COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A-133/CENIPA/2022

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PP-OBL**
MODEL:	**AT-502A**
DATE:	**18NOV2022**

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 on the accident that occurred on November 18th, 2022, involving the AT-502A aircraft with registration marks PP-OBL. The occurrence was classified as “[LOC-I] Loss of control in flight and [LALT] Low altitude operation”.

During an agricultural crop-spraying flight, while performing a repositioning maneuver for a new application pass, the pilot lost control of the aircraft, which subsequently crashed into the terrain.

The recorded flight data showed that in the last five reversal turns performed in the northeastern sector of the spraying area circuit, the climbs were steeper than those used in other equivalent phases of the operation.

The aircraft sustained substantial damage.

The pilot suffered fatal injuries.

Since Canada was the State of the aircraft’s engine manufacture, and the USA the State of the aircraft’s manufacture, two Accredited Representatives - one from the Canadian Transportation Safety Board (TSB) and one from the USA’s National Transportation Safety Board (NTSB) - were appointed for participation in the investigation of the accident.

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GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

AFM	Airplane Flight Manual
ANAC	Brazil's National Civil Aviation Agency
AG-NAV	Aeroagricultural Navigation-Equipment Manufacturer
CENIPA	Aeronautical Accidents Investigation and Prevention Center
CIV	Pilot Logbook
CVA	Certificate of Airworthiness-Verification
GPS	Global Positioning System
LABDATA	Cenipa's Flight Recorders Readout and Analysis Laboratory
METAR	Routine Meteorological Aerodrome Report
MNTE	Single-Engine Land Airplane Rating
PAGA	Agricultural Pilot Rating - Airplane
PCM	Commercial Pilot License - Airplane
PIC	Pilot in Command
POB	Persons on board
QAV	Aviation kerosene
RBAC	Brazilian Civil Aviation Regulation
SBSO	ICAO location designator - *Adolino Bedin* Regional – *Sorriso* – Aerodrome, municipality of *Sorriso*, State of *Mato Grosso*
SERIPA	Regional Service for Aeronautical Accidents Investigation and Prevention
SIGWX	Significant Weather Chart
SIPAER	Aeronautical Accidents Investigation and Prevention System
SN	Serial Number
TCU	Towering Cumulus
TPP	Private Air Services Registry Category
UTC	Coordinated Universal Time

1. FACTUAL INFORMATION.

Aircraft	**Model:** AT-502A **Registration:** PP-OBL **Manufacturer:** *AIR TRACTOR*	**Operator:** Private.
Occurrence	**Date/time**: 18NOV2022 - 18:00 (UTC) **Location:** *Fazenda Araçatuba* **Lat.** 12°19'11"S **Long.** 055°30'15"W **Municipality – State:** *Vera – Mato Grosso*.	**Type(s):** [LOC-I] Loss of control - inflight [LALT] Low altitude operations

1.1. History of the flight.

At around 17:55 UTC, the aircraft took off from the airstrip for agricultural use of *Fazenda Araçatuba*, municipality of *Vera*, *Mato Grosso*, for an aerial application flight, with 01 POB (pilot).

Approximately five minutes into the flight, during a repositioning maneuver for a new pass, the pilot lost control of the aircraft, which subsequently crashed into the ground.

The aircraft sustained substantial damage.

The pilot suffered fatal injuries.

1.2. Injuries to persons.

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

1.3. Damage to the aircraft.

The aircraft sustained substantial damage.

The forward section of the fuselage and the powerplant assembly were severely damaged. There was wrinkling on the leading edges of the wings and significant denting on the upper section of the cockpit.

1.4. Other damage.

NIL.

1.5. Personnel information.

1.5.1. Crew's flight experience.

FLIGHT EXPERIENCE	
	PIC
Total	3.502:45
Total in the last 30 days	61:00
Total in the last 24 hours	05:40
In this type of aircraft	100:36
In this type in the last 30 days	61:00
In this type in the last 24 hours	05:40

RMK: Flight experience data obtained from the Digital Pilot-Logbook (CIV) and from the Aircraft Logbook. The CIV data were up to date as of 26 June 2022. The latest record of the aircraft Logbook referred to the flight preceding the accident flight.

1.5.2. Personnel training.

The Pilot in Command (PIC) completed his PPR Course (Private Pilot - Airplane) in 2011.

From the pilot's flight records, it was not possible to determine the name and location of the flying school at which his training was performed.

1.5.3. Category of licenses and validity of certificates.

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

1.5.4. Qualification and flight experience.

The records of the Aircraft Logbook indicated that the PIC had been operating the AT-502A aircraft of registration marks PP-OBL since August 2022, and accumulated 100 hours and 36 minutes of flight time in the referred aircraft.

The majority of the pilot's operational background related to agricultural aviation operations. Between September 2012 and the date of the accident, the pilot accumulated more than 3,000 flight hours in various models of agricultural aircraft.

The PIC was qualified and had experience in the type of flight.

1.5.5. Validity of medical certificate.

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

1.6. Aircraft information.

The SN 502A-3223 aircraft was a product manufactured by Air Tractor Inc. in 2019, and registered in the Private Air Service Registration Category (TPP).

The aircraft’s CVA (Certificate of Airworthiness-Verification) was valid by 08 November 2023.

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

The aircraft's latest inspection (“100-hour” type) was performed on November 08, 2022, on the premises of the maintenance organization *SMA - Sorriso Manutenção Aeronáutica*, in *Sorriso*, State of *Mato Grosso*.

The said inspection comprised the airframe, engine, and propeller of the aircraft. On the occasion, the components had 1,421 hours and 48 minutes of operation.

According to records, the aircraft flew 28 hours and 54 minutes after the inspection.

<u>Flap control system.</u>

The electrically-operated flaps could be extended to any position between 0º and 26º.

On the external surfaces of the flaps, there were two marks visible from the cockpit indicating, respectively, the extensions of 10º and 20º.

1.7. Meteorological information.

The METARs (Routine Meteorological Aerodrome Reports) of SBSO, located at a distance of 14 NM to the southwest of the crash site, contained the following information:

METAR SBSO 181700Z 33008KT 9999 SCT020 BKN080 27/25 Q1011

METAR SBSO 181800Z 31006KT 9999 SCT020 BKN080 27/24 Q1011

The conditions were favorable for visual flights, with visibility greater than 10 km and FEW clouds at an altitude of 2,000 ft. The wind strength was between 06 and 08 kt. The SIGWX (Significant Weather Chart) updated at 14:48 UTC, valid until 06:00 UTC of

November 19, 2022, showed the presence of FEW Towering Cumulus (TCU) clouds with base at FL025 and top at FL250.

Observers confirmed that the weather conditions were favorable for VFR flights.

1.8. Aids to navigation.

NIL.

1.9. Communications.

NIL.

1.10. Aerodrome information.

The accident occurred in a non-aerodrome area.

1.11. Flight recorders.

Not required and not installed.

However, the aircraft was equipped with an “*AG-NAV Guia*” Real-Time Navigation Guidance System, Model P152, Serial Number 152180112, Rev. KG, manufactured by AG-NAV Inc. The equipment, damaged in the accident, was sent to the AG-NAV Representative in Brazil, where the data stored in its memory was downloaded. The equipment contained data related to the flight of the accident, as well as data from previous flights.

1.12. Wreckage and impact information.

The wreckage was found in a concentrated fashion in an area of dense vegetation, consisting of trees of medium and large sizes. The terrain was predominantly flat int the crash site. The surrounding vegetation was relatively well preserved.

According to physical evidence, the aircraft collided with the treetops and then with the ground at a very steep angle (Figure 1).

Figure 1 – Lateral view of the aircraft wreckage and of the vegetation.

The front section of the fuselage sustained severe damage and the powerplant ended up buried in the ground.

There was wrinkling of the leading edges of the wings and significant denting in the upper part of the cockpit.

The rear section of the aircraft was relatively preserved, showing deformations resulting from deceleration and impact with the vegetation.

The longitudinal axis of the aircraft was aligned with the 260°magnetic heading and the fuselage on the ground came to rest in an upside-down position.

Figure 2 - Front section of the aircraft buried in the ground, and position of the flaps.

The aircraft had its flaps extended close to the 10° position, as evidenced by the visualization of a black rectangle on its extrados, as shown in Figures 2 and 3.

Figure 3 – Rectangular mark indicating flaps at 10°.

The propeller hit the trunk of a tree moments before the collision with the terrain. The tip of one of the blades was embedded in the tree trunk, and detached from the rest of the component, as shown in Figure 4.

Figure 4 - Tip of the blade of one of the propellers embedded in a tree trunk.

The instrument panel sustained severe damage, making it impossible to read any indications. However, it was possible to recover the data from the "*AG-NAV Guia*" Navigation System.

There was no evidence of any preimpact failure or malfunction in the flight control systems.

1.13. Medical and pathological information.

1.13.1. Medical aspects.

The forensic examination concluded that the pilot sustained injuries consistent with the nature of the accident.

1.13.2. Ergonomic information.

NIL.

1.13.3. Psychological aspects.

NIL.

1.14. Fire.

There was no evidence of either inflight or post-impact fire.

1.15. Survival aspects.

NIL.

1.16. Tests and research.

Flight data analysis.

The CENIPA's Flight Recorders Data Readout and Analysis Laboratory (LABDATA) analyzed the information retrieved from the aircraft's navigation system. The recorders had the following parameters of interest both from the accident flight and from a few previous flights: flight path, groundspeed, Global Positioning System (GPS), altitude, true heading, and time.

Another aspect observed during the analysis was that the moments prior to the impact were not recorded in the equipment's memory.

Figure 5 - Recorded trajectory of the accident flight.

One found that the axes of the spraying runs were generally oriented on the 056° and 236° magnetic headings, with two reversal turns made in the northeastern and southwestern sectors of the application circuit, respectively.

The circuit flown by the aircraft had a counterclockwise rotation, that is, with turns made to the left. Analysis of the flight prior to the accident showed a similar flight pattern.

Figure 6 shows the trajectories of the previous flight in light blue, with the last 15 minutes highlighted in dark blue, and the trajectory of the accident flight in red.

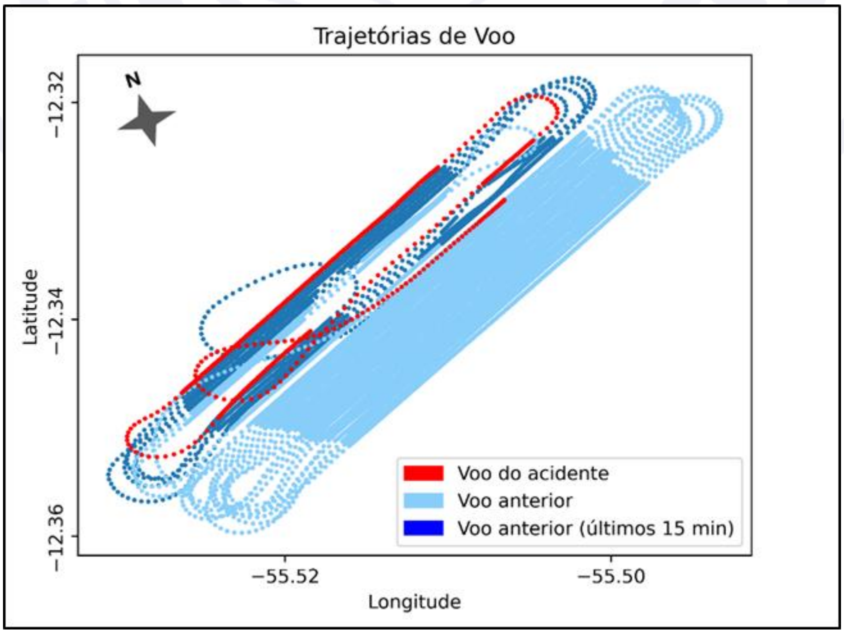

Figure 6 - Comparison of flight trajectories.

The solid lines indicate the trajectory where a stage of spraying, commonly known as “run” was carried out. The visibly spaced dots indicate the locations where the aircraft’s agricultural product application system was off.

This made it clear that the target areas for application on both flights were contiguous. The direction of rotation and the application headings were also similar.

In order to elucidate the factors that could have contributed to the aircraft losing control, a simplified model was constructed based on data recovered from the aircraft’s navigation system to evaluate the flight pattern performed by the aircraft, and correlating it with performance data.

Through a process of mathematical derivation of the data, it was possible to calculate other parameters that are important for understanding the event, such as the aircraft attitude and the rates of climb/descent and turn.

Also regarding the investigation of the flight data, one found that, based on the turn rate and aircraft speed, it would be possible to estimate the airplane's angle of bank.

Although this calculation was an estimate for the conditions of a sustained level turn (at a constant speed), for the flight profile experienced by the aircraft at the top of the reversal turns, this approximation was considered acceptable. Thus, the angle of bank estimator was used for comparison with the nominal stall speeds contained in the flight manual.

Based on the distance between the last coordinate recorded on the GPS and the crash site (2,826 meters), one estimated that the final 50 seconds of flight were lost, due to the lack of data immediately prior to the impact.

A vertical profile of the occurrence flight was constructed in order to graphically represent the data obtained (Figure 7).

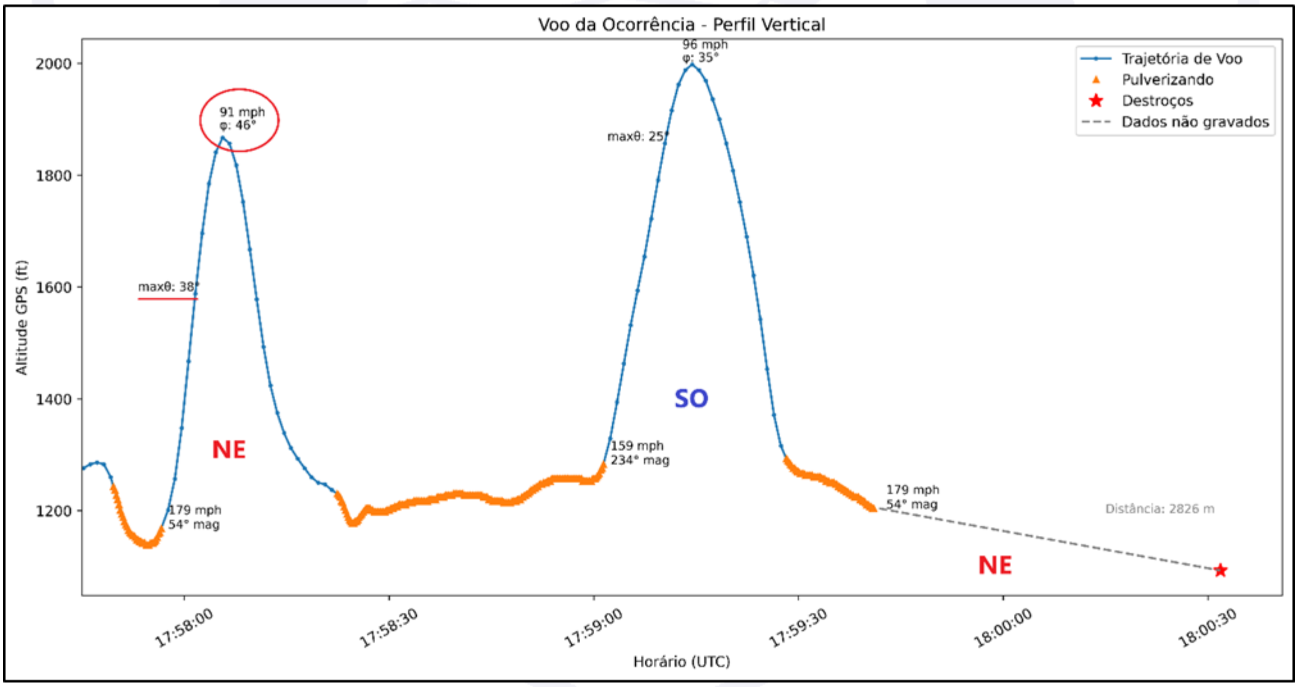

Figure 7 - Vertical profile of the accident flight.

The figure shows the speeds in miles/hour (mph), magnetic headings, and the banking of the aircraft's wings (φ) at the beginning and at the top of the reversal curves. The maximum climb attitudes reached in each of these maneuvers (maxθ) were also represented.

It was noteworthy that the attitude used during the climb in the reversal turn in the northeastern sector (NE) reached 38°, considered high for the type of aircraft and significantly higher than the 25° used in the opposite sector (SW).

It was also observed that the initial speed of the first reversal turn was 20 mph higher than the second one, however, the speed reached at the top was 7 mph lower. Thus, it was considered that the use of a very steep attitude contributed to the observed decrease in speed.

Still regarding the flight performance at the top of the northeastern turn, it was observed that the recorded speed was 91 mph and that the estimated wing banking was 46°.

Since the areas of application of the final part of the previous flight were adjacent to those of the accident flight, one began to observe the final segment of previous flight to see if a similar pilot behavior had been adopted.

The analysis of the previous flight showed that in the last four reversal turns in the northeastern (NE) sector, climb attitudes greater than 30° were also used and that the speeds at the top of these maneuvers were significantly lower than those in the southwestern sector of the circuit (Figure 8).

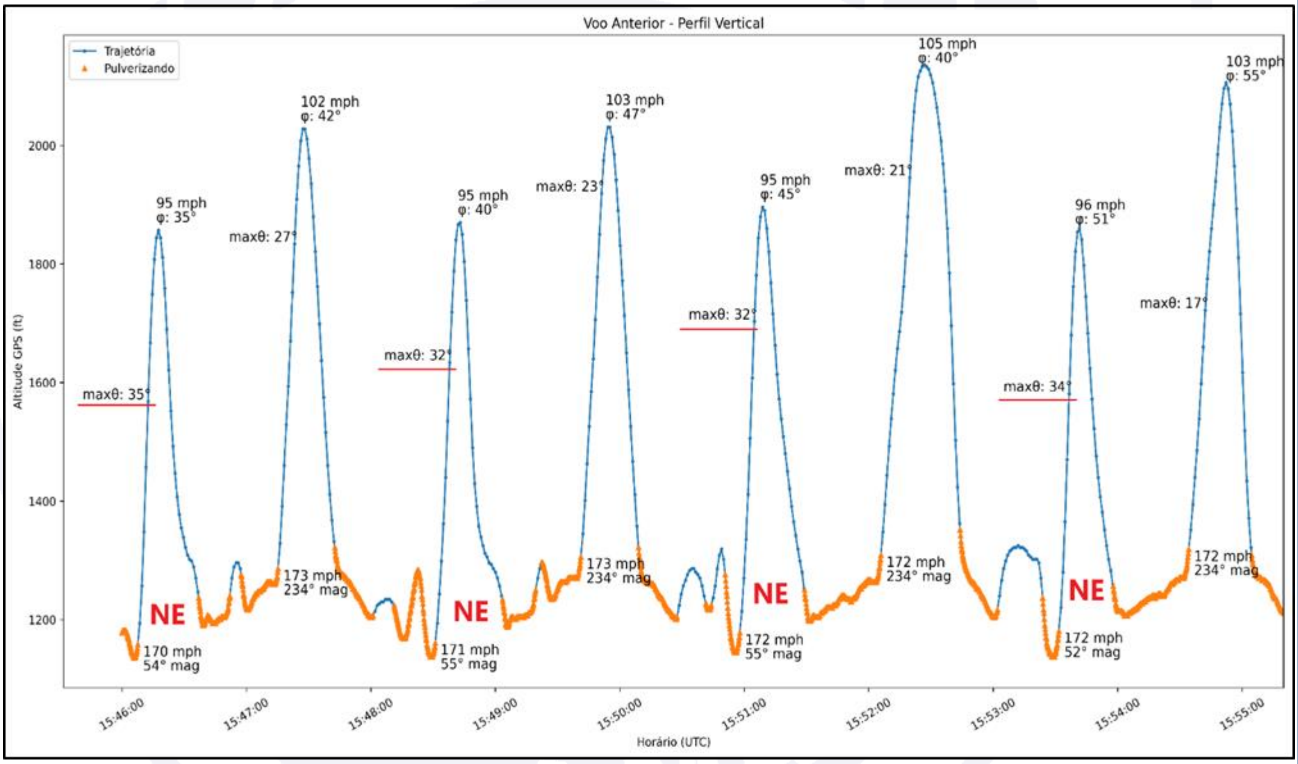

Figure 8 - Vertical profile of the flight before the accident flight.

Observing the projection of the flight path on the terrain (horizontal profile), it was noted that the last five “runs” in the southwesterly direction were initiated approximately 1,400 meters ahead of an imaginary perpendicular line connecting to the spot at which the runs in the opposite direction had ended. This was due to the fact that the strip of land in question consisted of an area of thick forest and, thus, there was no need for spraying (Figure 9).

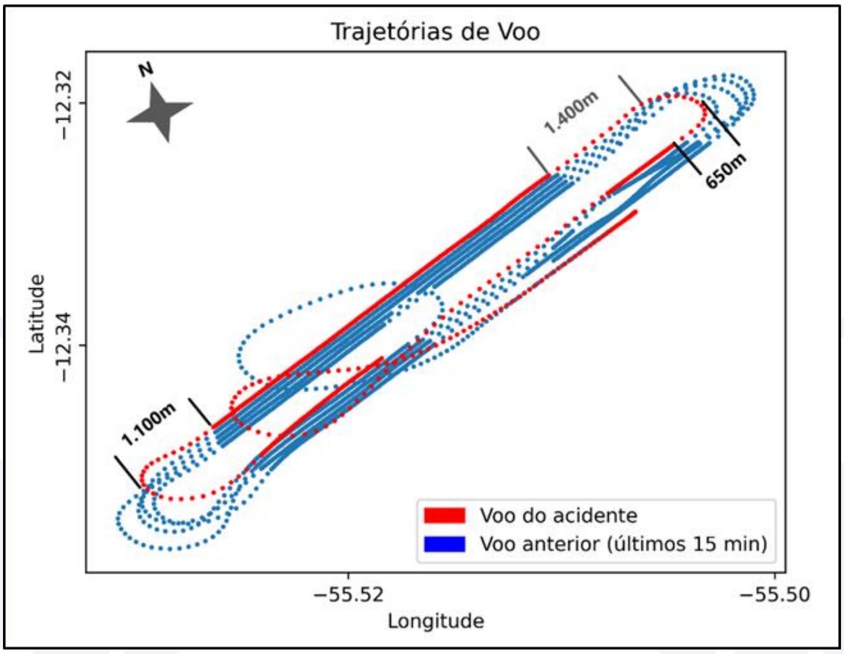

Figure 9 - Horizontal profile of the flights' trajectory.

It was also observed that, in the region of the accident, the turns to the northeast covered a shorter distance than those to the southwest. During the occurrence, for example, the distances between the start and end of the turns were 650 meters in the northeast and 1,100 meters in the southwest.

Analysis of the Powerplant

The Powerplant was taken to an approved maintenance organization, where it was evaluated by members of the Investigation Committee.

The SN CDA535 Hartzell HC-B4TN-3C propeller was visually inspected for identification of damage to the component.

The propeller logbook contained no records of repairs or interventions that could have affected its performance.

The four propeller blades had bends at their tips, as well as marks and scratches perpendicular to their longitudinal axis. Two of the blades had fractures near their tips, with part of the material having been sectioned (Figure 10).

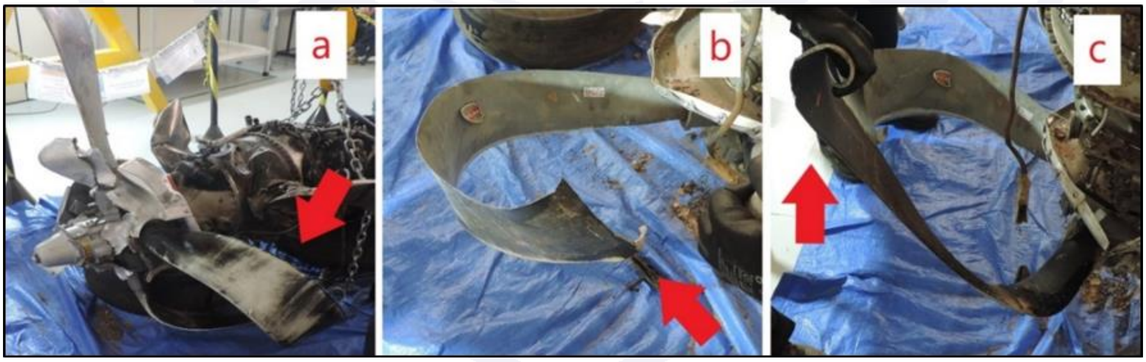

Figure 10 - (a) propeller, general appearance and perpendicular marks; (b) blade tip severed by impact with a tree; and (c) bent blade tip.

As a rule, when the rotation and angle of the propeller blades are compatible with values sufficient to produce aerodynamic reactions capable of keeping the aircraft flying, there will be a resulting force that tends to bend the blades forward, in the opposite direction to their traction force.

The level of deformation of the blade observed, the tip of which was found embedded in the tree trunk, was consistent with a rotating propeller. Its fracture, of the fragile type due to the impact, is characteristic of the imposition of high stress over a short period of time, possibly due to the conversion of the torque existing in the propeller shaft at the moment of the collision. These observations corroborated the hypothesis of the existence of power in the shaft of the propeller assembly at the moment of impact.

The (SN PCE-VB0075) PT6A-140AG Pratt & Whitney engine that equipped the PP-OBL aircraft was analyzed in order to identify evidence of operation.

Analysis of the engine revealed severe buckling damage to the engine case, especially to the exhaust duct. This type of failure occurs in thin-walled structural elements due to the application of compression stress, possibly resulting from impact at a high angle (Figure 11).

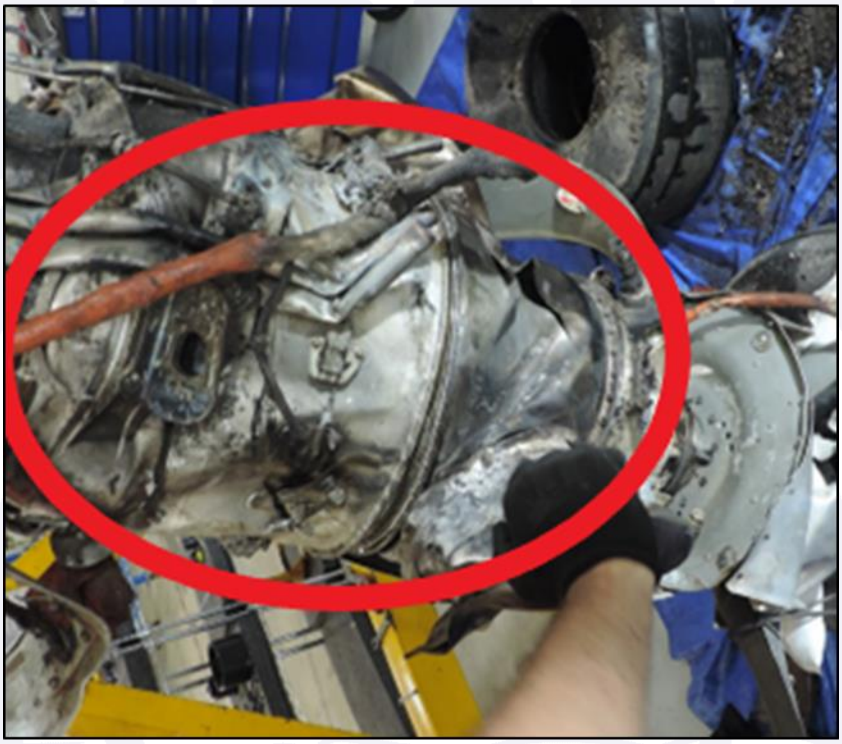

Figure 11 - Buckling damage.

The other examinations of the engine were inconclusive from the perspective of power development due to the high level of post-impact destruction.

From the evidence found in the analysis of the powerplant, the aircraft was considered likely to have developed power until the collision with obstacles, although it was not possible to quantify either the amount of engine power or the RPM of the propeller.

1.17. Organizational and management information.

The privately owned agricultural aircraft had been operated by the same pilot since August of that year.

1.18. Operational information.

It was as an aerial application flight on *Fazenda Araçatuba*, in consonance with the requirements of the Brazilian Civil Aviation Regulation n° 137 (RBAC-137).

According to records obtained from the aircraft logbook, the first takeoff of the day took place at 09:20 UTC for a ferry flight between *Fazenda Paranatinga* and *Fazenda Araçatuba*, where the aircraft landed at 09:38 UTC.

Shortly later, at 10:00 UTC, the aircraft took off for a crop spraying flight with duration of 3 hours.

At 14:57 UTC, another crop spraying flight was initiated. An hour later, according to observers, the flight was discontinued due to rain.

At 17:55 UTC, the last takeoff was performed, and the aircraft crashed approximately five minutes later.

The basic operating weight, as described in the aircraft's weight and balance sheet, was 2,230 kg.

According to reports from observers, the aircraft had been fueled with approximately 600 liters of QAV-1 before the previous flight, and there was no refueling between the flights. The estimated fuel at the time of the crash was 350 liters (QAV-1), representing an approximate mass of 280 kg of fuel.

Also according to observers, the aircraft had approximately 400 liters of fungicide at the time of the accident, an approximate mass of 440 kg.

Considering that the equipped pilot had a weight of approximately 90 kg, one estimated that the aircraft had an approximate mass of 3,040 kg at the time of the occurrence.

The aircraft was within the weight and balance limits.

The Airplane Flight Manual (AFM), Air Tractor Document 01-0163, section 5, page 100. 5-8, listed the following stall speeds (Figure 12):

5.8 STALL SPEEDS

Indicated stall speeds at 3166 Kg (6,980 lbs) gross weight, power idle are as follows:

Angle of Bank (Degrees)	0	15	30	45	60
Stall Speed (KNOTS) Flaps Up	67	70	72	80	94
Stall Speed (KNOTS) Flaps Down	57	59	60	67	80
Stall Speed (MPH) Flaps Up	77	80	82	92	109
Stall Speed (MPH) Flaps Down	65	68	70	77	92

Figure 12 - Stall speeds.

The values applied in this table refer to an aircraft weighing 3,166 kg, the closest value available in relation to the estimated value at the time of the accident, with reduced power (*idle*), for the various angle-of-bank values in the configurations of flaps both retracted and fully extended (up and down).

Despite the lack of a stall speed diagram for the conditions related to the accident (flaps 10º, weight of 3,040 kg, and an angle of bank of 46º), it was estimated that the stall speed for the aircraft configuration at the time of the accident was approximately 87 mph.

1.19. Additional information.

Spins:

The AFM Section 3, *Emergency Procedures*, 3.2.17 *Spins* read that the characteristics of spins of this aircraft model had not been fully investigated, and that recovery techniques had not been established. However, in the event of an inadvertent spin, it suggested the adoption of the following procedures, as shown in Figure 13.

3.2.17 Spins:

The spinning characteristics of this aircraft have not been fully investigated and spin recovery techniques have not been established. In the event of an inadvertent spin, the following procedure is suggested:

POWER LEVER.................IDLE
AILERONS.................NEUTRAL
RUDDER.................FULL, OPPOSITE DIRECTION OF SPIN
ELEVATOR.................FULL FORWARD

After Spin Stops:

RUDDER.................NEUTRAL
ELEVATOR.................RECOVER FROM DIVE

Figure 13 – Suggested procedure for recovery from a spin.

Flying on a turn at speeds close to stall may foster entry in an inadvertent spin, a situation in which the aircraft, upon losing lift asymmetrically, rotates around its longitudinal axis in a sharply descending trajectory.

The actions for spin recovery suggested in the AFM included reducing the engine to minimum power (*idle*) and applying rudder in the direction opposite to the aircraft's rotation.

Figure 14a represents the spin condition during a left turn. Figure 14b represents the estimated final trajectory of the accident flight.

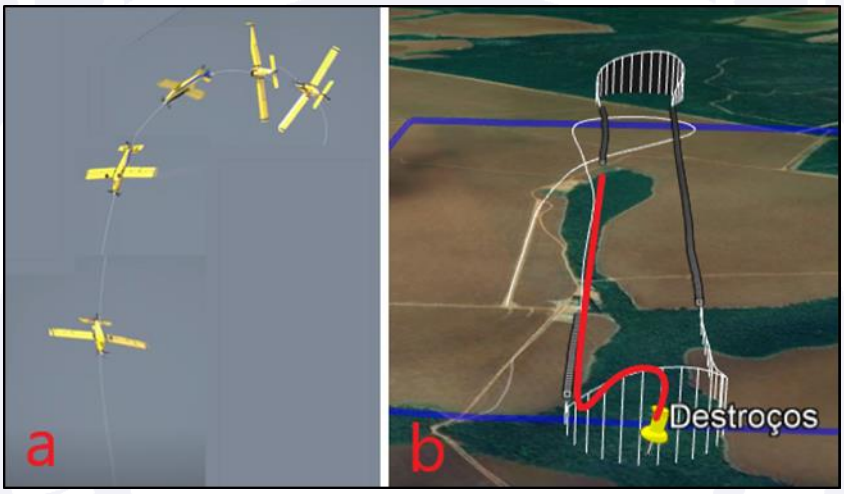

Figure 14 - spin image (a); and image of the estimated final flight trajectory (b) in red.

1.20. Useful or effective investigation techniques.

Attitude calculations and angle-of-bank estimators were used with data from the *"AG-NAV Guia"* Navigation System.

2. ANALYSIS.

The Air Tractor 502A involved in the accident was an aircraft registered in the TPP category.

According to the maintenance records, the airframe, engine, and propeller logbooks were up to date. The aircraft underwent its last inspection ("100-hour" type) on 08 November 2022, when its accumulated flight time was 28 hours and 54 minutes. The aircraft's CVA (Certificate of Airworthiness-Verification) was valid by 08 November 2023. The aircraft logbook did not list any discrepancies that could have resulted in a malfunction in any of the systems.

The wreckage had a concentrated pattern. The longitudinal axis of the aircraft was aligned with the 260° magnetic heading, and the fuselage was on the ground in an upside down position. The powerplant rested buried in the ground, and the entire front section of the aircraft was destroyed. The surrounding vegetation was relatively preserved. The wings showed plastic deformation ("wrinkling") characteristic of rapid deceleration. All of these elements together indicated that the impact probably occurred at a steep angle and high speed.

The physical evidence found in the accident site (linear marks on the bark of a tree juxtaposed with the tip of a propeller blade tip embedded in the tree trunk) indicated that the aircraft was developing power at the time of impact.

The analysis of the powerplant assembly reinforced this hypothesis, evidenced by the rotational damage suffered by the engine and propeller during the high-angle impact with the trees and terrain. However, it was not possible to determine the power or RPM developed by the said components.

The observation of the wreckage revealed that the aircraft was configured with flaps at 10°, denoted by the visible marking on the extrados of those surfaces.

Based on the analyses carried out, one estimated that the speed at the top of the northeast reversal turn made in the crop spraying circuit prior to the accident would be 91 mph. Such condition would provide little margin in relation to the stall speed estimated for the aircraft configuration during the occurrence.

Regarding the projection of the horizontal flight path on the ground, one noted that the last five “runs” in the southwesterly direction were initiated approximately 1,400 meters ahead of an imaginary perpendicular line connecting to the spot at which the “runs” in the opposite direction had ended. This was because that strip of land consisted of a dense forest area that did not require being sprayed.

It was also observed that the turns in the northeastern sector covered a shorter distance in longitudinal terms from start to end than those in the southwestern sector. It was found that in the flight of the accident, the longitudinal distances of the turns in the northeast were 650 meters, whereas the longitudinal distances in the southwest were 1,100 meters. This condition was possibly a direct consequence of the use of more steep attitudes in the former sector.

Analyzing these factors, one assumed that, in order to increase the efficiency of the operation, the decision was to adopt higher climb angles in order to reduce the time spent in the turns, since the “runs” in the opposite direction would be initiated in a position further ahead than the usual.

However, with the implementation of this type of piloting technique, the speeds at the apex of the reversal turns became increasingly lower and, consequently, rendered the aircraft more susceptible to loss of lift.

With reduction of the aircraft's controllability margins, factors such as lack of aircraft coordination or the occurrence of wind gusts had the potential to affect the aircraft's lift, causing the wings to suddenly reach a critical angle of attack, which, in consequence, would lead to a stall.

Making a turn with the aircraft close to the stall speed may foster inadvertent entry into a spin. It was not possible to determine whether the pilot would have noticed the inadvertent entry into a spin or adopted the actions recommended to recover the aircraft.

The hypothesis of development of a spin condition was further supported by the angle of impact of the aircraft's nose against the ground and the orientation of the aircraft on the terrain (260°). The fuselage possibly assumed the upside-down position due to the inertia of the impact with a pitch-down attitude at an angle greater than 90°.

In summary, the elements obtained in the investigation strengthened the hypothesis that the use of steeper attitudes with greater angles of bank in the northeastern sector, with the aim of improving the efficiency of the operation, would have resulted in the reduction of the controllability margins during the reversal turns. These conditions may have contributed to the loss of lift near the top of the turn and the inadvertent entry into a spin, with control of the aircraft not being recovered in time to prevent the collision with the ground.

3. CONCLUSIONS.

3.1. Findings.

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

b) the pilot held a PCM License (Commercial Pilot - Airplane) and valid ratings for MNTE (Single-Engine Land Airplane) and PAGA (Agricultural Pilot - Airplane);

c) the pilot was qualified and had experience in the type of flight;

d) the aircraft had a valid CVA (Certificate of Airworthiness-Verification);

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

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

g) the weather conditions were above the minima for the flight;

h) the first takeoff was at 09:20 UTC, for a ferry flight between *Fazenda Paranatinga* and *Fazenda Araçatuba*;

i) the pilot was performing the fourth flight of the day, totaling 04 hours and 20 minutes;

j) the aircraft was equipped with an "AG-NAV Guia" Real-Time Navigation Guidance System, Model P152, SN 152180112, Rev. KG, manufactured by AG-NAV Inc.;

k) the above mentioned equipment contained data related to the flight of the occurrence and previous flights;

l) the axes of the spraying runs were generally oriented on the 056° and 236° magnetic headings, with the spraying circuit being made with left turns;

m) in the last five reversal turns made in the northeastern sector, climb attitudes greater than 30° were used;

n) the last five "runs" in the southwesterly direction were initiated approximately 1,400 meters ahead of an imaginary perpendicular line connecting to the spot at which the "runs" in the opposite direction had ended;

o) in the sector where the accident would occur, the reversal turns made by the airplane in the northeast were less distant longitudinally from their starting points when compared to the reversal turns in the southwestern sector;

p) the wreckage arrangement had a concentrated pattern and the powerplant laid buried in the ground, whereas the entire front section of the aircraft was obliterated;

q) the aircraft flaps were at the 10° extended position;

r) the longitudinal axis of the aircraft was aligned with the 260° magnetic heading, and the fuselage was on the ground in an upside-down position;

s) there was no evidence of preimpact failure or malfunction in the flight control systems;

t) the aircraft sustained substantial damage; and

u) the pilot suffered fatal injuries.

3.2. Contributing factors.

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

Pitch attitudes greater than 30° were used during the climbing stage of the last reversal turns recorded in the "*AG-NAV Guia*" in the northeastern sector of the aerial application circuit. Such characteristic may have contributed to the aircraft reaching speeds close to stall at the time of the occurrence, something that would reduce its margin of control, favoring an inadvertent entry into a spin.

- **Piloting judgment – undetermined.**

The sequential use of speeds close to stall conditions at the top of the reversal turns in the northeastern sector exposed the aircraft to the risks arising from loss of control in flight. This inadequate assessment of the parameters related to the operation of the aircraft may have contributed to the accident.

- **Motivation – undetermined.**

A possibility was considered that, with the intention of improving the efficiency of the operation, the option chosen was to adopt steeper climb angles to reduce the time spent during turns in the northeastern sector. Such heightened motivation may have led to inadequate operational performance.

- **Perception – undetermined.**

It was not possible to determine whether the pilot would have either noticed the inadvertent entry into a spin or taken the actions to recover the aircraft.

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

It is possible that the decision to employ pitch attitudes greater than 30° in the northeastern sector of the aerial application circuit contributed to reducing the aircraft's controllability margins.

4. SAFETY RECOMMENDATIONS

None.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

NIL.

On December 09th, 2024.