COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A-144/CENIPA/2024

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PR-UEA**
MODEL:	**BK117 C-2**
DATE:	**11OUT2024**

NOTICE

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

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

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

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

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

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

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

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

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

SYNOPSIS

This Final Report refers to the accident involving the BK117 C-2 aircraft, registration marks PR-UEA, which occurred on 11OCT2024 and was classified as UIMC (Unintended Flight in IMC) and CFIT (Controlled Flight Into or Toward Terrain).

After takeoff, the aircraft entered adverse weather conditions and impacted the terrain in the *Serra do Amolar* region, state of *Minas Gerais*.

The aircraft was destroyed.

All six operational crew members sustained fatal injuries.

An Accredited Representative from the Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile (BEA), France, the State of Design and Manufacture of the engines, was appointed.

An Accredited Representative from the *Bundesstelle für Flugunfalluntersuchung* (BFU), Germany, the State of Design and Manufacture of the aircraft, was appointed.

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1. FACTUAL INFORMATION.

Aircraft	**Model:** BK117 C-2 **Registration:** PR-UEA **Manufacturer:** *Airbus Helicopters Deutschland GmbH*	**Operator:** *Corpo de Bombeiros Militar de Minas Gerais* (CBMMG)
Occurrence	**Date/time**: 11OUT2024 – 20:45 (UTC) **Location:** *Serra do Amolar* mountain range. **Lat.** 20°22'02''S **Long.** 043°32'06''W **Municipality – State:** *Ouro Preto* – MG	**Type(s):** [UIMC] Unintended flight in IMC [CFIT] Controlled flight into or toward terrain

1.1. History of the flight.

The aircraft took off from an unregistered area located at a road interchange in the municipality of *Ouro Preto*, state of *Minas Gerais*, bound for *Pampulha–Carlos Drummond de Andrade* Aerodrome (SBBH), *Belo Horizonte*, state of *Minas Gerais*, at approximately 20:45 UTC, in order to return to its home base after conducting a search flight, with two pilots, two aerotactical operators, one physician, and one nurse on board.

After takeoff, the aircraft entered adverse weather conditions and impacted the terrain in *Serra do Amolar*, state of *Minas Gerais*.

1.2. Injuries to persons.

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

Note: In accordance with the note to Section 90.21 of Brazilian Civil Aviation Regulation (RBAC) No. 90, Amendment No. 2 — Requirements for the Special Operation of Public Aircraft — although the aerotactical and medical support operators were part of the operational crew, they were not aircraft crewmembers.

1.3. Damage to the aircraft.

The aircraft was destroyed.



Figure 1 – Aircraft destroyed after the collision.

1.4. Other damage.

NIL.

1.5. Personnel information.

1.5.1. Crew's flight experience.

Flight Experience		
	PIC	SIC
Total	751:00	237:42
Total in the last 30 days	18:48	24:06
Total in the last 24 hours	00:30	00:54
In this type of aircraft	165:30	95:00
In this type in the last 30 days	08:48	13:54
In this type in the last 24 hours	00:30	00:54

Note: Flight-hour data obtained from the pilots' Digital Pilot-Logbook (CIV) records.

1.5.2. Personnel training.

Both pilots were members of the CBMMG. Their involvement in aviation began after internal selection processes, following which they underwent training at a Civil Aviation Training Center (CIAC) contracted by the Public Aviation Unit (UAP).

The Pilot in Command (PIC) completed the PPH course (Private Pilot – Helicopter) in 2017, at *Minas Helicópteros*, in *Belo Horizonte*, state of *Minas Gerais*.

The Second in Command (SIC) completed the PPH course at *Minas Aviation* in 2021, in *Belo Horizonte*, state of *Minas Gerais*.

1.5.3. Category of licenses and validity of certificates and ratings.

The PIC had held a PCH license (Commercial Pilot – Helicopter) since 2019, and his HMLT rating (Multi-Engine Helicopter Class), which included the aircraft type involved in this occurrence, and Instrument Flight – Helicopter (IFRH) rating were valid.

The SIC held a PPH license, and his HMLT rating was valid.

1.5.4. Qualification and flight experience.

The records maintained by the operator, together with the information obtained from the Integrated Civil Aviation Information System (SACI), indicated that the PIC began his aviation career in 2017, when he obtained his first rating and operated R-22 aircraft. In 2018, he began conducting operational flights at the Air Operations Battalion (BOA), based in Belo Horizonte, state of Minas Gerais, flying AS 350 B2 aircraft and, concurrently, the BK117 C-2 aircraft, registration PR-UEA, involved in this occurrence.

As he continued his operational progression, he began serving as PIC in 2019 and obtained the IFRH rating in 2023. Approximately one month before the occurrence, he completed the regulatory proficiency check flight for the revalidation of his ratings, during which no operational issues related to aircraft handling were recorded.

According to the available records, the PIC had accumulated approximately 751 total flight hours, of which more than 165 hours were in the aircraft registered PR-UEA. Although he had experience in flights conducted under Visual Flight Rules (VFR), the SIPAER Investigation Commission found that he had accumulated only approximately five flight hours under Instrument Flight Rules (IFR) in Instrument Meteorological Conditions (IMC).

Additionally, the PIC had been operating in the region for approximately seven years and had records of recent flights conducted in the vicinity of Ouro Preto, state of Minas Gerais, a few days before the occurrence under investigation.

The SIC began his pilot training in 2021, also in R-22 aircraft. In 2022, he began operating UAP aircraft, including the AS 350 B2 and the BK117 C-2 (PR-UEA). In 2024, following the acquisition of a new aircraft by the BOA, he completed four flights in the A-119 Koala with a view to obtaining the corresponding rating.

The SIC had accumulated approximately 237 total flight hours, of which 95 hours were in the aircraft PR-UEA, and did not hold an instrument flight rating. The records indicated that he had been operating at the UAP for approximately two years; however, there were no records of flights in the accident region. Nevertheless, accounts obtained by the SIPAER Investigation Commission indicated that he had flown over the region on previous occasions.

With regard to pilot qualifications, RBAC 90, Amendment No. 2, established the following requirements for the pilot in command:

> 90.23 Requirements for serving as pilot in command
>
> (a) The minimum requirements for serving as pilot in command at the UAP are:
>
> (1) be a public agent as defined by the UAP;
>
> (2) hold a PCA/H license;
>
> (3) have completed, as pilot in command, the initial, **recurrent,** upgrade, or transition **training** prescribed in this Regulation; **(emphasis added)**
>
> (4) hold a valid category, type, and/or class rating in accordance with RBAC No. 61;
>
> (5) hold a valid first-class Medical Certificate (CMA) in accordance with RBAC No. 67;
>
> (6) have accumulated 500 total flight hours in the category of aircraft in which the respective function will be performed, or 300 total flight hours in the case of a single-engine piston airplane operated under VFR;
>
> (7) have the minimum experience (number of flight hours) in special public aircraft operations, as established by the UAP in the MOP;
>
> (8) have completed the supervised operational experience for pilot in command in accordance with Section 90.201 of this Regulation;
>
> (9) for multiengine aircraft, have the minimum experience (number of flight hours) in each multiengine aircraft model, as established by the UAP in the MOP; and
>
> (10) comply with the requirements for serving as pilot in command established by the aircraft manufacturer, the operational evaluation report, or the OSD published by ANAC or by a civil aviation authority, if so specified.
>
> 90.25 Requirements for serving as second in command
>
> (a) The minimum requirements for serving as second in command in aircraft certified for a minimum crew of one pilot (single-pilot) are:
>
> (1) be a public agent as defined by the UAP;
>
> (2) notwithstanding the provisions of Section 61.85 of RBAC No. 61, hold a PPA/H license and have at least 10 flight hours recorded in the aircraft model in which the respective function will be performed;
>
> (3) have completed, as second in command, the **initial**, **recurrent**, or **transition training** prescribed in this Regulation; **(emphasis added)**
>
> (4) hold a valid category, type, and/or class rating for the aircraft in which the function will be performed;
>
> (5) hold a valid first-class Aeronautical Medical Certificate (CMA) in accordance with RBAC No. 67; and
>
> (6) comply with the requirements for serving as second in command established by the aircraft manufacturer, the operational evaluation report, or the OSD published by ANAC or by a civil aviation authority, as applicable.

With regard to recurrent pilot training, RBAC 90 established a program comprising two phases—a theoretical ground phase and a practical flight phase—to ensure that pilots maintained their technical proficiency, as follows:

90.179 Recurrent training: general requirements

(a) Recurrent training shall comprise the following phases:

(1) ground curriculum, in accordance with Section 90.181 of this Regulation; and

(2) flight curriculum, in accordance with Section 90.183 of this Regulation.

(b) The recurrent training ground curriculum prescribed in Section 90.181 of this Regulation shall be completed at the following intervals:

(1) 24 months for the aircraft theoretical knowledge (ground school) and SOP curriculum components prescribed in paragraphs 90.181(a)(1)(i) and (a)(4) of this Regulation, respectively; and

(2) 36 months for the remaining curriculum components prescribed in Section 90.181 of this Regulation.

(c) The recurrent training flight curriculum prescribed in Section 90.183 of this Regulation shall be completed every 12 months, calculated from the date of the last training flight.

(d) The time limits prescribed in paragraph (b) of this Section shall be calculated from the start date of the previous corresponding curriculum component.

(e) ANAC may extend the time limits prescribed in paragraphs (b) and (c) of this Section for up to eight months, provided that such extension is duly justified. Once this period has expired, the pilot shall complete the entire initial training prescribed in Section 90.171 of this Regulation.

90.181 **Recurrent training: ground curriculum (emphasis added)**

(a) The recurrent training ground curriculum shall consist of the following curriculum components:

(1) aircraft theoretical knowledge (ground school);

(2) general knowledge in accordance with Section 90.157 and paragraph 90.173(d) of this Regulation;

(3) **CRM** or SRM, in accordance with Section 90.157 and paragraph 90.173(e) of this Regulation; **(emphasis added)**

(4) the UAP SOP, in accordance with Section 90.157 and paragraph 90.173(f) of this Regulation; and

(5) the knowledge curriculum component for flight operations above FL 250 or at speeds exceeding Mach 0.75, in accordance with Section 90.157 and paragraph 90.173(g) of this Regulation, if applicable.

(b) Upon completion of the theoretical instruction included in the recurrent ground curriculum, the pilot shall complete a learning assessment within two months from the date of completion of that curriculum.

90.183 **Recurrent training: flight curriculum (emphasis added)**

(a) The recurrent training flight curriculum shall consist of flight instruction in the aircraft model, in the capacity of pilot in command or second in command, in accordance with Subpart L of this Regulation and in compliance with the UAP SOP.

(b) The recurrent training flight curriculum shall include, at a minimum, the content and training hours established in the operational evaluation report, the OSD, the aircraft manufacturer's documentation, or equivalent documents, in accordance with paragraph 90.151(d) of this Regulation.

(1) In the absence of the provisions referred to in paragraph (b), the UAP shall define the syllabus and minimum training hours for each instructional lesson/mission, considering the UAP operational environment and the level of safety risk tolerability.

(c) Depending on the responsibilities of the public body or entity, specific regulations, fleet, aircraft models, geographical area of operation, and operational and safety

> criteria, the UAP may establish supplementary flight curricula to preserve safety performance.
>
> (d) Upon completion of recurrent training, the pilot shall have attained the performance level assigned to each maneuver and to the respective function before completing the proficiency check required by ANAC.

Section 90.181 prescribed theoretical ground training that covered, among other subjects, general knowledge, Crew Resource Management (CRM), and the UAP Standard Operating Procedures (SOP). A learning assessment was also required within a maximum of two months after completion of the training.

Section 90.183, in turn, established flight training that was required to include instruction in the aircraft model, in the capacity of PIC or SIC, in compliance with the UAP SOP and ensuring the minimum proficiency required for the operation.

Regarding ground training, the SIPAER Investigation Commission identified that neither pilot participated in the most recent recurrent CRM training cycle conducted in 2023. According to the available records, the PIC had last completed this type of training in 2017, whereas the SIC had last completed it in 2021. In both cases, the training was conducted during each pilot's initial training. In this context, it was found that the UAP did not consider this type of instruction mandatory.

Therefore, according to the available records, the pilots were not qualified, although they had experience consistent with the type of flight conducted.

In addition to the pilots, the operational crew included two aerotactical operators and two healthcare professionals on board.

Regarding the recurrent training of aerotactical operators, RBAC 90 established the following:

> 90.31 Requirements for serving as an aerotactical operator
>
> (a) The minimum requirements for serving as an aerotactical operator are:
>
> (1) be a public agent as defined by the UAP;
>
> (2) have completed aerotactical operator training in accordance with Subpart N of this Regulation; and
>
> (3) hold a medical authorization certifying his or her psychophysical fitness to perform the respective function.

Accordingly, they were not required to undergo recurrent training. However, CRM was provided during initial training. Regarding the aerotactical operators involved in this accident, one of them, who had recently joined the UAP operational crew, completed that training in 2023, while the other completed it in 2021.

Likewise, RBAC 90 did not establish recurrent training requirements for healthcare professionals on board.

> 90.45 Healthcare professional on board
>
> (a) The PSE shall:
>
> (1) be a healthcare professional in accordance with the applicable legislation and/or specific regulations;
>
> (2) have received a safety briefing from the pilot in command of the aircraft or from a crewmember—or another person performing a function on board—designated by the pilot in command, covering at least the following subjects:
>
> [...]

1.5.5. Validity of medical certificate.

The pilots' Aeronautical Medical Certificates (CMA) were valid.

1.6. Aircraft information.

The aircraft, serial number 9650, was manufactured in 2013 by Airbus Helicopters Deutschland GmbH (formerly Eurocopter Deutschland GmbH) and was registered in the Public – State Direct-Administration (ADE) category.

The Airworthiness Verification Certificate (CVA) was valid.

The airframe and engine logbooks were up to date.

Aircraft maintenance was performed by an outsourced company, which followed the maintenance program established by the manufacturer. According to the available records, all scheduled maintenance was up to date.

The aircraft's most recent 100-hour inspection was performed on 15AUG2024 by *HBR Aviação S/A* maintenance organization, in *Belo Horizonte*, state of *Minas Gerais*. The aircraft had flown 60 hours and 12 minutes since that inspection.

The aircraft's most recent major inspection, a 2,400-hour inspection, was performed on 09FEB2024 by *HBR Aviação S/A* maintenance organization, in *Belo Horizonte*, state of *Minas Gerais*. The aircraft had flown 219 hours and 6 minutes since that inspection.

The PR-UEA, a BK117 C-2 aircraft, was a medium-sized, multipurpose twin-engine helicopter. This model was certified for single-pilot operations and widely used for passenger transportation, medical evacuation, search and rescue, and cargo transportation operations.

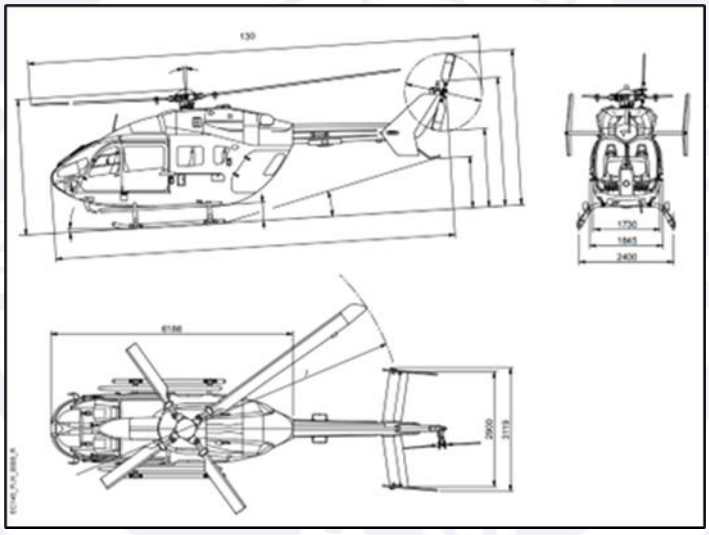


Figure 2 – Image of the aircraft.
Source: Adapted from the Rotorcraft Flight Manual (RFM).

The model was equipped with two *Turbomeca Arriel* 1E2 engines, had a maximum takeoff weight of 3,585 kg, and could fly at altitudes of up to 18,000 ft.

It had a maximum seating capacity of 11 occupants, comprising two pilots and nine other crewmembers or passengers.

The aircraft was equipped with the *EuroNav IV Moving Map* system in support of primary navigation. The system contributed to pilot situational awareness and flight management by displaying real-time, oriented digital maps on a cockpit panel. An example of its graphical display is shown in Figure 3.

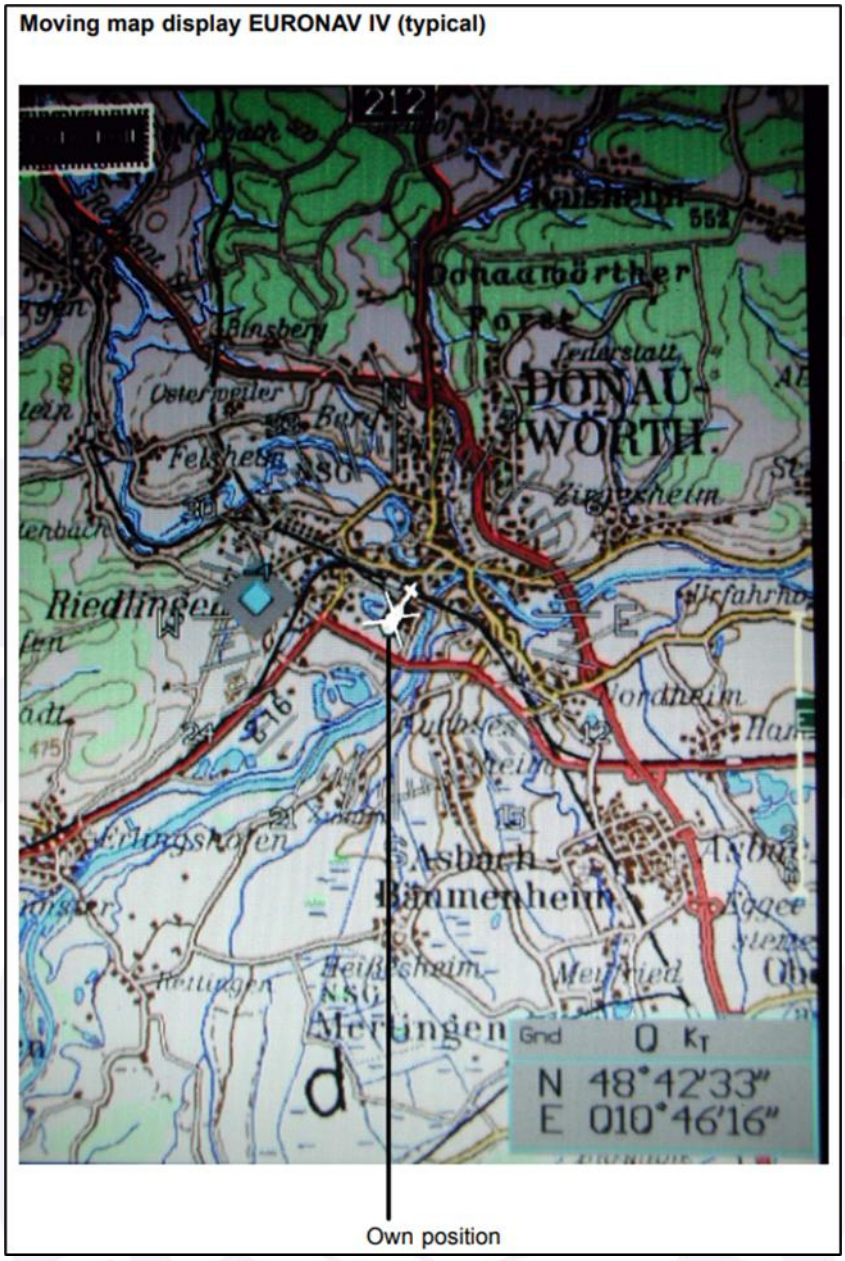


Figure 3 – Example of a EuroNav IV display.
Source: Adapted from the RFM.

However, this system was not designed for operation in instrument flight conditions and was to be used only under VFR, as established by the manufacturer in the RFM.

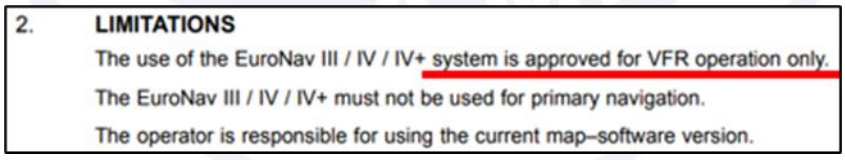


Figure 4 – EuroNav IV limitation.
Source: Adapted from the RFM.

The aircraft was equipped with an Enhanced Ground Proximity Warning System (EGPWS), integrated with data sources such as the altimeter, GPS, and a terrain database. The purpose of this system was to enhance pilot situational awareness by providing visual information on terrain proximity through a color scale displayed on the navigation panel, as illustrated in Figure 5.

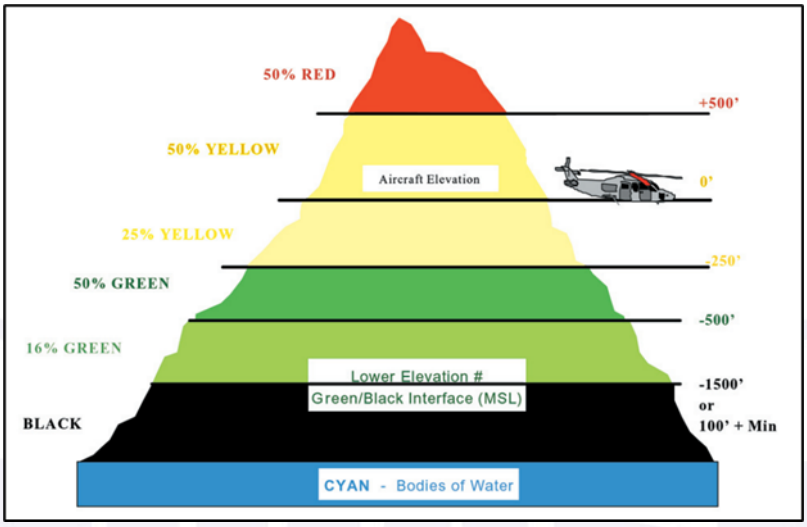


Figure 5 – EGPWS color scale.
Source: EGPWS Pilot's Guide.

Figure 6 shows the system display as presented in the aircraft RFM, with the typical display configuration used to indicate terrain proximity in relation to the aircraft flight path.



Figure 6 – Example of the EGPWS display.
Source: RFM.

1.7. Meteorological information.

The Meteorological Aerodrome Reports (METAR) for SBBH provided the following information:

METAR SBBH 111800Z 10010KT 9999 SCT035 28/20 Q1014

METAR SBBH 111900Z 12012KT 9999 SCT035 29/20 Q1013

METAR SBBH 112000Z 11012KT 9999 FEW048 SCT060 27/18 Q1014

Thus, it was determined that the destination aerodrome was operating under visual meteorological conditions from the time aircraft PR-UEA took off until the time of the accident.

However, to analyze the meteorological conditions at the accident site, specialists from the Integrated Center for Aeronautical Meteorology (CIMAER) conducted a specific study of the conditions prevailing in the region where the occurrence took place.

According to these specialists, the Significant Weather Chart (SIGWX), which covered forecasts from the surface to FL250 and was valid for 18:00 UTC on 11OCT2024, with a validity period from 15:00 UTC to 21:00 UTC, forecast the following meteorological conditions for the region under analysis:

- low-level Stratus (ST) clouds, with bases at 800 ft and tops at 1,500 ft, covering five to seven oktas (BKN) of the sky;
- low-level Cumulus (CU) and Stratocumulus (SC) clouds, with bases at 1,500 ft and tops at 6,000 ft, covering five to seven oktas (BKN) of the sky;
- Towering Cumulus (TCU) clouds, with bases at 2,500 ft and tops at 21,000 ft, covering one to two oktas (FEW) of the sky;
- Cumulonimbus (CB) clouds, with bases at 2,500 ft and tops above 25,000 ft, covering one to two oktas (FEW) of the sky;
- mid-level Altocumulus (AC) and Altostratus (AS) clouds, with bases at 7,000 ft and tops at 18,000 ft, covering five to seven oktas (BKN) of the sky;
- a frontal system over the continent, moving northeastward at a forecast speed of 20 kt;
- areas of mist;
- extensive areas of precipitation; and
- rain showers.

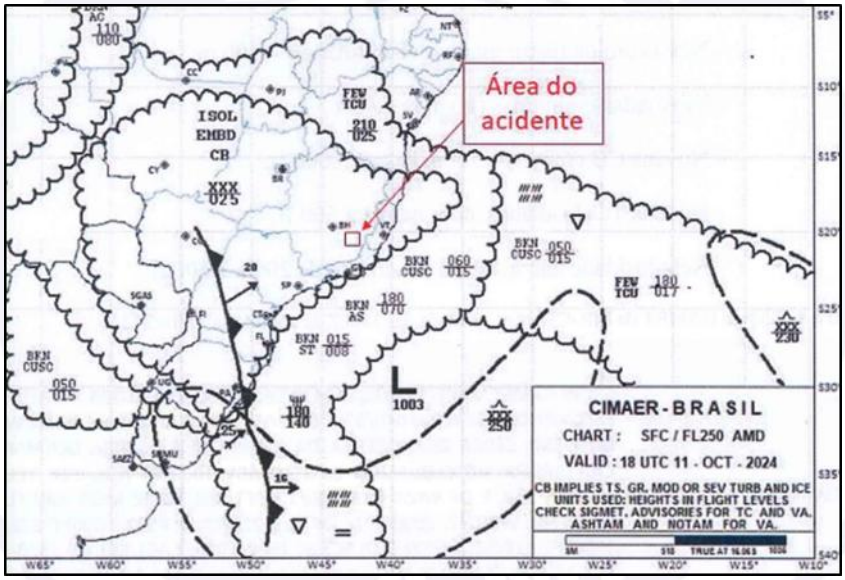


Figure 7 – SIGWX chart for 18:00 UTC on 11 OCT 2024.
Source: adapted from the Air Force Command Meteorology Network (REDEMET).

In this context, it is important to highlight the presence of areas of instability over the region of the accident, with forecast formation of CB clouds, rain showers, and visibility-restricting phenomena, such as mist.

In turn, the General Aviation Meteorological Information (GAMET) provided a regional forecast for lower flight levels, covering, within a Flight Information Region (FIR), the airspace between the surface and FL100 (or FL150 in mountainous regions). The GAMET message for the *Curitiba* Flight Information Region (FIR-CW), valid from 18:00 UTC to 00:00 UTC on 11OCT2024, forecast conditions for the region under analysis similar to those depicted on the SIGWX chart:

- moderate rain reducing visibility to 2,000 m;

- mist reducing visibility to 1,500 m;
- embedded thunderstorms (EMB TS);
- embedded CB clouds with bases at 3,000 ft;
- isolated TCU clouds with bases at 2,500 ft; and
- low-level clouds forming a ceiling ranging from 200 to 1,200 ft.

SBCW GAMET 11/10/2024 SBCW GAMET VALID 111800/112400 SBGL- SBCW CURITIBA FIR BLW FL100 SECN I SFC WIND: E OF W050 040/32KT SFC VIS: 1500M BR 2000M RA SIGWX: EMBD TS MT OBSC: SERRA GERAL SERRA DA MANTIQUEIRA SERRA DO MAR SERRA DA CANTAREIRA SIG CLD: EMBD CB 3000/ABV 10000FT AGL ISOL TCU 2500/ABV 10000FT AGL E OF W050 BKN 200/1200FT AGL TURB: MOD ABV FL080 SECN II PSYS: NIL WIND/T: 2000FT N OF S25 310/30KT PS22 5000FT 310/35KT PS19 10000FT 310/55KT PS09 CLD: SCT SC 1600/5000FT AGL SCT CU 1900/6000FT AGL SCT AC 8000/10000FT AGL FZLVL: ABV 10000FT AGL MNM QNH: 1005HPA SEA: T21 HGT 4M VA: NIL=

Figure 8 – GAMET for FIR-CW, valid from 18:00 UTC to 00:00 UTC on 11 OCT 2024.
Source: adapted from REDEMET.

Likewise, the GOES-16 infrared satellite image taken at 20:40 UTC on 11OCT2024 showed the formation of multilayer clouds west of the accident site, with considerable vertical development. This condition indicated the presence of adverse weather in the region, with the possibility of thunderstorms, icing, hail, strong winds, moderate to heavy rain, and moderate to severe turbulence.

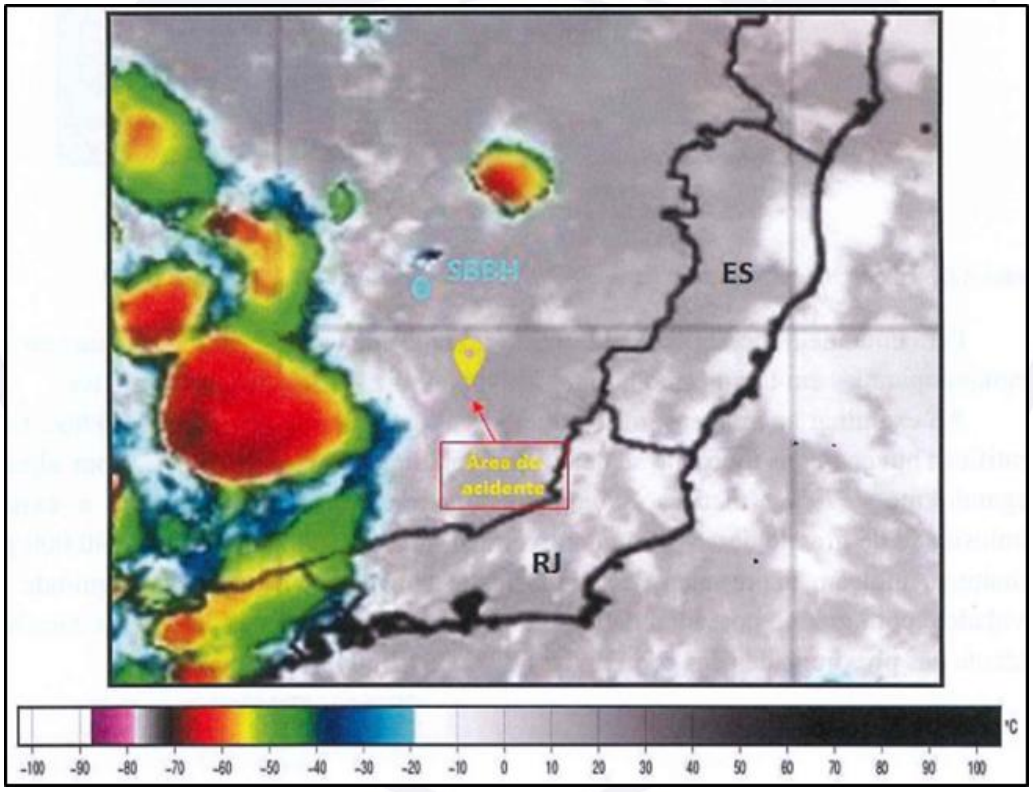


Figure 9 – GOES-16 satellite image taken at 20:40 UTC on 11 OCT 2024.
Source: adapted from the Center for Weather Forecasting and Climate Studies.

1.8. Aids to navigation.

NIL.

1.9. Communications.

NIL.

1.10. Aerodrome information.

The occurrence took place outside an aerodrome.

1.11. Flight recorders.

Neither required nor installed.

1.12. Wreckage and impact information.

Serra do Amolar is a geological formation near downtown *Ouro Preto*, *Minas Gerais*, resembling a rock wall and extending for several kilometers, with its summit exceeding an elevation of 5,080 ft.

The aircraft impacted a point near the summit of the mountain range, at an approximate elevation of 5,023 ft. The wreckage was concentrated around the main impact area. However, due to the steep slope of the terrain, heavier aircraft components, such as the engines, moved downslope and were found at lower positions along the hillside, as shown in Figure 10.



Figure 10 – Wreckage concentrated near the summit of the mountain range.

Due to the extensive destruction of the components, it was not possible to determine the positions of the switches associated with the EGPWS.

1.13. Medical and pathological information.

1.13.1. Medical aspects.

Specialists from the Institute of Aerospace Medicine (IMAE) of the Brazilian Air Force Command (COMAER) analyzed the accident and provided the findings contained in this section.

Reports gathered during the investigation indicated that, in the days preceding the occurrence, the PIC displayed signs consistent with a possible state of exhaustion. Frequent complaints of headaches and memory lapses were mentioned, as were the crewmember's own reports of feeling overwhelmed due to the accumulation of work-related duties.

Similarly, information obtained from persons close to the SIC indicated signs of physical and mental fatigue, and the crewmember was reported to have experienced difficulty balancing operational demands with additional administrative duties.

Task overload may directly impair a crewmember's piloting ability by affecting essential cognitive functions, such as attention, decision-making, working memory, and the ability to respond to unforeseen situations. When required to perform multiple duties simultaneously, particularly outside the operational environment, a pilot may experience reduced situational awareness and psychomotor performance, both of which are critical to the safe operation of an aircraft. In addition, continuous exposure to occupational stress and fatigue may lead to lapses, operational errors, and poor judgment, thereby increasing the risk of occurrences.

Regarding the accident under analysis, meteorological conditions conducive to visual illusions were identified, that is, false sensory impressions or misinterpretations of the external environment capable of directly affecting the pilots' perception.

Along the entire extent of *Serra do Amolar*, the aircraft's flight path was directed toward a point located above an indentation in the rock face. Amid dense and massive meteorological formations, this terrain feature could have been perceived as a possible opening in the sky, leading the crew to misinterpret the space ahead as an area clear of obstacles, as illustrated in Figure 11.



Figure 11 – Indentation in the rock face.

1.13.2. Ergonomic information.

NIL.

1.13.3. Psychological aspects.

The operational crew consisted of two pilots, two aerotactical operators, and two healthcare professionals. The pilots and aerotactical operators were assigned to the UAP, while the healthcare professionals were members of the Mobile Emergency Care Service (SAMU) and were regularly rostered to remain on standby at the UAP to perform aeromedical missions.

The PIC was described by coworkers as a focused, experienced, discreet professional who was committed to his duties. He demonstrated a solution-oriented and even-tempered demeanor, maintained good working relationships, and was recognized for his collaborative attitude and prioritization of operational safety.

Reports indicated that he generally carried out his assignments without reluctance, striving to maintain a high standard of performance across all areas of responsibility, and was regarded as a role model by several younger pilots.

A few months before the accident, the PIC was appointed head of the UAP maintenance department, assuming responsibility for managing the aircraft fleet, including those stationed at detached bases in other cities. At the same time, he was involved in organizing a large-scale institutional event that required a high level of dedication and commitment. Consequently, he began performing multiple roles in addition to his regularly scheduled flight duties.

In this context, persons close to the PIC reported signs indicative of physical and mental exhaustion, mentioning episodes of fatigue and concerns arising from the accumulation of responsibilities. It was also noted that he frequently performed work-related activities even during periods intended for rest.

With regard to his personal circumstances, the PIC was facing personal and financial problems that had been causing significant emotional strain, requiring his constant attention and making it difficult to balance his personal life and work obligations.

On the day of the accident, according to the information obtained, the PIC told some coworkers that he was not feeling well; however, he did not formally report his condition and continued performing his operational duties.

In turn, the SIC was described as a methodical, introspective, and reserved professional, recognized for his technical competence. Information gathered during the investigation indicated that, at an earlier time, he had been temporarily removed from duty due to stress associated with the accumulation of responsibilities. At that time, he was performing several duties simultaneously, including coordinating a large-scale project in an area in which he had no prior experience.

During that period, he sought psychological support on his own initiative and returned to operational duties following his leave, with no subsequent reports of similar issues.

Of the two aerotactical operators, one was described as an experienced professional with a firm demeanor who was critical of conducting missions under adverse conditions and did not ordinarily agree to operations that, in his assessment, posed a high risk. The second aerotactical operator had recently been transferred to the BOA and was participating in his first mission with the team, having requested to be included in the duty roster as a means of adapting to the new unit.

With regard to the healthcare professionals on board, the information obtained indicated that both adopted a passive stance toward the crew’s operational decisions, raising no questions or offering any assessment regarding the criteria for leaving the aircraft overnight at the highway interchange or for conducting the takeoff procedure.

In the context of the flight, the PIC expressed concern to some persons about the adverse meteorological conditions and even requested a vehicle to enable the entire operational crew to return to UAP headquarters. However, he expressed considerable discomfort at the prospect of leaving some personnel to guard the aircraft overnight at the highway interchange.

1.14. Fire.

The aircraft’s impact with the mountainous terrain caused the fuel tanks to rupture, resulting in the immediate spillage of fuel. The probable ignition source was the friction generated when the aircraft collided with the rock, which, combined with the high kinetic energy and the presence of heated surfaces, resulted in the outbreak of a fire.

The flames consumed a large portion of the aircraft structure, compromising the integrity of several components and hindering their visual identification during the field investigation.

1.15. Survival aspects.

NIL.

1.16. Examinations, tests and research.

One of the operational crewmembers recorded the flight of aircraft PR-UEA, from takeoff until impact, on a mobile phone. The material was forwarded to CENIPA's Flight Recorder Data Analysis Laboratory (LABDATA), which performed noise filtering and spectral analysis of the audio to identify any voice signals or aural alerts, such as those generated by the EGPWS. Among other procedures, the analysis included the application of filters at the rotor fundamental frequencies and the examination of the resulting spectrum.

As a result, no signals indicative of voice or other alerts were identified in the audio analyzed. It was noted, however, that the high intensity of noise from the engines and other aircraft components may have masked possible conversations or warning sounds; therefore, it was not possible to confirm that such manifestations did not occur during the flight.

1.17. Organizational and management information.

The UAP was subordinate to the Specialized Command of the *Minas Gerais* Military Fire Department, which was part of the Department's General Command structure. At the time of the occurrence, the UAP had its headquarters in *Belo Horizonte*, state of *Minas Gerais*, as well as three deployed bases located in the municipalities of *Montes Claros*, *Varginha*, and *Uberaba*. The operational structure was also expected to be expanded through the establishment of new bases in *Governador Valadares* and *Juiz de Fora*, state of *Minas Gerais*.

The UAP operated a fleet comprising the following fixed-wing aircraft: two Cessna Grand Caravans (C-208) and one Air Tractor (AT-502), as well as the following rotary-wing aircraft: three *Esquilo* helicopters (AS 350: two B2 and one B3), one BK117 C-2 (the aircraft involved in the occurrence), and one *Koala* (AW-119). There were also plans to incorporate two BK117 D-3 aircraft and two additional AW-119 units.

The missions encompassed a variety of activities in support of the population, including search and rescue operations and the aeromedical transportation of patients. In most cases, the flights were conducted to assist persons in emergency situations.

Mission activations were initiated through the coordination center, which screened the requests and dispatched the appropriate resources. Upon receiving a request, the operational crew assembled to assess the mission, with the final decision being made by the PIC in coordination with the medical team, according to the complexity and risks associated with the occurrence.

According to the operational history provided, rotary-wing aircraft flights were conducted predominantly during daylight hours, with operations normally ending by sunset. According to the accounts obtained, this practice represented a strategy adopted by the organization to mitigate the risks associated with nighttime operations, also considering the hazards inherent in the activities performed by the UAP. It should also be noted that the internal regulations in effect at the time stipulated that rotary-wing aircraft flights be conducted exclusively under visual conditions.

The duty roster structure was managed by a UAP officer who also served as deputy commander. The officer responsible for preparing the roster integrated personnel from the decentralized bases, including military personnel who, although assigned to other units,

provided operational support to the UAP after communicating their availability in advance. The composition of the duty roster was influenced by hierarchical considerations, which posed challenges to balancing operational demands and ensuring an equitable distribution of personnel among the missions.

According to the data collected, UAP crewmembers commonly perceived themselves as being overworked. There were reports that some personnel continued to perform administrative duties, often in person, even during designated rest periods, thereby reducing the time effectively available for physical and mental recovery.

The Investigation Commission found that the perceived workload was largely associated with personnel shortages in the face of the expansion of the organizational structure and the increase in the UAP's responsibilities.

In 2022, following the accident involving aircraft PT-SUS, UAP personnel were assessed by psychology professionals. The assessment included observation of the operational routine and a survey of aspects related to mental health, workload, occupational stress, and organizational needs. As a result, several measures were implemented, including the establishment of a compensatory time-tracking system. However, information collected by the Investigation Commission indicated that these measures were not fully effective because of the constant operational demands and personnel shortages.

With regard to aviation safety management, it was found that prevention reports were submitted voluntarily; however, until 2023, there was neither institutional encouragement for their submission nor systematic processing of the information they contained. Additionally, less serious occurrences involving UAP aircraft that did not meet the criteria established by CENIPA for the initiation of a formal investigation process by the SIPAER investigation authority were not investigated internally, resulting in the absence of structured processes for investigating such occurrences and identifying contributing factors.

From a cultural standpoint, the data indicated that the challenges encountered within the UAP's organizational environment were largely internalized by its own personnel. Work overload, constant fatigue, and operational difficulties were perceived as inherent aspects of serving in a unit belonging to the Military Fire Department.

According to the data obtained, many personnel reported viewing such conditions as part of the expected routine and developing a high tolerance for physical and emotional strain.

1.18. Operational information.

The operation being conducted complied with the requirements established in RBAC 90.

According to the available data, the aircraft was operating within the weight and balance limits established by the manufacturer, and its maintenance was up to date in accordance with the criteria prescribed in the technical manuals applicable to the model.

The crew had previously been assigned to remain on standby at UAP headquarters to respond to unscheduled mission requests. At the beginning of the duty period, a joint briefing was conducted, followed by the completion of the prescribed aircraft inspection procedures.

After this stage, the operational crewmembers remained on standby, during which the pilots and aerotactical operators performed administrative duties until they were called upon to conduct the flight in question.

At approximately 18:00 UTC, the operational crew was dispatched on a search and rescue mission to locate a missing aircraft in the region of *Ouro Preto*, state of *Minas Gerais*.

At 18:23 UTC, aircraft PR-UEA took off from SBBH under visual flight conditions. According to the flight plan filed with the air traffic control units, the flight was to be conducted

under VFR, including an overflight of the search area followed by a return to the departure aerodrome.

After takeoff, the aircraft proceeded to the designated region, where it encountered adverse weather conditions. Nevertheless, the aircraft being searched for was located at a site where PR-UEA could not land. To enable the medical team to reach the site, PR-UEA landed at a highway interchange, from where the physician and nurse proceeded in a Military Fire Department vehicle. At the site, the pilot of the accident aircraft was confirmed deceased, eliminating the need for aeromedical evacuation and allowing PR-UEA to return to UAP headquarters.

As the highway interchange was not a heliport registered with ANAC, the requirements established in RBAC 90 for UAP operations of this nature were applicable:

> 90.301 General requirements for landing or takeoff at a location not registered with ANAC
>
> […]
>
> (c) The initial requirement for conducting a landing or takeoff at a location not registered with ANAC is that the risks inherent in the operation, including the protection of the aircraft, crew, other persons performing duties on board, passengers, and third parties, be controlled within the NADSO.
>
> (d) Notwithstanding the provisions of this section, the pilot-in-command of the aircraft may refuse to conduct any air operation at a location not registered with ANAC in the interest of flight safety.
>
> (e) The UAP shall establish in the MOP and SOPs an express provision concerning landing and/or takeoff operations at locations not registered with ANAC.
>
> (f) The requirements for takeoff or landing at locations not registered with ANAC are as follows:
>
> (1) **the operation shall be conducted under VMC (emphasis added);**
>
> […]
>
> (4) the **selected** approach and **climb routes shall minimize the aircraft's exposure to adverse weather phenomena (emphasis added)**;
>
> […]
>
> (7) the **crew** and other persons performing duties on board **shall be properly trained for this type of operation**, including syllabus components intended to prevent collisions with wires and obstacles near the ground **(emphasis added)**;
>
> […]
>
> (i) **Landing or takeoff at locations not registered with ANAC under IMC** or IFR **is prohibited (emphasis added)**.

With regard to the rules established by DECEA, Aeronautics Command Instruction (ICA) 100-4/2021, which addressed "Special Air Traffic Rules and Procedures for Helicopters," established the following:

> 3. VISUAL FLIGHT RULES
>
> 3.1 GENERAL CRITERIA
>
> […]
>
> 3.1.3 Outside controlled airspace, below an altitude of 3,000 ft or a height of 1,000 ft above the terrain, whichever is higher, a helicopter VFR flight shall be conducted only when the following conditions can be met simultaneously and continuously:
>
> a) maintain flight **visibility equal to or greater than 1,000 m**, provided that **the flight speed is sufficient to allow** traffic or **any obstacle to be** seen and **avoided** in sufficient time to prevent a collision; and **(emphasis added)**
>
> b) **remain clear of clouds and maintain visual reference with the ground** or water **(emphasis added)**.

In turn, the UAP General Operations Manual (MGO), October 2009 edition, established on page 50 the operational requirements applicable to flights conducted under VFR during daylight hours. According to the document, the PIC was responsible for determining the minimum altitude and the speed to be adopted, considering the prevailing weather and operational conditions, as well as mission safety.

> VFR FLIGHT:
>
> During daylight hours:
>
> The flight shall be operated under visual conditions, **with the pilot-in-command being responsible for determining the minimum altitude** and the speed to be flown, considering, among other aspects: **(emphasis added)**
>
> ➢ **Weather conditions (current conditions and forecast development)**; **(emphasis added)**
>
> ➢ Fuel quantity required for diversions and return, if applicable;
>
> ➢ Map of the hazards identified in the area to be overflown;
>
> ➢ Possible occasional landing sites, if necessary.

Regarding the additional restrictions internally established by the operator, the Safety Management Manual (MGSO), May 2012 edition, stipulated, at the time of the occurrence, that rotary-wing aircraft were restricted to Visual Flight Rules (VFR) operations, both daytime and nighttime, as transcribed below:

> 2.2 OPERATIONAL RESTRICTIONS
>
> Daytime and nighttime Visual Flight Rules (VFR) operations for rotary-wing aircraft, and Instrument Flight Rules (IFR) operations and daytime and nighttime VFR operations for fixed-wing aircraft.

Thus, IFR flights were not included in the operational authorizations for the aircraft model involved, constituting an additional operational limitation imposed by the operator itself, although not required by the regulations in effect.

Sunset at SBBH on the day of the accident occurred at 20:56 UTC, as shown in Figure 12.

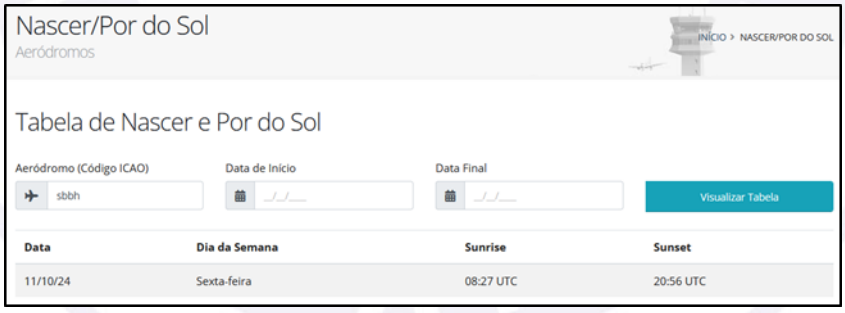


Figure 12 – Sunset time at SBBH.
Source: AISWEB.

Observers recorded aircraft PR-UEA on the ground at the highway interchange under weather conditions incompatible with VFR flight, with severely reduced horizontal and vertical visibility.

According to information obtained by the SIPAER Investigation Commission, the PIC contacted UAP personnel by telephone and initially reported that horizontal visibility was restricted to approximately 100 m, although the sky above remained visible. Shortly thereafter, he reported a further reduction in horizontal visibility, estimating it at 50 m, but stated, in his own words, that he could still see a large portion of the sky.

Considering the deteriorating weather conditions, the PIC requested support from a UAP vehicle to transport part of the operational crew back to headquarters at SBBH. However, it was established practice within the UAP that, whenever the aircraft remained overnight at locations other than aerodromes equipped with appropriate infrastructure, part of the operational crew would be assigned to remain and guard it. Nevertheless, by the time the vehicle arrived at the highway interchange, the aircraft had already taken off.

The flight was partially documented in two videos. The first, recorded by an external observer, showed the aircraft taking off from the highway interchange. The second and more complete video, recorded by an operational crewmember seated in the right-hand seat in the rear section of the aircraft, captured the entire flight from takeoff until impact.

The images in Figure 13 show the recordings synchronized over the first three seconds of the flight, with the external observer's recording on the left and the operational crewmember's recording on the right.



Figure 13 – Aircraft three seconds into the flight: the external observer's recording on the left and the operational crewmember's recording on the right.

Figure 14 shows the aircraft 17 seconds after takeoff, in stabilized flight and still maintaining visual contact with the ground.



Figure 14 – Aircraft 17 seconds into the flight.

Figure 15 shows the aircraft 27 seconds into the flight, beginning to enter an area of progressively reduced visibility.



Figure 15 – Aircraft 27 seconds into the flight.

The recording made by the external observer ended at this point. However, the video recorded by the operational crewmember continued, showing that, approximately 30 seconds into the flight, the crew lost visual contact with the ground and entered Instrument Meteorological Conditions (IMC), as shown in Figure 16.



Figure 16 – Recording 30 seconds into the flight, showing the loss of visual contact with the ground.

Finally, Figure 17 shows the aircraft 55 seconds into the flight, when the rock face abruptly came into view approximately one second before impact, which occurred 56 seconds into the flight at an altitude of approximately 5,023 ft.



Figure 17 – Recording 55 seconds into the flight, showing the rock face abruptly coming into view.

To assess the crewmembers' visual perception of a possible improvement in the weather conditions, the composite image shown in Figure 18 was prepared. On the left is a frame from a recording made by an external observer shortly after PR-UEA landed, showing the vegetation beside the highway interchange. On the right, the image shows the same location as recorded by the operational crewmember aboard the aircraft during the first few seconds after takeoff. A comparison of the two images indicates that horizontal visibility had improved between the two observed moments.



Figure 18 – Improvement in horizontal visibility: visibility shortly after landing on the left and at takeoff on the right.

Despite the foregoing, the SIPAER Investigation Commission estimated that horizontal visibility at the time of takeoff was approximately 180 m, which was insufficient for operating the aircraft under VFR, as illustrated in Figure 19.



Figure 19 – Estimated visibility.
Source: Adapted from Google Earth.

With regard to the operation of the aircraft, it should be noted that this model was equipped with an EGPWS, which displayed in yellow areas where the terrain was between 250 ft below and 500 ft above the aircraft, and in red terrain more than 500 ft above the aircraft.

As the aircraft was at an altitude of 4,220 ft at the highway interchange, it was possible to infer that, during takeoff, the EGPWS displayed the area near the aircraft in yellow, while *Serra do Amolar* was displayed in red.

Figure 20 illustrates how the EGPWS would have displayed the terrain elevations 34 seconds into the flight, when the aircraft climbed above approximately 4,523 ft and was less than 500 ft below most of the mountain range ahead, including the impact point, located at approximately 5,023 ft.



Figure 20 – On the left, how the EGPWS would have displayed the terrain elevations up to approximately 34 seconds into the flight; on the right, how the same area was subsequently displayed.

Despite this change in color, *Serra do Amolar* remained an obstacle along the aircraft's flight path, as shown in the diagram in Figure 21.

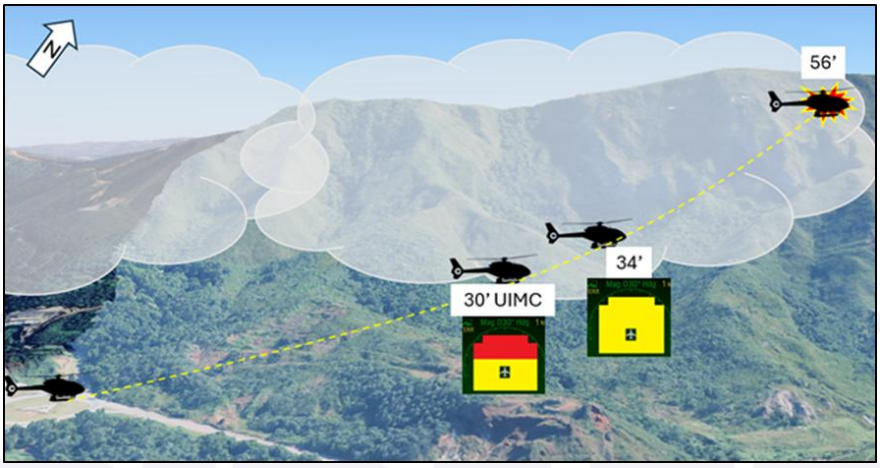


Figure 21 – Diagram of the EGPWS color change.
Source: Adapted from Google Earth.

However, it was not possible to confirm whether the crew effectively used the EGPWS during the flight, since this aircraft model was not equipped with a data recording system capable of providing such information. It should be noted that recurrent training did not include any familiarization with or operation of the EGPWS.

With regard to training, it was found that only the pilots had a formally established Operational Training Program (PTO). For the aircraft model involved, the PTO provided for recurrent training comprising an 11-hour ground training syllabus, followed by a 1-hour-and-40-minute flight, in addition to 1 hour allocated for a theoretical examination, as shown in Figure 22.

2. TREINAMENTO PERIÓDICO

O treinamento periódico é voltado para a função de Comandante ou Segundo em Comando que **já possuem qualificação no equipamento**. Seu objetivo é atualizar os conhecimentos e as informações adquiridas durante o treinamento inicial dos pilotos em deste órgão.

CURRÍCULO	CARGA HORÁRIA
CURRICULO DE SOLO (*GROUND SCHOOL*)	11h00
CURRICULO DE VOO	01h40
EXAME PRÁTICO PARA REVALIDAÇÃO	01h00

Figure 22 – Recurrent training.
Source: Adapted from the operator's PTO.

Thus, the PTO was intended to comply with the requirements established in RBAC 90 concerning the recurrent procedures prescribed by ANAC.

However, the Investigation Commission found that, in practice, recurrent training was not conducted in the prescribed format and was replaced by instruction primarily focused on specific operational phases of firefighting activities, as established in the On-the-Job Technical Training (TTS) program.

Interviews with different UAP crewmembers revealed that the training focused on stages considered more complex and characteristic of their duties, such as rescue operations, firefighting, external-load hoisting, and search missions, which were perceived as more technically demanding.

Conversely, conventional phases of flight, such as landings and takeoffs, were frequently underestimated because they were regarded as routine and less complex. This perception contrasted with the UAP's occurrence history, which indicated that most events did not take place during specialized operations, but rather during basic phases of flight, as shown in Table 1.

Year	Registration	Model	Flight phase	Occurrence summary
2012	PR-COB	C210L	Landing	Runway excursion
2016	PR-COB	C210L	Landing	Gear-up landing
2017	PR-UEA	BK117C2	Takeoff	Engine failure
2017	PR-COB	C210L	Landing	Tire deflation during landing
2018	PR-COB	C210L	Landing	Tire deflation during landing
2019	PP-SAV	AS350B3	Cruise	Communication equipment failure
2019	PR-BOA	AS350B2	Maneuver	Tail rotor contact with water
2021	PT-SUS	AS350B3	Landing	Brownout during landing
2022	PR-FNO	AT502	Landing	Runway excursion
2023	PR-UEA	BK117C2	Takeoff	Fairing opened and impacted rotor
2024	PR-UEA	BK117C2	Takeoff	Controlled flight into terrain
2025	PP-SAV	AS350B3	Landing	Engine governor failure
2025	PS-SES	C208	Landing	Tire burst
2025	PS-USA	AW119	Maneuver	External load moving beyond the expected limits

Table 1 – History of aeronautical occurrences involving the UAP.

1.19. Additional information.

The Helicopter Flying Handbook (FAA-H-803-21B), published by the Federal Aviation Administration (FAA), presented the following information on Controlled Flight into Terrain (CFIT) in Chapter 13—Effective Aeronautical Decision Making:

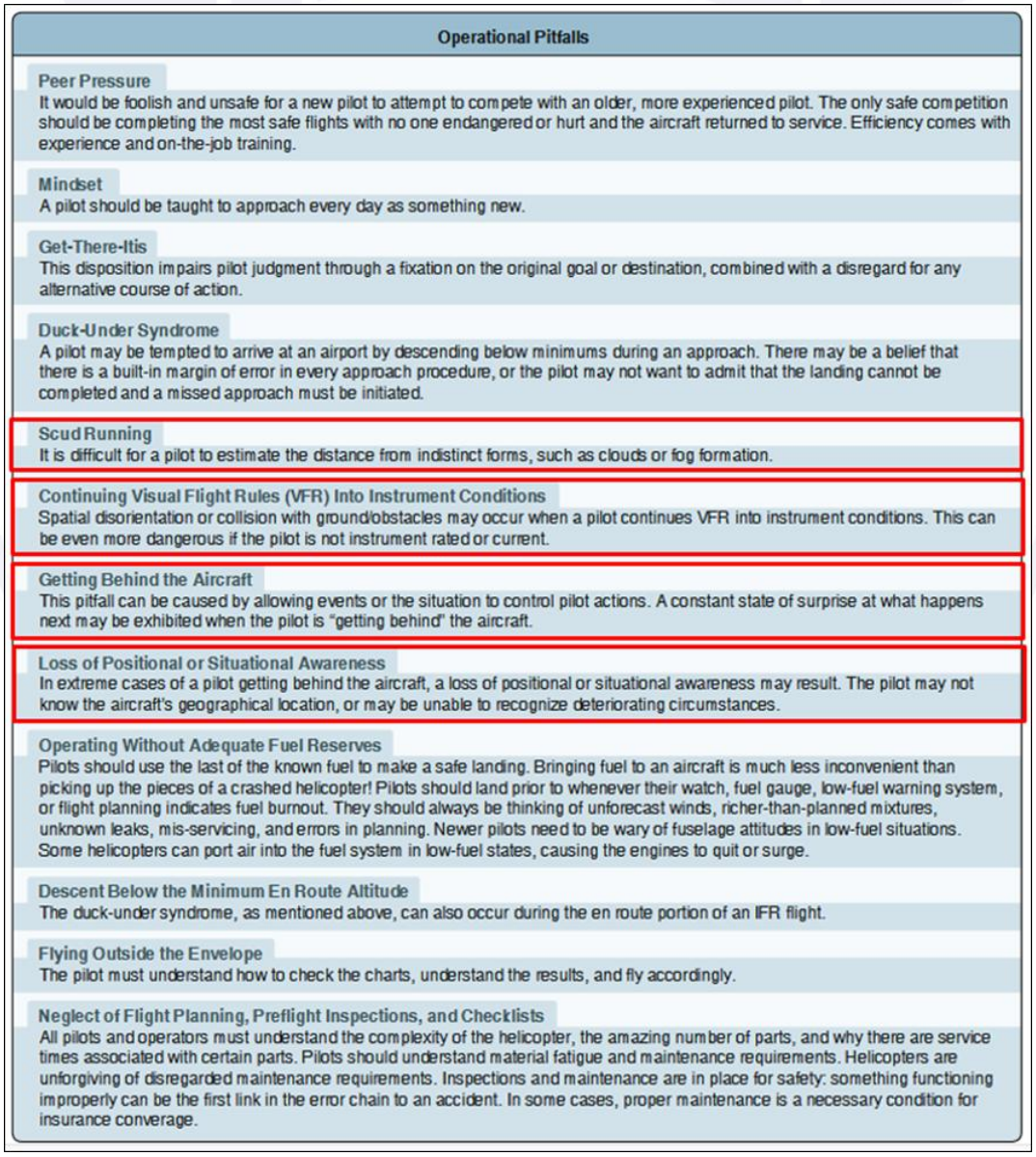
> *Controlled Flight Into Terrain (CFIT) Awareness*
>
> *CFIT is a type of accident that continues to be a major safety concern, while at the same time difficult to explain because it involves a pilot controlling an airworthy aircraft that is flown into terrain (water or obstacles) with inadequate pilot awareness of the impending disaster.*
>
> *One constant in CFIT accidents is that outside visibility is limited, or the accident occurs at night and the terrain is not seen easily until just prior to impact. Another commonality among CFIT accidents is lack of SA. This includes not only horizontal awareness, and knowing where the helicopter is over the ground, but also vertical awareness.*
>
> *Training, planning, and preparation are a pilot's best defenses for avoiding CFIT accidents. For example, take some time before takeoff to become familiar with the proposed flight and the terrain. Avoidance of CFIT begins before the helicopter departs the home location. Proper planning, including Applied risk mitigation must occur before the aircraft is even started. Thorough assessment of terrain, visibility, pilot experience and available contingencies must be conducted. If necessary, delay or postpone the flight while on the ground. The decision to abort the flight is much easier to make in the planning room than in the air. In case conditions deteriorate once in flight. Have contingency options available.*
>
> *[...]*
>
> *Limited outside visibility is one constant in CFIT accidents. In the accident cited at the beginning of this section, it appears the pilot failed to obtain a weather briefing. If the pilot had obtained one, he would probably have learned of the cloud cover and light precipitation present along his planned route of flight. The limited outside visibility probably caused the CFIT accident, since no evidence was found of any pre-impact mechanical discrepancies with the helicopter's airframe or systems that would have prevented normal operation.*

CFIT was described as an accident in which the pilot flew an airworthy aircraft into terrain, water, or obstacles without being aware of the impending danger. Recurring characteristics included limited external visibility or nighttime conditions, with the terrain being perceived only moments before impact, as well as a loss of both horizontal and vertical situational awareness.

The document identified training, planning, and preparation as the primary defenses against this type of accident. These measures should be undertaken while still on the ground and should include a careful assessment of the terrain, visibility, pilot experience, and available alternatives, including postponing or canceling the flight when necessary and maintaining contingency options.

Finally, the document emphasized that limited external visibility was a recurring feature of such accidents and identified the lack of weather information as the probable origin of an event previously cited in the document.

The document went on to describe what it referred to as Operational Pitfalls, as shown in Figure 23.



Operational Pitfalls

Peer Pressure
It would be foolish and unsafe for a new pilot to attempt to compete with an older, more experienced pilot. The only safe competition should be completing the most safe flights with no one endangered or hurt and the aircraft returned to service. Efficiency comes with experience and on-the-job training.

Mindset
A pilot should be taught to approach every day as something new.

Get-There-Itis
This disposition impairs pilot judgment through a fixation on the original goal or destination, combined with a disregard for any alternative course of action.

Duck-Under Syndrome
A pilot may be tempted to arrive at an airport by descending below minimums during an approach. There may be a belief that there is a built-in margin of error in every approach procedure, or the pilot may not want to admit that the landing cannot be completed and a missed approach must be initiated.

Scud Running
It is difficult for a pilot to estimate the distance from indistinct forms, such as clouds or fog formation.

Continuing Visual Flight Rules (VFR) Into Instrument Conditions
Spatial disorientation or collision with ground/obstacles may occur when a pilot continues VFR into instrument conditions. This can be even more dangerous if the pilot is not instrument rated or current.

Getting Behind the Aircraft
This pitfall can be caused by allowing events or the situation to control pilot actions. A constant state of surprise at what happens next may be exhibited when the pilot is "getting behind" the aircraft.

Loss of Positional or Situational Awareness
In extreme cases of a pilot getting behind the aircraft, a loss of positional or situational awareness may result. The pilot may not know the aircraft's geographical location, or may be unable to recognize deteriorating circumstances.

Operating Without Adequate Fuel Reserves
Pilots should use the last of the known fuel to make a safe landing. Bringing fuel to an aircraft is much less inconvenient than picking up the pieces of a crashed helicopter! Pilots should land prior to whenever their watch, fuel gauge, low-fuel warning system, or flight planning indicates fuel burnout. They should always be thinking of unforecast winds, richer-than-planned mixtures, unknown leaks, mis-servicing, and errors in planning. Newer pilots need to be wary of fuselage attitudes in low-fuel situations. Some helicopters can port air into the fuel system in low-fuel states, causing the engines to quit or surge.

Descent Below the Minimum En Route Altitude
The duck-under syndrome, as mentioned above, can also occur during the en route portion of an IFR flight.

Flying Outside the Envelope
The pilot must understand how to check the charts, understand the results, and fly accordingly.

Neglect of Flight Planning, Preflight Inspections, and Checklists
All pilots and operators must understand the complexity of the helicopter, the amazing number of parts, and why there are service times associated with certain parts. Pilots should understand material fatigue and maintenance requirements. Helicopters are unforgiving of disregarded maintenance requirements. Inspections and maintenance are in place for safety: something functioning improperly can be the first link in the error chain to an accident. In some cases, proper maintenance is a necessary condition for insurance coverage.

Figure 23 – Operational Pitfalls.
Source: Adapted from the FAA Helicopter Flying Handbook.

The document listed four noteworthy situations among the *Operational Pitfalls*. The first, referred to as Scud Running, concerned the pilot's difficulty in estimating distances based on indistinct forms, such as clouds or fog formations.

The second, *Continuing Visual Flight Rules (VFR) into Instrument Conditions*, addressed the continuation of visual flight into instrument conditions, which could result in spatial disorientation or collision with the ground or obstacles. The risk was even greater when the pilot was not instrument-rated or was not current for instrument flight.

The third, *Getting Behind the Aircraft*, described a situation in which the pilot allowed events or circumstances to dictate his or her actions, remaining in a constant state of surprise regarding subsequent developments during the flight.

The fourth, *Loss of Positional or Situational Awareness*, indicated that, in extreme cases in which the pilot fell behind the aircraft, positional or situational awareness could be lost, causing the pilot to become unaware of the aircraft's geographic location and to fail to recognize deteriorating conditions.

Reinforcing this perspective, on 15JUN2021, the United States Helicopter Safety Team published a study entitled "*56 Seconds to Live: Unintended Flight in Instrument Meteorological Conditions (UIMC) Safety Initiative.*" The research was conducted during Heli-Expo using virtual-reality simulation, in which volunteer pilots were placed in a scenario involving inadvertent entry into IMC while operating under VFR.

The study revealed that, on average, participants lost control of the aircraft or collided with terrain 56 seconds after entering IMC. The results varied according to the pilots' levels of experience, training, and currency, with operational experience being the most influential factor in their performance. The study also highlighted the potential of synthetic training, such as virtual-reality simulators, as an accessible and effective means of preparing crewmembers for UIMC scenarios.

1.20. Application of other investigation techniques.

For illustrative purposes regarding factors that may contribute to visual illusions, the SIPAER Investigation Commission captured the images shown in Figures 25 and 26 in the vicinity of *Galeão–Antônio Carlos Jobim* Aerodrome (SBGL), *Rio de Janeiro*, state of *Rio de Janeiro*.

Figure 24 shows a weather formation with two distinct shades. This difference in color may be interpreted by a pilot as the mountain range, which is actually obscured by the weather formation. Consequently, it becomes impossible to determine the upper limit of the obstacle ahead.

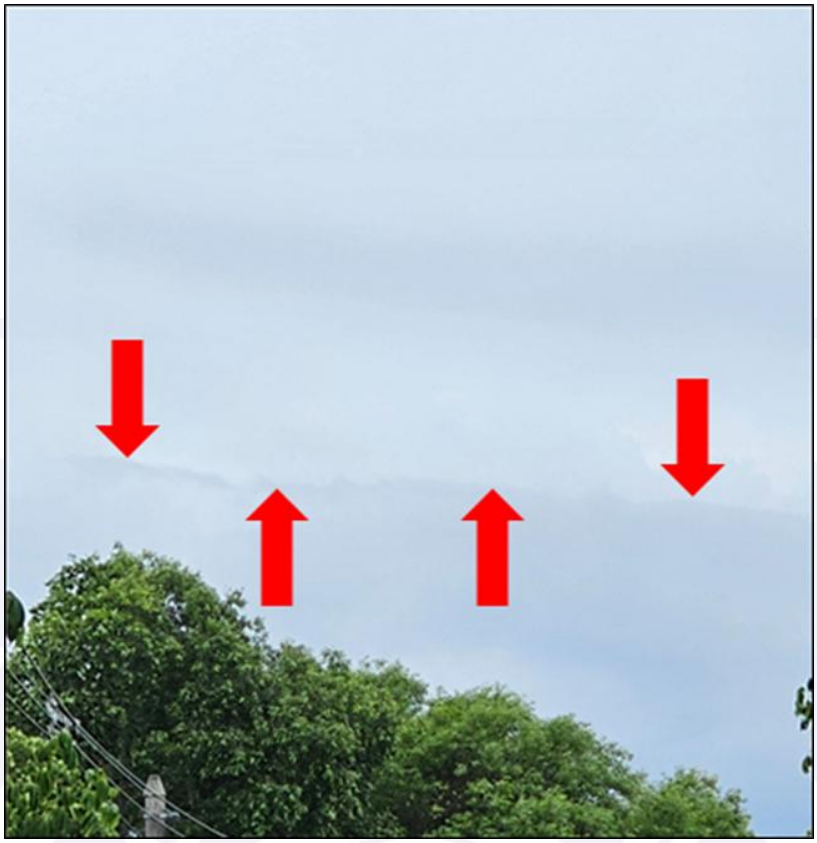


Figure 24 – Illusion caused by adverse weather conditions.

Similarly, Figure 25 shows *Serra dos Órgãos (a mountain range)*, *Rio de Janeiro*, partially obscured by clouds. It can be observed that the weather formation significantly reduces the visual perception of the topography. If the cloud base were higher, a pilot flying solely by visual reference, without prior knowledge of the local geography, might fail to perceive the presence of the obscured mountain range.



Figure 25 – Image of *Serra dos Órgãos*, *Rio de Janeiro*, partially obscured by clouds.

Additionally, this atmospheric condition may lead an observer to interpret the visible obstacle as being at a safe distance, while a smaller terrain feature concealed by the cloud may pose an immediate risk to the aircraft's flight path.

2. ANALYSIS.

The PR-UEA aircraft, model BK117 C-2, was operated by a UAP based at SBBH, which belonged to the Military Fire Department of the state of *Minas Gerais* and whose

activities were regulated by RBAC 90 – Requirements for Special Public Aviation Operations.

Maintenance of the aircraft was performed by an outsourced company, which followed the maintenance program established by the manufacturer. According to the available records, all scheduled maintenance was up to date, and the Airworthiness Verification Certificate was valid.

At the time of the accident, the aircraft was operating within the weight and balance limits established by the manufacturer.

The operational crew consisted of two pilots and two aerotactical operators assigned to the UAP, as well as two SAMU healthcare professionals—a physician and a nurse—who provided aeromedical care.

In addition to previously planned missions, the UAP maintained an operational crew on standby at the unit headquarters during daylight hours to respond to calls at any time. The missions encompassed various activities in support of the population, including search, rescue, and aeromedical patient transport operations. In most cases, the flights were intended to assist persons in emergency situations.

During the investigation, the Commission identified a strong sense of mission accomplishment and self-sacrifice among UAP personnel, stemming from the institutional culture of the Military Fire Department. This sense of duty, intrinsic in nature and not arising from hierarchical pressure, led the military personnel to make every effort to accomplish the mission, sometimes to the detriment of their own personal well-being.

Under those circumstances, the operational environment created by this attitude may have favored prioritizing mission completion and the return to headquarters over adherence to flight safety principles.

Along the same lines, the organizational culture encouraged behavior aimed at overcoming personal limitations, leading to the systematic prioritization of the mission over individual considerations.

It was observed that, even when experiencing signs of physical or emotional strain, UAP personnel frequently set aside personal needs to remain available and ensure the continuity of operations.

On the day of the accident, the Commission determined that the six operational crewmembers conducted a joint briefing, followed by routine checks of the aircraft. Subsequently, the two pilots and the two aerotactical operators performed administrative activities associated with their duties at the UAP.

At approximately 18:00 UTC, the operational crew was dispatched to search for a missing aircraft in the region of *Ouro Preto*, *Minas Gerais*, and departed from SBBH at 18:23 UTC under Visual Flight Rules (VFR).

Although the meteorological conditions at SBBH were favorable for visual flight, conditions in the *Ouro Preto* region were more degraded and were not suitable for that type of operation. Nevertheless, the missing aircraft was located after having crashed in *Serra do Amolar*, in an area unsuitable for the landing of aircraft PR-UEA. Therefore, the crew landed at a nearby highway interchange to allow the aeromedical team to proceed by ground to the accident site in an attempt to assist the pilot of the crashed aircraft.

The aeromedical team proceeded to the site and confirmed that the pilot had died. It the returned to the PR-UEA to rejoin the operational crew and return to the UAP headquarters at SBBH. At that time, the meteorological conditions had deteriorated, prompting the aircraft to remain on the ground pending a possible improvement in the weather. A UAP vehicle was requested to transport the operational crew by ground.

However, the PIC expressed discomfort with this alternative because part of the team would have to remain behind to guard the aircraft.

This discomfort may have been related to characteristics of his personal profile, particularly a tendency to assume responsibilities in a centralized manner and to avoid imposing burdens or inconvenience on other team members. Such a predisposition may have contributed to the continuation of the operation amid deteriorating meteorological conditions, reducing the likelihood that more conservative alternatives would be adopted and favoring the crew's exposure to the risks that culminated in the accident.

At 20:45 UTC, external observers witnessed aircraft PR-UEA take off from the highway interchange under meteorological conditions unfavorable for VFR flight. After takeoff, the aircraft remained under control, continuously climbing and moving forward. Thirty seconds into the flight, visual contact with the ground was lost, and at 56 seconds, the aircraft collided with terrain near the summit of *Serra do Amolar*.

In the accident under analysis, the PIC held an IFRH rating, and the aircraft was certified for flight under IFR. However, because the takeoff was conducted outside an aerodrome, there was no instrument departure procedure to ensure adequate clearance between the aircraft and the terrain.

According to the information gathered, no pre-takeoff planning was conducted to account for the terrain characteristics in the region, which may have significantly reduced the crew's situational awareness. This condition increased the risk of collision with terrain, particularly in a reduced-visibility scenario in which the terrain would not be readily discernible.

The SIC did not hold an IFRH rating and had conducted all his flights prior to the accident under visual meteorological conditions, indicating a lack of practical experience in flight operations under adverse meteorological conditions.

Considering that the PIC was regarded as a role model by the less experienced UAP pilots, the SIC may have placed complete trust in the PIC's ability to conduct the flight, without questioning or independently assessing the operational risks. This attitude revealed inadequacies in flight deck resource management, since a more balanced distribution of responsibilities among the crewmembers could have contributed to a more thorough assessment of the operating conditions.

With regard to the aerotactical operators, it was found that only one of them had participated in the most recent CRM training, and that same operator was on his first mission with the UAP. This circumstance may have reduced the likelihood that the decision to take off would be questioned, since, in the absence of practical parameters within the UAP, the conditions encountered could have been interpreted as normal.

As for the aeromedical team, a predominantly passive attitude toward operational decisions was identified, possibly resulting from their not being included in recurrent CRM training.

The lack of recurrent CRM training involving all onboard roles may have compromised the currency and alignment of coordination practices among the operational crewmembers. In this context, the absence of an environment conducive to sharing perceptions and cross-checking operational decisions favored the centralization of the decision-making process in a single crewmember.

The PIC had recently been appointed head of the UAP maintenance department, assuming responsibility for managing the aircraft fleet, including those stationed at detached bases in other cities. This position required considerable administrative involvement in addition to his responsibilities as a pilot on the UAP's regular flight duty rosters.

In addition to his professional demands, he was dealing with personal concerns that affected his emotional state. In the days preceding the accident, this combination of circumstances manifested itself in signs consistent with a possible state of exhaustion, including frequent complaints of headaches and memory lapses.

Personal factors may have generated self-imposed pressure to return to base, impairing his judgment and contributing to the decision to take off with visibility below the regulatory minima.

Similarly, the SIC appeared physically and mentally fatigued and reported difficulty balancing operational demands with the administrative activities he also performed. This condition may have impaired his ability to independently assess the operational risks and question the decision to take off.

The physical and emotional strain to which both crewmembers were exposed may have affected cognitive functions essential to the safe conduct of the flight, such as attention, situational awareness, and decision-making ability. It may also have fostered negative emotional states, such as tension and occupational stress, thereby contributing to the accident.

There may have been inadequacies in the planning conducted by the organization at the managerial level regarding the allocation of human resources for operational activities. Assigning the PIC to concurrently serve as head of a highly demanding section, in addition to his regular duties as a rostered pilot, coupled with the responsibility for organizing a large-scale institutional event, may have contributed to task overload and, consequently, to a reduction in his operational performance.

Sunset at SBBH on the date of the occurrence was at 20:56 UTC, and the takeoff was recorded at 20:45 UTC, when a slight improvement in visibility was observed at the highway interchange, reaching approximately 180 m—a value significantly below the regulatory minima. The combination of this improvement and the approaching sunset may have generated a compulsion to act at that moment, leading the crewmembers to interpret the situation as their last opportunity to conduct the flight. This condition may have compromised the process of analyzing and selecting alternatives, resulting in the decision to take off under conditions unsuitable for the operation.

This circumstance revealed a mismatch between the operational crewmembers' perception of risk and the actual conditions, impairing their ability to adequately assess the hazards associated with the operation.

The shortcomings in the operational crew's qualification and training processes may have contributed to this mismatch, reducing the team's ability to collectively identify, assess, and question the risks associated with the operation.

Through RBAC 90, ANAC established that the UAP was to conduct takeoffs from unregistered sites only under Visual Meteorological Conditions (VMC). In addition, it required the UAP to implement a risk management system for its flight operations. However, the SIPAER Investigation Commission found no evidence that such a risk management system had been effectively implemented by the UAP at the time of the occurrence.

In the same regard, the UAP's MGSO established that rotary-wing aircraft were to operate exclusively under VFR. In addition, the MGO reinforced the requirement that flights be conducted only under visual meteorological conditions, assigning the PIC responsibility for assessing the meteorological conditions and determining the minimum flight altitudes.

Effective risk management by the UAP could have established an operational barrier capable of mitigating the threats posed by the adverse meteorological conditions and the rugged terrain in the region, thereby revealing inadequacies in the operational support systems.

Furthermore, RBAC 90 established mandatory recurrent training for UAP crewmembers. The SIPAER Investigation Commission found that the operator focused its training on the practical phases considered more complex and related to specialized flights, while the remaining phases, perceived as simpler, did not receive the same emphasis. In this context, although the regulations in force required CRM training to be included in the recurrent training cycle, the UAP did not treat it as mandatory.

By contrast, the history of aeronautical occurrences involving the UAP indicated that most did not take place during specific phases of operational missions, such as search, rescue, or external-load hoisting, but rather during conventional takeoff and landing procedures. This pattern suggested that the predominant focus of training on the phases considered critical in rescue operations did not provide balanced coverage of all phases of flight, revealing inefficiencies in the qualification and training processes that may have contributed to the accident.

Still regarding the pilots' qualification and training process, the commission inferred that, after takeoff, the EGPWS depicted *Serra do Amolar* in red and, 34 seconds into the flight, changed the indication to yellow. Since the PIC had accumulated only five hours of instrument flight time and his recurrent training did not include any familiarization with or operation of this equipment, he may have misinterpreted the color change as indicating that the aircraft had climbed above the obstacle.

The meteorological conditions at the accident site, with visibility below the minimum regulatory requirements, created an environment conducive to degraded pilot perception and the occurrence of visual illusions, constituting a decisive operational threat to the outcome of the occurrence.

The decision to take off with visibility below the regulatory minima and to continue the flight until entering IMC reflected a failure to comply with the established operational and regulatory requirements, contributing to the accident.

The Helicopter Flying Handbook (FAA-H-8083-21B) stated that CFIT accidents were characterized by the controlled impact of an aircraft with terrain or obstacles without the pilot being aware of the imminent danger, with limited visibility and loss of situational awareness being factors frequently associated with this type of event. The document further emphasized that CFIT prevention should begin before takeoff through adequate planning and a careful assessment of meteorological conditions, including the decision to delay or cancel the flight when adverse conditions existed. It also warned of operational traps, such as difficulty estimating the distance from cloud formations, continuing visual flight into IMC, and loss of situational awareness—conditions that were present during the accident flight.

These elements reinforced the importance of continuous training, the use of navigation support tools, and the adoption of a risk-management mindset to reduce pilot vulnerability to scenarios involving collision with terrain.

The study "*56 Seconds to Live"*, published in 2021 by the U.S. Helicopter Safety Team, revealed that, on average, loss of control or impact with terrain occurred approximately 56 seconds after inadvertent entry into IMC, even among experienced pilots. Considering that the accident flight lasted approximately 56 seconds from takeoff to impact, the study data were consistent with the outcome of this occurrence, reinforcing the critical nature of the decision to take off under the meteorological conditions encountered.

Finally, this investigation revealed that even experienced and highly skilled crewmembers require recurrent theoretical training that reinforces basic airmanship fundamentals, such as takeoffs and landings, as well as CRM training to improve coordination, communication, and decision-making, thereby strengthening the operational safety culture.

3. CONCLUSIONS.

3.1. Findings.

a) the pilots' Aeronautical Medical Certificates (CMA) were valid;

b) the pilots' HMLT ratings were valid;

c) the pilots did not attend the most recent recurrent CRM training cycle held in 2023;

d) the UAP did not make this type of training mandatory;

e) the pilots were not qualified but had experience in the type of flight;

f) the aircraft's Airworthiness Verification Certificate (CVA) was valid;

g) the aircraft was within the weight and balance limits;

h) the airframe and engine logbook records were up to date;

i) the aircraft was equipped with the EuroNav IV Moving Map system to support primary navigation;

j) the referred system was not designed for use in IMC and was intended to be used only under VFR;

k) the meteorological conditions were below the minima required for the flight;

l) the aircraft encountered adverse weather conditions and impacted terrain in the *Serra do Amolar* mountain range approximately 56 seconds after takeoff;

m) the aircraft was destroyed; and

n) all occupants sustained fatal injuries.

3.2. Contributing factors.

- **Attitude – a contributor.**

The decision to take off with visibility below the regulatory minima and to continue the flight until entering IMC reflected a failure to comply with the established operational and regulatory requirements, contributing to the accident.

The PIC's discomfort with the ground transportation alternative, possibly arising from a tendency to assume responsibilities in a centralized manner and to avoid inconveniencing other team members, may have contributed to the decision to continue the operation amid deteriorating meteorological conditions, making the adoption of more conservative alternatives less likely.

- **Training – undetermined.**

The history of aeronautical occurrences involving the UAP indicated that most accidents did not occur during specific phases of operational missions, but rather during conventional takeoff and landing procedures. This suggested that the predominant focus of training on the phases considered critical in rescue operations did not provide balanced coverage of all phases of flight.

In addition, the absence of recurrent CRM training for all operational crewmembers impaired the team's ability to collectively identify and question the operational risks. These conditions revealed inefficiencies in the qualification and training processes that may have contributed to the accident.

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

The meteorological conditions at the accident site, with visibility below the minimum regulatory requirements, created an environment conducive to degraded pilot perception

and the occurrence of visual illusions, constituting a decisive operational threat to the outcome of the occurrence.

- **Crew Resource Management – undetermined.**

The SIC's excessive confidence in the PIC's abilities, the passive attitude of the aeromedical team, and the limited participation of the aerotactical operators in CRM training impaired the balanced distribution of responsibilities among the operational crewmembers, favoring the centralization of the decision-making process in the PIC and reducing the likelihood that operational decisions would be questioned, which may have contributed to the accident.

- **Organizational culture – undetermined.**

The sense of mission accomplishment and self-sacrifice shared by the organization's members directly influenced the UAP's operational environment, resulting in an attitude whereby the risks inherent in aviation activities were regarded as an integral part of the mission. Thus, the organizational culture encouraged behavior aimed at overcoming personal limitations, leading to the systematic prioritization of the mission over individual considerations.

Under the circumstances of the accident, the operational environment created by this culture may have favored prioritizing mission completion and the return to headquarters over adherence to flight safety principles.

Despite signs of physical or emotional strain, these conditions were disregarded to maintain availability and ensure the continuity of operations.

- **Emotional state – undetermined.**

The PIC's personal concerns, combined with the overload of work-related duties, may have generated self-imposed pressure to return to base, adversely affecting his emotional state and impairing his judgment and decision-making, which led him to take off despite the conditions encountered.

- **Fatigue – undetermined.**

The accumulation of professional and administrative duties to which the PIC and SIC were exposed, combined with signs consistent with a possible state of exhaustion in the PIC, may have impaired cognitive functions essential to the safe conduct of the flight, contributing to the decision to take off with visibility below the regulatory minima.

- **Visual Illusions – undetermined.**

The low-visibility meteorological conditions at the accident site, combined with the distinctive terrain features of the region, created an environment conducive to visual illusions and may have produced misleading sensory impressions that hindered the correct recognition of the mountain range ahead as an obstacle to the aircraft's flight path.

- **External influences – undetermined.**

Personal concerns faced by the PIC may have adversely affected his operational performance, impairing his judgment and decision-making ability at the time of takeoff.

- **Piloting judgment – a contributor.**

The decision to take off with visibility below the regulatory minima and to continue the flight until entering IMC revealed an inadequate assessment of the operational parameters and risks.

- **Perception – a contributor.**

The visibility below the minimum regulatory requirements, already present at the time of takeoff, was not adequately recognized by the operational crew as a threat to the safety

of the operation. During the flight, the adverse meteorological conditions, combined with the distinctive terrain features of the region, created an environment conducive to degraded perception and visual illusions, impairing the crewmembers' ability to identify and respond to the proximity of the obstacle in a timely manner.

- **Flight planning – undetermined.**

No pre-takeoff planning was conducted to account for the terrain characteristics in the region, which may have significantly reduced the crew's situational awareness. This condition increased the risk of collision with terrain, particularly in a reduced-visibility scenario in which the terrain would not be readily discernible.

- **Management planning – undetermined.**

There may have been inadequacies in the planning conducted by the organization at the managerial level regarding the allocation of human resources for operational activities. Assigning the PIC to concurrently serve as head of a highly demanding section, in addition to his regular duties as a rostered pilot, coupled with the responsibility for organizing a large-scale institutional event, may have contributed to task overload and, consequently, to a reduction in his operational performance.

- **Decision-making process – undetermined.**

The combination of the slight improvement in visibility observed shortly before takeoff and the approaching sunset may have impaired the crewmembers' process of analyzing and selecting alternatives, leading them to interpret that moment as their last opportunity to conduct the flight. The physical and emotional strain to which both pilots were exposed may have aggravated this condition, reducing their ability to objectively assess the operational risks and contributing to the decision to take off with visibility below the regulatory minima.

- **Support systems – undetermined.**

Effective risk management by the UAP could have established an operational barrier capable of mitigating the threats posed by the adverse meteorological conditions and the rugged terrain in the region, thereby revealing inadequacies in the operational support systems.

- **Task overload – undetermined.**

The accumulation of multiple highly demanding administrative duties, combined with the PIC's responsibilities as a pilot on the regular flight duty rosters, may have exceeded his ability to manage them adequately, impairing his judgment and decision-making and leading him to take off despite the conditions encountered.

4. SAFETY RECOMMENDATIONS

A safety recommendation is a proposal issued by an accident investigation authority, based on information derived from an investigation, with the intention of preventing aircraft accidents, and is under no circumstances intended to create a presumption of blame or liability.

In accordance with Law No. 7,565/1986, safety recommendations are issued solely for the benefit of flight safety. They shall be handled as established in NSCA 3-13, "Protocols for the Investigation of Civil Aviation Occurrences Conducted by the Brazilian State.

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

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Disseminate the lessons learned from this investigation to Public Aviation Units in order to reinforce the importance of complying with the requirements established in RBAC 90,

particularly mandatory compliance with the training program and the effective implementation of a Safety Management System (SMS) focused on hazard identification and risk management.

A-144/CENIPA/2024 – 02 **Issued on 10/28/2026**

Assess the possibility of implementing Safety Management System (SMS) audits within the Public Aviation Units governed by RBAC 90, in order to provide guidance for the continuous improvement of adequate operational safety levels.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

Following the occurrence under analysis, the Military Fire Department of *Minas Gerais* took the initiative to temporarily suspend the UAP's flight operations, both at its headquarters and at its detached bases, until corrective measures aimed at mitigating the identified latent conditions had been implemented.

Initially, meetings were held with all operational crewmembers to analyze potential organizational and individual factors that could affect operational safety.

In this context, a psychologist joined the UAP staff to closely monitor the operational crewmembers, enabling the identification of possible personal factors affecting operational performance. In addition, she began working to strengthen risk awareness and the unit's flight safety culture, with supplementary training planned to enhance her work in this specific area.

The on-call duty rosters were restructured to include additional compensatory rest periods and schedule adjustments based on statistical data for each aircraft type.

Along the same lines, selection processes were initiated to increase the number of crewmembers, allowing longer intervals between duty periods and reducing workload. In addition, crewmembers previously assigned to complex administrative duties were reassigned to simpler administrative functions.

At the same time, an operational exchange was conducted with qualified and experienced crewmembers from other UAPs.

A technical working group was established to review and update the internal procedures and regulations related to UAP operations, realigning recurrent training with the requirements of RBAC 90 and the unit's risk statistics, with emphasis on including CRM training for all operational crewmembers.

Finally, a Flight Safety Committee was established to develop and implement indicators covering all unit operations. In addition, UAP personnel began regularly attending courses conducted by CENIPA, with the aim of further disseminating the operational safety culture and consolidating its application within the Air Unit's organizational environment.

On October 28th, 2026.