COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A - 121/CENIPA/2021

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PT-ONJ**
MODEL:	**C90A**
DATE:	**05NOV2021**

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 is the Final Report of the 05NOV2021 accident with the C90-A aircraft model, registration PT-ONJ. The accident was classified as “[CFIT] Controlled Flight Into Terrain”.

During the approach phase, under Visual Meteorological Conditions (VMC), the aircraft collided against a lightning arrester cable of a power grid on the final approach to threshold 02 of Caratinga Aerodrome (SNCT), Ubaporanga - MG, resulting in loss of control and the impact of the aircraft against the ground.

The aircraft had substantial damage.

The two pilots and three passengers died.

An Accredited Representative of the Transportation Safety Board (TSB) - Canada (State where the engine was manufactured) was designated for participation in the investigation.

TABLE OF CONTENTS

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ACAS	Airborne Collision Avoidance System
ACC-BS	Area Control Center - Brasilia
AFIS	Aerodrome Flight Information Service
AGA	Aerodromes, Air Routes, and Ground Aids
AGL	Above Ground Level
AISWEB	Aeronautical information service on the WEB
ANAC	Brazil’s National Civil Aviation Agency
ANEEL	National Electric Energy Agency
APAPI	Abbreviated Indicator Of Precision Approach Track
ATC	Air Traffic Control
ATS	Air Traffic Services
AUTO	Automatic
BKN	Broken (5-7 oktas)
CAP	Aeronautical Piloting Chart
CAVOK	Ceiling and Visibility OK
CB	Cumulonimbus
CBMMG	Minas Gerais Military Fire Department
CEMIG	Companhia Energética de Minas Gerais S.A.
CENIPA	Aeronautical Accident Investigation and Prevention Center
CFIT	Controlled Flight Into Terrain
CIAC	Civil Aviation Instruction Centers
CIAP	Aeronautical Pilot Image Chart
CINDACTA III	Third Air Defense and Air Traffic Control Integrated Center
CMA	Aeronautical Medical Certificate
COM	Maintenance Organization Certificate
COMAER	Aeronautics Command
CPTEC	Weather Forecast and Climate Studies Center
CSN	Cycles Since New
CSO	Cycles Since Overhaul
CSO	Operational Safety Committee
CVA	Airworthiness Verification Certificate
CVR	Cockpit Voice Recorder
DECEA	Airspace Control Department
EGPWS	Enhanced Ground Proximity Warning System
EO	Operating Specifications
FAB	Brazilian Air Force
FAP	Pilot`s Evaluation Form

FCA	Frequency and Coordination Between Aircraft
FDR	Flight Data Recorder
FEW	Few (1 and 2 oktas)
GOES	Geostationary Operational Environmental Satellite
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
HSI	Hot Section Inspection
ICA	Command of Aeronautics' Instruction
IFR	Instrument Flight Rules
IFRA	Instrument Flight Rating - Airplane
INFOTEMP	Temporary Aerodrome and Helipad information published exclusively on the ROTAER
INSPSAU	Health Inspection
IS	Supplementary Instruction
MANINV	Brazilian In-flight Inspection Manual
METAR	Meteorological Aerodrome Report
MGO	General Operations Manual
MGSO	Safety Management Manual
MLTE	Airplane Multi-Engine Land Rating
NM	Nautical Miles
NOTAM	Notice to Airmen
NSCA	Aeronautics Command System Standard
NW	Northwest
OACI	International Civil Aviation Organization
OPEA	Object Projected in Airspace
PAOE	Present, Adequate, Operational, and Effective
PAPI	Precision Approach Path Indicator
PBZPA	Aerodrome Protection Zone Basic Plan
PBZPH	Helipad Protection Zone Basic Plan
PCH	Small Hydroelectric Power Plant
PCM	Commercial Pilot License – Airplane
PEZPA	Aerodrome Protection Zone Specific Plan
PF	Pilot Flying
PIC	Pilot in Command
PLA	Airline Pilot License - Airplane
PM	Pilot Monitoring
PMMG	Minas Gerais Military Police
PN	Part Number
PPR	Private Pilot License - Airplane
PROB	Probability

PSAC	Civil Aviation Service Provider
PSO-BR	Operational Safety Plan for the Brazilian Civil Aviation
PSOE	Specific Operational Safety Program
PTO	Operational Training Program
PZPANA	Air Navigation Aid Protection Zone Plan
PZPREA/H	Airplane and Helicopter Special Route Protection Zone Plan
RADAR	Radio Detection And Ranging
RBAC	Brazilian Civil Aviation Regulation
REDEMET	Brazilian Aeronautical Certification Regulation
RMK	Remark
ROTAER	Auxiliary Air Route Manual
SBBH	ICAO Location Designator - Pampulha Aerodrome - Carlos Drummond de Andrade, Belo Horizonte - MG
SBGO	ICAO Location Designator - Santa Genoveva Aerodrome, Goiânia - GO
SBGV	ICAO Location Designator - Coronel Altino Machado Aerodrome, Governador Valadares - MG
SBIP	ICAO Location Designator – Usiminas Aerodrome, Ipatinga - MG
SCT	Scattered (3 and 4 oktas)
SMS	Safety Management System
SIC	Second in Command
SIGWX	Significant Weather Chart
SIPAER	Aeronautical Accident Investigation and Prevention System
SN	Serial Number
SNCT	ICAO Location Designator – Caratinga Aerodrome, Ubaporanga - MG
SNXG	Former Location Designator of the Caratinga Aerodrome
SOP	Standard Operational Procedures
SPVV	Visual Flight Protection Surface
SW	Southwest
TAC	Conduct Adjustment Term
TAF	Terminal Aerodrome Forecast
TCU	Towering Cumulus
TN	Minimum Temperature (followed in TAF)
TPX	Aircraft Registration Category of Non-Regular Public Air Transport
TSB	Transportation Safety Board - Canada
TSN	Time Since New
TSO	Time Since Overhaul
TSRA	Thunderstorm Rain
TX	Maximum temperature (followed in TAF)
UTC	Universal Time Coordinated

VAC	Visual Approach Chart
VASIS	Visual Approach Chart
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions
VOR	VHF Omnidirectional Radio Range
VRB	Variable
WAC	World Aeronautical Chart ICAO 1: 1,000,000
ZPA	Aerodrome Protection Zone

1. FACTUAL INFORMATION.

Aircraft	**Model:** C90A **Registration:** PT-ONJ **Manufacturer:** Beech Aircraft	**Operator:** PEC Air Taxi Ltd
Occurrence	**Date/time**: 05NOV2021 - 18:15 (UTC) **Location:** Piedade de Caratinga **Lat.** 19°45'57"S **Long.** 042°06'32"W **Municipality – State:** Piedade de Caratinga - MG	**Type(s):** [CFIT] Controlled flight into or toward terrain

1.1. History of the flight.

The aircraft took off from the Santa Genoveva Aerodrome (SBGO), Goiânia - GO, to the Caratinga Aerodrome (SNCT), Ubaporanga - MG, at 1602 UTC to carry out a non-scheduled public passenger air transport flight, with two pilots and three passengers on board.

During the approach phase, the aircraft collided with the lightning arrester of a power grid.

The aircraft had substantial damage.

The two crewmembers and the three passengers suffered fatal injuries.

1.2. Injuries to persons.

Injuries	Crew	Passengers	Others
Fatal	2	3	-
Serious	-	-	-
Minor	-	-	-
None	-	-	-

1.3. Damage to the aircraft.

The aircraft had substantial damage throughout its length.

Both engines were detached, the fuselage and wings flexed downwards, and the tail cone was sectioned (Figure 1).

Figure 1 - Extent of damage to the aircraft.

1.4. Other damage.

The lightning arrester cable in the gap between towers 8 and 9 of the power grid that operated in 69 kV of the “*Pipoca*” Small Hydroelectric Power Plant broke (Figure 2).

Figure 2 - Position of the lightning arrester on the right of Tower 8.

1.5. Personnel information.

1.5.1. Crew’s flight experience.

Flight Experience		
	PIC	SIC
Total	16.352:30	2.768:24
Total in the last 30 days	38:06	40:12
Total in the last 24 hours	02:42	00:00
In this type of aircraft	unknown	unknown
In this type in the last 30 days	04:24	09:30
In this type in the last 24 hours	00:00	00:00

N.B.: The data relating to the flown hours were obtained from the aircraft operator's records.

It was verified that both pilots had previous experience in the C90A. However, it was not possible to specify the total number of hours in this model.

The total hours logged on the operator's C90 and C90A aircraft were 312 hours and 40 minutes by the PIC; and 169 hours and 55 minutes by the SIC.

1.5.2. Personnel training.

The PIC took the PPR course at the Juiz de Fora Aeroclub - MG in 1988.

The SIC took the PPR course at the Brasilia Aeroclub - DF in 2008.

1.5.3. Category of licenses and validity of certificates.

The PIC had a PLA License and had valid MLTE and IFRA Ratings.

The SIC had a PCM License and had valid MLTE and IFRA Ratings.

1.5.4. Qualification and flight experience.

The PIC had been a pilot for 33 years and had accumulated 16,352 flight hours and 30 minutes in C90, C90A, C208B, C535, C550, MU2B, PA31, PA34, and A319/320 aircraft.

He had been working for the operator in the role of Commander since July 2020 and, in the last 12 months, had performed approximately 299 hours and 06 minutes in the C90 and C90A aircraft. His first flight for the operator in this aircraft model took place on 05JUL2020.

In the 90 days before the accident, he flew a total of 155 hours and 30 minutes on flights to various destinations, fulfilling the recent experience requirement.

His latest FAPs contained satisfactory performance records.

The SIC had been a pilot for 13 years and had accumulated 2,768 flight hours and 24 minutes in C208, C208B, C90, and C90A aircraft.

He had been working for the operator in the role of co-pilot since April 2021, and in the last 12 months, he had worked around 167 hours and 36 minutes on the C90 and C90A aircraft.

In the 90 days before the accident, he flew a total of 158 hours and 30 minutes on flights to various destinations, fulfilling the recent experience requirement.

His latest FAPs contained satisfactory performance records.

Both had completed training according to the operator's PTO.

None of the pilots was familiar with the operation at SNCT, this being the first time that both would operate at that Aerodrome.

The operator's MGO, in its Section 3, Item 3.3.2 - "crew designation" read as follows:

> [...]
>
> b) Before assigning a crewmember to the flight, it must be ensured that he has the qualification and training valid until the end of the trip schedule. This procedure will be guaranteed by consulting the Crew Control panel available in the Company operations sector.
>
> c) The person responsible for assigning the crew must consult the last flight of the crewmember to ensure that he/she has recent experience (90 days) valid in the equipment involved in the operation. The consultation of flights performed by the crewmember can be carried out through the Individual Flight Hours Record, crossing the information with copies of the logbook pages filed at the Company.

Concerning the requirements contained in the MGO, it was found that the crew assigned to the flight was within the criteria established by the operator.

Therefore, the Investigation Team considered that both were qualified and had experience in the type of flight.

1.5.5. Validity of medical certificate.

The PIC had a first-class CMA, valid until 16DEC2021.

The SIC had a first-class CMA, valid until 16OCT2022.

1.6. Aircraft information.

The aircraft, model C-90A, serial number LJ-1078, was manufactured by Beech Aircraft in 1984 and was registered in the TPX category.

The aircraft CVA was valid until 01JUL2022.

The airframe, engines, and propellers logbook records were updated.

In the logbook, which was on the aircraft, no discrepancies were identified that had resulted in the malfunction of any of the aircraft systems.

The last aircraft inspection, the “200 hours” type, was completed on 13SEPT2021 by the maintenance organization PEC Air Taxi, COM 1212-61, in Goiânia - GO, with 170 hours and 9 minutes flown after inspection.

The last more comprehensive aircraft inspection, the “Phase IV" type, carried out every 800 hours, was also completed on 13SEPT2021 by the maintenance organization PEC Air Taxi, with 170 hours and 9 minutes flown after the inspection.

General characteristics of the King Air C90A aircraft.

The King Air C90A model was a metal structure aircraft with a pressurized cabin, an operational ceiling of 30,000 ft, low wing, twin turboprop engine with conventional empennage, and retractable tricycle landing gear.

Both the auxiliary landing gear and the main landing gear were hydraulically operated and had an actuator on each landing gear. The regular drive for extension and retraction was electrical. The landing gear could also be activated manually through a lever located on the aircraft floor, to the left of the central pedestal of the cockpit.

The flap system consisted of four surfaces, two on each wing. The surfaces were controlled electrically, through a lever on the central pedestal, which had three positions: UP, APPROACH, and DOWN; and were moved using actuators, shafts, and an electric engine.

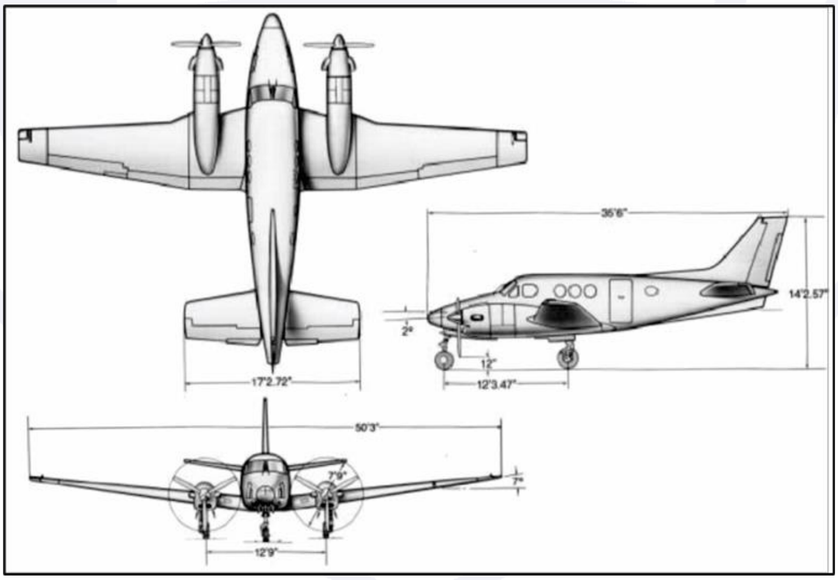

Figure 3 - Dimensions in three views of the C90A aircraft. Source: Adapted from the Pilot Training Manual.

Enhanced Ground Proximity Warning System (EGPWS).

The PT-ONJ aircraft was equipped with an EGPWS system, model GNS 530W, Part Number (PN) 011-0106500, manufactured by Garmin.

One of the main functions of this system was to provide situational warnings to the crew of the presence of obstacles and proximity to terrain.

The EGPWS received information from the GPS, uncorrected barometric pressure, and outside air temperature; it also had a database of terrains, obstacles, and runways.

To issue warnings, the system compared the aircraft trajectory with information from the terrain database, known obstacles, and the distance to known runways.

The EGPWS had a protection mode related to high rates of descent. This mode issued the "Sink Rate" warning based on the flight altitude and the aircraft's rate of descent. If the aircraft entered a more critical condition, a "Pull Up" warning would be issued.

When the equipment detected a risk condition in relation to terrain or obstacles at a distance of approximately one minute ahead of the aircraft "Too Low - Terrain, Too Low - Terrain" warnings were issued to increase the pilot's situational awareness regarding the presence of obstacles that would pose risks to the flight.

According to the Pilot Guide, PN 190-00357-00 Rev K, the equipment issued alerts when certain flight conditions reached previously established parameters.

Among the alerts issued by the EGPWS, there was the premature descent alert, which was triggered when the system detected that the aircraft was significantly below a normal approach path for landing (Figure 4).

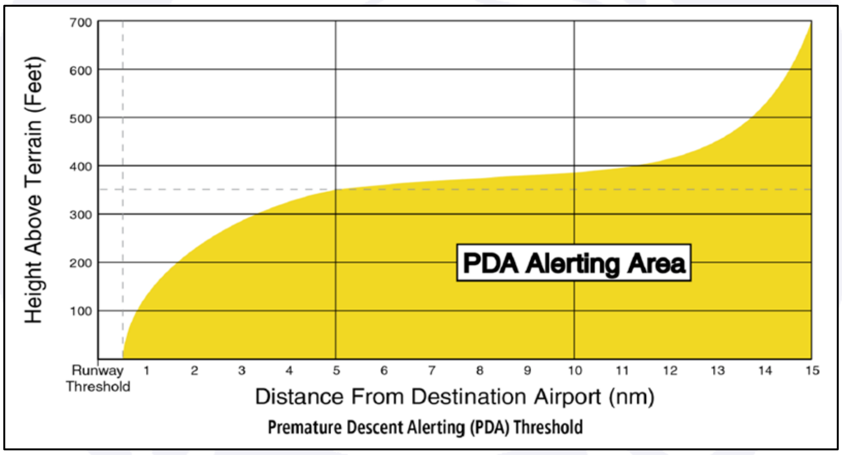

Figure 4 - Parameters for triggering the premature descent alert.

Still, according to the aforementioned Pilot's Guide, the system had an alert inhibition mode that could be activated when deemed necessary by the pilot. The manual pointed out that during flights under VFR, the system could issue annoying alerts.

There was an interface with an activation button on the aircraft panel, which allowed pilots to inhibit the sound alerts emitted by the EGPWS system at any time during the flight. Given the extent of damage to the PT-ONJ aircraft panel, however, it was not possible to determine the position of the button at the time of impact.

1.7. Meteorological information.

The TAF at the Coronel Altino Machado Aerodrome (SBGV), in Governador Valadares - MG, 50 NM away from the SNCT, provided the following information:

TAF SBGV 051625Z 0518/0606 15007KT 9999 SCT035 TX31/0518Z TN22/0605Z PROB40 0520/0524 8000 TSRA BKN030 FEW040CB RMK PGG

For the time interval that comprised the time of the accident, the SBGV TAF of 05NOV2021 issued at 1625 (UTC) predicted sparse cloudiness at 3,500 ft and visibility above 10 km.

The SIGWX at 1800 (UTC) on 05NOV2021 showed a chance of showers and low cloud cover based on 1600 ft and top at 6000 ft, medium cloud cover based on 9000 ft and top at 14,000 ft, as well as the presence of a few Towering Cumulus clouds with a base at 2,000 ft and top at 21,000 ft, for the region of Caratinga, MG (Figure 5).

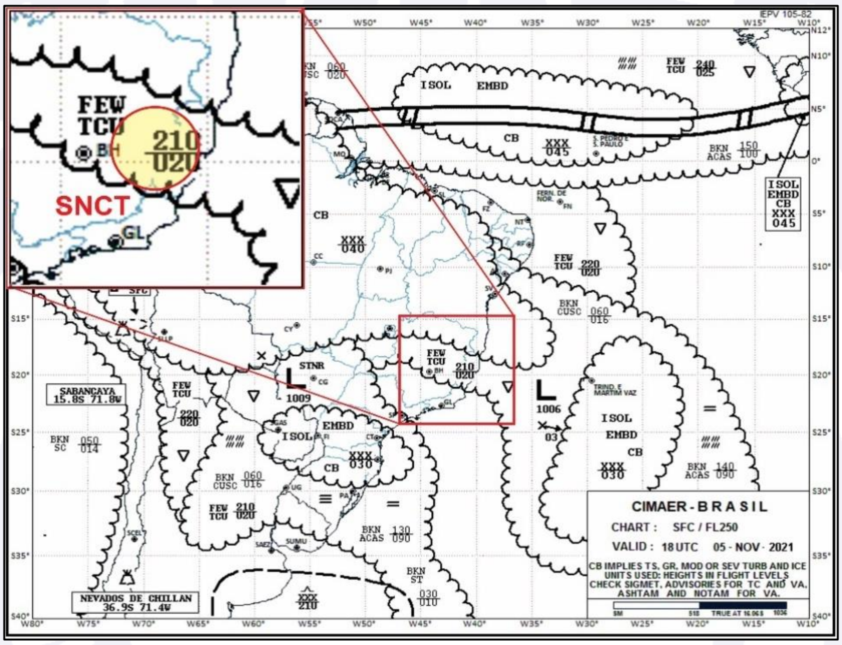

Figure 5 - SIGWX chart of 1800 (UTC), on 05NOV2021. Source: REDEMET.

The METAR from the SBGV and Usiminas (SBIP) Aerodromes, Ipatinga - MG, located, respectively, 50 NM and 28 NM from the accident site, provided the following information:

METAR SBGV 051700Z 15005KT 9999 SCT040 21/31 Q1009

METAR SBGV 051800Z 13005KT 9999 SCT045 22/31 Q1008

METAR SBGV 051900Z 18003KT 9999 SCT045 21/31 Q1007

METAR SBIP 051700Z AUTO VRB03KT CAVOK 32/20 Q1009

METAR SBIP 051900Z AUTO 16003KT 120V200 CAVOK Q1008

SBIP's automatic METAR system did not generate a message for 1800 (UTC). According to the messages generated, the base of the clouds was above 5,000 ft., the horizontal visibility was more than 10 km, and there were neither Cumulonimbus clouds (CB) nor significant weather for aviation; meanwhile, the conditions in SBGV were favorable for visual flights, with a scattered cloud base above 4,000 ft., and a visibility of more than 10 km.

The satellite image at 1810 UTC, on 05NOV2021, channel 16, showed a cloudy sky with medium and high clouds, temperatures between -40 ºC and -50 ºC, indicating cloud tops between 30,000 and 35,000 ft (Figure 6).

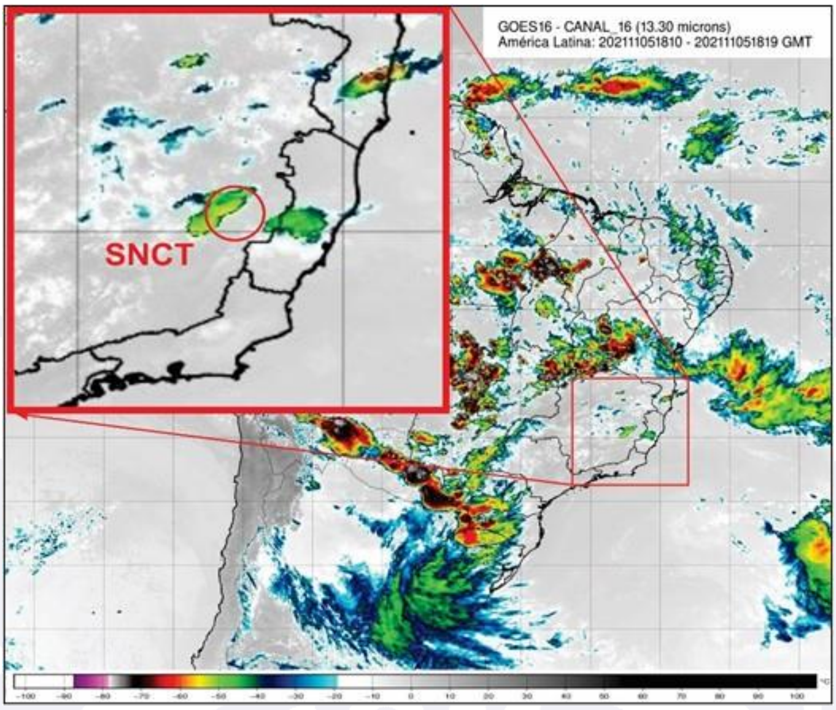

Figure 6 - Satellite image GOES 16 channel 16, from 05NOV2021 to 1810 (UTC).
Source: Adapted from the CPTEC.

In the satellite image of 1810 UTC, on 0 NOV2021, channel 1, a cloudy sky with low clouds was observed west of SNCT (Figure 7).

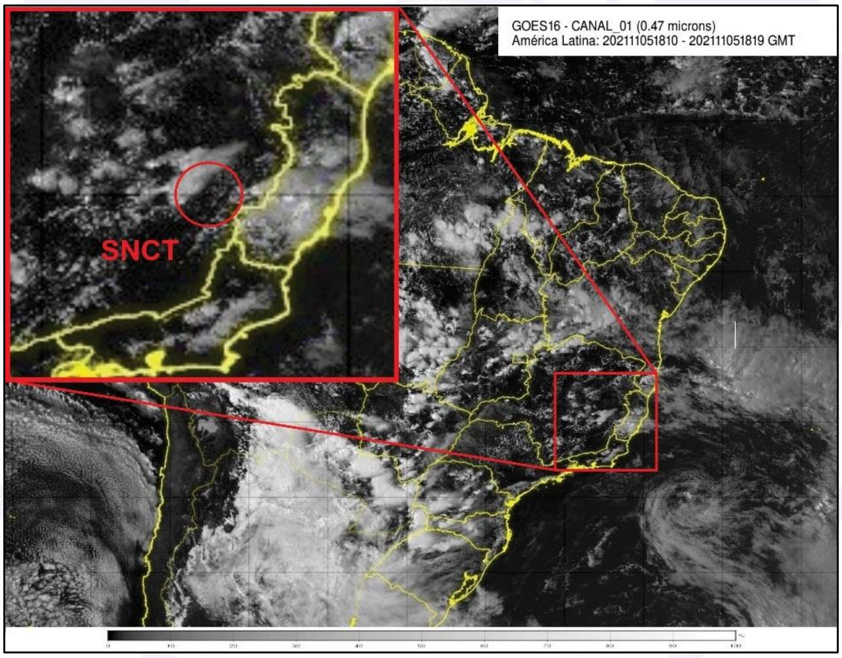

Figure 7 – Satellite image GOES 16, channel 1, from 05NOV2021 to 1810 (UTC).
Source: Adapted from the CPTEC.

The images of the Meteorological RADARs located in Petrópolis - RJ (Pico do Couto); from Almenara - MG; and Três Marias - MG, from 1815 UTC recorded precipitation West of SNCT at distances greater than 21 NM. RADARs did not register precipitation in the SNCT region, at the time of the accident (Figure 8).

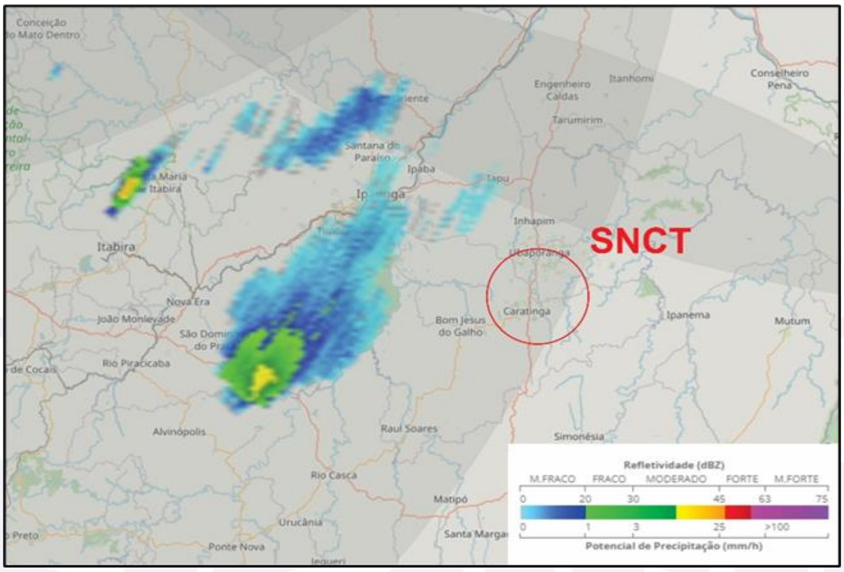

Figure 8 - Summary of the Meteorological Radars of Pico do Couto - RJ; from Almenara - MG; and from Três Marias - MG from 1815 (UTC). Source: adapted from REDEMET.

The surface winds on 05NOV2021, at 1810 UTC, in the region of Caratinga - MG, were blowing from the South and Southeast quadrants with an average speed of 3 kt. Also, no significant variations in wind intensity and direction were observed at heights up to 2,500 ft.

Based on all the information collected, it was found that the meteorological conditions were favorable for the visual flight in the SNCT region.

1.8. Aids to navigation.

Precision Approach Path Indicator (PAPI).

RBAC No. 154 - "Aerodrome Project", Amendment 07, of 01JUL2021, had the following provisions in requirement 154.305(j):

> 154.305 - Lights
>
> [...]
>
> (j) Approach slope indicator visual systems
>
> (1) Application
>
> (i) A visual-approach ramp indicator system must be intended to assist in approaching a runway, whether or not the runway has other visual or instrument aids when one or more of the following conditions are present:
>
> (A) the runway is used by turbojets or other aircraft with similar approach guidance requirements;
>
> (B) The pilot of any aircraft type may have difficulties in judging the approach due to the:
>
> (1) Inadequate visual guidance, such as during approaches over water or terrain without visual cues during the day or in the absence of sufficient external lights in the approach area at night; or
>
> (2) erroneous information, such as that produced by neighboring land with illusory characteristics or runway slopes;
>
> (C) the presence of objects in the approach area that could pose serious hazards if an aircraft descends below the regular approach path, especially if there are no visual or instrument aids to warn of such objects;
>
> [...]
>
> (iv) PAPI or APAPI systems must be made available when the code number is 1 or 2 when one or more of the conditions specified in paragraph 154.305(j)(1)(i) are present.

In the case of the SNCT Aerodrome, the application of the requirements of the RBAC 154 was subject to the "Transitional Provisions" in its item 154.601, which provided for the following:

> 154,601 Transitional Provisions
>
> (a) Subject to the provisions of paragraph 154.5(d), airport facilities existing before 12MAY2009 must conform to the provisions of this Regulation, and airport facilities established after 12MAY2009 must conform to the requirements entered or modified by Amendment to this Regulation in the following situations:
>
> (1) when replaced or upgraded after that date to accommodate more demanding operations or critical new aircraft operations;
>
> (2) when the ANAC establishes a deadline for compliance with the airport operational certification process;
>
> (3) when the ANAC establishes a deadline for adequacy in airport concession contracts;
>
> (4) when the ANAC establishes a deadline for adequacy in specific infrastructure adequacy programs; or
>
> (5) when the ANAC establishes a deadline for adequacy in proven exceptional hypotheses, because of identified high operational risk.
>
> (b) As long as they do not fall under the hypotheses of paragraphs 154.601(a)(1) to 154.601(a)(5) or in a specific transitional provision established in section 154.601, the existing airport facilities may be maintained: (our emphasis)
>
> (1) under the conditions of the respective registration; or
>
> (2) under the conditions of its implementation and the requirements in force on the date of its operationalization for installations not subject to the registration process or cadastral alteration. (our emphasis)

Since the SNCT Aerodrome had its homologation on 25JUN1992 and has not been subjected to the situations of paragraphs 154.601(a)(1) to 154.601(a)(5) since its opening to air traffic, requirement 154.305(j) was not mandatory on the date of the accident.

As an illustration, the MANINV-Brazil, in item 13.1.1, described the VASIS/PAPI as ground devices that used white and red lights to define a visual ramp during the visual approach, as shown in Figure 9.

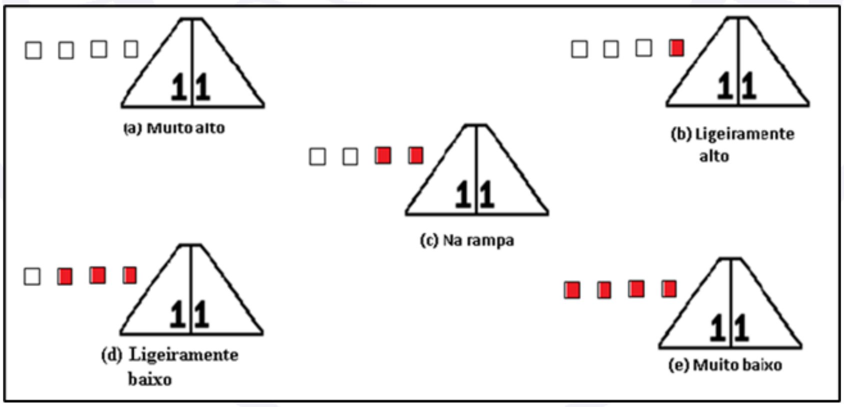

Figure 9 - PAPI system indications in a final approach. Source: MANINV- Brazil.

Under standard conditions, the final approach area of these systems had a 10° swath on either side of the runway centerline, measured from the nearest light bar or box to the runway threshold, extending from the runway threshold to a point on the final approach, at a minimum distance of 4 NM. However, the particularities of the place could indicate parameters different from the established standard.

Item 13.9.5 of the MANINV recommended that the system's regular approach ramp should provide clearance above all obstacles within the approved coverage area.

Item 13.10 of the MANINV, which dealt with VASIS/PAPI tolerances, usually advised that an angle of 3° should be established to be used as a regular approach ramp.

If it was necessary to establish a larger angle to avoid obstacles, or a smaller angle to meet special requirements (military or private Aerodromes), the issuance of a NOTAM should be requested.

ICA 63-18 of 2020 - “Criteria for the Implementation of Operational Agencies, Air Navigation Aids and Support Systems for ATS Bodies” in force at the time of the accident, in its item 6.7.1, defined the following criteria for the PAPI implementation:

> 6.7.1 The following criteria must be met:
>
> a) Aerodrome operated by regular international airlines with medium and large aircraft, at the threshold whose annual number of landings is equal to or greater than 5,000;
>
> b) Aerodrome with the operation of regular regional airlines, at the threshold whose annual number of landings is equal to or greater than 5,000;
>
> c) Aerodrome with the operation of general or military aviation aircraft, at the threshold whose annual number of landings is equal to or greater than 5,000; or
>
> d) Aerodrome of strategic interest defined by the DECEA.

Thus, since the SNCT Aerodrome had a volume of landings of less than 5,000 per year and there was no strategic interest defined by the DECEA, it did not meet the criteria of the ICA 63-18 for the implementation of the PAPI.

Aeronautical Information Published.

Official aeronautical information from SNCT was available on the AISWEB and aimed to assist airmen in planning and performing flights in Brazilian airspace.

In that Portal, the ROTAER manual established that the traffic circuit should be carried out by the Aerodrome Western sector as a regulation for local traffic.

In addition, the information on the Portal showed, through Temporary Information on Aerodromes and Helipads published exclusively on ROTAER (INFOTEMP), that there were unlit obstacles (tower and antenna), which were violating the PBZPA, at coordinates 19°45'25.28” S /042°07'45.19” W and 19°45'25.81” S/042°07'45.48” W, both with an elevation of 729 m (2,392 ft).

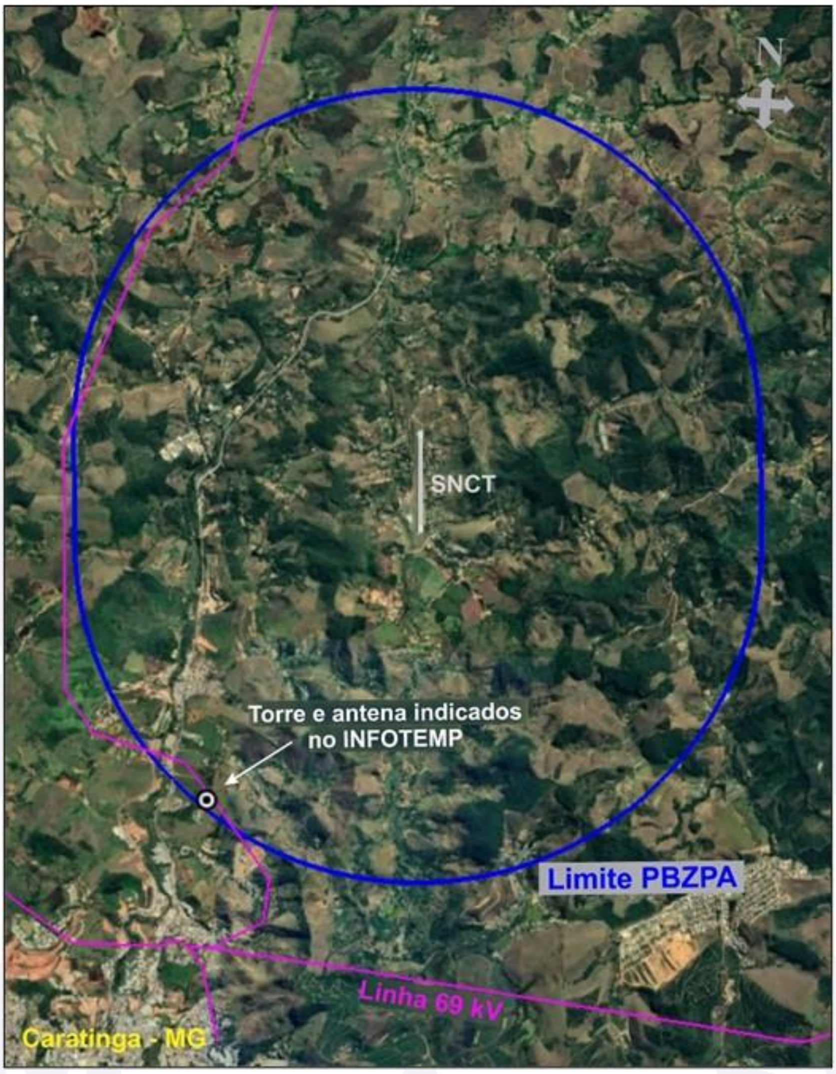

Figure 10 - Tower location indicated in the INFOTEMP.

ICA 53-4 - "Request for Disclosure of Aeronautical Information" of 12MAR2019, in its item 1.3.27, defined "obstacle" as follows:

> Any object of a permanent or temporary nature, fixed or mobile, or part thereof, that is located in an area intended for the movement of aircraft on the ground or that extends above the surfaces intended for the protection of aircraft in flight or, even that is outside or below these defined surfaces and causes an adverse effect on the safety or regularity of air operations. (our emphasis)

According to Table 3-1 of ICA 63-19 - "Aerodrome Area Technical Analysis Criteria (AGA)" of 04JAN2021, the adverse effect of the OPEA was characterized by some conditions in each of the following respects:

- aerodrome control service;
- physical characteristics of the Aerodrome;
- air navigation aids;
- air operations; and
- flight safety.

As the Aerodrome did not have an Aerodrome control service, clear zone, or aids to air navigation, the aspects "Aerodrome control service", "physical characteristics of the Aerodrome" and "aids to air navigation" were not applicable, with the remaining aspects applicable of "air operations" and "flight safety", which were directly related to the limits of the PBZPA.

Since the 69 kV line was outside the limits of the ZPA established by the PBZPA, it was not characterized as an obstacle that could have an adverse effect on the safety or regularity of the air operations at the Aerodrome, not being eligible for publication of information concerning the SNCT Aerodrome.

Although not included in the specific information of the SNCT Aerodrome, the 69 kV power grid on which the PT-ONJ aircraft collided was presented in the WAC 3189 and the CAP 9453 (Figures 11 and 12).

Figure 11 - 69 kV power grid indicated in the WAC 3189.

Figure 12 - 69 kV power grid indicated in CAP 9453.

Items 14.1.1 and 17.1.1 of the ICA 96-1 - "Aeronautical Charts" of 08JUL2020 described the following purposes for the WAC and CAP Charts:

> 14 WORLD AERONAUTICAL CHART - WAC 1:1,000,000
>
> 14.1 PURPOSE AND AVAILABILITY
>
> 14.1.1 This chart provides information that meets the needs of air navigation supported by visual reference. In addition, the WAC has information that can be used for pre-flight planning purposes and as a basis for other chart preparation intended for air navigation. (our emphasis)
>
> [...]
>
> 17 AERONAUTICAL PILOTING CHART (CAP) AND AERONAUTICAL PILOT IMAGE CHART (CIAP)
>
> 17.1 PURPOSE AND AVAILABILITY

17.1.1 These charts are intended to meet the needs of visual flight for air operations at low altitudes and short distances within the scope of the Brazilian Air Force (FAB), which require peculiarities of the representation of visual references in scale. It also serves other small civil aviation activities. (our emphasis).

1.9. Communications.

According to the recordings, it was verified that the aircraft maintained full radio contact with the air traffic control agencies and that there was no technical abnormality in the communication equipment during the entire flight.

The PT-ONJ's communication with the ACC-Brasilia was carried out in a coordinated and clear manner.

The initial contact with the ACC-BS took place at the moment of the sector transfer at 17:49:25 UTC. Subsequently, the ACC-BS instructed the PT-ONJ to maintain FL210 and call when ready to descend.

At 17:49:57 (UTC), the AAC-BS authorized the descent of the PT-ONJ to FL 150. The ATS agency added that the descent below this level was at the crew's discretion, requesting that it be reported when in VMC for a change of flight plan rules.

At 17:56:59 (UTC), the ACC-BS interrogated the PT-ONJ, informing that the RADAR service was closed on the 093º radial, 60 NM away from the Confins VOR (CNF), and requested it to report VMC for plan modification. Then the PT-ONJ reported that it was going to cross FL150, which was visual, and proposed the flight plan under IFR cancellation.

In the last contact made with the ACC-BS, this control agency confirmed the cancellation of the IFR flight plan at 1757 (UTC) and informed that it was unaware of traffic that would interfere with the descent of the PT-ONJ aircraft, releasing it from that Area Control Center frequency.

1.10. Aerodrome information.

The Caratinga Aerodrome (SNCT), Ubaporanga - MG, was public, managed by the Ubaporanga City Hall - MG, and operated under VFR during the day.

It was not possible to precisely identify when the Aerodrome was open to air operations. However, the Investigation Team identified a homologation Ordinance n° 326/SOP, dated 29JUL1987, when its call sign was still SNXG.

Subsequently, this ordinance was revoked by the Aerodrome Homologation Ordinance No. 229/SOP, dated 25JUN1992.

According to what was stated in the ROTAER, the runway was located at an elevation of 599 m (1,965 ft), was made of asphalt, with thresholds 02/20, and had 1,080 x 23 m.

The windsock was in a visible place, located in the middle third of the runway.

The Aerodrome was located in a mountainous region, with several elevations in the vicinity of the runway.

Figure 13 - Relief around the Caratinga Aerodrome observed from the approach sector to threshold 02.

According to reports from local operators, given the topographic characteristics of the Aerodrome and region, it was common for calm winds to prevail, aligned with the runway.

Aerodrome Protection Zone Basic Plan (PBZPA) of SNCT.

The Protection Zone Plans were a set of plans used to discipline land occupation such as:

- Aerodrome Protection Zone Basic Plan (PBZPA);
- Aerodrome Protection Zone Specific Plan (PEZPA);
- Helipad Protection Zone Basic Plan (PBZPH);
- Airplane and Helicopter Special Route Protection Zone Plan (PZPREA/H); and
- Air Navigation Aid Protection Zone Plan (PZPANA).

One of the elements that made up the PBZPA was the SPVV, whose purpose was to protect the aircraft that performed the Aerodrome traffic circuit for visual approaches.

For the establishment of the SPVV of the SNCT Aerodrome, "Category B" was considered a critical performance aircraft parameter, as provided in Table 4-2 - "Aircraft Performance Category" contained in ICA 11-408 - "Restrictions on Objects Designed in Airspace That May Adversely Affect the Safety or Regularity of Air Operations" (Figure 14).

TABELA 4-2 – Categoria de Performance de Aeronaves

Categoria	Velocidade de Cruzamento da Cabeceira (V_{at})(1)
A	V_{at}< 169 Km/h (91 Kt)
B	169 Km/h (91 Kt) < V_{at}< 224 Km/h (121 Kt)
C	224 Km/h (121 Kt) < V_{at}< 261 Km/h (141 Kt)
D	261 Km/h (141 Kt) < V_{at}< 307 Km/h (166 Kt)
E	307 Km/h (166 Kt) < V_{at}< 391 Km/h (211 Kt)
H	Não aplicável

(1) Velocidade de cruzamento da cabeceira baseada em 1,3 vezes a velocidade de estol ou 1,23 vezes a velocidade de pouso na configuração e peso máximo certificado.

Figure 14 - Table 4-2 in ICA 11-408.

To define critical aircraft, the ICA 11-408 adopted the following concept:

2.1.7 CRITICAL AIRCRAFT

An aircraft in operation or expected to operate at a given Aerodrome that demands the highest requirements in terms of configuration and dimensioning of the airport infrastructure due to its physical and operational characteristics.

Thus, according to table 4-4 of the ICA 11-408, the dimensions of the SPVV were determined based on values established in the table shown in Figure 15.

TABELA 4-4 – Dimensões da Superfície de Proteção do Voo Visual – PBZPA

ÁREAS(1)	TODOS OS TIPOS DE OPERAÇÃO				
	Categoria de Performance de Aeronave(2)				
ÁREA(1)	H	A	B	C	D e E
Altura mínima do circuito de tráfego (m)	H(3)	H(4)	H(4)	H(4)	457
Largura (m)	2350	2350	2780	4170	7410
Buffer* (m)	470	470	470	930	930
Comprimento (m)	2350	2350	2780	4170	5560
Seção de Través					
Altura (m)	H - 76	H - 152	H - 152	H - 152	305
Seção de Aproximação e Decolagem					
Altura (m)	H - 99	H - 198	H - 198	H - 198	259

(1) A não ser que exista proibição de operações de helicópteros, todos os aeródromos deverão possuir uma superfície de operação VFR para a categoria da aeronave de asa fixa de projeto e outra superfície de operação VFR para a categoria H. A nomenclatura das áreas será a mesma da categoria de performance aplicada (Área H, Área A, Área B, Área C e Área D)

(2) Para os aeródromos cuja a categoria da aeronave de projeto seja D ou E, serão aplicados os valores de altura das seções de través e de aproximação e decolagem somente a partir do limite da superfície de operação VFR para categoria C.

(3) O valor da altura mínima do circuito de tráfego pode ser 152 ou 183 metros.

(4) O valor da altura mínima do circuito de tráfego pode ser 305, 335, 366, 396, 427 ou 457 metros.

** o termo "buffer" é utilizado na elaboração de procedimentos à navegação aérea e está relacionado com uma margem adicional de segurança.*

Figure 15 - Dimensions of the Visual Flight Protection Surface for critical aircraft, of "Category B".

The elements that made up the ZPA, including the SPVV, were related to aspects of airport planning and not the current operation of aircraft. Thus, the SNCT SPVV prevised a height for the traffic pattern of 396 m (1,299 ft).

Figure 16 illustrates the limits of the SNCT ZPA in blue, together with the SPVV's 1 and 2 represented by the areas inside the rectangles in orange, and the approach surfaces for thresholds 02 and 20 in cyan.

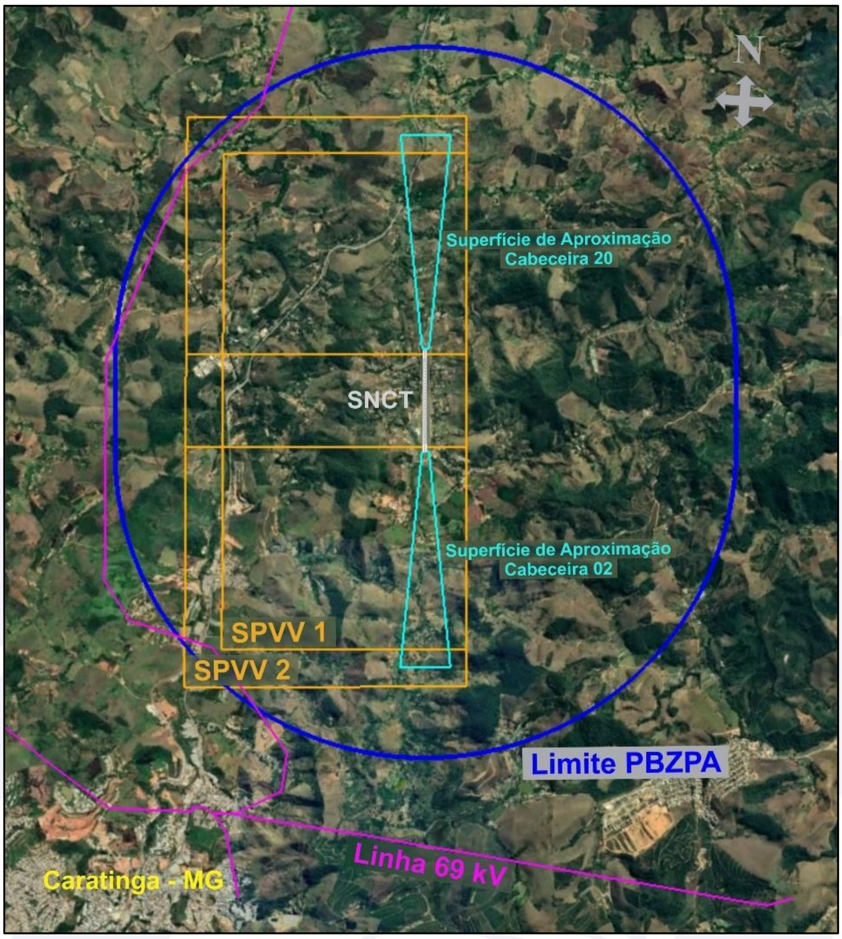

Figure 16 - Representation of the PBZPA at the Caratinga Aerodrome.

Regarding the distance from SPVV2 and from the approach surface to runway 02, it was verified that the distance corresponded to 1.5 and 1.4 NM, respectively.

1.11. Flight recorders.

RBAC No. 135 - "Public Air Transport Operations with Airplanes with Maximum Certified Configuration of Seats for Passengers of up to 19 Seats and Maximum Capacity of up to 3,400 kg (7,500 lb.)" established the following requirement for the installation of a CVR on aircraft:

> 135.151 In-cabin voice recorder
>
> (a) A multi-engine, turbine-powered aircraft having a passenger configuration of six or more seats and for which two pilots are required by certification or operating rules is only permitted if it is equipped with a voice recorder approved in the cockpit that: (our emphasis)
>
> [...]

The operation conducted by the operator required two pilots and according to the design of the PT-ONJ aircraft, the maximum configuration for passengers would be six seats. However, the aircraft was configured with five seats for passengers.

Concerning the installation of FDR, it was required for aircraft with a configuration for passengers from 10 to 19 seats and that had been manufactured after 11OCT1991, according to section 135.152 (a) of the RBAC 135.

Therefore, given the configuration of five seats for passengers incorporated into the aircraft it was found that the installation of flight recorders in the PT-ONJ was not required. So, they were not installed.

1.12. Wreckage and impact information.

The first impact of the aircraft occurred against a lightning arrester cable located in the gap between towers 8 and 9 of the 69 kV Caratinga power grid - PCH “Pipoca”.

According to observers’ reports, after impacting the cable, the aircraft would have entered an abnormal attitude, with high angular variations in altitude and inclination.

The aircraft collided with the rocky terrain with high energy on the banks of a waterfall, about 730 m ahead of the lightning arrester cable.

No points of contact between the aircraft and the ground were identified in the section between the impact point against the lightning arrester and where the aircraft stopped.

There were no reports of explosions or flames at the site, but a strong odor of fuel was reported in the vicinity of the wreckage spot.

The left engine detached from the wing still in flight due to inertial and impact forces, coming to rest at a distance of about 85 m ahead of the aircraft (Figure 17).

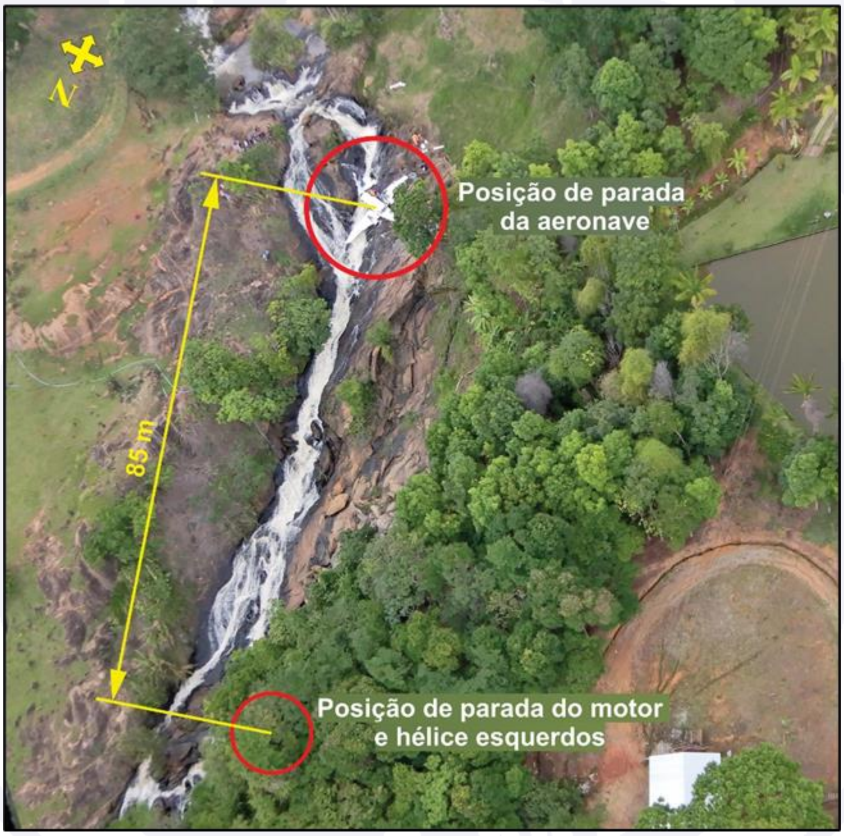

Figure 17 - Identification of the location of the fall and stop of the left engine/propeller.

The right engine detached from the wing upon impact with the ground and stopped about 9 m ahead of its attachment point on the aircraft, being partially submerged in the waterfall (Figure 18).

Figure 18 - Identification of the stop location for the right engine/propeller.

The auxiliary landing gear along with some fragments of the forward section was also detached and came to rest about 30 m ahead.

Except for the engines, auxiliary landing gear, and small parts of the fuselage, most of the wreckage was concentrated where the aircraft stopped. The structure had several deformations, folds, dents, and fractures, mainly due to the impact against the ground.

Figure 19 - Location of the final stop and damage to the aircraft structure.

The angle of the flaps identified in the wreckage was compatible with the APPROACH position (Figure 20).

Figure 20 – Left-wing flap position after impact with the ground.

The studies performed did not indicate a precise estimate of the behavior and angular variations of the aircraft in the trajectory between the point of impact against the lightning arrester cable and its place of stop.

However, considering the extent of the damage, the pattern of deformation of the fuselage and wings, as well as the reduced distance traveled in flight after the impact against the lightning arrester, it was concluded that the aircraft had a strong deceleration in its horizontal speed still in flight, and impacted the ground with a high sink rate, with a high lateral inclination to the left and an attitude close to the leveled one.

1.13. Medical and pathological information.

1.13.1. Medical aspects.

The PIC had valid first-class CMA. He was 56 years old and had carried out his last INSPSAU on 20NOV2020, in a clinic accredited by the ANAC.

According to the INSPSAU result, he was physically and mentally healthy and considered fit to perform aerial activities, with the indication of using corrective lenses (H52.2 - astigmatism). It was not possible to confirm whether he was wearing corrective lenses at the time of the accident.

The SIC, in turn, had a valid first-class CMA. He was 37 years old and had performed his last INSPSAU, on 24SEPT2021, at an ANAC-accredited clinic.

According to the INSPSAU result, he was healthy physically and mentally and considered fit to perform aerial activities.

According to information collected in post-accident interviews, none of the pilots had commented on any health problems.

None of them smoked or consumed alcohol did not use any medication for continuous use and did not show signs of stress or fatigue. Also, they were not seen as stressed people. They were considered quite centered and professional.

According to the flight schedule, the PIC was off on the 1st and 2nd of November, being called to fly between the 4th and 6th of the same month.

On the day before the accident, the PIC flew from Brasilia - DF, to Uberlândia - MG, in the C208 aircraft, totaling 2 hours and 45 minutes (round trip), having fulfilled the regulatory rest period prevised in the RBAC n° 117 - “Requirements for Risk Management of Human Fatigue” - Amendment No. 00, of 13MAR2019.

The SIC was off duty on the same days as the PIC and on-call on 04NOV2021, but he was not called that day.

According to reports from people close to them, the pilots had a regular sleep routine, with adequate hours per night. Likewise, there was no change in their routine the 48 hours before the accident.

After the accident, toxicology tests (drugs and/or metabolites, drugs of abuse, and pesticides) and ethanol dosage tests were performed. The presence of the investigated substances was not detected in the samples collected.

The expert examination concluded that the cause of death of the pilots was blunt force trauma. Based on the necropsy reports, and after evaluating the severity and diversity of the injuries presented, it was concluded that the injuries were fatal, with immediate death resulting from the impact forces.

Vision Physiology and Vision Acuity.

Given the collision of the aircraft against the lightning arrester cable, it is necessary to explain some aspects related to the physiology of vision, visual acuity, and the distance that the human eye can identify and perceive an object.

The visual system, stimulated by light, must primarily perform three basic functions: it must be able to perceive an object by detecting light emitted or reflected from it (light discrimination); it must be able to perceive the details of an object (visual acuity); and it must allow one to judge distances of objects and perceive movement in the visual field (depth perception). Visual acuity and depth perception combined are referred to as spatial discrimination.

Visual acuity is influenced by the refractive state of the eye. The most common refractive errors that can compromise visual acuity and depth perception include myopia, hyperopia, astigmatism, and presbyopia.

As far as depth perception is concerned, one should consider that it can be distorted by optical illusions. Higher wires, for example, appear to be farther away when viewed in combination with lower wires, and this effect is only reduced at distances of less than 100 m, thus leaving little time for the pilot to react.

In summary, vision must be considered one of the most relevant requirements for aircraft operation. It is essential in all phases of flight, being responsible for the identification of distant objects and the perception of details of shape and color. The visual sense also allows the judgment of distances and the perception of movements in the visual field, which is a fundamental characteristic for the correct determination of the aircraft trajectory by pilots.

1.13.2. Ergonomic information.

One aspect to be considered for the visibility of an object concerns its size and contrast with the background. The perception of objects is reduced as their contrast decreases in relation to their background and, in this case, an object with lower contrast must have a relevant size or be closer so that it can be more easily perceived.

In the scenario where the accident with the PT-ONJ occurred, it was verified that the power grid had low contrast concerning the vegetation in the background. On the other hand, the tower supporting the line was on a high area and presented a more favorable contrast to its identification (Figure 21).

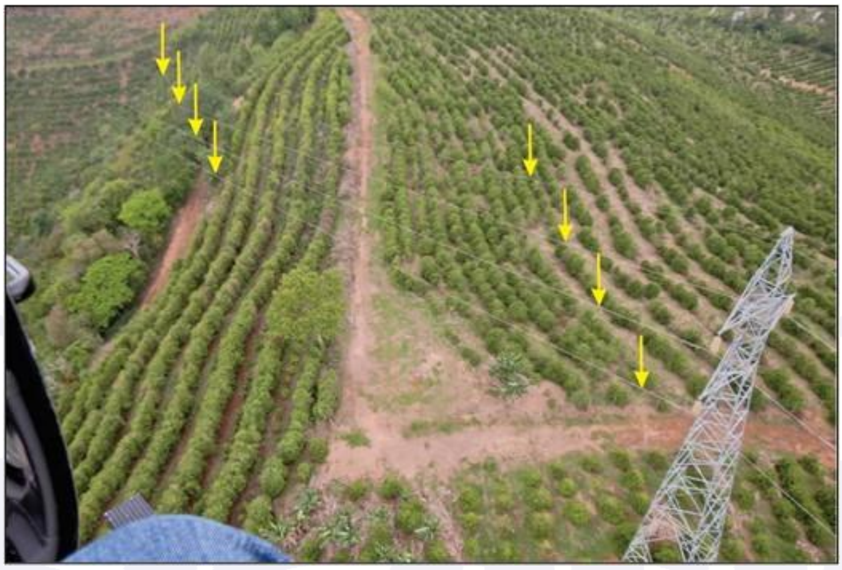

Figure 21 - Demonstration of the contrast of the cables and the tower, in relation to the terrain. The arrows indicate the positions of the cables between the two towers.

Thus, the way to compensate for a low-contrast condition must be considered through signage that allows the identification of objects at greater distances.

1.13.3. Psychological aspects.

The PIC was considered by family members and people close to him as a calm, charismatic, committed person who, in his free time, dedicated himself to his family and religion.

On 20JUN2020, he was hired by the operator, indicated by a company employee, and after participating in the selection process, he was hired without restrictions. He was assigned to the function of the commander of aircraft C208 in 30JUN2020 and of C90/C90A in 19SEPT2020.

According to reports gathered, the PIC was satisfied with his job because he identified himself with the work environment. Besides, he was managing to devote himself to his family because of the fewer working hours, and the fact that the operator's base was close to his residence.

In the work environment, he was seen by colleagues and managers as a standard professional, as he demonstrated technical rigor and was concerned about following all the operator's procedures to the letter. He also had no history of interpersonal problems with coworkers.

Regarding his operational history, the Investigation Team verified that the PIC had worked from 19MAR2007 to 01SEPT2017 in a company governed by the RBAC 121 as a copilot of A-319/320.

According to the data collected, at a certain moment, he had low performance in training sessions conducted in flight simulators in the role of Pilot Flying. The difficulties presented were related to his manual flying skills, situational awareness, and piloting judgment, especially when there was a workload increase during the sessions.

In the referred training, the instructors' orientations were directed to him to seek an evolution in the refinement of his piloting, cabin management improvement, and situational awareness in abnormal situations.

Being oriented, the PIC presented a satisfactory evolution after the feedback but needed reinforcement when his performance dropped.

On the other hand, his record revealed good performance as Pilot Monitoring (PM), with good monitoring, assertiveness, and teamwork.

In 2019, the PIC underwent a psychological evaluation for CMA revalidation, and on that occasion, the Personality, Attention, Memory, and Reasoning tests were applied, which had a "Favorable" result.

Regarding compliance with the Air Taxi Operator Training Program, his practical evaluations of the training performed revealed satisfactory results and no relevant observations.

About the SIC, he was considered, by people he knew, as a hardworking professional, self-taught in aviation matters, and that sought new knowledge to keep himself updated. In his free time, he dedicated himself to his family and studies.

On 10APR2021, the SIC was hired by the operator, also indicated by a company employee, and after taking part in the selection process, he was hired without restrictions. At the time of hiring, there was the expectation of his promotion to the role of Commander in the medium term, and thus, he accepted the offer for the copilot position.

In the operator's environment, he was considered, by his peers and managers, as a professional who stood out for his professional commitment and technical capacity.

With regard to his operational background, the Investigation Committee verified that he had had previous experience as a pilot of single-engine aircraft in another air-taxi operator in the period from 03NOV2011 to 10AUG2015.

Between 2015 and 2021, the SIC assumed a position as instructor in simulators at a Civil Aviation Instruction Center* (**CIAC* in Portuguese).

In 2019, he underwent a psychological evaluation for revalidation of his CMA, having received at the time a “Favorable” result in the Personality, Attention, Memory and Reasoning tests.

According to the information collected, neither of the pilots had any family, personal, financial, or psychological problems that could interfere with their performance in flight.

As for the interactions between the PIC and the SIC, according to the information obtained, the pilots maintained a friendly relationship with each other and, sometimes, commuted to work together, as they lived in Brasília, Brazil’s Federal District. Both of them were praised by their co-workers for their ethical posture and for behaving in a way that favored common sense and collective well-being.

In the period from August to November 2021, they worked together as a crew on nine flights and, the day before the accident in question, they were called on by the operator, and were informed that there would be a celebrity among their passengers.

On the day of the accident, the PIC left home at approximately 10:00 (UTC), and went to SIC’s residence. Then, both of them proceeded to Goiânia, Goiás State, by car, in order to get to the operator’s base around 13:00 (UTC).

A pilot of another aircraft that was approaching to land at SBCT reported having heard the communications made by the PT-ONJ, and said to the Investigation Committee that he had not noticed any difference or alteration in the transmissions, suggesting that everything was within normality until that moment.

1.14. Fire.

There was no fire.

1.15. Survival aspects.

The first information received by the rescue team indicated that victims had been seen inside the aircraft through the front windshield.

The access to the site was made through a trail with a slope of approximately 30 meters in the vegetation that preceded the rocky part of the waterfall.

The initial rescue work was conducted by military personnel from the PMMG and the CBMMG.

Afterward, a medical expert had access to the aircraft's interior and confirmed the death of all occupants.

The aircraft's interior had an extensive detachment of its internal lining, the instrument panel, the floor, and all the seats (Figure 22).

Figure 22 - Extent of damage inside the aircraft.

It could not be determined whether the passengers were wearing their seatbelts. The force of the impact was much greater than the resistance and absorption capacity of both the fuselage and the seats.

Due to the deformation of the fuselage, it was rather difficult to open the main door through which the victims' corpses were rescued.

1.16. Tests and research.

Examinations of aircraft components.

Both visual and stereoscopic examinations were performed on the control cables, engine brackets, indicator lamp filaments, and the filaments of the landing gear light lamps of PT-ONJ.

From the examinations performed on the primary flight control cables, it was observed: the spreading of the wires that composed the cables, different heights of wire breakage, and stranding; were indicative of overloading due to the aircraft impact (Figure 23).

Figure 23 - Aircraft control cables with overload indicator.

In the visual examination carried out on the landing gear control lever, it was observed that it was in the “gear down” position and with the safety lock activated (Figure 24).

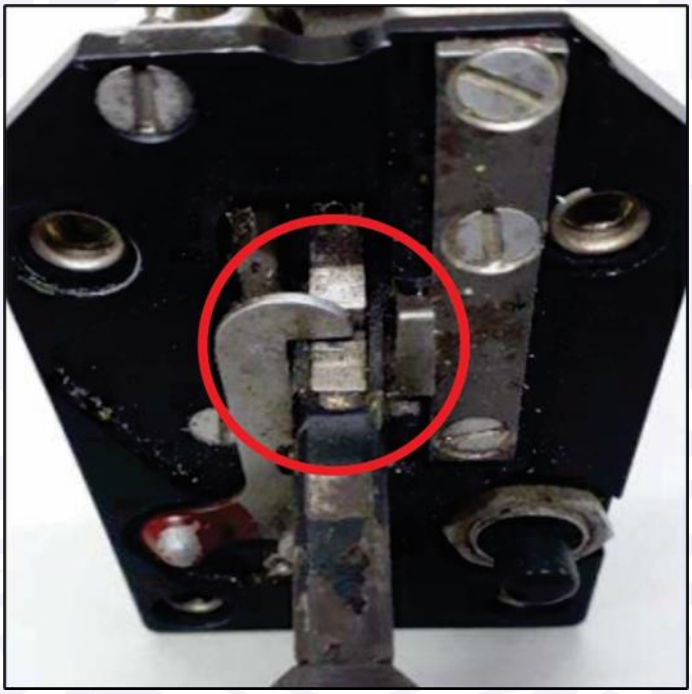

Figure 24 - Landing gear activation lever with protection lock activated.

The landing gear components showed fractures indicative of overloading due to the impact. A tread mark observed on one of the tires indicated that the trains were down at the time of the impact.

The landing gear compartment door showed little damage, indicating that it had not suffered direct impact against the arrester cable.

Examination of the lamps revealed that the filaments of the landing gear lock indicator and headlight had suffered hot plastic deformation, indicating that they had been lit at the moment of impact (Figure 25).

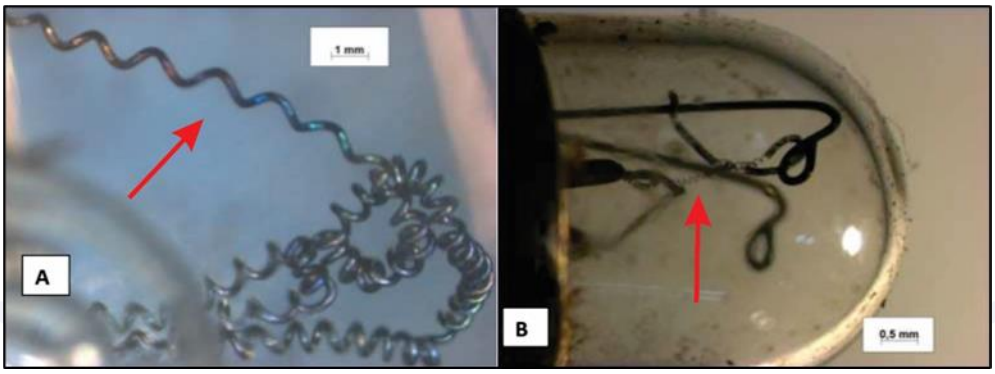

Figure 25 - Photo stereoscopy of the lamp filaments, landing gear headlight (A), and lock indication (B).

The other lamps of the other systems showed aspects of fragile fracture and natural aging through use, and none showed plastic deformation characteristic of being lit during the impact.

Oil and fuel analysis.

The analysis results indicated that the flash point of the lubricating oil of the right engine was below the specified flash point. This discrepancy could be understood as a possible contamination of the sample, considering that the collected material was in contact with water and fuel at the accident site.

However, because water is not miscible with oil, this possibility was ruled out. What could be admitted is that the aircraft fuel contaminated the lubricating oil.

Assuming the possibility that the fuel contaminated the oil, the flash point of the oil would be reduced because the flash point of aviation kerosene starts at approximately 35 ºC. The contact with the oil at its normal working temperature, 80 ºC, may have caused the evaporation of the lower boiling temperature fractions present in the fuel.

Thus, it is possible that only the fractions of the fuel with the highest flash point remained. Thus, when the oil sample was tested, the remaining fuel fractions mixed with the oil may have combusted, causing the flash point of the lubricating oil to be below the minimum specified by the standard during the test.

The other results obtained in the physical-chemical tests on the fuel and lubricating oil samples were in accordance with their respective specifications and showed no signs of contamination.

Engine examinations.

The aircraft was equipped with Pratt & Whitney engines, model PT6A-21, Serial Number (SN) PCE 25594, left side, and SN PCE 025595, right side.

The left engine (PCE 25594) had a TSN of 7,162 hours, CSN of 6,473, TSO of 3,188 hours and 35 minutes, CSO of 2,741, and HSI of 1,339 hours and 40 minutes.

According to the engine logbook, the last record referred to a repair due to lightning incidence, done on 05FEB2020. The TSN at that time was 6,488 hours and 20 minutes and the CSN was 6,091 cycles.

The exams of the left engine revealed that the external part was covered with dirt and organic debris, and that there was a piece of steel cable wrapped around the propeller hub. The front was deformed and twisted upwards, altering the engine shaft (Figure 26).

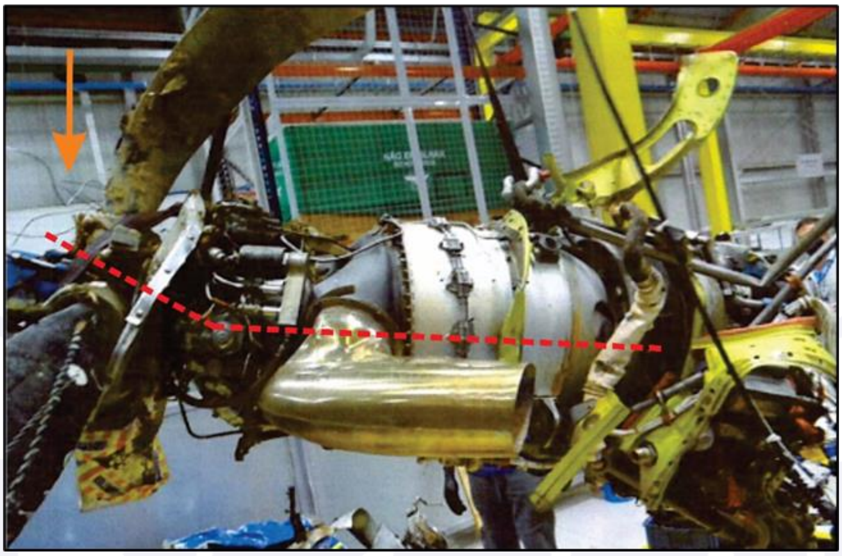

Figure 26 - View of the left side of the left engine without fairing. The dashed line projects the engine's longitudinal axis. The arrow indicates the cable wrapped around the propeller hub.

The analysis of the compressor's rotating assembly revealed rubbing marks on the casing in the region of the compressor's first stage, compatible with the development of power at the moment of impact against the lightning arrester cable (Figure 27).

Figure 27 – View of the rotor of the first stage of the left engine compressor with rubbing marks observed on the housing.

The hot section of the engine was examined in detail. Because this type of engine operates with independent turbines, heavy rubbing marks left by the compressor turbine rotor on the diaphragm were found (Figure 28).

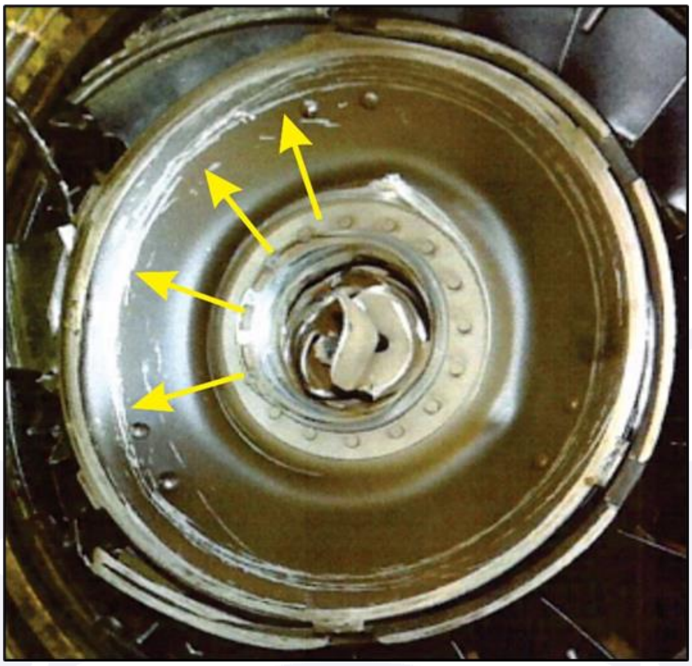

Figure 28 - Anterior view of the left-engine diaphragm with intense rubbing marks.

On the other side of the same diaphragm, facing the power turbine, there were impact marks left by the turbine rotor. The marks indicated that the rotor was stationary the moment the engine suffered compression and the consequent misalignment (Figure 29).

Figure 29 - Rear view of the diaphragm with smooth rubbing and impact marks with the power turbine rotor stopped.

The rupture of the blades of the power turbine rotor, at half the length, corroborates the absence of rotation in that engine section at the moment of the collision against the ground. This is explained by the fact that the left propeller collided with the lightning arrester cable and had its rotation abruptly interrupted (Figure 30).

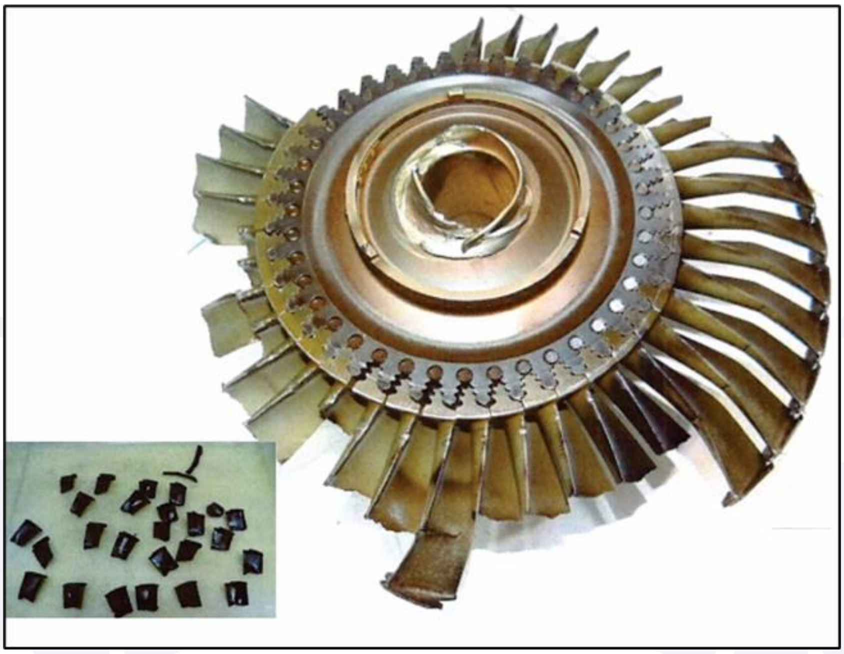

Figure 30 - Front view of the left engine power turbine rotor and part of the blades that were recovered.

Like the rotor, the power turbine stator also showed marks of stopped impact and damage to the fins (Figure 31).

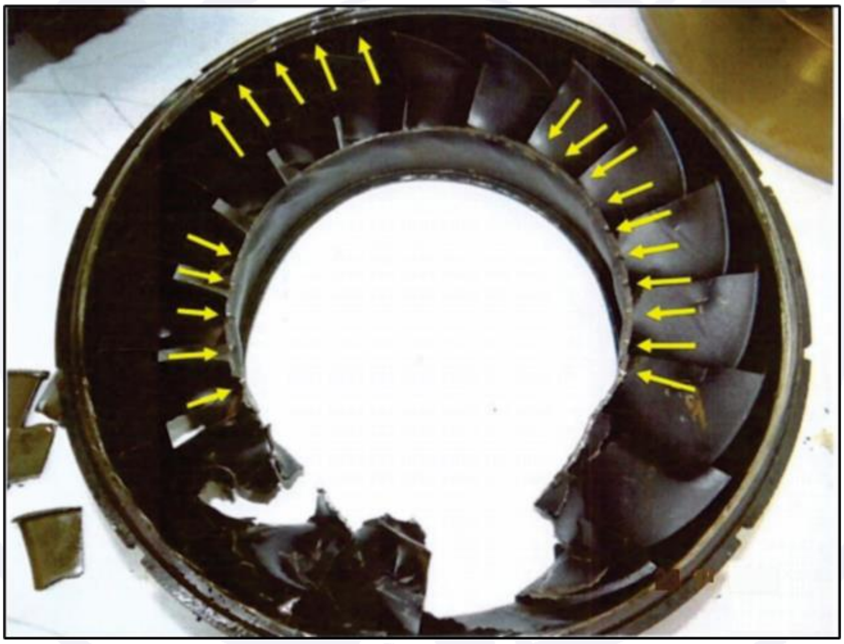

Figure 31 - Rear view of the left engine power turbine stator with stopped impact marks and damage to the fins.

The impact marks with the stopped power turbine rotor appeared due to the locking caused by the lightning rod cable on the propeller. This lock condition passed through the reduction box and reached the engine's power turbine.

In the engine lubrication system, no abnormality was detected that could compromise the engine operation. During disassembly, it was noticed that the internal components, which require lubrication, showed evidence that they worked lubricated all the time (Figure 32).

Figure 32 - Left engine oil filter without abnormalities.

Internally, this engine showed evidence that it was operating normally and developing power the moment the aircraft collided with the lightning arrester cable.

Analysis of the left engine propeller showed that initially, the lightning arrester cable hit the spinner and sectioned it. Then, the spinner was pulled from its attachment point to the propeller plate. The lightning arrester cable, when wrapped around the propeller, blocked the servo piston and the propeller blades in the position they were in at that moment of the flight (Figure 33).

Figure 33 - Impact marks on the left engine spinner.

It was observed that the propeller cylinder presented a deformation of about 25 mm from its base (Figure 34).

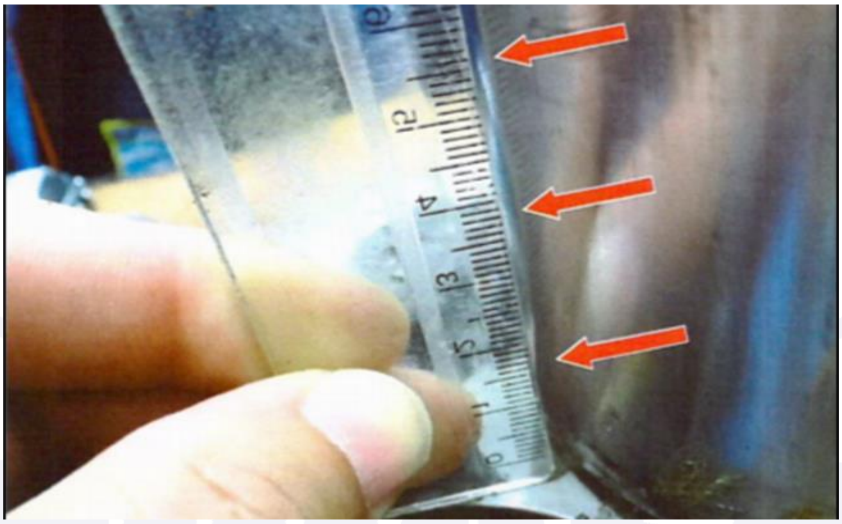

Figure 34 - Deformation observed at the base of the left engine propeller cylinder.

This deformation indicates that the servo piston was displaced from its rest position and that hydraulic wedging occurred at the instant of the collision. The observed marks indicated that the servo piston and propeller blades were out of their rest (feather) position, therefore, in-flight pitch.

The right engine (PCE 025595) had a TSN of 7,015 hours, CSN of 6,312 hours, TSO of 3,043 hours and 35 minutes, CSO of 2,580 hours, and time since HSI of 1,341 hours and 30 minutes.

According to the engine logbook, the last record referred to an inspection performed on 01OCT2020. The TSN at that time was 6,342 hours, and the CSN was 6,142 cycles.

Based on the results arising from the investigative work performed on the left engine, the analysis performed could be extended to the aircraft's right engine, as the internal signatures in both engines were similar.

The right engine's gearbox housing was fractured due to traction overload. The engine exhaust duct showed compressive deformation at the bottom and left side. The remaining surfaces were buckled with dents from inside to outside near the left outlet. The exhaust ducts were severely damaged (Figure 35).

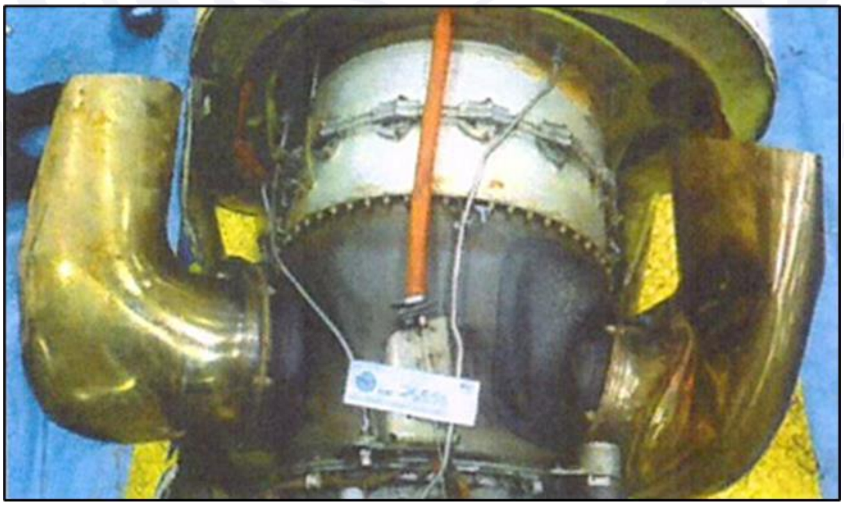

Figure 35 - Detail of the deformations of the lower part of the exhaust duct of the right-hand side engine.

Upon being examined internally, the right-hand side engine revealed no evidence of malfunctioning of the lubricated components. All the bearings looked normal, showing that there were no problems with the lubrication system and that there were no problems with the lubricating oil.

On the right engine propeller, it was observed that there was a collision of the lightning arrester cable against the spinner, causing a deformation below the dynamic counterweight. As a result, the perforation of the spinner by the dynamic counterweight caused it to remain in the position it was in at the moment of impact (Figure 36).

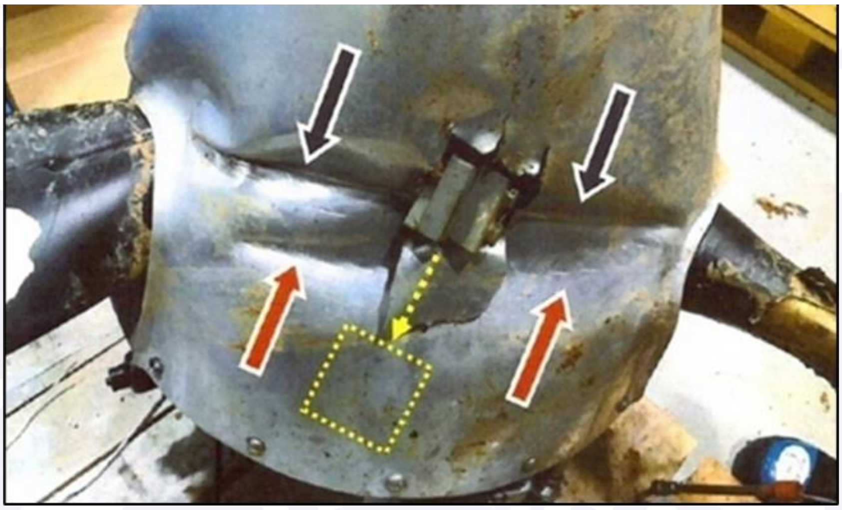

Figure 36 - Lightening arrester cable mark left on the right engine spinner.

The deformation observed in the upper part of the dynamic counterweight, indicated by the black arrows, was understood to result from the compression suffered by the spinner upon impact. The dashed square shows the probable position it should be in if the propeller were in the feather position.

Finally, the analysis of both Pratt & Whitney engines, model PT6A-21, SN PCE 25594, and SN PCE 025595, which equipped the Beechcraft King Air C-90A, registration PT-ONJ, indicated that the internal signatures found indicated that both were operational. They also indicated that both were developing power at the instant of the collision with the lightning arrester cable.

Analysis of the impact of the engines against the Power Grid Cables.

The left engine, which was located about 85 m ahead of the aircraft, had part of the power grid's lightning arrester cable wrapped between the spinner tray and the propeller blade clamps (Figure 37).

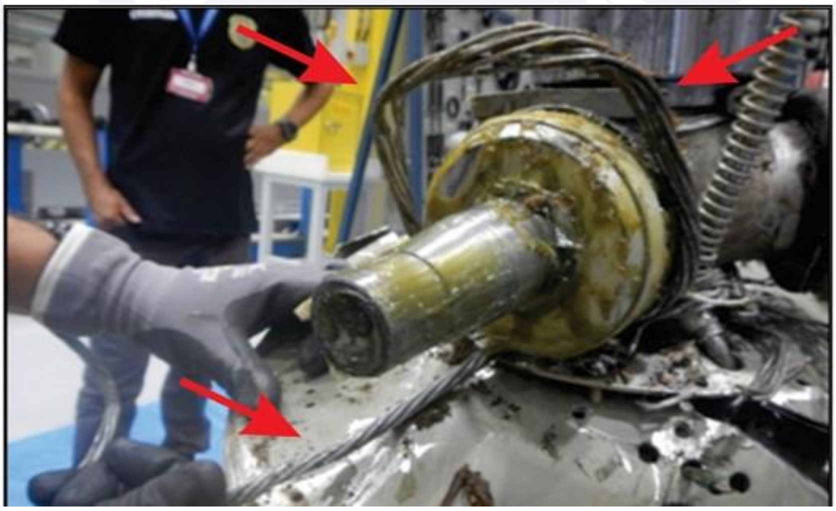

Figure 37 - Lightning arrester cable wrapped around the left engine propeller shaft, indicated by red arrows.

An approximately 8.0 mm diameter and about 4.20 m long section of the power grid lightning arrester cable was removed from the left engine propeller shaft.

The Investigators collected two sections of approximately 4.0 m of the same lightning arrester cable from the power grid to perform tests and compare the fracture characteristics and the maximum breaking strength of the steel cable.

The fractures of the steel cable wires submitted to the tensile test were compared with the fractures of the cable removed from the aircraft engine shaft. The results were similar. In both cases, the wires that make up the steel cable underwent stress in the axial direction and were plastically deformed with a reduction in the cross-sectional area, indicating overload (Figure 38).

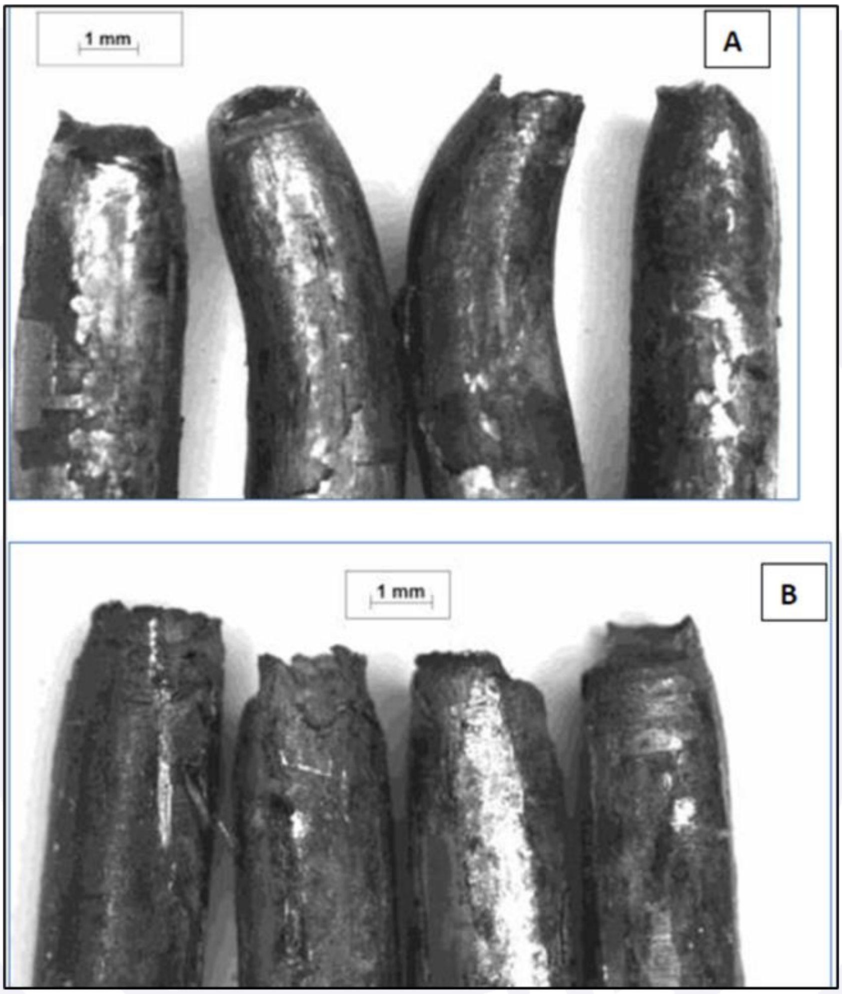

Figure 38 – Photo stereoscopies of the cable removed from the engine shaft (A) and cable submitted to the traction test (B).

Therefore, it was found that the cable removed from the left engine shaft of the crashed aircraft suffered traction effort, at both ends, above its resistance limit.

Considering the marks left by the cable on the spinners and the fuselage, it was verified that the aircraft hit the cable with the upper part of the nose, in a position slightly ahead of the projection of the electronic equipment compartment door. This point was located below the pilots' line of sight (Figure 39).

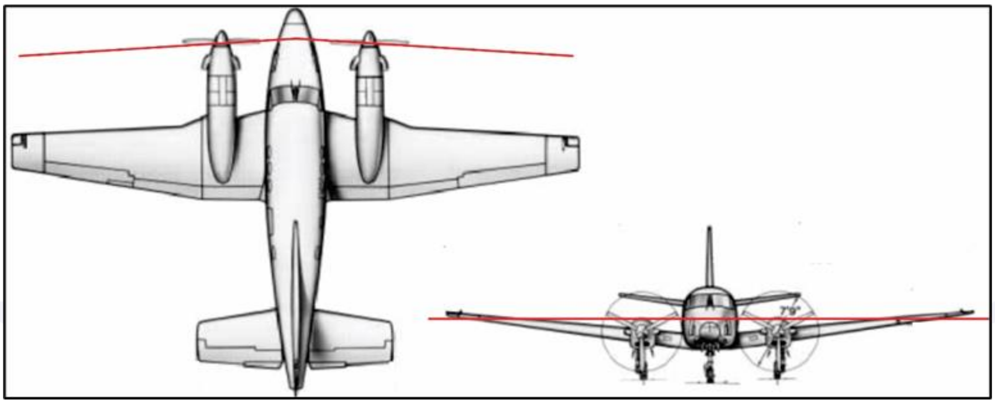

Figure 39 - Illustration of the cable's contact points on the aircraft (the red line represents the lightning arrester cable).

As illustrated in Figure 39 and based on the damage to the spinners, it is concluded that the aircraft had a bank corresponding to that of leveled wings at the moment of impact.

With the breakage of the cable, it rotated, attached to the propellers, and reached the sides of the fuselage, piercing its coating (Figure 40). [Upon breaking, the cable rotated attached to the propellers, and hit the sides of the fuselage, piercing its coating (Figure 40).]

Figure 40 - Contact marks of the cable against the nose of the aircraft. The red arrows point to friction marks, and the yellow arrow shows one of the perforation points in the coating.

In addition, the existence of marks on the propeller blade at different angles indicated that the traction exerted by the cable attached to the propeller shaft moved the left powertrain on its vertical axis, resulting in the mark that is revealed along the entire length of the propeller blade. (Figure 41).

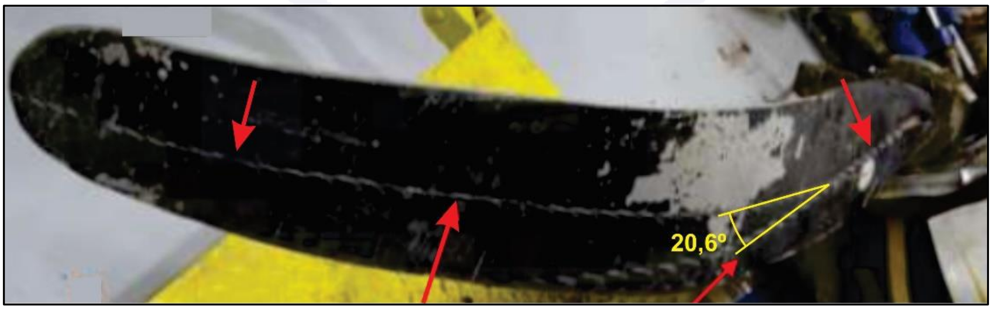

Figure 41 - Details of the impact marks of the cable against the left engine propeller blade.

Examinations performed on the rivets that fasten the engine brackets to the airframe showed fractures by shear mechanism, indicative of the application of force perpendicular to the longitudinal axis of the rivets, characteristic of a shear force (Figure 42).

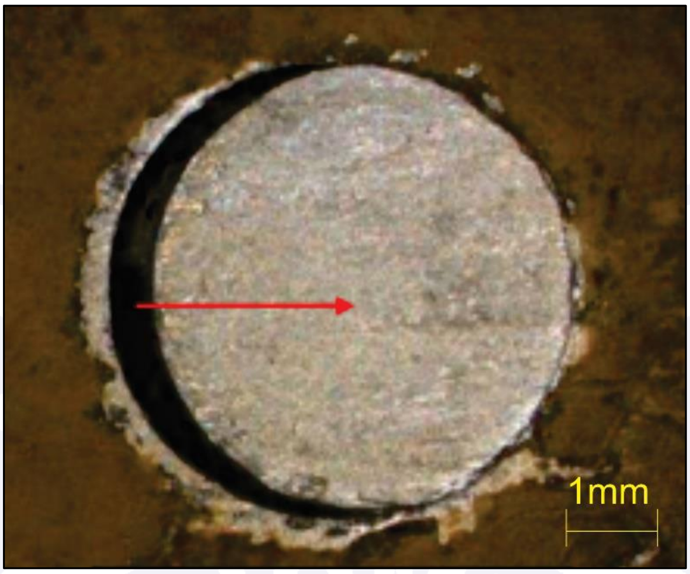

Figure 42 - Detail of the shear marks on the left engine support rivet. The arrow indicates the direction of the shear.

The rivets of two brackets belonging to the left engine suffered shear forces in one direction, and the rivets of two other brackets suffered shear forces in an opposite direction. All rivets of the four right-hand engine brackets were fractured by a shear mechanism in the same direction (Figure 43).

Figure 43 - (A) Engine fixing brackets of the left engine (above) and the right engine (below).

From the analysis of the marks on the aircraft and the characteristics of the lightning cable rupture, one deduces that there were traction forces that pulled the left engine out of its attachment while still in flight, and caused the loss of control of the aircraft.

1.17. Organizational and management information.

Aircraft Operator Structure and Management.

The operator, whose headquarters was located at the Santa Genoveva Aerodrome, Goiânia - GO, had been in the market for over sixteen years and had two other operating bases, one in Brasília - DF, and the other in Porto Velho - RO.

According to the EO, which was found in revision No. 41 of 06JUN2021, the operator did not have any exemption from regulatory requirements.

Three aircraft were part of the operator's fleet, a Cessna 208B, a Beech Aircraft C90A, and a Beech Aircraft C90.

The operator had a family culture centered on maintaining its values. It was composed of a lean staff that pursued quality and control of the organizational processes.

The operator's employees received all the training required for the functions they performed.

The selection process began with the announcement of vacancies and receipt of resumes. The candidates went through some stages, such as interviews; psychological assessment for pilots; behavioral tests performed by an outsourced psychology service; technical interviews; and, theoretical and practical training applied by the Director of Operations.

When offering vacancies, the operator gave priority to people who were indicated by employees, as long as they went through the entire selection process.

According to the information gathered, the operator had a friendly and favorable working environment and climate, fulfilled commitments under the Aeronaut Law, and there were no signs of competitiveness, pressure, or disrespect. Employees felt valued and found the work stable.

The operator had all the manuals required by the ANAC for that type of operation, which formalized the procedures to be used by the crew in the air operations performed.

As reported, when there was a demand for flights to destinations not previously operated, additional information was sought through available official means and through contact with operators at the destination.

Regarding this accident, contact between the contracting party and the operator began on 30OCT2021, and the flight was scheduled for 05NOV2021, with a forecast take-off at 1600 (UTC).

It was the first time the operator transported those passengers and flew to that destination.

Considering the exceptional character of that flight, due to the boarding of a renowned artist, the crewmembers were chosen by the operator for having a reserved and technical profile.

Supervision of the SMS by the Civil Aviation Authority.

In October 2009, the ANAC approved the RBAC 119 - "Certification: Public Air Transport Operators" with new requirements for the certification of regular and non-regular operators, which established the need to implement an SMS in the certification process, in addition to defining the requirements and phases for such implementation.

The RBAC 119 established that air-taxi operators, with a deadline of 31AUG2011, had to hand in the Manual of Operational Safety Management (MGSO) containing their proposal for the implementation of the SMS.

According to the IS 119-002 - “Guide for Preparing an SMS for an Airline Certified in accordance with the RBAC 119”, Revision D, in force at the time of the occurrence, companies should have an SMS accepted by the ANAC, implemented and operating until December 2014.

In 2019, the ANAC approved the "Guidelines for Evaluation of the SMS", which aimed to: "detail the guidelines for civil servants to harmonize the evaluation of the SMS in the certification and continued surveillance activities of the PSAC".

Regarding the continued surveillance carried out by the ANAC on the operator of the aircraft PT-ONJ, the Investigation Team consulted the records that could elucidate their performance and the effectiveness of the inspection mechanisms.

The first Operational Safety Surveillance Report, which contained information about the operator's SMS, was prepared on 27SEPT2017, during an on-site inspection at the main base, in which the operations sector and the air operator's risk management were checked.

In this inspection, non-conformities were found in eight of the thirteen elements or processes that comprise the SMS among them: the "hazard identification processes" and the "risk assessment and mitigation processes"; which were considered unsatisfactory.

The recommendation made by the ANAC to the operator was directed to the processes assessed as "non-compliant", which should be implemented within thirty days.

On 10JAN2018, through a form standardized by the ANAC, the operator informed the actions taken regarding the non-conformities pointed out in the inspection of 27SEPT2017. In this form, the operator clarified that about the mentioned processes, hazard identification processes are performed, and the outputs of these processes are duly registered"; and that "risk assessment and mitigation processes are performed, and the outputs of these processes are duly registered".

The ANAC, in turn, closed the inspection process of Main Base Surveillance and SMS, considering satisfactory the corrective actions that were informed by the operator and, for this, issued a favorable opinion that accepted the Corrective Action Plan presented.

Aircraft Operator's Operational Safety Management.

The aircraft operator had the first version of its MGSO accepted by the ANAC in July 2011, in compliance with the deadline established by the RBAC 119. In this document, the operator assured “to maintain the highest quality standards of its pieces of equipment, and to act with persistence to maintain the awareness, discipline, and correct attitude of all the ones involved in its scope”.

The revision history of the MGSO revealed that the last revision was conducted in September 2020 and affected all chapters of the manual.

The definition of hazard, found in the operator's MGSO, delineated this concept as: "a condition, object, or activity that could potentially cause injury to persons, damage to property (equipment or structures), loss of personnel, or reduced ability to perform a given function."

Similarly, the concept of risk was defined as: "an evaluation of the consequences, expressed in terms of probability and severity, taking the worst possible condition as a reference".

Additionally, Operational Safety risk management was defined in that manual as: "the identification, analysis, and elimination and/or mitigation of risks that threaten the capabilities of a civil aviation organization to an acceptable level.

These concepts were aligned with IS 119-002. In 2018 there was a publication of an amendment to the RBAC 135, repealing several appendices that were cited in the IS 119-

002 and changed concepts that still remained in the operator's MGSO. It is worth noting that the concepts, although different, were not contradictory.

The operator's safety policy and objectives had, as one of its guidelines, the establishment of a hazard identification system to enable reactive, proactive, and predictive risk management.

The Operational Safety Director, in turn, had the role of managing and supervising the hazard identification system.

The operator had an Operational Safety control, where the identified hazards were registered and treated.

The operator's MGSO prevised the establishment of an Operational Safety Committee, whose purpose was to provide support to the Operational Safety Director and ensure that the SMS worked properly.

The CSO was a high-level committee, chaired by the Manager in Charge and composed of the other members of the management team, including the managers of the departments that were directly responsible for the performance of the operational activities and other relevant administrative areas.

Among the attributions of the aforementioned Committee, the following stand out: the formulation of recommendations for actions and mitigation of the risks identified to Operational Safety; and assistance in the identification of hazards and defenses.

Hazard identification was dealt with in the operator's MGSO in chapter 18, with emphasis on the following:

> [...]
>
> Hazard identification processes include the following steps:
>
> - Identifying Operational Safety related to hazards, events, or facts;
>
> - Collection and storage of Operational Safety data;
>
> - Analysis of the Operational Safety data; and
>
> - Distribution of Operational Safety information, obtained from the collected and analyzed data.

Sources of hazard identification for Operational Safety mainly included Civil Aviation Reports and Operational Safety Surveys.

The SOP for the operator's King Air 90 Series aircraft established procedures to minimize risks of operating at aerodromes without routine flights and without provision of the ATS.

In this SOP, the following procedures were to be performed by the operator's Flight Coordination and crewmembers:

> a. Whenever possible, survey the runway before the flight occurs;
>
> b. If not possible, verify with local people the runway's situation and its infrastructure;
>
> c. Verify the credibility of the information provided and the person who forwarded it;
>
> d. Information that should be collected
>
> 1. length and width of the runway;
>
> 2. the condition of the runway;
>
> 3. research the existence of holes, depressions, or other deficiencies that could compromise the safety of the operation;
>
> 4. situation and dimensions of the apron;
>
> 5. obstacles such as hills and antennas in the vicinity;

6. Existence of some kind of safety for the aircraft, such as hangar, field guard, refueling, lookout, etc.;

7. Ask about the incidence of incursions of people and animals in the aerodrome areas.

There was also a determination that if the crewmembers did not have the above information, the following actions were to be taken:

a. The crew should make a low pass over the runway at a minimum of 1,000 ft (AGL) in VFR conditions to observe its condition, the existence of obstacles or animals, and the direction and intensity of the wind;

b. It will be up to the Commander of the aircraft to decide whether to land or perform a go-around procedure;

c. At Aerodromes, where there are no published instrument descent procedures, they should only be operated when weather conditions are at or above the predicted minimums.

According to observer reports, there was no overpass over the SNCT runway on the day of the accident.

According to interviews, the operator made contact with the SNCT Aerodrome to gather information about its operation. From the information processed, no abnormalities or hazards were identified.

Operational Safety Management of the Airport Operator.

The SNCT Aerodrome had been in operation for over fifty years, and it was a public entity of the Ubaporanga City Hall - MG, administered by a legally appointed manager and with no history of accidents related to its infrastructure.

The Aerodrome had a lean structure, with twelve employees, and had little demand for flights, with an average of three takeoffs per day in the year before the accident with the PT-ONJ aircraft.

According to information gathered from the Aerodrome's employees, occasionally, pilots from other regions contact the Aerodrome by phone to get basic information about the runway conditions, weather, and ground support available. When such contacts occurred, it was usually informed that the runway length was approved as 1,090m, but the runway was 1,230m. It was also customary to indicate threshold 02 for landing because of the prevailing wind and better conditions for a possible takeoff.

Regarding the SMS, the SNCT Aerodrome had as mandatory requirement only a statement of commitment to ensure Operational Safety, by requirement 153.51 (d) of the RBAC 153 - "Aerodromes - Operation, Maintenance and Emergency Response", Amendment No. 06.

When consulted by the Investigation Team, the ANAC informed that the statement had been received.

According to the COMAER's Ordinance 957/GC3, of 09JUL2015, which dealt with "Restrictions on Objects Projected into the Airspace that May Adversely Affect the Safety or Regularity of Air Operations", the Aerodromes registered in the ANAC's Aerodrome registry, when the Ordinance took effect, the Aerodromes registered in the ANAC's Aerodrome register were required to adapt to the new provisions by amending the DECEA's Aerodrome register, even if no changes had been made to the physical or operational characteristics of the Aerodrome.

On 04MAY2016, the Municipal Government of Ubaporanga signed a TAC with the DECEA, and on 30AUG2016 the PBZPA of the Caratinga Aerodrome was submitted to the CINDACTA III.

The need to adapt the Caratinga Aerodrome to the new provisions contained in Ordinance 957/GC3 also led to the updating of its registration with the ANAC. Thus, through Ordinance No. 3721/SIA (issued by ANAC), dated 15DEC2016, the information on altitude and runway width was corrected. According to the requirements established in Resolution No. 158 of 13JUL2010, this update did not mean a cadastral change; therefore, it would not imply the applicability of other requirements.

On 04JAN2021, the restrictions established in Ordinance 957/GC3 were replaced by ICA 11-408, dated 14DEC2020, with no change in the PBZPA design parameters.

The Aerodrome situation, at the time of the accident, was regular, both concerning registration in the ANAC's aerodrome registry and the approval of the PBZPA by the DECEA.

1.18. Operational information.

It was a flight to carry passengers through a contract signed for the provision of air taxi services, operating according to the requirements established in the RBAC 135, from SBGO to SNCT.

According to reports, the PIC would perform the SBGO - SNCT route as a PF, and the SIC would act as a PM.

According to the information reported about the planning and preparation for the flight, on the day of the accident, the pilots arrived at the operator's headquarters in advance and held a briefing, together with the Operations Director.

On that occasion, they made the preparations for the flight, consulted the available meteorological information, and the official aeronautical information and, in addition, the Director of Operations passed on information collected from an official of the SNCT Aerodrome, obtained the day before.

The aircraft was fueled at SBGO on the day of the accident, at 1416 (UTC), with 1,054 l (278.4 gals) of JET A1, and the tanks were full.

According to the cargo manifest found on board and reviewed by the Investigation Team, the aircraft was within the weight and balance limits specified by the manufacturer.

The flight plan was scheduled to depart from SBGO at 1500 (UTC) under IFR to position 1933S/04232W, where it would make the transition from IFR to VFR and proceed to destination SNCT. The planned alternate Aerodrome was Pampulha - Carlos Drummond de Andrade (SBBH), Belo Horizonte - MG.

The aircraft took off at 1605 (UTC) on 05NOV2021. The takeoff and climb to FL210 went smoothly, and at 17h51min (UTC) the aircraft began its descent.

According to the RADAR revisualization, synchronized with the Meteorological RADAR data of 18h07min (UTC), it was observed that the aircraft made deviations of up to 6 NM to avoid areas with low precipitation (Figure 44).

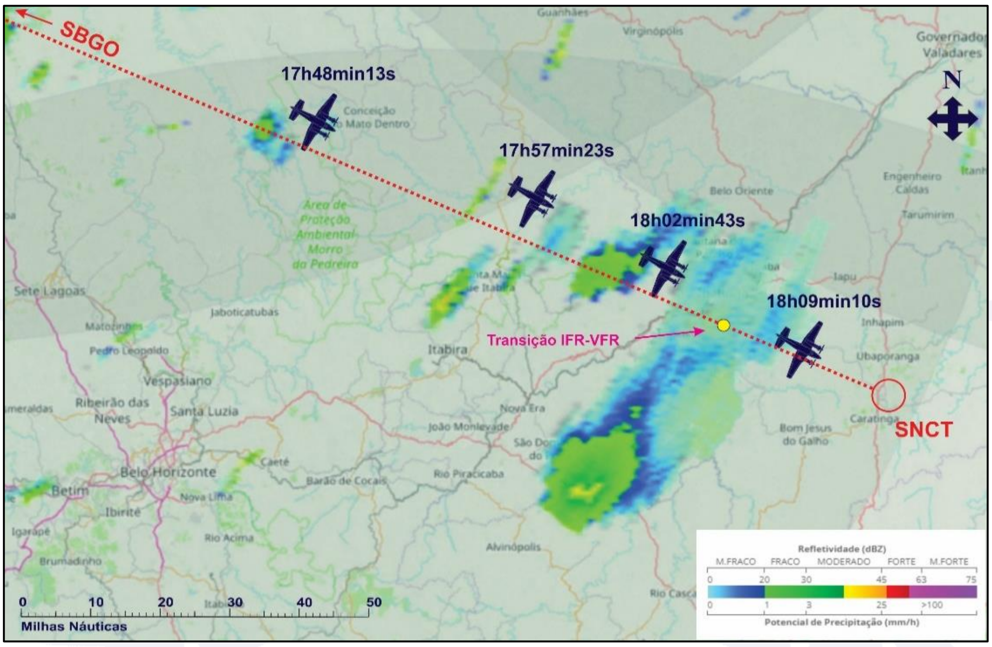

Figure 44 - Route deviation in relation to the areas with precipitation recorded at 18h07min (UTC). The dot indicates the coordinates recorded in the flight plan for the change of rules from IFR to VFR (*aircraft out of range).

The last RADAR contact was at 18h09min10s (UTC) when the aircraft was at 5,400 ft, in the NW sector, 13.9 NM away from SNCT.

Since the operation at the SNCT Aerodrome was in "Class G" airspace and restricted to daytime VFR rules, the air traffic requirements outlined in ICA 100-12 - "Rules of the Air" 2018, applied, which provided the following:

> 5.2 PILOT RESPONSIBILITY
>
> It shall be the responsibility of the pilot in command of an aircraft in VFR flight to provide his separation from obstacles and other aircraft through the use of vision, except in Class B airspace, where the separation between aircraft is the responsibility of ATC. However, the provisions of 4.2.1 shall be observed.
>
> [...]
>
> 4.2 COLLISION AVOIDANCE
>
> 4.2.1 The rules described below do not relieve the pilot-in-command of the responsibility to take the best action to avoid a collision, including maneuvers based on resolution advisories provided by ACAS equipment.
>
> NOTE 1: To prevent possible collisions, it is important that surveillance be exercised on board aircraft, regardless of the flight rules or the class of airspace in which the aircraft is operating, and also when operating in the movement area of an Aerodrome.
>
> [...]

Additionally, according to the ICA 100-37 Annex C - "Air Traffic Services", entry and operation in the Aerodrome traffic circuit should take place as follows:

> 1.1.1 Before entering an Aerodrome traffic circuit, all pilots must transmit their position and intent to the AFIS agency or, in the absence of such an agency, through the FCA.
>
> [...]
>
> 1.1.4 Preferably, the approach to the Aerodrome traffic circle should occur by the downwind leg sector (as indicated in Figures 1 and 2). When entering from the downwind leg sector, the pilot must plan the descent to cross the runway in level flight at 1,000 feet (or 1,500 feet as per 1.1.7) above the published Aerodrome elevation or circuit height. This height must be maintained until the descent to landing.

Since the SNCT Aerodrome did not have an AFIS, entry into the traffic circle could occur under item 3.1 of "Annex C" of ICA 100-37 (Figure 45).

> 3.1 Alternatively to that specified in 1.1.4, once the pilot is satisfied that there will be no conflict with other traffic entering or evolving in the circuit, the aircraft may enter the circuit aligned with the start of the downwind leg, as indicated in Figure 2.
>
> NOTE: In this case, for entry, the aircraft must be in level flight at the height of the circuit, and this height must be maintained until the descent for landing.

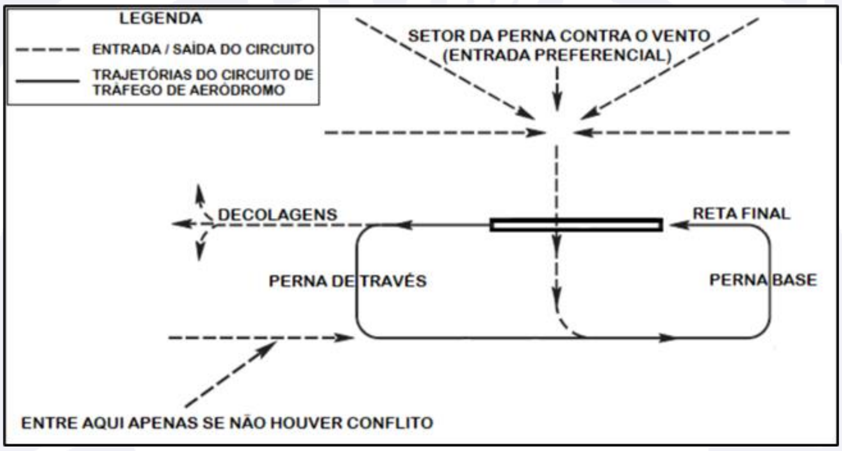

Figure 45 - Illustration in Figure 2 of “Annex C” of the ICA 100-37.

According to the report of a pilot who was on board another aircraft bound for SNCT, moments before the accident, the PT-ONJ crew made three reports on the free coordination frequency 123.45 MHz.

On the first report, the crew of the PT-ONJ aircraft informed its position 44 NM away. On the second report, it informed that it was in the downwind leg of runway 02, sector W. In the last report, about 30s after the second report, it informed again that it was in the downwind leg of runway 02, sector W. After that, there were no more contacts.

The operator's SOP - King Air 90 Series, in item 12.1.1 "Operation at Aerodromes without Published Procedures for the Landing Phase", contained the following:

> [...]
>
> h. Concentrate most of the time the attention directed away from the aircraft to avoid collisions with other aircraft, obstacles, gliders, skydivers, hang gliders, birds, etc.;
>
> i. Upon sighting the Aerodrome, perform the standard visual traffic procedure or according to the VAC chart (visual aerodrome circuit entry and exit chart).

Additionally, the operator's MGO provided, for EGPWS warnings, for not questioning or analyzing the warnings and executing the evasive maneuver in item 11.4, as transcribed below:

> 11.4 Escape maneuver
>
> a) Ground proximity warning (GPWS): The following procedures contribute to reducing the risk of a Controlled Flight Into Terrain (CFIT) accident:
>
> - Familiarization with the destination route;
> - Alertness to altitudes;
> - Knowledge of local NOTAM;
> - Complying with the stabilized approach profile
> - Avoid last-minute changes to prepared approaches;
> - Do not question or analyze the EGPWS warning, executing the evasive maneuver as planned;
> - Maintain the appropriate level of training;
> - Keep in mind that the recovery is only complete when the AR indications cease (+/2500 ft), meaning that the airplane is clear of obstacles at the acceleration altitude.

Concerning EGPWS, however, it should be considered that the equipment manufacturer provided the pilot with the possibility of inhibiting the alerts when flying under VFR since the system could emit nuisance alerts. This possibility was because, under VFR, the separation from the terrain should be through visual references.

According to the operator's PTO (Figure 46), in its Annex C - "Flight Maneuvers (BE9L/C90), Parameters for Visual Approach and Landing", this approach was divided into phases, with flight procedures to be performed in each one.

The parameters established were:

a) on the downwind leg.

- lower flaps to approach; and
- maintain the indicated speed of 120 kt.

b) on the crosswind leg of the runway in use.

- lower the landing gear; and
- hold the straight for 30 seconds before making the turn to the base leg.

c) On the base leg.

- Maintain a speed of 120 kt (or VYSE + 10 kt in case of single-engine flight)

d) on the final.

- maintain speed VYSE + 10 kt;
- with landing assured, lower flaps to down, turn the yaw damper off, and complete the landing checklist.

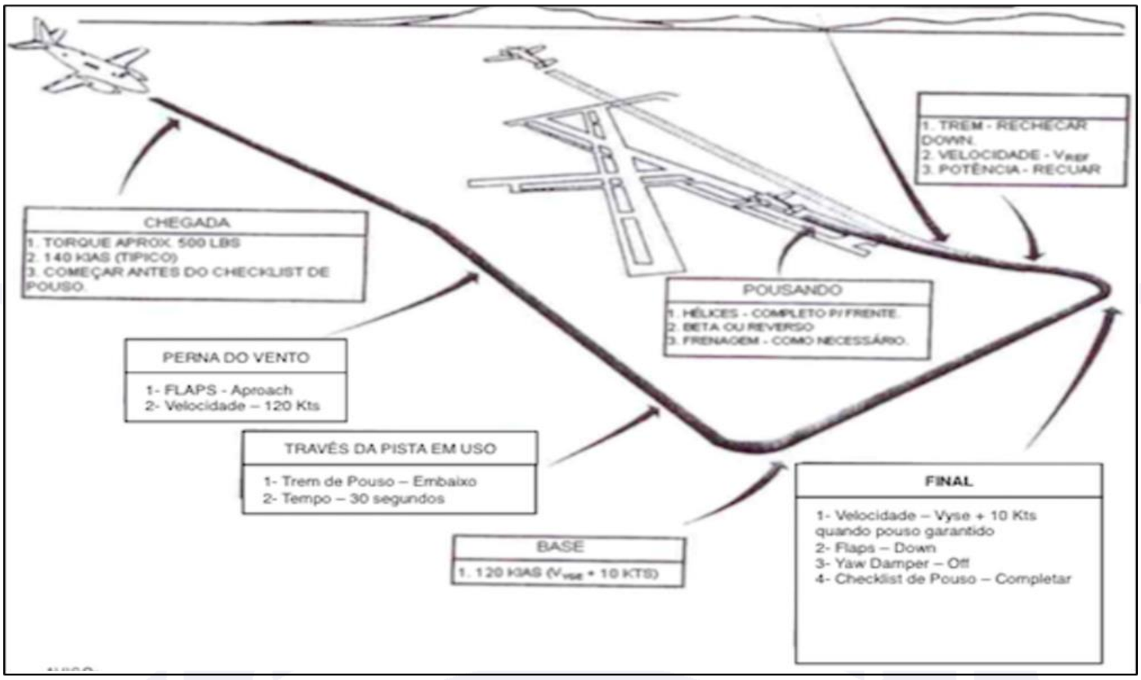

Figure 46 - Landing procedures provided in the operator's PTO and similar to the contents of the operational checklist on board the PT-ONJ aircraft.

An observer waiting to land PT-ONJ at SNCT saw the aircraft entering the windward leg of runway 02. He then lost sight of it for some time. By the time the observer could see the aircraft again, it was very close to the elevations, lined up at the end of runway 02 at SNCT, with its headlights on. Next, he heard a noise and saw the aircraft turning toward the ground.

Based on the information corresponding to the last RADAR contact; the approach sector concerning SNCT; reports from crewmembers who contacted the aircraft in flight; ground observers who saw PT-ONJ in the traffic circle; and the aircraft impact point, the Investigation Team considered that the PT-ONJ followed a trajectory as estimated in Figure 47.

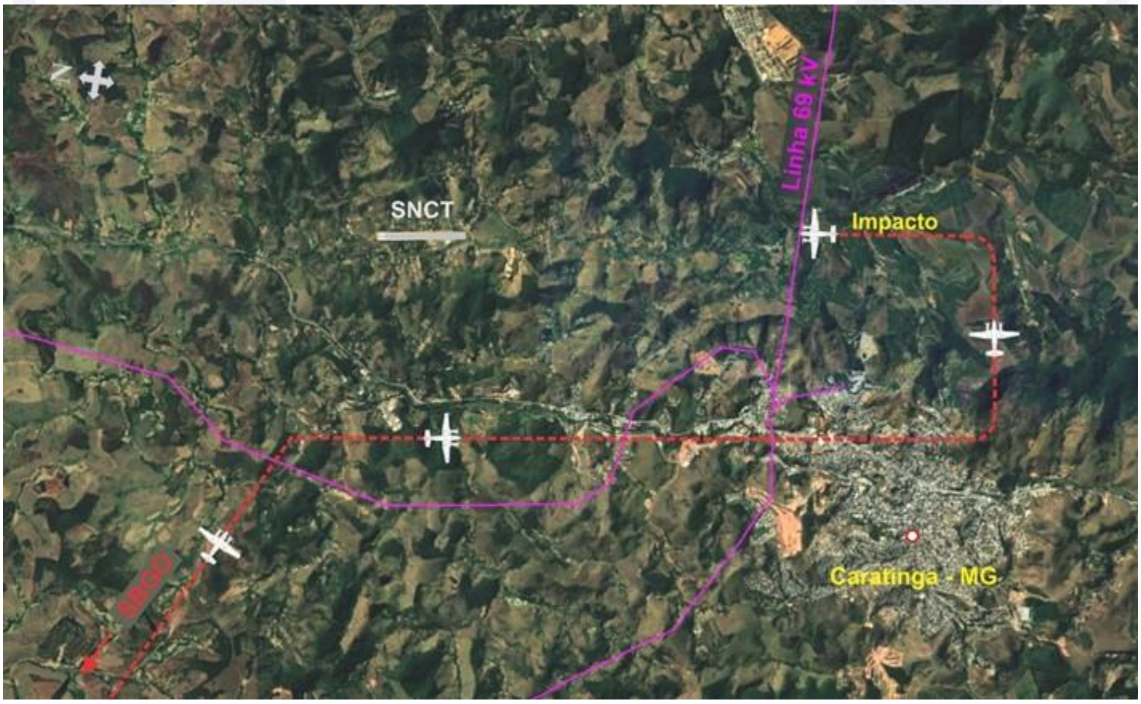

Figure 47 - Estimated trajectory until the impact (aircraft out of range).

The collision with the power grid lightning arrester occurred aligned with the SNCT runway extension, at a distance of 2.5 NM from the threshold 02 and at a height of 920 ft. relative to the runway. At that point, the aircraft was at a height of about 115 ft. from the ground and with a 3.46° ramp relative to threshold 02 (Figure 48).

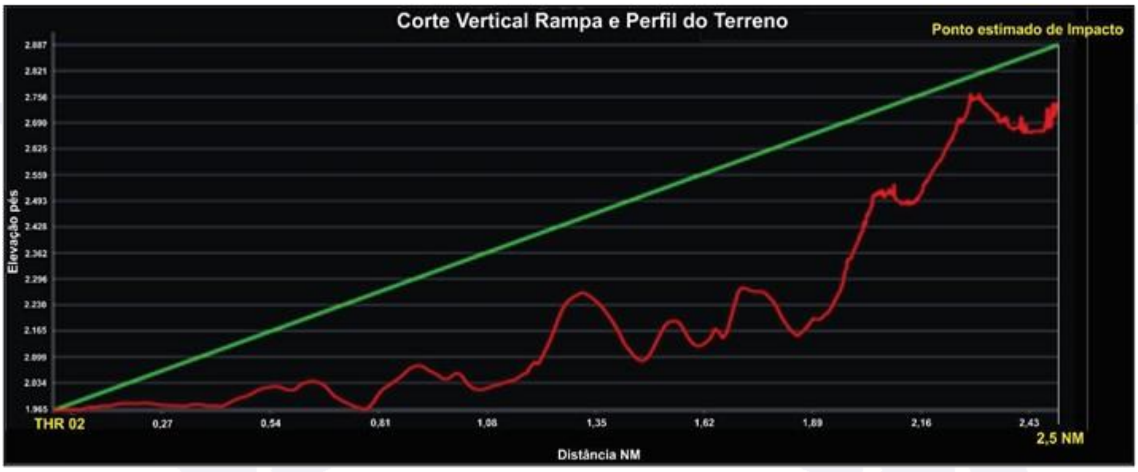

Figure 48 - Vertical section of the terrain and the projected assumed ramp between the estimated point of impact and threshold 02 (THR02).

Considering the standard traffic predicted in the operator's PTO, for a downwind leg performed at a speed of 120 kt, the clearance to the start of the base leg frame would correspond to 1 NM. Since the impact against the cables was within 2.5 NM of the threshold, it was found that there was clearance on the downwind leg at a distance exceeding 1.5 NM of that predicted in the operator's program.

1.19. Additional information.

Characteristics of the 69 kV power grid.

According to information collected by the Investigation Committee, the 69 kV single circuit power grid between Caratinga and Ipanema was built in 1965, and later, in 2009, with the entry into the system of the generating PCH's "*Areia Branca*" and "*Pipoca*" the system started to have a different configuration.

The stretch between towers 8 and 9 was built laterally to the layout of the towers that existed in the initial project of 1965. The lateral displacement was necessary to replace the wooden with metal towers, and the displacement between the axes of the old line and the stretch of the new line was of 50 m.

The upgrade of the new stretch that resulted in the transmission line Caratinga - PCH "Pipoca" 69 kV was designed in 2009 and had its construction completed in 2010. The energization occurred in October 2010, with the entry into operation of the PCH "Pipoca".

It was also surveyed that the characteristics of the transmission line in the stretch between towers 8 and 9, where the PT-ONJ aircraft collision occurred, were as follows:

- the span had 856.56 m, and the length of the launched lightning arrester cable was approximately 864 m;
- tower 8 was a structure with a useful height [1]of 29.5 m and a total height of 38.5 m; and
- tower 9 was a structure with a useful height of 26.5 m and a total height of 35.5 m.

[1]The height of the lowest conductor cable next to the structure indicates the usable height for that tower and, the lightning arrester cable is located at the top of the structure.

On the date of the last modification of the power grid project, the Ordinance nº 1.141/GM5, of 08DEC1987 (issued by the COMAER), was in force. It made provisions concerning the "Protection Zones" and approved the PBZPA, the Noise Zoning Basic Plan, PBZPH, and the PZPANA.

According to Art. 3 of that Ordinance, the definition of obstacle was:

> Any physical accident or object of a temporary or permanent nature, fixed or mobile, located in a Protection Zone and that is higher than the height established by the various Plans defined in this Ordinance.

According to Chapter V of Ordinance No. 1.141/GM5, the signaling criteria were prescribed for obstacles, i.e., physical accidents or objects that were located in the Protection Zone and with a height above the gauge.

For obstacles located outside the Protection Zone, Chapter V, Article 34, it stipulated the installation of high-intensity obstacle lights to indicate the presence of obstacles whose height was 150 m or more, as well as towers supporting high electrical lines, overhead cables, or other obstacles that could provide similar risks to air navigation.

On the date of the accident, the ICA 11-408 - "Restrictions on Objects Projected into the Airspace that Could Adversely Affect the Safety or Regularity of Air Operations" dated 14DEC2020 was in force, which replaced Ordinances nº 1.141/GM5, dated 08DEC1987; nº 256/GC5 dated 13MAY2011; and nº 957/GC3 dated 09JUL2015 with the same content.

When analyzing the ICA 11-408, it was observed that it presented the following definition for obstacle:

> Any object of a permanent or temporary nature, fixed or mobile, or part thereof, which is located in an area intended for the movement of aircraft on the ground, or which extends above the surfaces intended for the protection of aircraft in flight, or even which is outside or below those defined surfaces, and causes an adverse effect on the safety or regularity of air operations. (*underline added*).

With regard to object signaling and lighting, the ICA 11-408 provided the following:

> 9.1 GENERAL
>
> 9.1.1 A new or existing object shall be marked and illuminated, under the provisions of this chapter, in the following cases:
>
> (a) when it concerns towers, masts, poles, overhead power grids, overhead cables, or other objects whose configuration is barely visible at a distance that is located within the lateral limits of the transition surface or within 3,000 meters of the inner edge of the approach or takeoff surfaces, even if they do not exceed the vertical limits of these surfaces;
>
> (b) in the case of overhead power grids, overhead cables, or other objects of similar configuration which cross rivers, waterways, valleys, or roads;
>
> c) In the case of objects that rise 150 meters or more in height;
>
> (d) in the case of an obstacle; or
>
> e) when requested, at the discretion of the DECEA Regional Authority.

Thus, considering that the 69-kV power line was outside the limits of the SNCT Aerodrome Protection Zone; had a height of less than 150 m (38.5 m); was outside the approach or take-off surfaces; and, despite crossing over the *Ribeirão do Lage* (a local stream), it did represent an adverse effect to the safety and regularity of the air operations, the aforementioned power line did not fit the requirements that could characterize it as an obstacle or object liable to be signaled.

1.20. Useful or effective investigation techniques.

None.

2. ANALYSIS.

The King Air C90A (PT-ONJ) aircraft was registered in the TPX category and was operated by PEC Air Taxi Ltd.

The maintenance of the PT-ONJ aircraft was performed at the operator's own headquarters or by an outsourced company, according to the applicable requirements. The operator used the maintenance program recommended by the manufacturers of the aircraft, engines, propellers, and components.

According to the maintenance records, the airframe, engine, and propeller logbooks were updated. The last aircraft inspections, the "200 hours" type and "Stage 4", were completed on 13SEPT2021, being with 170 hours and 9 minutes flown after the inspection. The aircraft CVA (Airworthiness Verification Certificate) was valid until 01JULY2022.

In the logbook that was in the aircraft, no discrepancies were identified that would have resulted in any system malfunction.

Analysis of the wreckage of the left powerplant did not detect any abnormality that could have compromised its operation. During the disassembly of the engine, it was found that the internal components, which required lubrication, showed evidence that they had operated lubricated all the time.

Internally, this engine showed evidence that it was functioning normally and developing power at the moment the aircraft crashed into the lightning arrester cable.

Similarly, the right-hand powerplant showed no evidence of malfunctioning lubricated components. All the bearings appeared to be functioning normally, showing that there were no problems in the lubrication system and there were no problems with the lubricating oil.

Thus, the analysis of both Pratt & Whitney engines, model PT6A-21, SN PCE 25594 and SN PCE 025595, revealed that the internal signatures found indicated that both were operational. They also indicated that both were developing power at the instant of the collision with the lightning arrester cable.

The examinations carried out on the primary flight control cables revealed the spreading of the wires that made up the cables, and different heights of wire breakage and stranding, indicating that the breakage was caused by the overload resulting from the impact of the aircraft.

The examination of the lamps revealed that the filaments of the brake lights and the landing gear light had suffered hot plastic deformation, consistent with the condition of the lights on at the time of impact of the aircraft.

The other lamps of the other systems showed aspects of brittle fractures, and natural aging through use, and none showed plastic deformation characteristic of being on during the impact.

Thus, the condition of the filaments of the analyzed lamps pointed to the regular operation of the landing gear and the absence of warning lights on the aircraft alarm panel at the time of impact.

Thus, with regard to airworthiness conditions, there were no indications of failure or malfunction of systems and/or components of the aircraft that could have affected its performance or control in flight.

The SNCT Aerodrome was public, managed by the Ubaporanga City Hall - MG, operated under VFR during daylight hours, and was located in a mountainous region, with several elevations in the vicinity of the runway.

The Aerodrome had been in operation for over fifty years, and no records of accidents related to its infrastructure were found. In the year before the accident, the Aerodrome averaged three takeoffs per day.

At the time of the accident, the situation of the Aerodrome was regular, both with respect to registration in the ANAC's Aerodrome registry and with respect to approval of the PBZPA by the DECEA.

Regarding the PBZPA, given the physical and operational characteristics of the Aerodrome, the SPVV was established for "Category B" critical aircraft. The aircraft in this category had, as a performance characteristic, a threshold crossing speed between 91 kt. and 121 kt, which the Beech Aircraft C90A fitted.

Since the SPVV was related to aspects of airport planning and not day-to-day aircraft operation, it provided for a traffic pattern height of 1,299 ft, as well as approach surface limits of up to 1.4 NM from the threshold.

Regarding the SNCT navigation aids, it was verified that: due to its approval date, its type of operation, and estimated annual landings; the Aerodrome did not fit the criteria for the PAPI implementation, both in the requirements established by the ANAC and those established by the DECEA.

Still, with respect to the requirements for the installation of aids, the Investigation Team identified differences between the established criteria, which could generate doubts to the Aerodrome operators about their applicability due to the existence of two regulations that dealt with the same subject (RBAC 154 and ICA 63-18).

It was found that while the ANAC regulation (RBAC 154) approached the requirements from the perspective of the Aerodrome operating characteristic, the DECEA instruction (ICA 63-18) approached them based on the annual number of landings at a given threshold.

Although the SNCT Aerodrome did not meet the requirements of both regulations, either by the transition criterion provided by the RBAC 154 or by the landing volume provided by the ICA 63-18, the Investigation Committee identified an opportunity to improve these criteria, which could affect other Brazilian Aerodromes.

The published aeronautical information for SNCT operation was available in the ROTAER, which established that the traffic circuit should be through Aerodrome's Western (W) sector. Additionally, there was an INFOTEMP that warned of unlit obstacles (tower and antenna), which were in violation of the PBZPA, located about 2 NM Southwest (SW) of SNCT.

As regards the 69 kV line, against which the PT-ONJ collided, it was found to be outside the ZPA limits established by the PBZPA, and in turn, it was not characterized as an obstacle with "adverse effect on the safety or regularity of Aerodrome air operations".

Although not included among the pieces of aeronautical information specific to the SNCT Aerodrome, the 69-kV power grid was depicted in both the WAC 3189 and the CAP 9453, intended for pre-flight planning and visual reference air navigation.

Regarding the physical signaling of the 69 kV line, it was found that, according to Chapter V of Ordinance No. 1.141/GM5, the signaling criteria were provided for obstacles, i.e., for physical accidents or objects that were located in the ZPA and had a height above the gauge defined by the PBZPA.

For obstacles located outside the ZPA, the ordinance stipulated the installation of high-intensity obstacle lights to indicate the presence of obstacles whose height was 150 m or more, as well as towers supporting high electrical lines, overhead cables, or other obstacles that could provide similar risks to air navigation.

On the accident date, ICA 11-408 was in force, superseding Ordinance No. 1.141/GM5, with the same content.

The ICA added some more conditions under which an object had to be signaled, besides those already prescribed in the aforementioned ordinance. Such conditions, however, concerned objects characterized as "obstacles" within 3,000 m of the inner edge of the approach or takeoff surfaces; as well as overhead power grids, overhead cables, or other objects of similar configuration, crossing rivers, waterways, valleys, or roads.

Thus, considering that the 69-kV power line was outside the limits of the SNCT ZPA, and that it was less than 150 m (38.5 m) high. Also considering that the power line was away from approach or takeoff surfaces, and, that, despite crossing over a stream, it did not pose any adverse effects to the safety and regularity of air operations, one concludes that the referred power line did not meet the requirements that would characterize it as an obstacle or object liable to be signaled.

Regarding the organization and management of the aircraft operator, it was found that the company had a friendly and favorable work environment and climate, met its commitments according to the Aeronaut Law and there were no signs of competitiveness, pressure, or disrespect among its employees. Employees felt valued and considered the work stable.

The operator met the safety management requirements and was subject to the ANAC's continued surveillance. On 27SEPT2017, it underwent an in-person inspection at its main base, in which the operations sector and risk management were checked.

On that occasion, ANAC found non-compliances in eight of the thirteen elements or processes that made up the SMS, among them: the hazard identification processes and risk assessment and mitigation processes, which were considered unsatisfactory.

Such non-conformities did not require the shutdown of operations. However, ANAC stipulated a period of thirty days for the non-conformities to be corrected. On 10JAN2018 the operator informed the actions taken regarding the non-conformities pointed out, and the ANAC, in turn, closed the inspection process, accepting as satisfactory the corrective actions that were informed by the operator.

Based on this inspection, it was considered that, on the accident date, the operator met the minimum requirements for "hazard identification processes" and "risk assessment and mitigation processes" foreseen in its SMS.

The PIC was 56 years old, had been a pilot for 33 years, and accumulated 16.352 flight hours on C90, C90A, C208B, C535, C550, MU2B, PA31, PA34, A319/320 aircraft, and was considered quite experienced. He was hired by the operator for the Commander role in July 2020 and had accumulated 299 hours and 06 minutes on the company's C90 and C90A aircraft.

In 2019, he underwent a psychological evaluation for CMA revalidation, and at the time, the Personality, Attention, Memory, and Reasoning tests were applied, which had a "Favorable" result.

According to the INSPSAU results, he was physically and mentally healthy and considered fit for exercising aerial activity, with the indication to use corrective lenses (H52.2 - astigmatism).

The day before the accident, he flew from Brasilia - DF, to Uberlândia - MG, in the C208 aircraft, having fulfilled the regulatory rest period prevised in the RBAC No. 117.

The PIC was considered by family members and people close to him as a calm, charismatic, committed person who, in his free time, dedicated himself to his family and religion. According to reports, he was satisfied because he identified with the work environment and was able to dedicate more time to his family.

He was seen by colleagues and managers as a standard professional because he demonstrated technical rigor and was concerned about following to the letter all procedures prescribed by the operator. He also had no history of interpersonal problems with co-workers.

The SIC was 37 years old, had been a pilot for 13 years, and had accumulated 2,768 flight hours and 24 minutes in C208, C208B, C90, and C90A aircraft. He was hired by the operator for the copilot role in April 2021 and had accumulated about 167 hours and 36 minutes on the company's C90 and C90A aircraft.

In 2019, he underwent a psychological evaluation for CMA revalidation and, on the occasion, the Personality, Attention, Memory, and Reasoning tests were applied, which had a "Favorable" result.

According to the INSPSAU result, he was physically and mentally healthy and considered fit for exercising aerial activity.

The SIC was off duty on the same days as the PIC and on-call on 04NOV2021, but he was not called, thus having fulfilled his rest period.

He was considered, by people around him, a hard-working professional, self-taught in aviation-related matters and who sought new knowledge to keep himself updated. In his free time, he used to dedicate himself to his family and studies.

In the operator's environment, he was considered, by his peers and managers, as a professional who stood out for his professional commitment and technical capacity.

According to reports from people close to him, both pilots had a regular sleep routine, with adequate duration per night. Likewise, there was no change in the routine 48 hours before the accident.

According to information collected in post-accident interviews, none of the pilots commented on any health problems. None of them smoked or drank alcohol. They did not use any medication for continuous use and did not show signs of stress or fatigue.

According to the information gathered, none of the pilots had family, personal, financial, or psychological problems that could interfere with their flight performance.

As for the interactions between the PIC and the SIC, according to the information obtained, the pilots had a friendly relationship. Both were praised by their coworkers for their ethical posture and for behaving in a manner that favored common sense and collective well-being.

During the accident flight, a pilot of another aircraft approaching to land at SNCT reported having heard the communications from the PT-ONJ. According to his report, he did not notice any difference or alteration in the transmissions, suggesting that, until that moment, everything was running smoothly.

The post-accident tests did not detect any drugs, metabolites, drugs of abuse, pesticides, or alcohol in the pilots.

The expert examination concluded that the cause of death for both was blunt force trauma. Additionally, based on the necropsy reports; after evaluating the severity and diversity of the injuries presented, it was concluded that the injuries were fatal, with immediate death resulting from the impact forces.

Therefore, based on the Human Factors information gathered, no alterations were evident from the medical point of view, as well as psychological issues that could have affected the pilots' performance in flight.

The purpose of the flight that resulted in the accident was to carry passengers under an Air Taxi service agreement, operating according to the requirements established in the RBAC 135, from SBGO to SNCT.

The planning and preparations went normally, according to the pilots' routine. The aircraft was fueled with 1,054 l (278.4 gallons) of JET A1. The tanks were full, with enough endurance to complete the flight to the destination.

The takeoff took place at 1605 UTC, and the flight proceeded at FL210, as scheduled in the flight plan. According to the recordings of the ATC radiotelephony frequencies, it was verified that the aircraft maintained radio contact with the air traffic control agencies.

The communications between the PT-ONJ and the ACC-BS were coordinated and clear, and no abnormalities in the operation were evidenced.

In the last contact with the ACC-BS, the ACC confirmed the cancellation of the IFR flight plan at 17h57min (UTC) and informed that there was no traffic that could interfere with the descent of the PT-ONJ aircraft, releasing it from the frequency of that ATC agency.

During the descent, the aircraft made short detours to avoid areas with low precipitation. Despite these areas of precipitation, the weather conditions were favorable for the visual flight in the SNCT region, with a scattered cloud base above 4,000 ft. and visibility higher than 10 km. The wind was blowing from the South and Southeast quadrants with low intensity.

The last RADAR contact was at 18h09min10s (UTC) when the aircraft was at 5,400 ft, in the NW sector, 13.9 NM away from SNCT.

Based on the information corresponding to the last RADAR contact; the approach sector in relation to SNCT; the reports from crewmembers who contacted the aircraft in flight; and from ground observers; the Investigation Team concluded that the aircraft joined the traffic circuit aligned with the beginning of the downwind leg, as provided in "Annex C" of the ICA 100-37.

After entering the downwind leg, the aircraft was to begin framing for the base leg after 30 seconds from the threshold traverse of the runway in use. In the case of the King Air C90A, for a downwind leg performed at a speed of 120 kt, the distance to the beginning of the base leg framing would correspond to 1 NM.

However, it was found that the collision against the lightning arrester cable occurred in a position aligned with the extension of the SNCT runway, at a distance of 2.5 NM from threshold 02.

At the time of the collision against the lightning arrester cable, the aircraft was configured with landing gear down, landing lights on, and flaps in the APPROACH position.

Considering the marks left by the cable on the spinner and fuselage, it was found that the aircraft hit the cable with the top of its nose and was wing-leveled at the time of impact.

Based on the aircraft configuration, banking, and the aircraft position relative to the runway axis, it is inferred that, at the time of the collision, the crew was seeking to fit into a final approach that was longer than the normal pattern for a C90A aircraft (Figure 49).

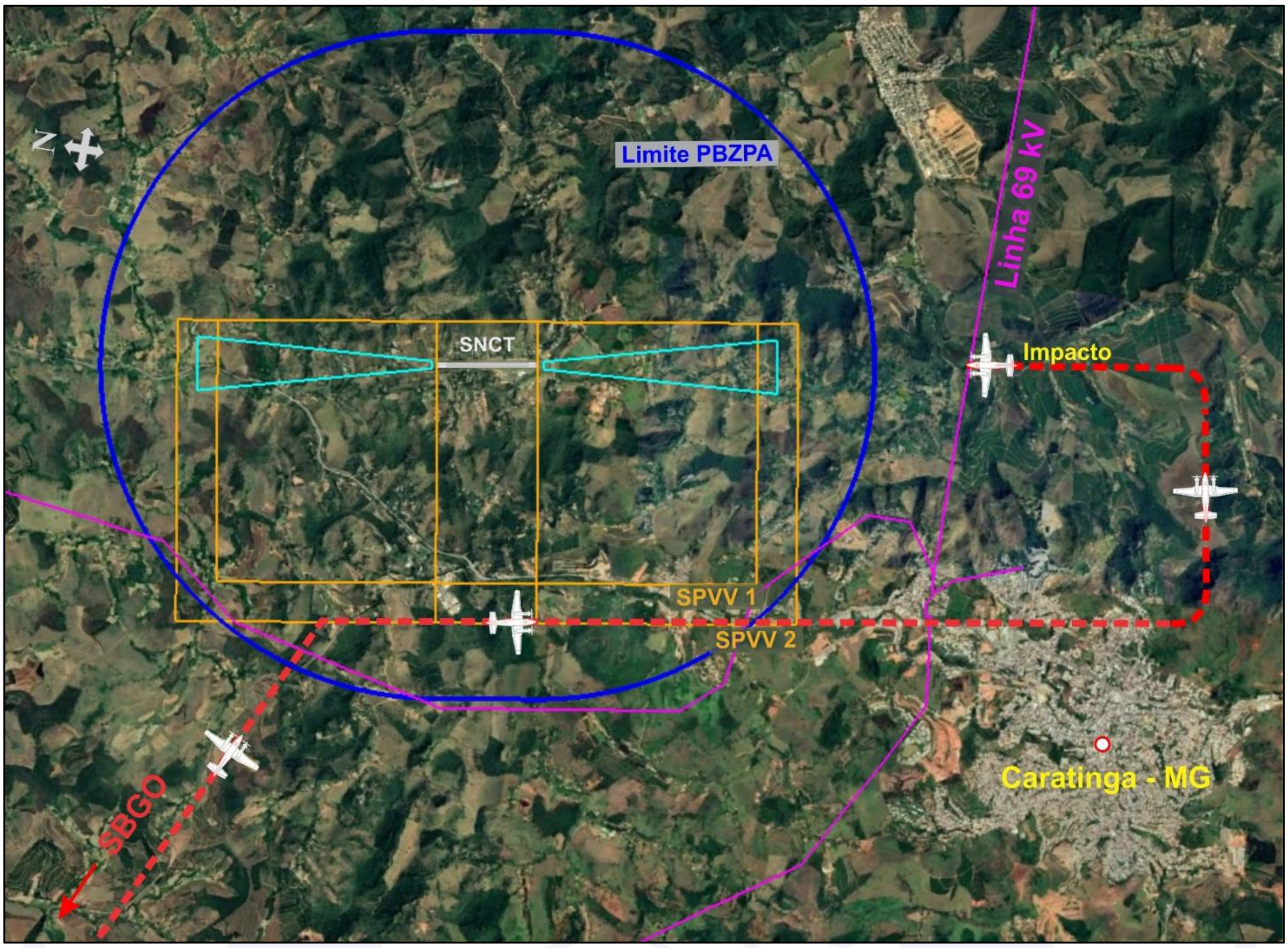

Figure 1 – Estimated Trajectory of the PT-ONJ in relation to SPVV and the point of impact against the 69 kV power grid.

Despite the fact that there were no aircraft or air traffic operational limitations that restricted the lengthening of the downwind leg, the Investigation Team sought to infer the reasons why this procedure had occurred during that operation.

Since the PIC had operated for ten years in a company governed by the RBAC 121 as co-pilot of A-319/320, it was considered that he may have chosen to lengthen the downwind leg in order to seek a longer final approach, which tends to be more comfortable for passengers.

In that scenario, the investigation committee highlights the decision-making process involved, where there is the possibility that the PIC made such a decision due to an unconscious process generated by the experiences of the approaches performed during a long period in which he operated in regular aviation.

Additionally, it was not possible to confirm if there was the use of aeronautical charts (CAP 9453 and WAC 3189) for planning and monitoring the flight under VFR, which would allow a better situational awareness about the characteristics of the relief and the presence of the 69 kV power grid, which would allow a more accurate decision-making process.

The collision with the lightning arrester cable resulted in traction forces that pulled out the left engine from its attachment, still in flight, and caused the total loss of control of the aircraft.

Considering the extent of the damage, the deformation pattern of the fuselage and wings, as well as the short distance flown after the impact against the lightning arrester cable, it was concluded that the aircraft had a strong deceleration of its horizontal speed, still in flight, and hit the ground with a high sink rate, with a great lateral tilt to the left and an attitude close to level.

The point where the lightning arrester cable touched the fuselage was against the top of the nose, in a position slightly ahead of the projection of the electronic equipment compartment door.

Regarding the possibility of visualization of the cable, it should be considered that such a point was located below the pilot’s line of sight, at a moment of the flight when their attention would be on the runway.

Another aspect to be considered for viewing the lightning arrester cable is its low contrast in relation to the vegetation in the background, which resulted in a reduced perception and, consequently, reduced the chances of sighting the cable at great distances.

Additionally, the PIC had an indication to use corrective lenses due to a diagnosis of astigmatism. Since it was not possible to confirm whether the PIC was wearing corrective lenses at the time of the accident, it must be considered that, in the eventual absence of lenses, there would be some reduction in his visual acuity and depth perception.

Therefore, since they initiated the approach at a significantly greater distance than the one expected for a "Category B" aircraft, and with a reduced separation from the ground, the operation was subject to the possibility of collision with objects that might not be identified with the necessary anticipation.

3. CONCLUSIONS.

3.1. Findings.

a) the pilots had valid CMAs;

b) the pilots had valid MLTE and IFRA Ratings;

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

d) the aircraft had a valid CVA until 01JUL2022;

e) the aircraft was within weight and balance limits;

f) the airframe, engines, and propellers logbook records were updated;

g) there was no evidence of any failure condition or malfunction of aircraft systems and/or components that could have affected performance or control in flight;

h) There was no evidence of any medical or psychological changes in the period before the accident that could have affected the pilots' flight performance;

i) Weather conditions were favorable for the flight;

j) the SNCT Aerodrome situation was regular, both concerning the registration in the ANAC's Aerodrome register and in relation to the approval of the PBZPA by the DECEA;

k) the SNCT Aerodrome had SPVV for "Category B" critical aircraft;

l) there was a 69 kV power grid outside of the SNCT Aerodrome ZPA limits;

m) the 69 kV power grid did not meet the requirements that would qualify it as an obstacle or object that could be signaled;

n) the 69 kV power grid lightning arrester cable had low contrast in relation to the vegetation in the background;

o) the approach of the PT-ONJ was initiated at a significantly greater distance than expected for a "Category B" aircraft and with a very low separation from the ground;

p) the collision of the aircraft in flight against the lightning arrest cable resulted in traction forces that pulled out the left engine from its attachment, and caused the total loss of control of the aircraft;

q) the aircraft hit the ground with a high rate of sink, with a large lateral tilt to the left and an attitude close to level;

r) the aircraft had substantial damage; and

s) all the aircraft occupants suffered fatal injuries.

3.2. Contributing factors.

- **Attention – undetermined.**

It was found the possibility that the PT-ONJ aircraft crew had their attention (focused vision) on the runway at the expense of maintaining proper separation with the terrain on a visual approach.

- **Piloting judgment – a contributor.**

Regarding the approach to landing profile, there was an inadequate assessment of the aircraft's operating parameters, since the downwind leg was elongated by a significantly greater distance than that expected for a "Category B" aircraft in landing procedures under VFR.

- **Memory – undetermined.**

It is likely that, based on the experience of ten years of operation in a company governed by the RBAC 121, the PIC procedural memory has influenced the decisions made concerning the conduct of the aircraft.

The habit of performing long final approaches in another type of operation may have activated his procedural memory, involving cognitive activities and motor skills, making the actions automated in relation to the profile performed in the accident.

- **Flight planning – undetermined.**

A possible non-use of the available aeronautical charts (CAP 9453 and WAC 3189), which were intended to meet the needs of visual flight, may have contributed to low situational awareness about the characteristics of the relief around the SNCT Aerodrome and the presence of the power grid that interfered with the aircraft's landing approach.

4. SAFETY RECOMMENDATIONS

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

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

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

A-121/CENIPA/2021 - 01 **Issued on 05/15/2023**

Disseminate the lessons learned from this investigation to companies operating under the requirements established in the RBAC 135, in order to promote an increase in the Operational Safety culture and risk management.

A-121/CENIPA/2021 - 02 **Issued on 05/15/2023**

Manage with the DECEA, in order to harmonize the requirements of the RBAC 154, concerning the installation of navigation aids, with the requirements of the ICA 63-18.

To the Air Space Control Department (DECEA):

A-121/CENIPA/2021 - 03 **Issued on 05/15/2023**

Manage with the ANAC, in order to harmonize the requirements of the ICA 63-18, concerning the installation of aids to navigation, with the requirements of the RBAC 154.

A-121/CENIPA/2021 - 04 **Issued on 05/15/2023**

Establish administrative contacts before the Companhia Energética de Minas Gerais S.A. (CEMIG - Electric Power Company of Minas Gerais State) to exceptionally implementation signage in the portion of the 69-kV power grid corresponding to the extension of the runway 02 of SNCT.

À Agência Nacional de Energia Elétrica (ANEEL), recomenda-se:

A-121/CENIPA/2021 - 04 **Issued on 05/15/2023**

Evaluate, in coordination with the DECEA, the establishment of requirements for the signaling of transmission and distribution power grids in the vicinity of Aerodromes, especially those located in regions with rugged terrain, with the aim of preventing aeronautical accidents.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

Surveillance inspection of the aircraft operator's SMS.

On 09JUN2022, ANAC conducted a surveillance inspection of the aircraft operator, adopting new guidelines for measuring the maturity of the SMS.

At the time, the new PAOE scale was used, which considered the initials of the acronym for the description of the levels: Present, Adequate, Operational, and Effective. The levels were increasing, so that "Present" was the lowest level, and "Effective" was the highest. If an item was found to be "Adequate", it implied that it was "Present"; if it was found to be "Operational", it implied that it was "Present" and "Adequate", and so on.

The PAOE scale was described in the "SMS Assessment Guidelines" document. This document contained the following definitions and guidelines for each of the levels mentioned:

> [...]
>
> Present: There is evidence that the process is documented in the organization's Operational Safety Management Manual and/or SMS documentation.
>
> Adequate: the process is adequate based on the size, nature, and complexity of the organization and the inherent risk of the activity. The assessment of adequacy is specific to the organization.
>
> Operational: there is evidence that the process is in use and delivering results to the organization.
>
> Effective: there is evidence that the process is achieving the desired outcome and has a positive impact on safety.

The scale was applied according to the guidelines and a checklist indicated which level of the scale needed to be evident for the question to be considered compliant.

During the inspection, it was found that the elements: "hazard identification processes" and "risk assessment and control processes" did not reach the "Operational" level.

As a result of this inspection, the operator formulated a Corrective Action Plan to raise the maturity level of its SMS.

Publication of a Visual Approach Chart (VAC) for SNCT.

According to item 10.1.1 of ICA 96-1, the purpose of a VAC is to provide flight crews with information that allows them to pass from the en-route and descent flight phase to the planned runway landing approach phase through visual references.

With the intention of improving the situational-awareness status of pilots operating in SNCT, the DECEA issued a VAC (valid from 20APR2023 onwards), which raises the aerodrome traffic altitude to 3,300 ft., and alerts about the risks of flying beyond the distance of 1.5 NM from the approach-runway threshold.

With this detailed treatment of the traffic profile in SNCT, one expects that greater separation will exist between aircraft and terrain, as well as separation between aircraft in procedure for landing at that aerodrome.

On, May 15th, 2023.