COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A - 168/CENIPA/2016

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PR-AJF**
MODEL:	**AT-502B**
DATE:	**13DEC2016**

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 taking into account 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 different 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 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. Taking into account 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 13DEC2016 accident with the AT-502B aircraft, registration PR-AJF. The accident was classified as “[AMAN] Abrupt Maneuver and [SCF-NP] System/Component Failure – Malfunction Non-Powerplant / Loss of Component in Flight”.

The aircraft was performing a pesticide spraying flight when it crashed into the ground at a high impact angle and with high energy.

The aircraft was destroyed.

The pilot suffered fatal injuries.

An Accredited Representative of the National Transportation Safety Board (NTSB) - USA, (State where the aircraft was designed and manufactured) was designated for participation in the investigation.

CONTENTS

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ANAC	Brazil's National Civil Aviation Agency
CA	Airworthiness Certificate
CAS	Calibrated Airspeed
CENIPA	Aeronautical Accident Investigation and Prevention Center
CG	Center of Gravity
CI	Investigation Team
CIV	Pilot's Flight Logbook
CMA	Aeronautical Medical Certificate
DCTA	Department of Science and Airspace Technology
DGPS	Differential Global Positioning System
EPI	Individual Protection Equipment
FAP	Pilot's Evaluation Sheet
HBV	Brazilian Daylight Saving Time
IAM	Annual Maintenance Inspection
INSPAC	Civil Aviation Inspector
LABDATA	Flight Data Recorders Read-Out and Analysis Laboratory
MNTE	Airplane Single Engine Land Rating
MPH	Miles Per Hour
NM	Nautical Miles
NTSB	National Transportation Safety Board (USA)
PAGA	Agricultural Pilot Rating
PCM	Commercial Pilot License – Airplane
POLITEC	Official Expertise and Technical Identification
PPR	Private Pilot License – Airplane
QAV-1	Aviation Kerosene
RBAC	Brazilian Civil Aviation Regulation
RS	Safety Recommendation
SIPAER	Aeronautical Accident Investigation and Prevention System
TPP	Registration Category of Private Service - Aircraft
UTC	Universal Time Coordinated
VA	Maneuvering Speed
VHF	Very High Frequency
Vne	Speed Never Exceed

1. FACTUAL INFORMATION.

Aircraft	**Model:** AT-502B **Registration:** PR-AJF **Manufacturer:** Air Tractor	**Operator:** Private
Occurrence	**Date/time:** 13DEC2016 - 1930 UTC **Location:** Caimbé I Farm **Lat.** 14°55'15"S **Long.** 054°14'18"W **Municipality – State:** Primavera do Leste – MT	**Type(s):** [AMAN] Abrupt Maneuver; [SCF-NP] System/Component Failure – Malfunction Non-Powerplant **Subtype(s):** Loss of Component in Flight

1.1 History of the flight.

The aircraft took off from the Caimbé I Farm Agricultural Landing Area, located in the municipality of Primavera do Leste (MT), at about 1900 (UTC), to conduct a pesticide spraying flight with a pilot on board.

About thirty minutes after takeoff, an observer near the application area spotted the aircraft descending at a steep angle and then impacting the ground.

The aircraft was destroyed.

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 was destroyed due to the impact and the action of fire.

1.4 Other damage.

None.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Flight Hours	Pilot
Total	1,316:15
Total in the last 30 days	Unknown
Total in the last 24 hours	03:20
In this type of aircraft	Unknown
In this type in the last 30 days	Unknown
In this type in the last 24 hours	03:20

N.B.: It was not possible to obtain all data relative to the pilot's flown hours.

1.5.2 Personnel training.

The pilot took the PPR course in 2000.

1.5.3 Category of licenses and validity of certificates.

The pilot had the PCM License and had valid PAGA and MNTE Ratings.

1.5.4 Qualification and flight experience.

The pilot was qualified and had experience in that type of flight.

1.5.5 Validity of medical certificate.

The pilot had valid CMA.

1.6 Aircraft information.

The aircraft, serial number 502B-2852, was manufactured by Air Tractor, in 2012 and it was registered in the TPP category.

The aircraft had valid Airworthiness Certificate (CA).

The last inspection of the aircraft, the "100hours/IAM" type, was carried out on 17OCT2016 by the *Marca Manutenção de Aeronaves* LTD. maintenance organization, in Primavera do Leste – MT, with the aircraft, on that date, being with 771 hours.

It was not possible to determine how many hours the aircraft flew after the inspection, because the Logbook, which was inside the aircraft, was consumed by the action of fire.

1.7 Meteorological information.

According to reports from Caimbé I Farm workers, there was no cloudiness and the wind was apparently calm at the time of the occurrence.

1.8 Aids to navigation.

Nil.

1.9 Communications.

The pilot carried out bilateral communications with the aero agricultural assistant on the VHF frequency, through a portable radio. At about 1915 (UTC), the pilot informed the assistant that he was proceeding for final landing on the farm landing area.

1.10 Aerodrome information.

The occurrence took place outside the Aerodrome.

1.11 Flight recorders.

Neither required nor installed.

1.12 Wreckage and impact information.

The impact occurred in an area of agricultural cultivation, 2,540 meters from the area used for Caimbé I Farm landings and takeoffs.

The distribution of the wreckage was of concentrated type. The nose of the aircraft was approximately pointed at the magnetic course 189°.

The impact occurred with the aircraft in a pitch down flight attitude (approximately 90° relative to the ground plane) and with high energy, causing a hole in the ground that housed the entire front section of the aircraft, up to the wings height.

On the impact, there was fire spread. The components located in the front section and wings were totally destroyed (powertrain, instrument panel, cockpit, landing gear, fuel tanks, ailerons, flaps, among others).

Components located in the tail cone section had substantial or minor damage. One of the three blades of the propeller assembly detached from its hub, due to the ratio of inertial and impact forces and was 150 meters from the wreckage site.

A farm worker at about 1,800 meters away from the crash site observed the collision of the aircraft against the ground.

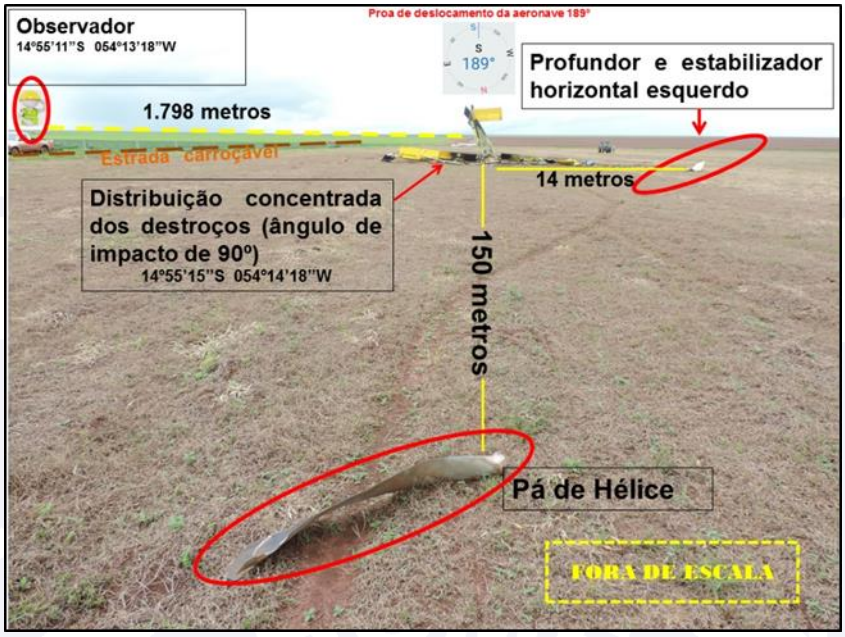

Figure 1 - Distribution of the wreckage.

Figure 2 - Position of the command, control and trim surfaces.

Using as reference the aircraft direction of travel and its longitudinal axis, the steering rudder was deflected to the right and its associated trim tab was commanded to the left. The right elevator was deflected down and its associated trim tab was upward. The left horizontal stabilizer was fourteen meters from the wreckage site, indicating that it was detached in flight. The left elevator trim tab was in the neutral position.

The degree of destruction and carbonization of the aircraft prevented the verification of equipment and instruments.

Figure 3 - Degree of the powertrain destruction and, in particular, only two of the three propeller blades.

1.13 Medical and pathological information.

1.13.1 Medical aspects.

The pilot's body was fully carbonized, making it impossible to identify physiological or disability aspects that could have affected his performance.

1.13.2 Ergonomic information.

Nil.

1.13.3 Psychological aspects.

The pilot had been in aviation for over sixteen years. He had been conducting the PR-AJF aircraft performing pesticide spraying services on the farm since the 2014 harvest, while still working for one of the companies previously hired by the Caimbé Group. Thus, it was the third crop in which he served in the locality.

After the acquisition of the aircraft by the group, he was then hired, since the standard of his services was already known, coupled with the fact that he has been flying the same aircraft for a long time.

According to information gathered, he was considered a good agricultural pilot by industry professionals and was considered a competent person, suitable and with calm temperament.

1.14 Fire.

The fire started immediately after impact. The combustion material was the aircraft fuel and the ignition source could not be determined.

The Caimbé I Farm workers using portable fire extinguishers and water from a tanker truck carried out the firefighting. However, due to the speed of fire spread, it was not possible to contain the fire damage to the aircraft.

The situation was aggravated by the fact that the tanks had been filled before the pre-crash flight and were just under half of their full capacity.

1.15 Survival aspects.

The pilot's body was found in the middle of the aircraft cabin wreckage in the dorsal decubitus.

According to information provided by the agricultural assistant, at the time of the occurrence, the pilot was wearing a flight suit. It is not possible to say, however, if such clothing was adequate to protect him from the action of the fire.

1.16 Tests and research.

The aircraft, whose maximum takeoff weight was of 3,629kg, was equipped with a PT6-34AG turboprop engine with 750 SHP of power. In the accident, the engine was severely damaged, due to the high impact energy and fire action, and its external components were subjected to high temperatures during the fire, making it impossible to verify its operating condition, its adjustments and the existence of leaks on bench tests.

Due to the fire action, it was not possible to determine the position of the control and trim surfaces located in the wings areas. All flight control and trim surfaces located in the rear section were present in the aircraft fuselage frame, except for the left horizontal stabilizer, which was fourteen meters away from the wreckage site.

Technicians from the Materials Division of the DCTA, an organization belonging to the Air Force Command (COMAER) structure, performed tests and analysis of failures in the left horizontal stabilizer assembly and elevator, as follows:

On visual examination, the surface of the left horizontal stabilizer could be observed with loss of rivets and plastic deformation of the coating (Figures 4 and 5).

Figure 4 - Loss of rivets on the left horizontal stabilizer surface.

Figure 5 - Plastic deformation on the left horizontal stabilizer surface.

Stereoscopic examinations showed upstream overload by compression and tensile stresses (Figures 6 and 7), and it was also possible to observe fracture surfaces with typical overload characteristics (Figures 9 and 10).

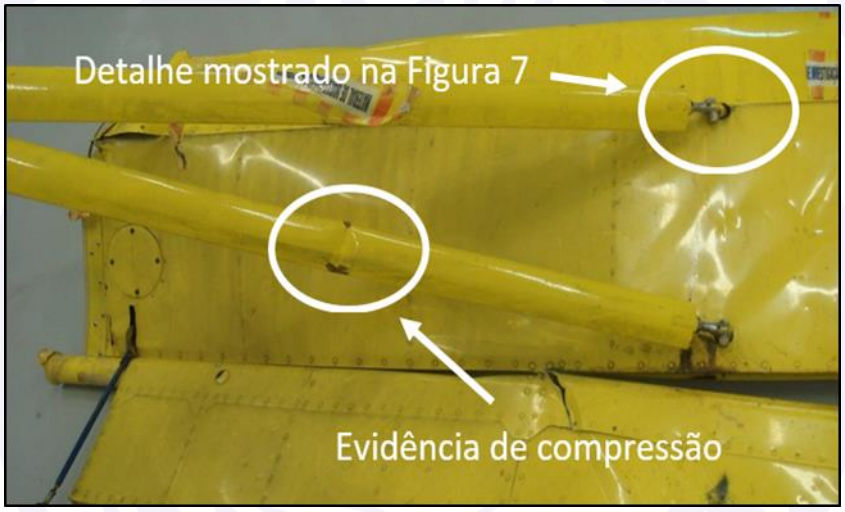

Figure 6 - Overview of the brace strut and compression strain.

Figure 7 - Fastening of the brace strut with characteristic of overload and tensile deformation (detail of Figure 6).

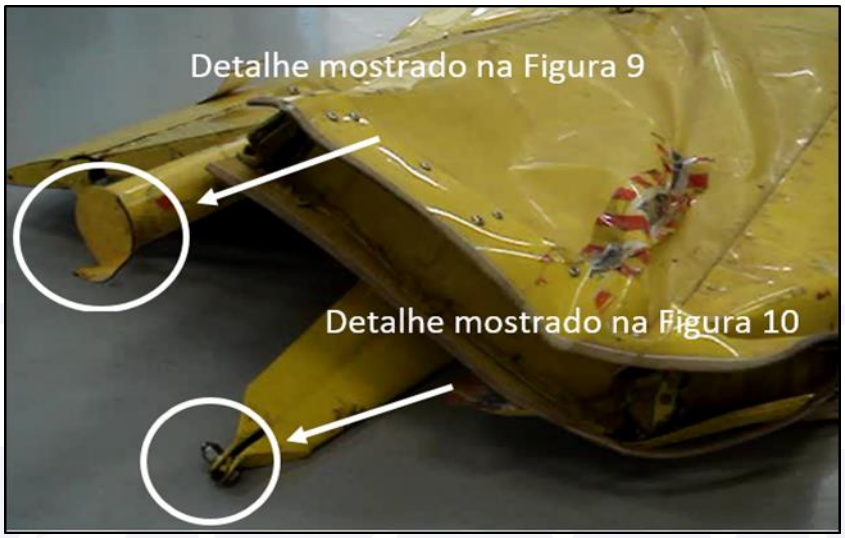

Figure 8 - End of the brace strut that was fixed to the aircraft structure.

Figure 9 - Surface with typical characteristics of structure overload fracture (Detail of Figure 8).

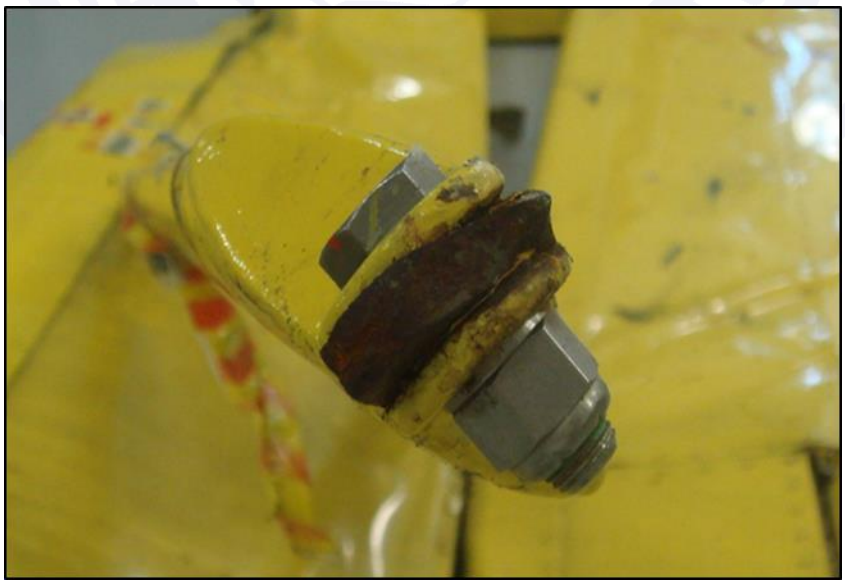

Figure 10 - Fracture surface with overload characteristic (Detail of Figure 8).

In addition, thinner metal sheets presented characteristics such as those found in Figure 11 below, indicating that they were subjected to excessive forces applied outside the sheet plane, where the junction surface of the elevator bar with the transfer bar, showed reversal of material on the edges, which is a characteristic of tear fracture.

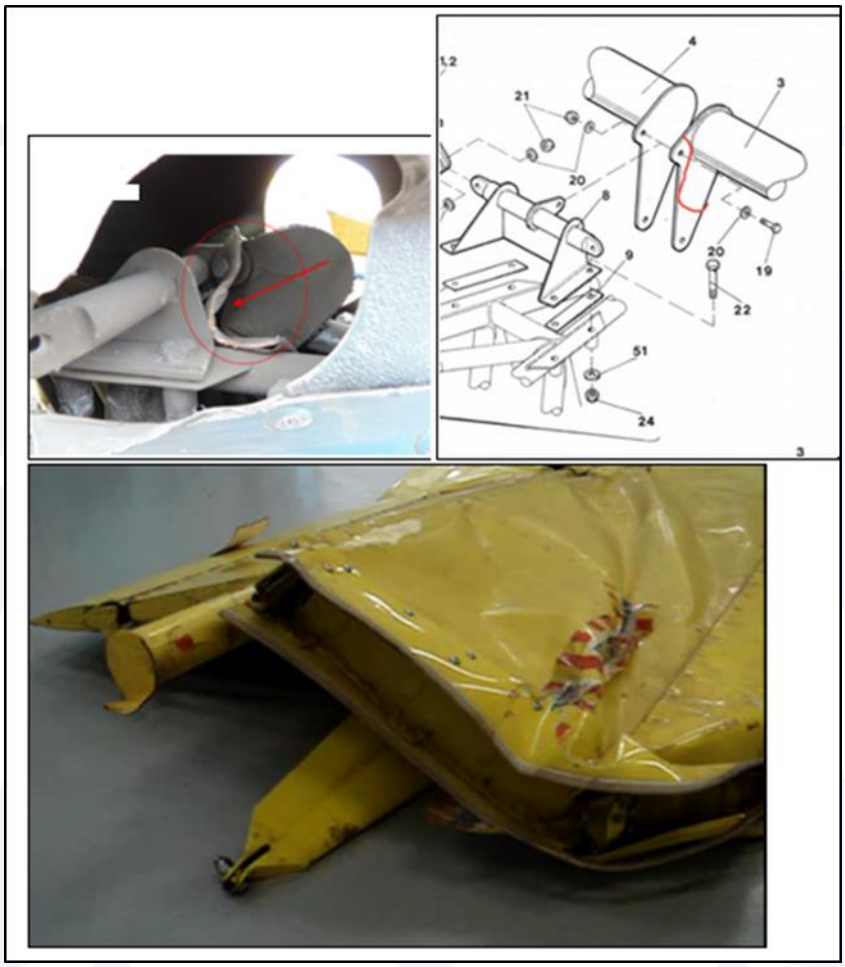

Figure 11 - Tearing fatigue on the left elevator fixation frame.

The aircraft was equipped with a DGPS, AGNAV model. It was a Differential Global Positioning System, whose main function was to eliminate or minimize aircraft positioning errors, guiding the pilot during application over parallel and evenly spaced lanes, ensuring greater accuracy in the execution of aero agricultural services.

In addition to the basic function mentioned above, which is present in all DGPS models for use in agricultural aviation, other important functions could be performed by the equipment (depending on the model), such as:

- recording flight information (altitude, speed, head) for later reproduction and computer analysis (service map);

- memorization of unfinished areas, for subsequent completion of the application;

- calculation of applied area;

- pre-flight work planning;

- area delimitation and calculation before application (polygon marking); and

- Navigation functions for reference points and monitoring of variables such as application rate, flow rate, volume applied, product balance in the tank, etc.

Although the DGPS does not meet the certification requirements for data recording or impact resistance, it was glimpsed the possibility of extracting those data recorded in the

moments prior to the accident, in order to obtain possible information about the dynamics of the flight.

The data extraction was performed by a technician from the company DGPS & CIA, in Primavera do Leste - MT, on 15DEC2016, and this procedure was followed on the spot by the members of the Investigation Team.

Despite the degree of carbonization and destruction of some of the internal components of the DGPS, the data extraction was successful and it was verified that the equipment had recorded information that corresponded to the accident flight with the PR-AJF aircraft, such as: day and hour; application area; flow rate of the applied product; magnetic heading; speed and altitude; etc.

Figure 12 - Physical conditions of the DGPS that equipped the PR-AJF aircraft upon its opening in a specialized laboratory.

Secondly, the extracted data were cataloged by the technicians of the CENIPA's LABDATA, with the participation of two other DGPS & CIA technicians, and in the end, using a computer program designed for debriefing, parameters and information related to the performance and flight characteristics of the aircraft just before the accident have been produced.

It should be noted that the data was overwritten on another flight and the information obtained was in UTC time, which is why, after 19h:18min:23s, the approximate time of the accident, the spreadsheet presents 12h:58min:53s (recording of the previous flight).

The information obtained by data recording will be described in item 1.18. Operational Information.

1.17 Organizational and management information.

The Caimbé Group was a consolidated company. It owned two farms in the state where it operated, totaling approximately 16,000 hectares, especially the cultivation of cotton, soy and corn, which earned it the title of one of the largest agribusiness companies in the region.

According to the report of one of its owner partners, during the harvest period, companies providing specialized air services to the agricultural sector were hired. These hires took place until May 2015, when the business group acquired the crashed aircraft. This organization had no other aircraft.

According to information obtained, although the company had a human resources sector, there was no specific formal process for hiring professionals who would perform duties related to the air activity.

The company had no actions related to Flight Safety. There were also no training or recycling programs for the pilot, as well as there was no supervision and management of activities related to air operations, which were delegated to the pilot himself.

According to the information obtained, the pilot's work routine was as follows (all times are expressed in local time): he would wake up at about 05h00, and the air operations would start between 06h30min and 07h00, with pause at 10h00 or 11h00min for lunch (the choice of one of these times depended on the temperature because, if it was high, would influence the pattern of application). In the afternoon shift, operations began at about 13h00, extending until sunset time.

This routine comprised the months from November to May, the harvest period. In the off-season, the pilot followed the inspections and maintenance of the aircraft, which were always performed in approved shops in the region.

1.18 Operational information.

According to the data obtained in the field investigation, it was found that:

- the empty basic weight of the aircraft was of 2,145kg;

- the pilot's weight was approximately of 90kg;

- the aircraft was with its hopper empty at the time of the crash;

- there were about 400 liters of QAV-1 (314kg, considering the fuel density of 0.7850kg/l at 20º C) at the last takeoff;

- the average consumption was of 220 liters/hour; and

- the aircraft flew about 20 minutes between the last takeoff and the time of the crash.

Therefore, according to the weight and balance sheet, the aircraft was within the weight and center of gravity (CG) limits specified by the manufacturer.

The pilot had revalidated his MNTE rating on 07JUL2015 and in the FAP, completed by the INSPAC, who checked his MNTE, the following observations were found:

> "MNTE recheck flight was carried out with the pilot, with local flight.
>
> During the briefing, the pilot demonstrated good technical/operational knowledge.
>
> After takeoff, stalls, steep curves, "CAP" and coordination were performed satisfactorily.
>
> Some maneuvers were marked "NA" or "ND" because it was a visual MNTE revalidation.
>
> Pilot demonstrated good standardization and safety in maneuvers.
>
> Able to revalidate his MNTE rating ".

The pilot had revalidated his PAGA Rating on 21AUG2015 and the FAP completed by the INSPAC that checked him contained the following observations:

> "The PAGA recheck flight of the pilot was performed, with local flight.
>
> During the briefing, the pilot demonstrated good technical/operational knowledge.
>
> Flight made with "BK-BK" profile, with 03 passes with applications, reversal curves and jettisoning. I consider him suitable for revalidation of the PAGA Rating. ”

The pilot obtained his PCM License and the PAGA Rating in September 2001 and has conducted flights in agricultural operations ever since.

Based on reports from coworkers, on the day of the crash the pilot woke up at 05h00 am (local), had breakfast and, due to unfavorable weather conditions (rain), the flight, which was planned to start in the morning period, was canceled.

The preflight procedure had been performed by the crewmember before the first takeoff of the day. This procedure was previsted in the aircraft flight manual (Airplane Flight Manual - Section 2, Normal Procedures, Preflight-Walk Around Inspection) and included the verification of 54 different items, which, according to the collected report, were commonly performed by the pilot from memory. There was no direct guidance in the flight manual as how to perform these checks.

After lunch, at about 13h30min (local time), pre-flight and refueling were performed. Then, already with favorable weather conditions, the pilot started the air activity, spraying about 525 hectares at the Caimbé I Farm and, later, 800 hectares at the Caimbé II Farm.

At the end of this first leg of the flight, the pilot proceeded to the landing at around 16h00 (local) to refuel the aircraft and proceed to a new takeoff.

According to information from the agricultural assistant, the pilot reported a slight shake on the stick when in flight. He interpreted this condition as a possible loose on the spray bar, which was tightened by the assistant after landing.

Shortly afterwards, the aircraft was refueled and, at the end, there were 400 liters of aviation kerosene (QAV-1) on its wings, plus a remnant of about 200 liters of hopper pesticide.

On this second leg of the flight, the other planned areas were sprayed without any reported abnormalities. According to the assistant's report, the pilot made radio contact, informing him that he would make a last pass in the application area (procedure known as “shooting”), in order to spray those small areas where it was not possible to apply the chemical previously (“edge of the field boundary”), due to the chosen passage profile and then he would then proceed to final landing on the runway of the Caimbé I Farm.

According to an observer's report, located about 1,800 meters from the crash site (open-air farming area), the aircraft was in the spraying passage pattern (straight, level flight and low altitude). Moments later, the aircraft began a sudden climb, at a sharp angle, but without knowing how many degrees.

The observer said that he returned to his work activities, looking away for a few seconds. When he turned his attention to the aircraft, he noticed that it was about 15 meters above ground, at a pitch down angle, developing speed above what he was used to see.

Then the aircraft crashed into the ground, followed by black smoke around it. Immediately, he passed the information about the occurrence to the other Farm workers by radio and then proceeded to the scene of the accident.

Arriving there, he observed that the fire spread very quickly and visualized the pilot inside the cockpit (dead, according to his perception). He reported that the aircraft formed an angle of approximately 90º between the ground plane and the fuselage, with the entire front section buried in the ground, forming a crater that sheltered the entire nose of the aircraft.

According to the information from the DGPS transcription, it was observed that the flight was uneventful until the pilot informed the assistant that he would make one last pass in the application area and that he would land on the Caimbé I runway.

According to the DGPS transcripted data, at 19h17min59s (UTC) the PR-AJF maintained the flight with approximate values of magnetic heading 107º, 2,600ft of altitude and speed of 138 MPH (Figure 13), when it started a left turn downward, stabilizing at the magnetic heading 348º, an approximate altitude of 2,334ft, reaching and maintaining a

speed of 150 MPH at 19h18min18sec (UTC), spraying the final 70 liters of the remaining pesticide on the hopper.

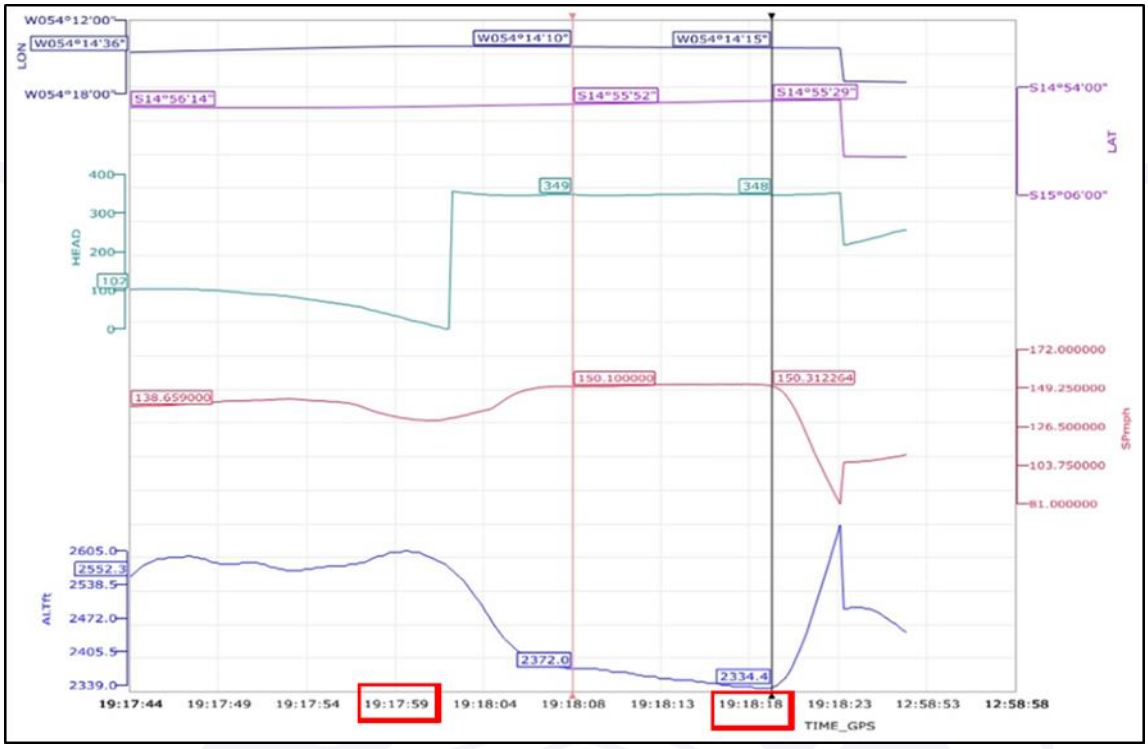

Figure 13 - DGPS data during application.

At 19h18min19s (UTC), the aircraft began an upward flight path (“recovery”), with a magnetic head ranging from 349º to 353º, reaching 2,655.8ft of altitude at its highest point, experiencing a speed reduction of 150 MPH to reach a minimum value of 81,17 MPH at 19h18min23s (UTC), that is, 4 seconds later. (Figure 14).

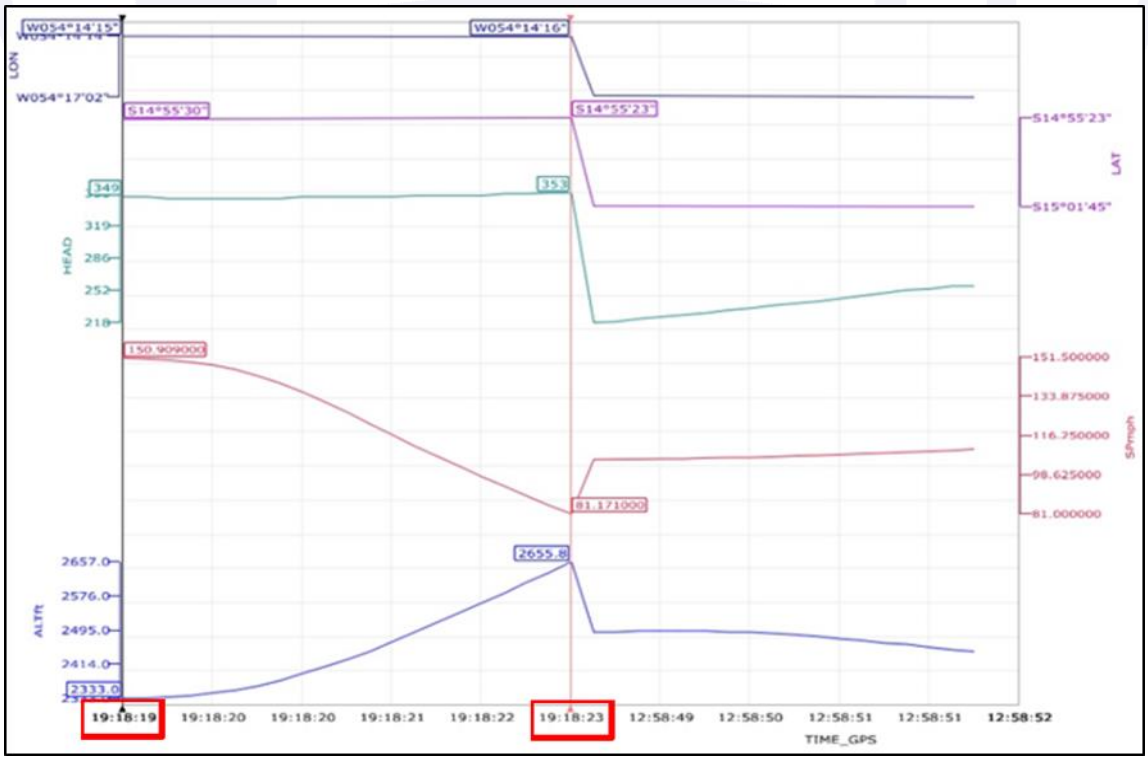

Figure 14 - DGPS data at the beginning of the change to a climb attitude (“recovery”) of the aircraft.

At this point (19h18min23s), the PR-AJF began a fast nose-left turn at a pitch down attitude, almost instantaneously reaching the magnetic heading of 219°, the altitude of 2,490ft and the speed of 105 MPH (Figure 15).

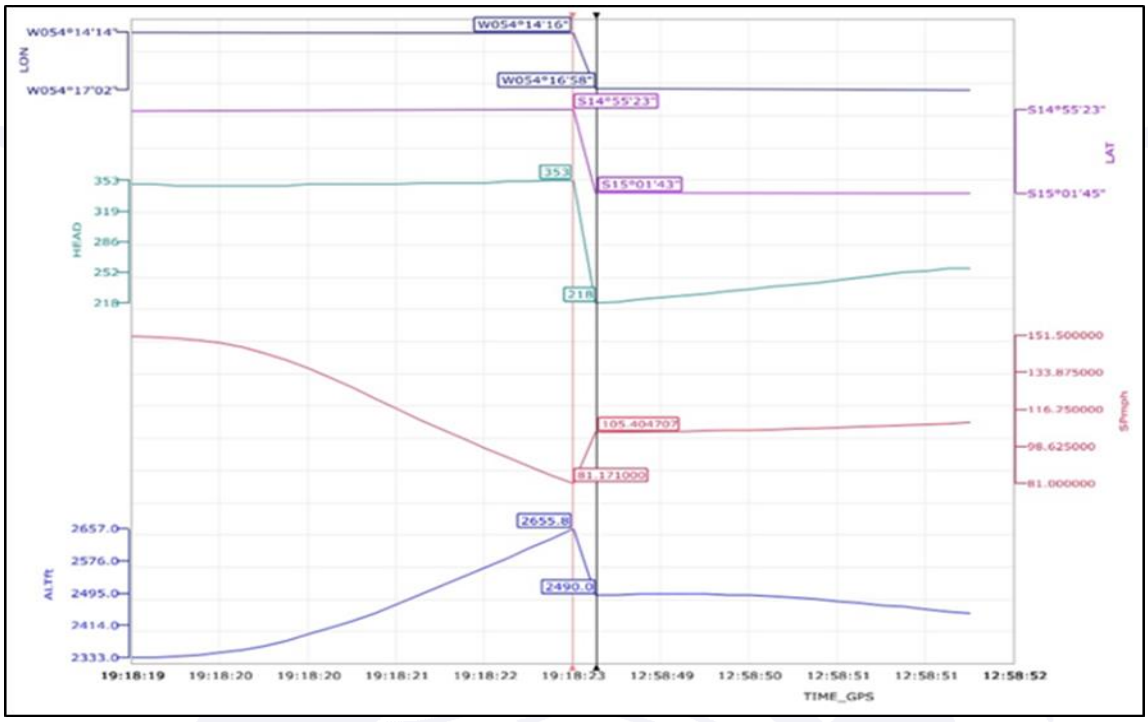

Figure 15 - DGPS data at the moment corresponding to an instantaneous change in the heading, speed and altitude values of the aircraft.

The Aircraft Flight Manual, Section 1 Limitations, stated that for AT-502B aircraft registered in Brazil, the speedometer markings should be presented as Calibrated Air Speed-Kts CAS and with the red radial (Speed never exceed) at 121kt CAS (139 MPH, whereas 1 MPH is equivalent to 0,869kt CAS), as shown in Figure 16.

NOTE 2: Australian registered aircraft require markings in Kts IAS.
Brazil requires markings in Kts CAS and red line at 121 Kts.
Canadian registered aircraft require markings in mph IAS.
U.S. and Other Countries require markings in mph CAS.
Chinese aircraft require markings in km/h CAS

NOTE 3: Never Exceed Speed for Brazilian Aircraft is 121 Kts.

FAA APPROVED
ISSUED: AUGUST 25, 2007 AT-502B AIRPLANE FLIGHT MANUAL

Figure 16 - Requirement and limitation for AT-502B aircraft speed registered in Brazil.

The Manual also provided the following information on Maneuvering Speed (Va):

AIR TRACTOR, INC.
Olney, Texas

SECTION 1 - LIMITATIONS

GENERAL:
Operations in compliance with the limitations presented in this section are required by the Federal Aviation Regulations.

AIRSPEED LIMITATIONS:

SPEED	CAS	IAS	REMARKS
Maneuver (V_a)	140 mph 122 kts 225 km/h	138 mph 120 kts 222 km/h	No full or abrupt control movements above this speed.

Figure 17 - Maneuvering Speed Limit Values (Va) for the AT-502B, contained in the Aircraft Flight Manual Maneuvering Speed (Va).

1.19 Additional information.

In order to know the distance traveled by the aircraft from the moment of the “recovery” maneuver until the crash against the ground, the latitude difference calculation was used, since it kept the displacement in the same meridian (054º14'15"W), this value being only 216 meters, even with the currently developed high speed. An average ascent rate of 4,800ft/min was also calculated.

According to the Aircraft Flight Manual, the maximum stall loss with leveled wings was of 220ft (67 meters) for the AT-502B at a maximum weight of 8,000lbs (3,629kg).

1.20 Useful or effective investigation techniques.

Nil.

2. ANALYSIS.

It was a pesticide spraying flight. The pilot was qualified as he had more than fifteen years of experience in this type of flight and for the last three years had been operating the PR-AJF registration aircraft at that location.

On the day of the occurrence, the pilot intended to start the flights in the morning, however, due to the rain, he decided to cancel the operation and, with the improvement of weather conditions, applications were then started in the afternoon. Thus, it was found that there was no contribution of this factor in the chain of events that led to the accident.

The preflight procedure had been performed from memory, as usual by the pilot, before the first takeoff of the day. Although there is no direct guidance in the flight manual as to how to carry out these checks, it is possible that at some point, or even recurrently, the pilot, relying solely on memory, did not identify discrepancies that might contribute to an unsafe condition in the operation, such as a stabilizer problem, which is a checklist check item and which in this instance has detached in flight.

After the first leg of the flight (1,325 ha spraying), the pilot proceeded to refuel the aircraft, at which point he reported to the aero agricultural assistant that he noticed a slight shake on the stick when in flight, which was initially attributed to the possibility that the spray bar was not properly fixed.

There was then, an action by the assistant to tighten the screws on the spray bar without any further research or investigation.

Although it was not possible to link this to the release of the left horizontal stabilizer, this evidenced an inadequate posture in the face of the possibility of a flight command failure or even a structural problem.

According to the analysis of the data from the DGPS transcription, it was observed that the second leg of the flight was uneventful until the pilot informed him that he would make a last pass on the application area and would proceed to landing.

It is important to note that the software used by the CENIPA's LABDATA for the purpose of reproducing PR-AJF flight information from the aircraft DGPS data produced speed parameters in Land Miles per Hour (MPH).

From the analysis of the flight parameters, as indicated by previous Figures 13, 14 and 15, it was observed that the aircraft maintained, just after the curve for heading 348°, a nearly constant altitude equivalent to 100ft above the field, and developed a 150 MPH speed (130kt CAS).

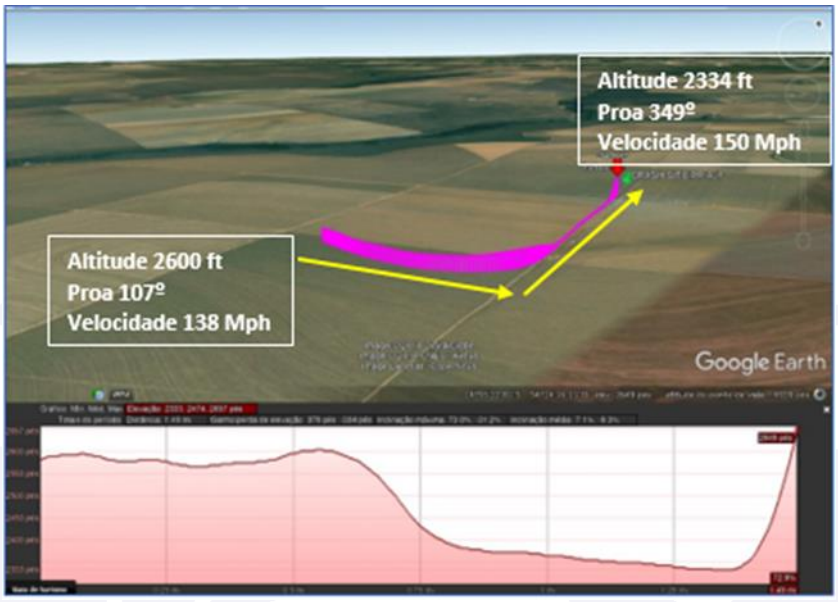

Figure 18 - Aircraft trajectory in the moments before the collision.

At 150 MPH (130kt CAS), the aircraft began a sudden maneuver that reached 2,655.8ft altitude at its highest point. The speed reached a minimum value of 81.17 MPH (70kt CAS) with magnetic heading of 353º at 19h18min23sec (UTC), that is, only 4 seconds after the start of the maneuver.

It was, therefore, verified that at the beginning of the maneuver the aircraft was 10 MPH (or 8kt CAS) above Va (140 MPH/122kt CAS) and that, taking into account the short time (4 seconds) to the rapid altitude gain (from 2,334ft to 2,655ft) and to the sudden drop in speed (from 150 MPH to 81 MPH), the aircraft began an abrupt upward maneuver at a sharp angle, subjecting the aerodynamic surfaces to high structural stress.

Therefore, it was observed that there was intentional extrapolation of the parameters when conducting the flight above the speed limit established in the manual, denoting non-compliance with the operational limits of the aircraft.

According to the examinations in the horizontal stabilizer / left elevator assembly, carried out at the DCTA Materials Division, it was possible to establish the hypothesis that as a result of the aircraft being above the maneuvering speed (Va) and an abrupt change in the elevator control in the pitch up (climbing) direction, there was a structural overload (positive loading) and the consequent loss of this surface in flight. This overload was evidenced by the loss of rivets and plastic deformation in the left stabilizer casing, which was found 14 meters away from the concentration of the aircraft wreckage.

In addition, thinner metal sheets presented characteristics such as those found in Figure 11, indicating that they were subjected to excessive forces applied outside the sheet plane, where the junction surface of the elevator bar with the transfer bar showed material reversal over the edges, which is a characteristic of tear fracture.

In the stereoscopic examinations performed on the left stabilizer / elevator assembly, there was overload in the amount of support by compression and traction efforts (Figure 6), and fracture surfaces with typical overload on the brace strut were also observed (Figures 9 and 10), corroborating the hypothesis of loss of control surface in flight, due to self-imposed overload.

It is supposed that the separation of the left horizontal stabilizer occurred during the application of the pitch up command, which would have caused a load above that the surface could withstand. This hypothesis is based on the fact that, if this surface had been detached

before the pitch up command (in a straight and leveled flight attitude), the moment in the aircraft would be the nose pitch down.

In addition, it was estimated that the aircraft traveled only 216 meters ahead, even with the high speed developed at the time of the occurrence, and that the average climb rate was of 4,800ft / min. The result of these analyzes is in line with that reported by an observer, who said he saw the aircraft start a steep climb.

In-flight separations are usually the result of material fatigue, improper design, imposing high aerodynamic loads or even maintenance deficiencies. Failure of a structural part or component results in changes in flight characteristics, usually initiating a catastrophic chain of events, during which other parts or components may also fail sequentially.

The left turn (fast nose turn) started at 19h18min23s (UTC) and the entry, then, in an attitude of pitch down flight to the collision against the ground, evidenced by the DGPS data, as shown in Figure 15, reveals a left head variation (from 353º to 218º), increase of longitude value W and increase of speed value.

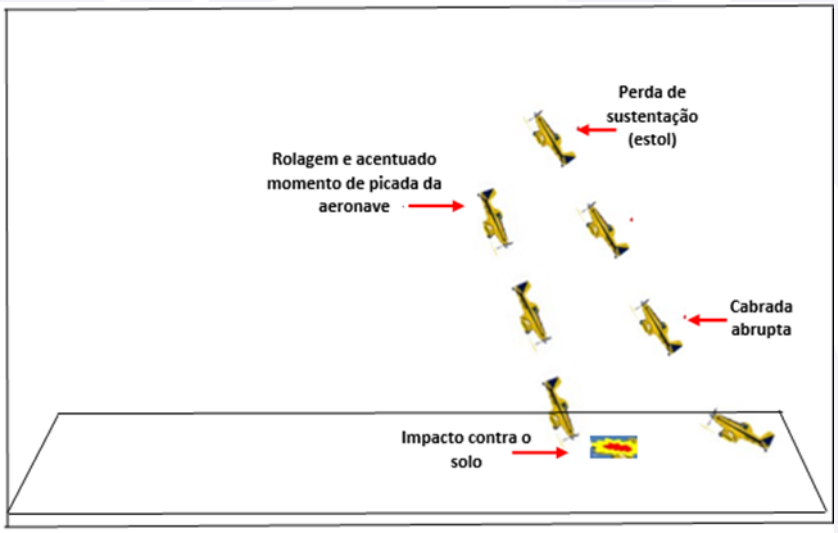

Figure 19 - Lateral profile of the accident dynamics.

Following inquiries from the comments recorded by the INSPAC in the latest FAP, especially regarding the training of stalls and curves, it was proved that the pilot had satisfactory coordination and demonstrated safety in the performance of these kinds of maneuvers.

Thus, it was hypothesized that the aircraft lost the left horizontal stabilizer during climbing, which would have led to a condition of unbalance of forces and moments, causing loss of control.

It is possible that, during the time the pilot was seeking to reestablish control of the aircraft, the pilot lost speed and reached a stalling condition or a speed very close to it, as verified by the DGPS transcription, where the minimum speed reached 81 MPH (70kt CAS), making it even more difficult to restore control of the aircraft.

Regarding the positions of the right elevator and its associated trim, in the aircraft pitch down direction, it could not be inferred that the pilot commanded this direction, since, at the moment of impact, the inertial forces may have caused changes.

3. CONCLUSIONS.

3.1 Facts.

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

b) the pilot had valid MNTE and PAGA Ratings;

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

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

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

f) according to reports, the weather conditions were favorable for the flight;

g) there was detachment of the left horizontal stabilizer, which was found separate from the other aircraft wreckage;

h) there was loss of control and the aircraft hit the ground at a wide angle;

i) after the impact, the aircraft caught fire and was destroyed; and

j) the pilot suffered fatal injuries.

3.2 Contributing factors.

- **Control skills – undetermined.**

The elevator command, abruptly applied to pitch up above the aircraft maneuver speed (Va), may have resulted in the detachment of the left horizontal stabilizer.

- **Attitude – undetermined.**

Adopting a higher speed than the recommended, has contributed to placing the aircraft in a hazardous condition and has demonstrated non-compliance with the safety operating procedures established in the aircraft manual, what may have contributed to the occurrence.

- **Flight indiscipline – undetermined.**

There was non-compliance with operational rules, without any reason for this, as evidenced by the speed employed, which was above the maximum allowed for any type of operation, what may have contributed to the detachment of the left horizontal stabilizer in flight.

4. SAFETY RECOMMENDATION.

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 addition to safety recommendations arising from accident and incident investigations, safety recommendations may result from diverse sources, including safety studies.

In consonance with the Law n°7565/1986, recommendations are made solely for the benefit of the air activity operational 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".

Recommendations issued at the publication of this report:

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

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Disseminate the lessons learned in this research, in order to alert the Brazilian civil aviation pilots and operators about the importance of knowing and respecting the operational limits established by aircraft manufacturers.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

None.

On February 09th, 2022.