicable, by April 12, 2020, under penalty of de-credentialing;

IV – UAPs lacking a duly qualified Tactical Operator and/or Medical Support Operator, as required by this Regulation, shall have until April 12, 2020, to comply with the crew composition requirements set forth in section 90.21, provided that associated risks are mitigated;

V – The implementation steps of the MOP (Operational Manual) shall be completed within the following deadlines:

a) by April 12, 2020 – MOP drafting;

b) by July 12, 2020 – MOP approval by the UAP manager;

c) by October 12, 2020 – MOP content dissemination to personnel involved in UAP aerial operations;

d) by April 12, 2021 – Implementation of all procedures and policies defined in the MOP by the UAP;

VI – The implementation steps of the SOP (Standard Operating Procedures) shall be completed within the following deadlines:

a) by April 12, 2020 – SOP drafting;

b) by July 12, 2020 – SOP approval by the UAP manager;

c) by October 12, 2020 – SOP content dissemination to personnel involved in UAP aerial operations;

d) by April 12, 2021 – Implementation of all procedures and policies defined in the SOP by the UAP;

VII – Government agencies and public entities must comply with the provisions of Subpart K of RBAC nº 90 starting April 12, 2020;

VIII – Government agencies and public entities shall have until July 12, 2020, to comply with the provisions of Subpart M of RBAC nº 90, and may continue to use training programs approved under Subpart K of RBHA 91 during the validity of this transitional provision;

IX – PICs and SICs of UAPs who completed their training by April 12, 2019, in accordance with Subpart K of RBHA 91, shall have a maximum of 24 (twenty-four) months, counted from the start date of the ground school phase of the initial, recurrent, upgrade, or transition training curricula, to complete the recurrent training required under section 90.179 of RBAC nº 90. After this deadline, the pilot must undergo initial training, as provided in section 90.171 of RBAC nº 90.

There were, therefore, transitional provisions established by Resolution nº 512, which set deadlines – some of them after the date of this occurrence – so that Public Aerial Units (UAPs) would have sufficient time to effectively implement and adapt to the requirements of the new RBAC for Special Public Aviation Operations.

Regarding training and qualification aspects, it is important to highlight that the Aviation Section (SAv), subordinate to the General Coordination of Operations (CGOp) of the DFNSP, included in its organizational structure a subsection responsible for the training and specialization of its crewmembers.

However, the SAv was in a transition process, and the documentation submitted to the Investigation Committee included the ordinance that approved the internal regulations with its structure, responsibilities, and duties, as well as the Operational Training Program – PTO (H350), approved by ANAC on December 16, 2015.

Still in accordance with the requirements established in RBAC 90, some documents – such as the Operations Manual (MOP), which outlines the policies, procedures, guidance, instructions, and doctrine for the development of UAP flight operations; the Standard Operating Procedures (SOP), which contains written instructions to ensure consistency in operational safety performance; and the Safety Management Manual (MGSO) – did not require approval by ANAC. These documents were not submitted to the Investigation Committee.

In addition, the PTO of a UAP, with regard to special training for public aviation operations, also did not require formal approval by ANAC (Figure 18).

Data da emissão: 12 de abril de 2019 RBAC nº 90
Data de vigência: 11 de julho de 2019 Emenda nº 00

APÊNDICE A DO RBAC Nº 90
APROVAÇÃO DE MANUAIS E TREINAMENTOS

Tabela 1

TIPO DO MANUAL	APROVAÇÃO REQUERIDA	
	UAP	ANAC
MOP	SIM	NÃO
SOP	SIM	NÃO
MGSO	SIM	NÃO
MEL, se aplicável	SIM	SIM
Programa de treinamento	SIM	Tabela 2

Tabela 2

TIPO DE TREINAMENTO	APROVAÇÃO	
	UAP	ANAC
Treinamento para pilotos - piloto em comando e piloto segundo em comando (inicial, periódico, elevação de nível, transição entre modelos e diferenças)	SIM	SIM
Treinamento de ambientação entre UAP	SIM	NÃO
Experiência operacional sob supervisão para piloto em comando	SIM	NÃO
Treinamento para comissário de voo (inicial e periódico)	SIM	SIM
Treinamentos para operador aerotático, operador de suporte médico e PSE	SIM	NÃO
Treinamento de instrutor de voo (inicial, transição)	SIM	SIM
Treinamento de ambientação de instrutor	SIM	NÃO
Treinamento em artigos perigosos (vide 90.285(c))	SIM	SIM
Treinamentos especiais (armas e munições embarcadas, pouso em local não cadastrado pela ANAC, voo tático à baixa altura, lançamento de objetos, operação helocasting, embarque e desembarque em voo pairado, paraquedismo, operações sobre extensões de água, operação com separação reduzida entre aeronaves, carga externa, NVIS, aeromédico etc.)	SIM	NÃO

Origem: SPO ANAC 120/120

Figure 18 – Approval of manuals and training programs.
Highlighted in red: manuals that did not require formal approval by ANAC
Source: RBAC 90, Amendment nº 00 – Appendix A.

Upon reviewing the SAv's Operational Training Program (PTO), no instructions, specific training, or standardizations were identified for low-altitude flights, procedures for operations under reduced visibility, training for landings at sites not registered with ANAC, or Crew Resource Management (CRM) training.

1.19. Additional information.

For a better understanding of this occurrence, it is important to highlight certain aspects related to helicopter flight controls, as well as the specific characteristics of the autorotation procedure. In the master's thesis entitled "Technical Guide for Helicopter Accident Investigation for SIPAER Investigators," Lírio (2012)[4] states the following:

> "[...] a helicopter has four independent flight controls: longitudinal, lateral, vertical, and directional. The pilot operates these controls with hands and feet using specific control levers located in the cockpit.
>
> The conventional flight control system consists of the cyclic control, collective control, pedals, and the fuel flow control lever, described as follows:
>
> Cyclic control: Located in front of the pilot, it is used for longitudinal and lateral control of the helicopter. The pilot moves the cyclic control stick in the desired flight direction (forward, sideways, or backward), cyclically changing the blade pitch angles of the main rotor. It is the primary speed control in helicopters.
>
> Collective control: Located to the left of the pilot, it is used for vertical control of the aircraft. The pilot moves the collective lever up or down, simultaneously changing the pitch angle of all the main rotor blades. It is the primary altitude control in helicopters.
>
> Pedals: Used for directional control, they act on the tail rotor's collective pitch or on the differential pitch of two contra-rotating rotors. To yaw the aircraft to the right, the pilot applies the right pedal, and vice versa.
>
> Fuel flow control lever: Located on the collective lever grip, the center console, or overhead panel, it controls the engine's power output. In piston-engine aircraft, the pilot may need to coordinate use of the collective and the fuel lever to ensure compatible changes in pitch and fuel flow. In turbine helicopters, the fuel lever is linked to an automatic regulation device called a governor, which frees the pilot from manually managing it under normal operation. However, in the event of governor malfunction, this lever must be manually controlled by the pilot."

Regarding the autorotation procedure in helicopters, it is important to emphasize that it is a critical flight technique, typically employed when the engine fails and no longer provides power to the main rotor blades. This procedure allows the helicopter to descend in a controlled manner and land safely, even without engine power.

About autorotation, Lírio (2012) emphasizes that it occurs mechanically through the freewheel unit, which allows the main rotor to continue spinning even if the engine is no longer functioning.

The most common reason for performing an autorotation is engine failure, but other emergencies can also require it, such as tail rotor failures or loss of available power.

In cases of sudden engine failure, the pilot's reaction time in identifying the emergency and immediately lowering the collective control is a decisive factor to avoid a sharp drop in main rotor RPM – an element intrinsically linked to the helicopter's lift.

Lírio (2012) also notes that the last 100 to 75 feet of the maneuver are critical, as they mark the transition from the autorotative descent to the power-off landing. During this phase, known as flare, the airflow through the main rotor is reversed, and the stored energy is converted into lift to reduce forward speed and rate of descent.

Deceleration should continue until just before ground contact, reaching the lowest possible forward speed and sink rate appropriate for the situation.

1.20. Useful or effective investigation techniques.

NIL.

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[4] *LIRIO*, T.A., ***Guia Técnico de Investigação de Acidentes Aeronáuticos com Helicópteros para Investigadores do SIPAER***. *Dissertação de Mestrado em Segurança de Aviação e Aeronavegabilidade Continuada - Instituto Tecnológico de Aeronáutica, São José dos Campos* -SP, p.31, 2012.

LIRIO, T.A., **Technical Guide for Helicopter Accident Investigation for SIPAER Investigators**. Master's Thesis in Aviation Safety and Continued Airworthiness – Aeronautics Institute of Technology (*Instituto Tecnológico de Aeronáutica*), *São José dos Campos* – SP, p.31, 2012.

2. ANALYSIS.

This was a flight from SBCR to SJQI, with two pilots and one tactical operator on board, in support of Operation *Pantanal II* for wildfire suppression in the region.

The pilots were qualified and had experience with the aircraft.

The aircraft had a valid Certificate of Airworthiness (CA), and the records of its maintenance logbooks were up to date.

At the time of takeoff, meteorological conditions at the departure aerodrome (SBCR) indicated visibility of 5,000 meters with the presence of smoke, and these conditions further deteriorated within the following hour.

Meteorological data gathered by the Investigation Committee – such as low relative humidity, temperatures near 40°C, presence of winds, and the very activation of Operation *Pantanal II* – confirmed that smoke from forest fires had spread evenly through the atmosphere, resulting in reduced visibility throughout the surrounding area.

These findings aligned with the pilots' report that the flight was being conducted at the limits of the applicable regulations in order to remain under visual conditions. That is, the meteorological conditions, including the smoke, interfered with the operation, prompting the Pilot Flying to lower the flight altitude.

Approximately five minutes prior to landing at the destination, with the flight being conducted at about 200 ft. AGL due to limited visibility, the helicopter experienced a loss of rotor RPM (NR). The PF performed an autorotation and an emergency landing in an open field.

Post-accident analysis of the engine's power modules revealed no malfunction and concluded that the engine was producing power at the time of ground impact.

Bench tests performed on the FCU did not reveal any instability or abnormal fuel flow variation that could justify the sudden drop in main rotor RPM (NR) as reported by the crew during the event.

Although the results indicated operation within normal parameters, it is important to consider that the absence of conclusive evidence in bench tests does not entirely rule out the possibility of anomalies during actual flight, as transient or partial failures may not manifest under controlled testing conditions.

Contamination found inside the FCU, consisting primarily of iron oxide elements, could be explained by corrosion of internal components, likely resulting from exposure to contaminated fuel at some point during its operational life – not necessarily during recent refueling.

The partial clogging of the internal filter in the FCU chamber led to increased modulated pressure of the NTL (N2 or free turbine), which in turn increased the fuel flow.

The FCU was compliant with its specifications, except for the NG STOP check, which, due to corrosion, may have altered the hydromechanical balance of the unit, affecting its regulation and potentially causing a momentary power loss. This condition did not recur during bench testing but may have occurred in this event, leading to the drop in NR.

The examinations revealed that the FCU's contamination condition had been present for at least 50 hours, when maintenance was performed on the anticipator to reduce NR. However, that task did not provide access to the FCU's internal components, and it was not possible to determine in which maintenance action the contamination might have been detected and corrected.

Regarding aural warnings, the manufacturer's instruction manual described procedures to be followed upon hearing specific tones. For a continuous tone, indicating a drop in NR, the PF was expected to lower the collective pitch and check engine parameters.

As also detailed by the manufacturer, a continuous NR warning tone could be triggered by either a complete engine failure or a governor failure, each requiring distinct procedures. It was up to the crew to assess engine instrument readings to correctly identify the failure and take appropriate action.

In this accident, upon hearing the NR aural warning, the PF initiated autorotation but did not verify engine parameters. The flight conducted at 200 ft. AGL, in an effort to remain VMC, reduced the available reaction time for properly identifying the failure and executing the emergency procedures outlined in the manufacturer's manual. These aspects reflected impairments in the ability to recognize, organize, comprehend, and anticipate the sensory cues present in that operational context.

The crew's decision to continue VFR flight under degraded visibility conditions, recognized as one of the primary contributing factors in fatal helicopter accidents according to CENIPA and NTSB records, revealed inadequate risk assessment, indicative of overconfidence and a tendency toward improvisation.

This critical operational decision was further aggravated by the subsequent reduction in flight altitude – down to approximately 200 ft. – which limited the available reaction time for handling the emergency and reduced the safety margin for executing the procedure.

The combination of these factors created an adverse operational scenario that may have compromised the crew's ability to complete a safe landing. Additionally, these elements indicated difficulties in perceiving, analyzing, and selecting alternatives, such as performing an intermediate landing en route, as well as inadequate risk assessment for that operational environment.

In this scenario, the PF interpreted the situation as an engine failure, executing an autorotation almost directly into *flare* and emergency landing.

It was not possible to determine whether the application of flight controls during the autorotation – from collective lowering to *flare* and landing – contributed to the occurrence. However, physical evidence from the wreckage showed limited dispersion, indicating a high rate of descent that led to an unsuccessful landing.

Although documents such as the MOP, SOP, and MGSO did not require approval from ANAC, they were not submitted to the Investigation Committee. Furthermore, the PTO submitted by the SAv did not include instructions, specific training, or standardization for low-altitude flights, operations under reduced visibility, or landings at sites not registered with ANAC. These findings pointed to a lack or inadequacy of the set of rules and manuals available to personnel to perform their duties, reinforcing a support system deficiency.

By not having manuals related to doctrine for the development of Special Public Aviation Operations or specific training to ensure uniform operational safety performance, the systematized processes for improving pilot knowledge, skills, and attitudes may have led the crew to inadequate performance and insufficient response in the context experienced.

Before being assigned to the FNSP, the crewmembers operated in different UAPs. It was not possible to determine whether operating with crew members from distinct UAPs affected or could have affected the safety level of the FNSP operation.

There was also no evidence of CRM training. The absence of such training may have resulted in inefficient use of the human resources available for aircraft operation in that scenario.

No clear motivation was identified for the crew's decision to remain at low altitude under reduced visibility conditions, although FAA studies have shown that pilots often underestimate visibility degradation and continue flight based on prior experience or in hope of weather improvement.

It was not possible to determine whether there was a gap between prescribed work and actual work, where the complexity of the task may have exceeded individual capabilities to meet the demands and particularities of Special Public Aviation Operations, which could have influenced pilot performance and led them to operate with reduced safety margins.

3. CONCLUSIONS.

3.1. Findings.

a) the pilots held valid CMAs (Aeronautical Medical Certificates);

b) the pilots held valid ratings for HMNT (Single-Engine Turbine Helicopter);

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

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

e) the aircraft was within weight and balance limits;

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

g) the engine anticipator had undergone maintenance approximately 50 hours prior to the event, after it was detected that the aircraft's NR was slightly above the allowable tolerance;

h) it was reported that visibility was reduced at the time of the occurrence;

i) there was smoke throughout the region;

j) the flight was being conducted at an average altitude of 300 ft. above the terrain;

k) the occupants stated they were approximately 200 ft. above the ground when the rotor RPM loss was perceived;

l) the crew heard the low rotor RPM (NR) aural warning;

m) the autorotation procedure was performed;

n) the aircraft collided with the ground at a high rate of descent;

o) the engine was producing power at the time of ground impact;

p) internal corrosion was found in the FCU;

q) partial clogging of the FCU filter was identified;

r) the aircraft sustained substantial damage; and

s) the pilots sustained serious injuries, with the PIC succumbing to injuries days after the occurrence, and the tactical operator sustained minor injuries.

3.2. Contributing factors.

- **Attitude – undetermined.**

The crew's decision to continue VFR flight under degraded visibility conditions – recognized as one of the primary contributing factors in fatal helicopter accidents according to CENIPA and NTSB records – revealed inadequate risk assessment, indicative of overconfidence and a tendency toward improvisation.

This critical operational decision was aggravated by the subsequent reduction in flight altitude, which limited the available reaction time to manage the emergency and reduced the safety margin for executing procedures. The combination of these factors created an adverse operational scenario that may have compromised the successful completion of the landing.

- **Training – undetermined.**

Due to the absence of manuals related to doctrine for the development of Special Public Aviation Operations or specific training aimed at achieving consistent safety performance within the UAP, the systematized processes for developing pilots' knowledge, skills, and attitudes may have led to inadequate crew performance under the conditions experienced.

- **Tasks characteristics – undetermined.**

It was not possible to determine whether there was a mismatch between prescribed work and actual work, in which task complexity exceeded individual capabilities to meet the demands and specificities of Special Public Aviation Operations, potentially influencing pilot performance and leading them to operate with reduced safety margins.

- **Adverse meteorological conditions – a contributor.**

The meteorological conditions, including the presence of smoke, interfered with the operation, causing the PF to lower the flight altitude. This scenario limited the available reaction time and reduced the safety margin for executing emergency procedures.

- **Crew Resource Management – undetermined.**

Prior to being assigned to the FNSP, the crewmembers operated in different UAPs. It was not possible to conclude whether operating with crew members from different UAPs affected or could have affected the safety level of the FNSP operation.

No CRM training was identified. The absence of this type of training may have led to inefficient use of the human resources available for aircraft operation in that scenario.

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

It was not possible to determine whether the application of flight controls during the autorotation procedure – from collective lowering to flare and landing – contributed to the occurrence. However, the physical evidence from the wreckage showed limited dispersion, indicating a high rate of descent that led to an unsuccessful landing.

- **Piloting judgment – a contributor.**

The crew's decision to continue VFR flight under degraded visibility conditions revealed inadequate assessment of the risks associated with such conditions, limiting the time available to respond to the emergency and reducing the safety margin for procedure execution.

- **Aircraft maintenance – undetermined.**

During the examinations, it was determined that the FCU contamination had already been present at least 50 flight hours earlier, when maintenance was carried out on the anticipator to reduce NR. However, that maintenance task did not provide access to the contaminated region, and it was not possible to determine in which maintenance action the contamination could have been identified and corrected.

- **Perception – a contributor.**

In this accident, upon hearing the NR aural warning, the PF initiated autorotation but did not verify engine parameters. The flight conducted at 200 ft., in an attempt to remain VMC, reduced the available reaction time for properly identifying the failure and applying the emergency procedures prescribed in the manufacturer's manual.

These aspects impaired the ability to recognize, organize, interpret, and project sensory input in that operational context.

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

In response to reduced visibility and with the intention of remaining VMC, the PF chose to reduce the flight altitude to approximately 200 ft. This pointed to a difficulty in perceiving, analyzing, and selecting alternatives - such as performing an en route intermediate landing.

The decision to fly at low altitude compromised the available reaction time for identifying aircraft malfunctions and demonstrated difficulty in recognizing and accepting alternative actions, as well as inadequately assessing risks present in that operational environment.

- **Support systems – a contributor.**

Although documents such as the MOP, SOP, and MGSO did not require formal approval by ANAC, they were not submitted to the Investigation Committee. Furthermore, the PTO submitted by the SAv did not contain instructions, specific training, or standardization for low-altitude flight, operations under reduced visibility, or landings at sites not registered with ANAC. These findings pointed to a lack or inadequacy in the set of rules and manuals available to personnel to perform their duties, confirming a failure in the support system.

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:

A-125/CENIPA/2020 - 01 **Issued on 07/03/2025**

Coordinate with the Public Aerial Unit (UAP) of the Department of the National Public Security Force (DFNSP) with the objective of assessing the adequacy of the Operational Training Program (PTO), as well as the Operations Manual (MOP), the Standard Operating Procedures (SOP), and the Safety Management Manual (MGSO) to the requirements for Special Public Aviation Operations established under the RBAC 90.

A-125/CENIPA/2020 - 02 **Issued on 07/03/2025**

Disseminate the lessons learned from this investigation to the Public Aerial Unit (UAP) of the National Public Security Force, so that they may be used in internal actions for the promotion of operational safety, with the aim of enhancing risk management in operations involving crews from other Public Aerial Units.

A-125/CENIPA/2020 - 03 **Issued on 07/03/2025**

Disseminate the lessons learned from this investigation to Public Aerial Units (UAPs), so that they may be used in internal actions for the promotion of operational safety, with the aim of enhancing risk management in their operations.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

None.

On July 3rd, 2025.