COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A-147/CENIPA/2022

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PP-IRC**
MODEL:	**AT 502A**
DATE:	**22DEZ2022**

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 22 December 2022 accident involving the model AT-502A aircraft of registration marks PP-IRC. The occurrence was typified as “[UIMC] Unintentional IMC” and “[LOC-I] Loss of Control in Flight.”

The aircraft took off at approximately 10:15 UTC from the agricultural-aircraft airstrip on *Fazenda Floresta* in the municipality of *Brasnorte*, State of *Mato Grosso*. During the climb, the aircraft inadvertently entered adverse weather conditions, with subsequent loss of control and collision with the ground.

The aircraft was destroyed, and the pilot suffered fatal injuries.

Being the USA the State of manufacture of the aircraft, and Canada the State of manufacture of the engine, accredited representatives (01 per country) were designated for participation in the investigation of the accident, respectively by the American NTSB (National Transportation Safety Board) and by the Canadian TSB (Transportation Safety Board).

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GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ANAC	Brazilian National Civil Aviation Agency
CB	Cumulonimbus cloud
CENIPA	Brazilian Center for the Investigation and Prevention of Aeronautical Accidents
CIMAER	Command of Aeronautics' Integrated Center of Meteorology
CIV	Digital Pilot-Logbook
CMA	Aeronautical Medical Certificate
CVA	Certificate of Airworthiness
DECEA	Command of Aeronautics' Department of Airspace Control
GPS	Global Positioning System
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
INMET	Brazilian National Institute of Meteorology
METAR	Routine Meteorological Aerodrome Report
MNTE	Single-Engine Landplane Rating
NTSB	USA's National Transportation Safety Board
OM	Maintenance Organization
PAGA	Ag-Pilot Rating - Airplane
PIC	Pilot in Command
PCM	Commercial Pilot License - Airplane
PPR	Private Pilot License - Airplane
RAB	Brazilian Aeronautical Registry
RBAC	Brazilian Civil Aviation Regulation
REDEMET	Command of Aeronautics' Meteorology Network
SACI	Integrated Civil Aviation Information System
SIGMET	Significant Meteorological Information
SIGWX	Significant Weather Chart
SIPAER	Aeronautical Accidents Investigation and Prevention System
TCU	Towering Cumulus cloud
TPP	Private Air Service Aircraft Registration Category
TSB	Transportation Safety Board - Canada
UTC	Coordinated Universal Time
VFR	Visual Flight Rules

1. FACTUAL INFORMATION.

Aircraft	**Model:** AT 502A **Registration:** PP-IRC **Manufacturer:** *Air Tractor.*	**Operator:** Private.
Occurrence	**Date/time**: 22DEZ2022 - 10:20 (UTC) **Location:** *Fazenda Floresta* **Lat.** 13°01'00"S **Long.** 058°03'33"W **Municipality – State:** *Brasnorte – Mato Grosso.*	**Type(s):** [UIMC] Unintended flight in IMC [LOC-I] Loss of control - inflight

1.1. History of the flight.

At around 10:15 UTC, the aircraft departed from the agricultural-aircraft airstrip on *Fazenda Floresta*, in the municipality of *Brasnorte*, State of *Mato Grosso*, bound for *Fazenda Pitanga*, municipality of *Tangará da Serra*, on a ferry flight, with 01 POB (pilot).

During the climb, the aircraft encountered adverse weather conditions, with subsequent loss of control and collision with the ground.

Figure 1 - Top view of the wreckage site of the aircraft PP-IRC.

The aircraft was destroyed, and the pilot sustained fatal injuries.

1.2. Injuries to persons.

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

1.3. Damage to the aircraft.

The aircraft was destroyed, and the pilot suffered fatal injuries.

1.4. Other damage.

NIL.

1.5. Personnel information.

1.5.1. Crew's flight experience.

HOURS FLOWN	
	PIC
Total	1,255:59
Total in the last 30 days	Unknown
Total in the last 24 hours	00:00
In this type of aircraft	809:32
In this type in the last 30 days	Unknown
In this type in the last 24 hours	00:00

Note: flight-hour data obtained from the pilot's CIV Digital Pilot-Logbook), available on the ANAC's SACI (Integrated Civil Aviation Information System), complemented by information provided by the aircraft operator. The most recent entry in the CIV was made on October 7, 2021.

1.5.2. Personnel training.

The Pilot in Command (PIC) completed the PPR course (Private Pilot – Airplane) in 2006.

1.5.3. Category of licenses and validity of certificates.

The PIC held a Commercial Pilot License - Airplane (PCM) and valid ratings for Single-Engine Landplane (MNTE) and Agricultural Pilot - Airplane (PAGA).

The PIC did not hold the Instrument Flight Rating - Airplane (IFRA) required to operate an aircraft under instrument flight rules or in meteorological conditions below the minimums prescribed for visual flight, as per the Brazilian Civil Aviation Regulations (RBAC) No. 61 - "Licenses, Ratings, and Certificates for Pilots," item 61.3, "Conditions for the Use of Licenses, Certificates, Ratings, and Authorizations":

> (d) Instrument Flight Rating (IFR): no-one is not allowed to act as pilot in command (or second in command) of an aircraft under instrument flight rules, or in meteorological conditions below the minima prescribed for visual flights, unless one holds a pilot license with a valid instrument flight rating appropriate for the category of the aircraft in operation, issued in compliance with this Regulation. (Emphasis added).

1.5.4. Qualification and flight experience.

Records from the pilot's CIV indicated that he had operated EMB-202 Ipanema aircraft from 2012 until December 2017. From that point onward, the pilot flew exclusively the PP-IRC, being its sole operator since its delivery from the factory in 2017.

A significant part of the PIC's operational history was associated with agricultural aircraft operations in the region where the accident occurred.

The pilot was qualified and experienced for visual flights but did not hold the required rating for instrument flights.

1.5.5. Validity of medical certificate.

The PIC held a valid CMA (Aeronautical Medical Certificate).

1.6. Aircraft information.

The serial number 502A-3112 turboprop quad-blade aircraft was a product manufactured by AIR TRACTOR in 2017, and registered under the Private Air Services Category (TPP). It was equipped with a P&W PT6A-140AG engine of 867 SHP.

The aircraft was part of the AT-502A series designated as AT-502XP (Extra Power) due to its re-engined configuration when compared to the "basic" model, which was equipped with a P&W PT6A-34AG engine producing 750 SHP.

The CVA (Certificate of Airworthiness) of the aircraft was valid. The records of the airframe, engine, and propeller logbooks were up to date.

The aircraft's latest inspection ("300-hour" type) took place on June 1, 2022, on the premises of the Maintenance Organization *SERRA - Serviço de Recuperação e Revisão de Aeronaves Ltda.* in *Tangará da Serra*, State of *Mato Grosso*. However, it was not possible to determine the total flight hours flown after the inspection, as the aircraft logbook could not be located.

The same maintenance organization conducted the most recent inspection of the aircraft (for the renewal of the CVA) in *Tangará da Serra* on September 22, 2022. The exact number of hours flown after the referred inspection until the accident could not be determined either. However, between the "300-hour" inspection and the CVA renewal, the aircraft flew approximately 5 hours over a span of 3 months and 21 days.

The aircraft was not equipped with navigation systems for operation under Instrument Meteorological Conditions. It was certified only for daytime VFR flights, as outlined in the AT-502A/B *Airplane Flight Manual (Brazil) - Section 1 - Limitations - Kinds of Operation*:

> This aircraft is certified in the RESTRICTED CATEGORY for agricultural and firefighting purposes and is eligible for the following types of operations when the appropriate instruments and equipment required by the airworthiness authority and/or operational regulations have been installed, approved, and operational:
>
> a. Day-time VFR;
>
> b. Flight in icing conditions is prohibited;
>
> c. Flights with storms in the vicinity are prohibited.

1.7. Meteorological information.

Fazenda Floresta did not have a meteorological station, but according to observer reports, at the time of takeoff, there was significant cloud coverage in the region, with an estimated ceiling below 1,000 ft. and visibility of less than 10 km.

The Aeronautical Integrated Meteorology Center (CIMAER) issued a meteorological analysis to support this investigation.

Regarding the wind, CIMAER reported that from the surface to FL050, the predominant direction was approximately 315º, with speeds of 10 to 15 knots.

For Significant Weather (SIGWX), from the surface to FL250, there were forecasted Towering Cumulus (TCU) clouds with bases at 2,500 ft., tops at 23,000 ft., and a coverage of 1 to 2 oktas, as shown in Figure 2.

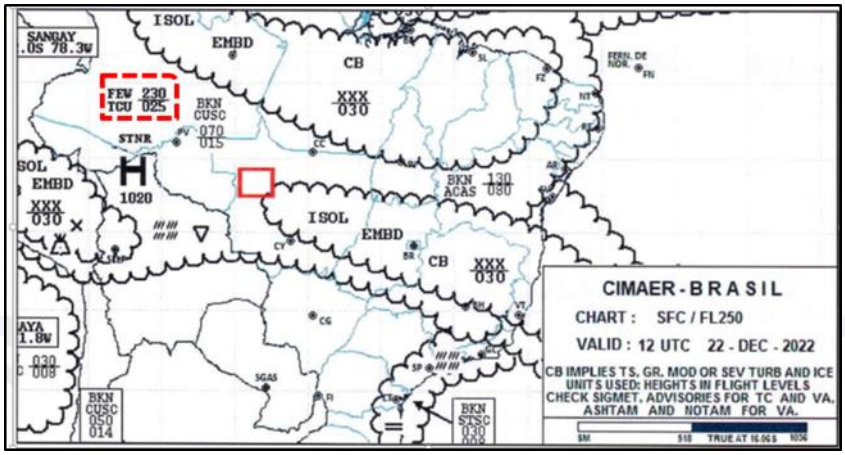

Figure 2 - SIGWX chart valid until 12:00 UTC on the day of the occurrence. Red dashed lines highlight the information on TCU clouds in the region; the solid red square indicates the accident location. Source: REDEMET.

Additionally, there was low cloud coverage consisting of a combination of *Cumulus* and *Stratocumulus* clouds, with base at 1,500 ft. and 5 to 7 oktas coverage, accompanied by rain showers and/or continuous rain. Medium-level cloud coverage included *Altostratus* and *Altocumulus* clouds, with base at 8,000 ft. and coverage from 5 to 7 oktas.

According to the CIMAER, the significant weather conditions in the region were as follows:

> The forecast of FEW TCU implies the presence of clouds with considerable vertical development, representing a pre-stage to cumulonimbus formation. The presence of TCU may result in moderate to severe turbulence and moderate to heavy rainfall. The forecast for rain showers and/or continuous rain, as well as medium-level clouds (ACAS) with base at 8,000 ft. suggests reduced horizontal and vertical visibility.

The Department of Airspace Control (DECEA) provided the GAMET (area meteorological forecast in abbreviated clear language for low-level flights). The FIR AMAZÔNICA GAMET (valid until 12:00 UTC on December 22, 2022) had the following forecast: Moderate rain, reducing visibility to 4,000 meters; Mist, reducing visibility to 3,000 meters; Isolated cumulonimbus clouds (CB) with base at 3,000 ft.; Isolated thunderstorms (ISOL TS) at 2,500 ft.; Low cloud coverage with base at 500 ft. and ceiling at 1,400 ft.; Wind at 2,000 ft. 040° at 10 knots; Altocumulus clouds (AC) with base at 8,000 ft. (Figure 3).

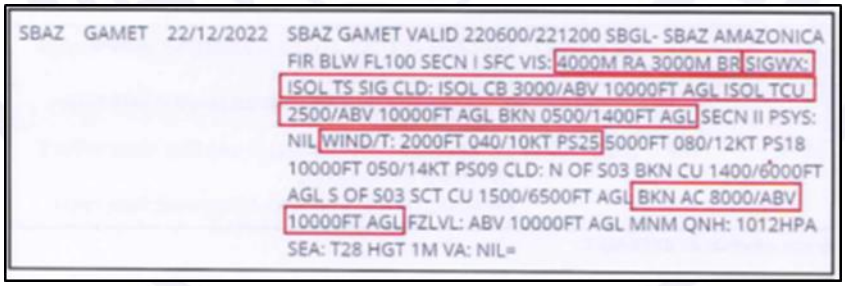

Figure 3 - GAMET valid from 06:00 to 12:00 UTC on the day of the occurrence. The main pieces of information are highlighted in red. Source: REDEMET.

Satellite images showed low and medium cloud coverage across the accident region, with clouds west of the area, indicating the presence of CB/TCU.

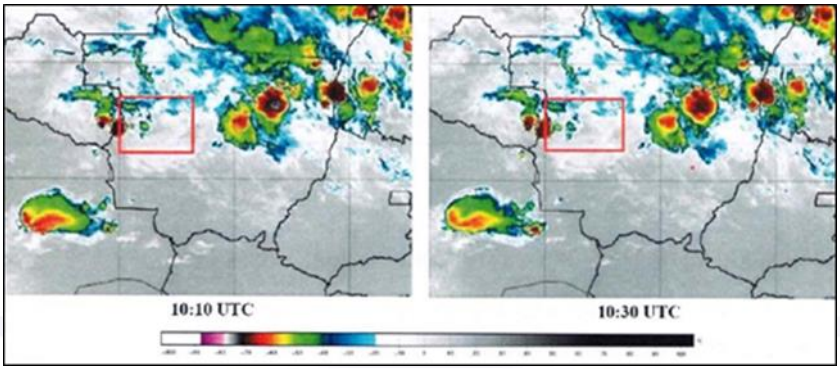

Figure 4 - Satellite imagery from December 22, 2022.
Source: Weather Forecast and Climate Studies Center.

The presence of low and medium cloud coverage, combined with convective clouds (CB/TCU), had the potential to cause light to moderate rainfall, as well as restrict horizontal and vertical visibility.

The CIMAER issued the following analysis regarding the weather conditions in the region:

> The forecast for CB clouds with isolated thunderstorms suggests the possibility of icing, hail, strong winds, moderate to heavy rainfall, and moderate to severe turbulence.
>
> Even if thunderstorm clouds (CB or TCU) do not form directly over the accident site, they are associated with strong updrafts and downdrafts. When these strong downdrafts reach the surface, the air mass diverges, potentially traveling tens of kilometers ahead of the storm, depending on its stage of development

In accordance with the pieces of information aforementioned, the meteorological conditions were below the minimums required for conducting operations under visual flight rules (VFR).

1.8. Aids to navigation.

NIL.

1.9. Communications.

NIL.

1.10. Aerodrome information.

Not applicable.

1.11. Flight recorders.

Not required and not fitted.

1.12. Wreckage and impact information.

The wreckage was located at a distance of 4 NM south of the point of departure, in the direction of the intended destination, consistent with the planned route. The site was flat and located at a distance of approximately 1.5 km from the highway MT-364, as shown in Figure 5.

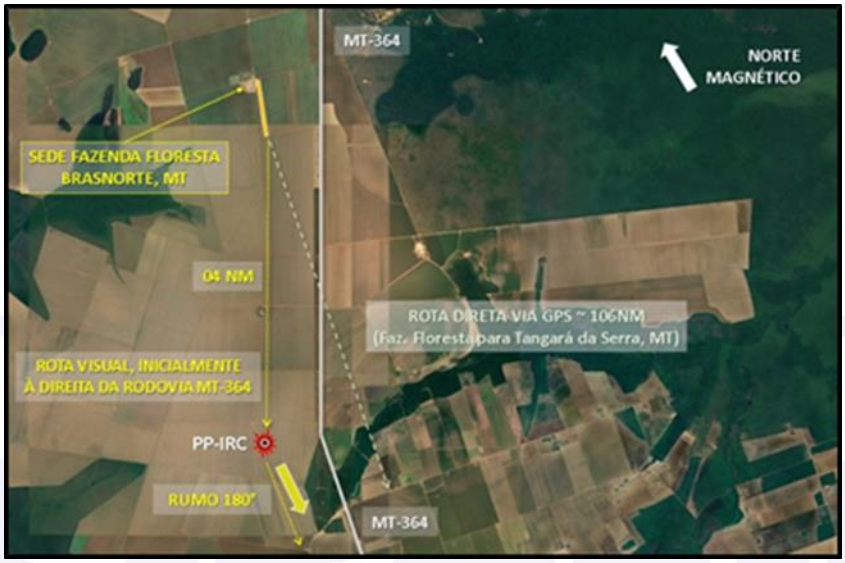

Figure 5 - Overview of the area where the crash occurred.

The concentrated disposition of the wreckage indicated that the aircraft collided with the ground at a high vertical speed with a steep angle (greater than 45°). The engine was found buried at a depth of 4 meters in a rural area of *Brasnorte*, MT.

There were no signs of horizontal movement of the aircraft on the ground. The discoloration of vegetation near the wreckage suggested fuel dispersion following the impact, indicating that the final heading of the flight was 180° (Figure 6).

Figure 6 - Overview of the aircraft wreckage.

The extent of destruction of the aircraft made it difficult to inspect most of the pieces of equipment and instruments. The aircraft's Global Positioning System (GPS), which could have recorded the trajectory, was either not turned on or did not record the flight in question. Only flights from previous days were found in its memory.

There was no separation of aircraft components in flight prior to the impact.

1.13. Medical and pathological information.

1.13.1. Medical aspects.

There was no evidence that issues of physiological nature or incapacitation might have affected the pilot's performance.

1.13.2. Ergonomic information.

NIL.

1.13.3. Psychological aspects.

According to family members, the Pilot in Command (PIC) enjoyed flying and was very confident. There was no evidence of motivation or compulsion to proceed with the flight despite the operation below the required meteorological minimums.

1.14. Fire.

There was no fire.

1.15. Survival aspects.

NIL.

1.16. Tests and research.

NIL.

1.17. Organizational and management information.

NIL.

1.18. Operational information.

The intended route between *Fazenda Floresta (Brasnorte*, MT) and *Fazenda Pitanga (Tangará da Serra*, MT) had already been flown on previous occasions. However, it was not possible to determine the altitude at which the flight was to be conducted, as no flight plan was filed.

The ferry flight was to be conducted under VFR in uncontrolled airspace, with an estimated duration of 45 minutes over a distance of approximately 106 NM. The aircraft had enough fuel for the flight.

According to witnesses at the location of departure, the aircraft took off heading south and began a normal climb. Moments later, a sound described as "similar to that of an agricultural operation" was heard coming from the engine. The sound was interpreted as some maneuver, although it was unclear whether it was a turn or a climb, and then the sound ceased.

1.19. Additional information.

Spatial disorientation refers to a variety of accidents and incidents in flight where the pilot cannot accurately sense the aircraft's position, movement, or attitude, or their own position within a fixed coordinate system defined by the Earth's surface and vertical gravity. Additionally, errors in the pilot's perception of their position, movement, or the aircraft's attitude can also be classified as spatial disorientation events in flight (Benson, 2006)[1].

The U.S. Navy reported that between 1980 and 1989, spatial disorientation among pilots contributed to some of the 112 major aviation accidents during that period (Bellenkes, Bason, Yacavone, 1992)[2].

Under normal conditions, humans orient themselves using information from three specialized sensory systems, namely, the visual system, the vestibular system (balance organs located in the inner ear), and the proprioceptive system.

These systems rely on various sensory receptors to gather references and send the data to the brain, which integrates the information into a single orientation model. Under normal conditions, this mechanism is highly accurate.

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[1] Benson, ALAN J., and J. R. Stott. "*Spatial disorientation in flight." Ernsting's Aviation Medicine. 4th ed. Cornwall: Edward Arnold Ltd* (2006): 433-58.

[1] Bellenkes A, Bason R, Yacavone DW. *Spatial disorientation in naval aviation mishaps: a review of class A incidents from 1980 through 1989. Aviat Space Environ Med*. 1992 Feb; 63(2) 128-131. PMID: 1546941.

The integrated information is used to determine our position within a fixed coordinate system, where the Earth's surface provides a horizontal reference, whereas gravity supplies the vertical reference.

The three systems have different levels of importance in providing orientation information. The visual system is the most important of the three, providing about 80% of the orientation information.

When visual indications are sparse or absent, such as in degraded weather or at night, up to 80% of normal orientation information may be lost.

The remaining 20% is divided equally between the vestibular and proprioceptive systems. Both are prone to illusions and misinterpretations. Therefore, they are less accurate.

In the absence or scarcity of visual cues, humans are forced to rely on the remaining 20% of orientation information.

In the aviation scenario, such a situation can result in spatial disorientation of the pilot. This is even more dangerous when the pilot is unaware that he has become disoriented, believing that his sensory information is correct, when in fact it is not.

Clearly, the lack of good visual cues deprives us of most orientation information. Most spatial disorientation events are associated with the absence of visual cues, such as in IMC and night flying.

The vestibular system is composed of two critical components: the semicircular canals and the otolith organs.

There are three semicircular canals in each ear, which functionally operate as three corresponding pairs, on each of the three primary axes of motion.

The canals in each ear are perpendicular to each other and function as angular accelerometers. Significantly, they have a stimulation threshold of 2°/sec. Below this value, they are unable to detect angular motion. This is of crucial importance in the aviation scenario, because if movement is performed, either intentionally or unintentionally, at an angular acceleration rate below this threshold, the canals will not register it.

In the absence of visual cues that the turn is taking place, the pilot will not notice it, if there is no change in proprioceptive information, and will interpret it as a straight and level flight.

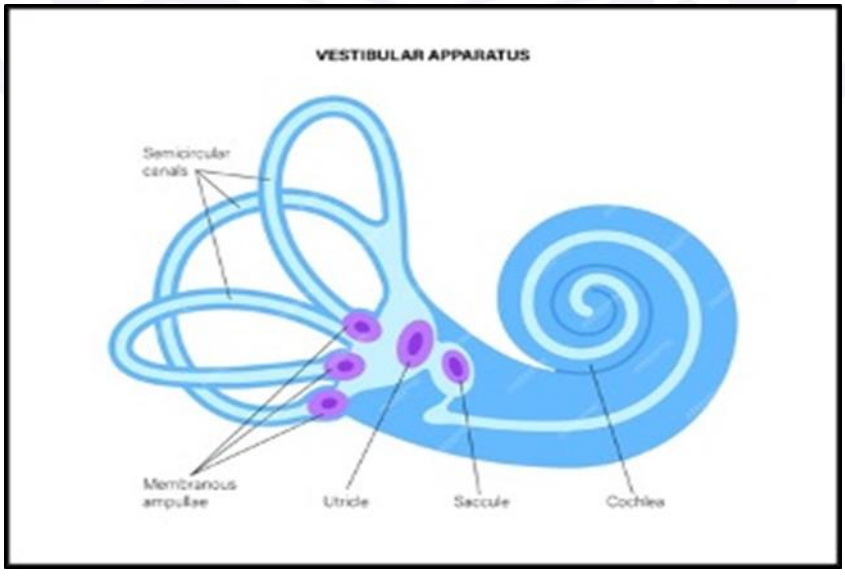

Figure 7 - Vestibular apparatus.

Each ear also contains two otolith organs: one oriented vertically and the other horizontally. These organs function as linear accelerometers. Under normal conditions, the vertical otolith provides signals about the Earth's gravitational field.

The vestibular system plays a crucial role in human spatial orientation by integrating angular and linear accelerations through its neural connections with the eyes and motor coordination centers in the brain. This integration helps regulate posture, maintain balance, and coordinate vision during motion.

Finally, the proprioceptive system consists of pressure sensors distributed throughout the body, particularly in the joints, tendons, ligaments, muscles, and skin. Under normal conditions, pressure exerted on a given set of pressure receptors contributes to the overall sense of orientation. For instance, pressure sensors in the soles of the feet and the joints of the ankles and knees send signals to the brain, indicating that an upright posture is being maintained.

All of this sensory information is constantly being sent to the brain for processing in order to maintain an accurate sense of orientation relative to the plane of the Earth's surface and the gravitational vertical plane.

It is important to remember that these systems, which humans depend on for orientation, are not designed for the three-dimensional flight environment. In this environment, pilots may need to operate without normal visual cues, such as in poor weather or night flight, leaving them exposed to the physiological limitations of human orientation systems.

1.20. Useful or effective investigation techniques.

NIL.

2. ANALYSIS.

It was a ferry flight departing from agricultural-aircraft airstrip of *Fazenda Floresta*, *Brasnorte*, MT, bound for *Fazenda Pitanga*, *Tangará da Serra*, MT, with 01 POB (pilot).

The investigation findings obtained from the analysis of the wreckage site and the witness reports ruled out engine failure. The records of the airframe, engine, and propeller logbooks were up to date, and the aircraft maintenance was current.

It was determined that the meteorological conditions at the time of the occurrence were below the minimums required for VFR operations. Additionally, the aircraft was not certified for IFR flights, and operations were not allowed in the presence of storms or icing conditions, as per the aircraft manual.

The weather on the day of the occurrence included heavy fog, poor weather, low visibility, and drizzle, as indicated in the meteorological report issued by the CIMAER. These conditions directly affected the safety of the operation and contributed to abnormal situations in flight.

According to information, the pilot had already conducted ferry flights between the said locations, being, therefore, familiar with the proposed route. He had already flown along that route a few times, but in visual meteorological conditions.

However, inadequate preflight preparation, including poor assessment of the weather conditions along the route and failure to meet the minimum requirements for VFR, resulted in the flight being conducted under IMC. Neither the pilot nor the aircraft was certified for IFR operations.

The disposition of the wreckage, indicating loss of control in flight, coupled with the prevailing meteorological conditions at the crash site, suggested that the pilot inadvertently entered IMC. Without visual references in flight, the pilot likely experienced spatial

disorientation, which led him to lose control of the aircraft and subsequently collide with the ground.

3. CONCLUSIONS.

3.1. Findings.

a) the PIC held a valid Aeronautical Medical Certificate (CMA);

b) the PIC had a Commercial Pilot License - Airplane (PCM) and valid ratings for Single-Engine Landplane (MNTE) and Agricultural Pilot - Airplane (PAGA);

c) the PIC was qualified and experienced in VMC flight;

d) the PIC did not hold an IFRA rating (Instrument Flight - Airplane);

e) the aircraft was not certified for flights in instrument meteorological conditions.

f) the aircraft had a valid CVA (Certificate of Airworthiness);

g) the aircraft was within weight and balance limits.

h) the records of the airframe, engine, and propeller logbooks were up to date;

i) the meteorological conditions were below the minimums required for visual flights.

j) the PIC had flown the intended route on previous occasions;

k) the aircraft had a high vertical speed at the time of impact;

l) there was no separation of aircraft components in flight, and the wreckage was concentrated at the crash site;

m) the aircraft was destroyed; and

n) the PIC sustained fatal injuries.

3.2. Contributing factors.

- **Attitude – a contributor.**

The disregard for adverse meteorological conditions along the planned route on an aircraft not certified for instrument operations, combined with the pilot's lack of IFR rating, reflected a complacent attitude. This directly increased the risks associated with the intended operation.

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

The adverse weather conditions at the crash site, predominantly IMC, prevented the pilot from maintaining visual references with the ground, leading to a loss of control in flight and subsequent collision with the terrain.

- **Disorientation – undetermined.**

It is plausible that the pilot experienced spatial disorientation while flying without visual references to the ground, which likely led to the loss of control and collision.

- **Perception – undetermined.**

The weather conditions at the time of the flight, combined with evidence of the high-energy and concentrated impact, suggest that the pilot lost visual references, which may have contributed to spatial disorientation.

- **Flight planning – a contributor.**

During preflight preparations, the existing meteorological conditions at the location of departure and along the route were not considered prohibitive, despite being below the minimum requirements for VFR operations.

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

The decision to proceed with the flight under adverse weather conditions, on an aircraft not certified for IMC operations and without IFR certification, reflects inadequate judgment. This led to difficulties in analyzing the situation, selecting viable alternatives, and responding appropriately to the evolving circumstances.

4. SAFETY RECOMMENDATIONS

None.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

None.

On April 14th, 2025.