COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A-015/CENIPA/2022

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PP-INQ**
MODEL:	**TBM700N**
DATE:	**31JAN2022**

NOTICE

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

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

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

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

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

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

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

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

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

SYNOPSIS

This Final Report pertains to the 31JAN2022 accident involving the model TBM700N aircraft of registration marks PP-INQ. The occurrence was typified as “[OTHR] Other – Meteorological phenomenon in flight and [LOC-I] Loss of control in flight.”

During a go-around attempt on final approach to landing, the aircraft touched down on the grassy area to the left of the runway and subsequently struck vegetation ahead before colliding with the ground in a dense forest area.

The aircraft sustained substantial damage.

The pilot and the passengers were uninjured.

France, the State of manufacture of the aircraft, by means of the BEA (*Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile*) designated an Accredited Representative for participation in the investigation of the accident.

Canada, the State of manufacture of the engine, by means of the TSB (Transportation Safety Board) also designated an Accredited Representative for participation in the investigation of the accident.

TABLE OF CONTENTS

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ANAC	Brazil's National Civil Aviation Agency
APP-BR	*Brasília* Approach Control
BEA	*Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile*
CB	Cumulonimbus Cloud
CIAC	Civil Aviation Instruction Center
CIMAER	Integrated Center of Aeronautical Meteorology
CIV	Digital Pilot-Logbook
CMA	Aeronautical Medical Certificate
CVA	Certificate of Airworthiness
CVR	Cockpit Voice Recorder
FAA	USA's Federal Aviation Administration
FDR	Flight Data Recorder
IFR	Instrument Flight Rules
IFRA	Instrument Flight Rating - Airplane
IAS	Indicated Airspeed
IMC	Instrument Meteorological Conditions
ISA	International Standard Atmosphere
LABDATA	Cenipa's Flight Recorder Data Readout and Analysis Laboratory
METAR	Routine Meteorological Aerodrome Report
MFD	Multi-Functional Display
MNTE	Single-Engine Landplane Class Rating
PFD	Primary Flight Display
PIC	Pilot in Command
PLA	Airline Transport Pilot License - Airplane
PPR	Private Pilot License - Airplane
RBAC	Brazilian Civil Aviation Regulation
SBBR	ICAO location designator - *Presidente Juscelino Kubitschek* Intl. Airport, *Brasília*, DF
SIGWX	Significant Weather Chart
SSGP	ICAO location designator - *Piquet* Aerodrome, *Brasília*, DF
SWFO	ICAO location designator - *Fazenda Santa Maria* Aerodrome, *Formosa do Rio Preto*, BA
TCU	Towering Cumulus Cloud
TPP	Private Air Services Aircraft Registry Category
UTC	Universal Time Coordinated

1. FACTUAL INFORMATION.

Aircraft	**Model:** TBM700N **Registration:** PP-INQ **Manufacturer:** DAHER SOCATA TBM	**Operator:** Private.
Occurrence	**Date/time**: 31JAN2022 - 12:35 (UTC) **Location:** SSGP – *Piquet* Aerodrome. **Lat.** 15°51'16"S **Long.** 047°48'24"W **Municipality – State:** Brasília-DF	**Type(s):** [OTHR] Other [LOC-I] Loss of control - inflight

1.1. History of the flight.

At approximately 11:10 UTC, the aircraft departed from SWFO (*Fazenda Santa Maria*, located in *Formosa do Rio Preto*, State of *Bahia*) bound for SSGP (*Piquet* Aerodrome, *Brasília*, Federal District) to perform a private flight with 05 POB (1 pilot and 4 passengers).

During a go-around attempt on final approach to landing, the aircraft touched down on the grassy area to the left of the runway and subsequently struck vegetation ahead before colliding with the ground in a dense forest area.

Figure 1 – General view of the aircraft.

1.2. Injuries to persons.

Injuries	Crew	Passengers	Others
Fatal	-	-	-
Serious	-	-	-
Minor	-	-	-
None	1	4	-

1.3. Damage to the aircraft.

The aircraft sustained substantial damage. Damage occurred to the wings, landing gear, engine, and fairings.

1.4. Other damage.

NIL.

1.5. Personnel information.

1.5.1. Crew's flight experience.

HOURS FLOWN	
	PIC
Total	9,500:00
Total in the last 30 days	17:00
Total in the last 24 hours	02:30
In this type of aircraft	60:00
In this type in the last 30 days	17:00
In this type in the last 24 hours	02:30

Note: Data regarding flight hours obtained via pilot's statement. According to him, the CIV's electronic records were out of date.

The pilot declared having flown a total of 70 hours in the past 90 days, approximately 45 of which on the aircraft type involved in the occurrence. The Investigation Committee identified these flights in the aircraft's Logbook.

1.5.2. Personnel training.

The Pilot in Command (PIC) did his PPR course (Private Pilot – Airplane) in 2004 at *Aeroclube de Franca*, State of *São Paulo*,

1.5.3. Category of licenses and validity of certificates.

The PIC held an Airline Transport Pilot License – Airplane (PLA) and had valid ratings for Land Single-Engine Airplane (MNTE) and Instrument Flight – Airplane (IFRA).

1.5.4. Qualification and flight experience.

The PIC had recently assumed the role of pilot on the aircraft, had completed all required training, and had approximately 60 hours on the model, about 35 of which under Instrument Flight Rules (IFR).

He had flown 44 hours and 54 minutes on the model in the 90 days preceding the occurrence, was qualified, and had extensive experience flying commercial aircraft, having previously worked as a pilot for air transport companies.

1.5.5. Validity of medical certificate.

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

1.6. Aircraft information.

The TBM700N airplane (SN 558) was manufactured in 2010 by DAHER SOCATA TBM. It had a maximum takeoff weight of 3,354 kg, and had been registered under the Private Air Services Category (TPP).

The CVA (Certificate of Airworthiness) of the aircraft was valid.

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

The latest major inspection ("200-hour" type) of the airplane, an inspection including CVA renewal, was carried out on September 22, 2021, on the premises of the maintenance organization *VOAR Aviation Manutenção de Aeronaves Ltda.* (COM 7701-01/ANAC), in *Uberlândia*, State of *Minas Gerais*. It flew 66 flight hours after the said inspection.

AIRCRAFT SYSTEMS DESCRIPTION

According to the TBM700 Pilot's Operating Handbook – Section 7, roll control was actuated by a system of rods and cables connecting the pulleys to the ailerons and spoilers.

The aircraft featured a specific characteristic in its flight control system: the aileron deflection was combined with that of the spoilers, which were located on the upper surface of each wing ahead of the flaps, as illustrated in Figure 2. This combination received the name of *spoilerons*.

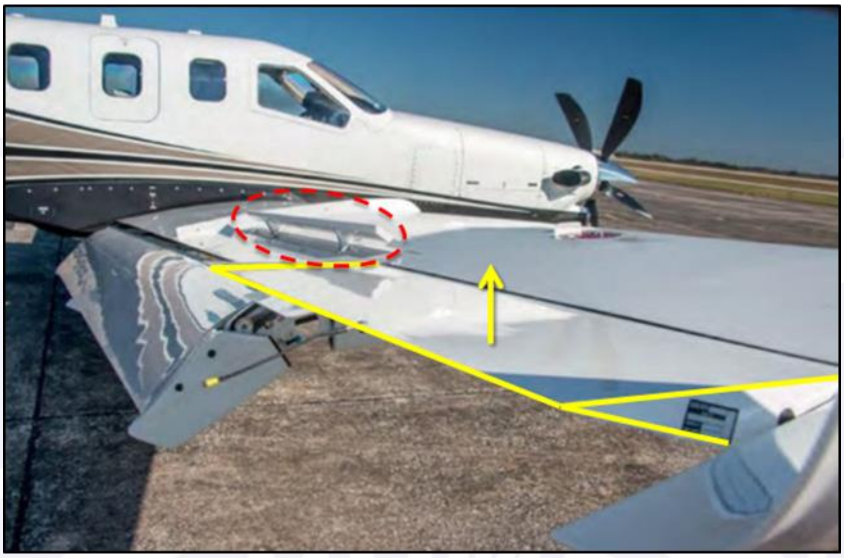

Figure 2 – Detail of the spoiler integrated with the aileron on an aircraft of the same model.

The spoiler would extend from the upper surface of the wing when the aileron was deflected upward (roll motion toward that side), and would deflect downward within the wing surface when the aileron was deflected downward (roll motion toward the opposite side).

The use of *spoilers* in the *spoileron* function reduced the lift on the corresponding wing, causing it to drop and thereby producing a roll in that direction.

Rudder control was also mechanically actuated by a system of rods and cables connecting the pulleys to the rudder. When the landing gear was down, the rudder pedals were connected to the nose gear steering system.

The flight controls also included a spring system that coupled yaw and roll movements. This mechanism provided rudder/roll coordination by commanding aileron deflection when the rudder pedal was displaced, and vice versa. With the aileron deflection, the *spoiler* could also be actuated in its *spoileron* function.

This aircraft model had a demonstrated crosswind limit of 20 kt., as stated in Section 5 – Performance of the TBM700 *Pilot's Operating Handbook*, item 5.6 *Wind Components*.

1.7. Meteorological information.

SSGP Aerodrome did not have aeronautical meteorological information available.

According to the meteorological report issued by the Integrated Center for Aeronautical Meteorology (CIMAER), there was instability over the SSGP region, which could cause rain showers and limitations for visual operations.

The 1200 UTC Significant Weather Chart (SIGWX) showed the presence of few Towering Cumulus (TCU) clouds, which exhibit significant vertical development but do not yet have electrical activity, with base at 2,000 ft. and tops at FL220, along with embedded and isolated Cumulonimbus (CB) clouds, which have strong vertical development with electrical activity associated with severe weather, with base at 3,000 ft., as shown in Figure 3.

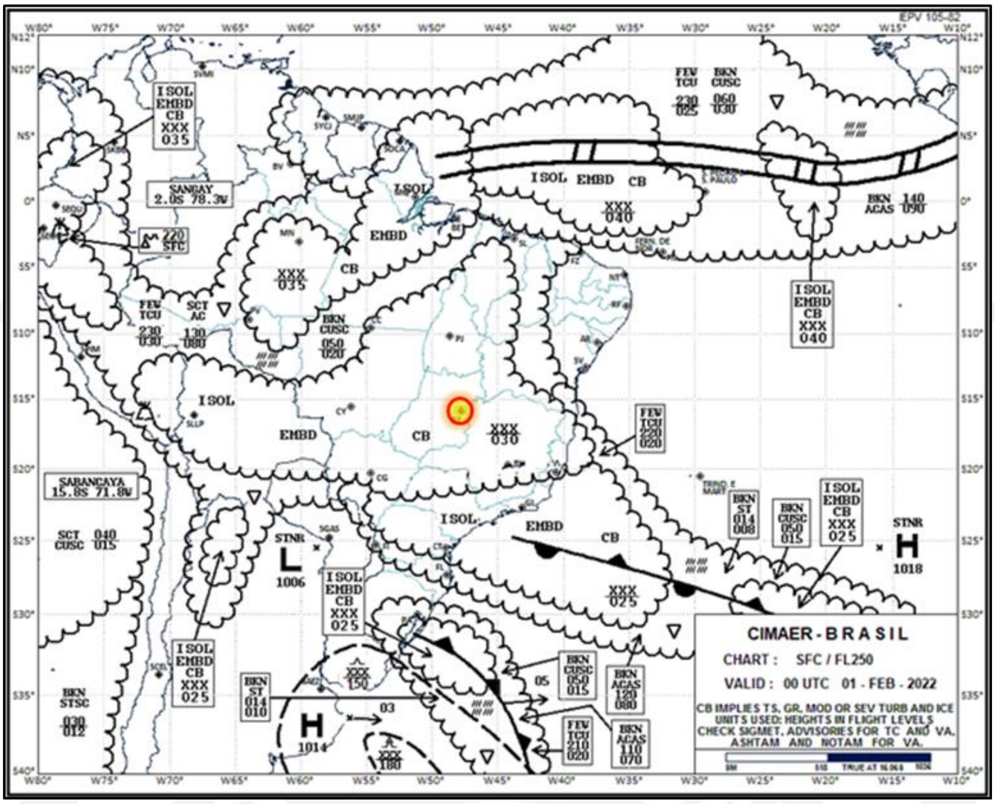

Figure 3 – SIGWX chart from the surface to FL250, for January 31, 2022, covering the time of the occurrence.
Source: https://www.redemet.aer.mil.br/.

The routine Meteorological Aerodrome Reports (METAR) for SBBR (*Presidente Juscelino Kubitschek* Intl Airport), located 6 NM from the accident site, provided the following information:

Localidade	Tipo	Data	Mensagem
SBBR	METAR	31/01/2022	METAR SBBR 311100Z 33005KT 9999 SCT015 FEW020TCU SCT080 21/18 Q1019=
SBBR	Aviso Aeródromo	31/01/2022	SBBR SBBR AD WRNG 1 VALID 311226/311425 SFC WSPD 15KT MAX 25 FCST NC=
SBBR	METAR	31/01/2022	METAR SBBR 311200Z 32007G18KT 9999 BKN020 FEW025TCU SCT080 23/18 Q1020=
SBBR	METAR	31/01/2022	METAR SBBR 311300Z 32008KT 9999 VCSH BKN025 FEW030TCU SCT080 24/18 Q1020=

Figure 4 – METAR and Aerodrome Warning for SBBR covering the period from 1100 to 1300 UTC. In highlight, data valid at the time of the occurrence.
Source: https://www.redemet.aer.mil.br/.

The 1200 UTC METAR reported wind from 320º at 7 kt., with gusts up to 18 kt., visibility greater than 10 km, overcast clouds with base at 2,000 ft., few clouds at 2,500 ft., and scattered clouds at 8,000 ft., with the presence of TCU, temperature 23°C, dew point 18°C, and pressure 1,020 hPa. These parameters allowed operation under visual flight conditions.

Since SBBR is located at an elevation of 3,498 ft. and had a temperature of 23°C at 1200 UTC, it was operating under International Standard Atmosphere (ISA) +15 conditions.

According to the messages, in addition to the wind instability and the presence of TCU, an Aerodrome Warning was issued for SBBR forecasting surface wind variations between 15 and 25 kt. during the period from 1226 to 14:25 UTC. The METAR at 1300 UTC added the information of rain in the vicinity of the aerodrome.

The meteorological conditions were above the minimum required for the type of flight proposed, but they indicated a forecast for deterioration in wind conditions and significant weather variation.

The significant weather indicated by the proximity qualifier “VC” (in the vicinity) was used to denote weather phenomena observed near the aerodrome, in this case “light rain showers in the vicinity” (VCSH). Such phenomena are reported with the qualifier “VC” only when observed between 8 km and 16 km from the aerodrome reference point, that is, between 4.3 NM and 8.63 NM.

1.8. Aids to navigation.

NIL.

1.9. Communications.

According to the transcripts of audio communications between the PP-INQ and air traffic control units, it was verified that the PIC maintained radio contact with *Brasília* Approach Control (APP-BR), performed heading deviations during descent to avoid cloud formations, and that no technical anomalies in the communication equipment were observed during the flight.

1.10. Aerodrome information.

The aerodrome was private and operated under Visual Flight Rules (VFR).

The runway was asphalt, with thresholds 10/28, measuring 590 m x 18 m, located at an elevation of 3,570 ft. It was situated 6.5 NM (12 km) east of SBBR, on a high terrain area surrounded by uneven topography.

1.11. Flight recorders.

Not required and not installed.

Although a Flight Data Recorder (FDR) and a Cockpit Voice Recorder (CVR) were not required and not installed, the aircraft was equipped with Garmin 1000 (G1000) avionics, 2 Primary Flight Displays (PFD), and a Multi-Function Display (MFD).

As such, it was possible to retrieve several data stored on the two memory cards from these systems (left and right), which were sent to the CENIPA’s Flight Data Recorder Readout and Analysis Laboratory (LABDATA) for extraction and validation.

It was identified that, approximately three minutes prior to the occurrence, some parameters were lost, raising the possibility of reduced reliability of GPS data from that moment onward.

The loss of GPS data may compromise the reliability of horizontal versus vertical trajectory information; however, when correlated with other available evidence, the following analysis can be conducted.

At the time of the data loss, the indicated barometric altitude was 150 ft lower than the altitude of the point relative to mean sea level. The altimeter setting was 30.09 inHg, approximately 1019 hPa.

The information shown in Figure 5 depicts the last minute of this recording, from the aircraft still in flight until its complete stop, followed by the shutdown of systems. The selected data include barometric altitude, speed, torque, NG (gas generator speed), attitude, and heading.

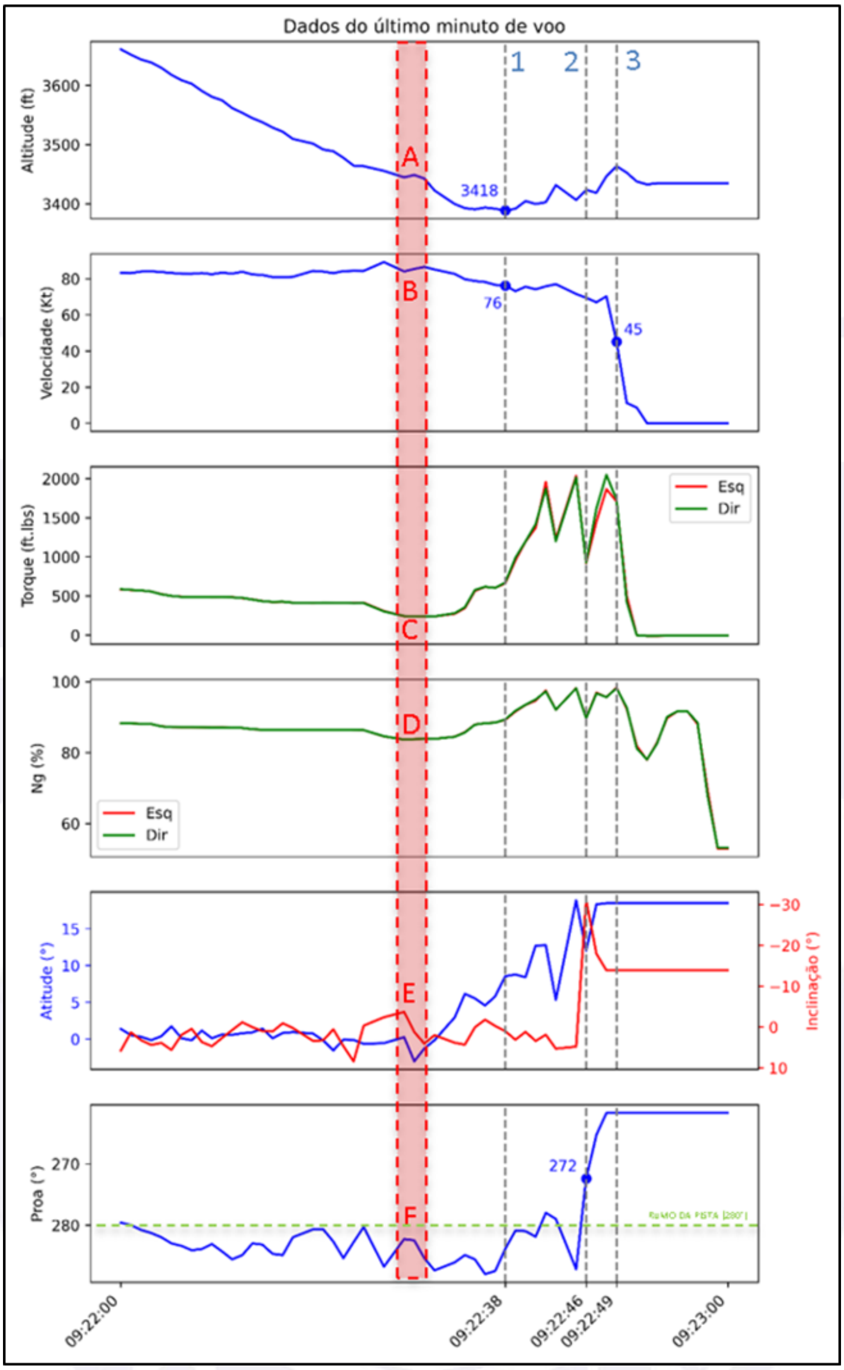

Figure 5 – Recorded data for the final minute of recording.

Line 1, shown as a dashed gray line, marks the lowest altitude reached in flight and the beginning of the go-around. Line 2 marks the maximum bank angle of the aircraft, 30° of left roll (negative sign), and Line 3 marks the moment of collision with denser vegetation, followed by the end of the recording.

The red band identifies a short period, seconds before the moment when the aircraft may have been exposed to a wind gust.

At point "A", a decrease is observed in the previously maintained descent rate, and after "A", there is an increase in that rate (steeper descent line).

At point "B", an increase in speed is followed by a sudden drop and return to a previous value. After "B", there is a gradual reduction in speed.

Points "C" and "D" show the maintenance of engine parameters, as recorded by the right and left sensors. At point "E", a right roll movement and a sudden drop in pitch angle are observed, followed by an increase. At point "F", a rightward heading variation (increase in heading) is noted.

Based on the data extracted, it was also possible to verify that, at the time of the aircraft's landing attempt, there was a right crosswind component with an intensity of 10 kt and a direction from 327°, approximately 50° to the right of the aircraft's heading.

Using the data retrieved from the avionics, an animation was created for visualization of the aircraft's final moments. It revealed that throughout final approach, the pilot made control inputs consistent with right crosswind corrections, with rudder use for heading adjustment being particularly evident.

The pilot attempted to conduct the approach at 85 kt. of Indicated Airspeed (IAS) and a vertical speed of 500 ft. /min, but the data showed the following actual profile (Figure 6).

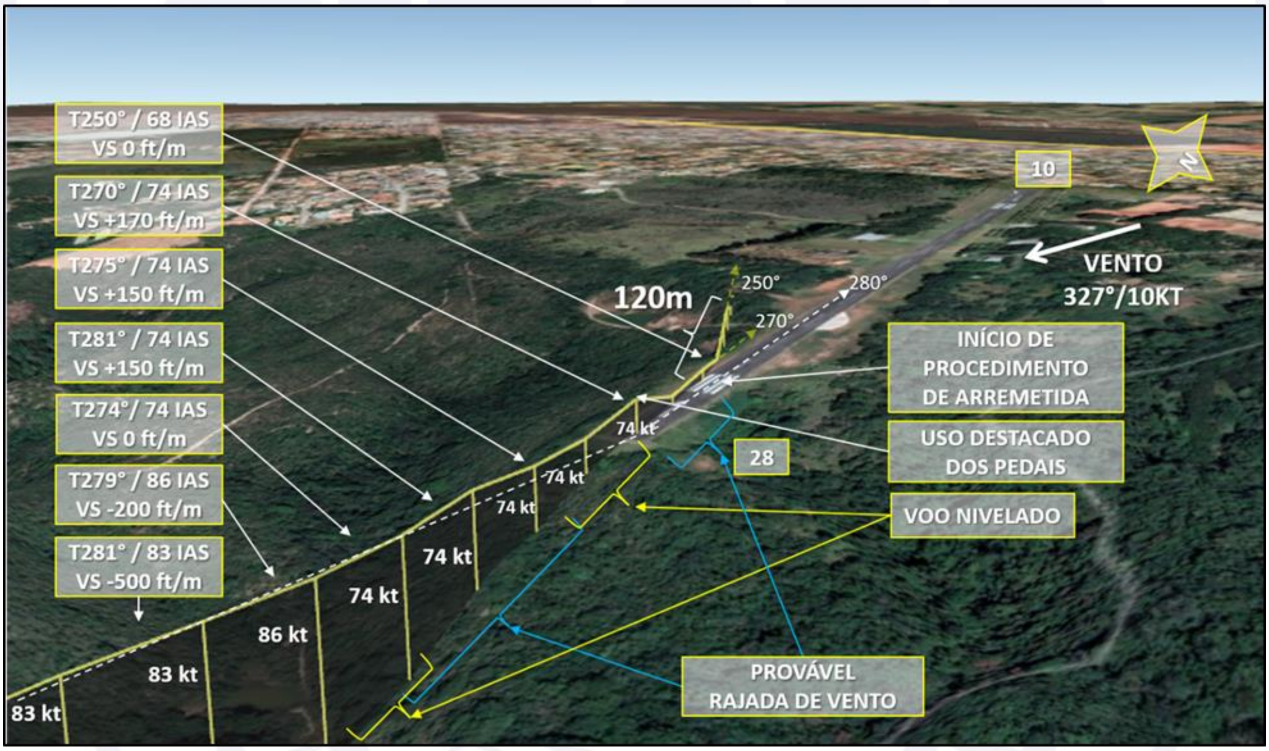

Figure 6 – Flight profile during final approach. Track, IAS, and VS data obtained from the onboard avionics readout.

1.12. Wreckage and impact information.

The initial impact occurred in the grassy area, approximately 3 meters beyond the lateral edge of runway 28 at SSGP, with no evidence of prior ground contact or impact.

The terrain alongside the runway sloped downward and was covered with native vegetation (*cerrado* biome). The aircraft collided with the vegetation, deviating approximately 20° to the left of the original heading maintained during final approach (280°).

Signs of the aircraft's collision with the ground and vegetation extended for approximately 120 meters until it came to a complete stop. The degree of tree destruction suggests that the aircraft had considerable horizontal speed at the time of impact.

Based on data retrieved from the avionics memory cards, the aircraft was estimated to be flying at 70 kt. when it struck the vegetation, decelerating to a full stop (Figure 7).

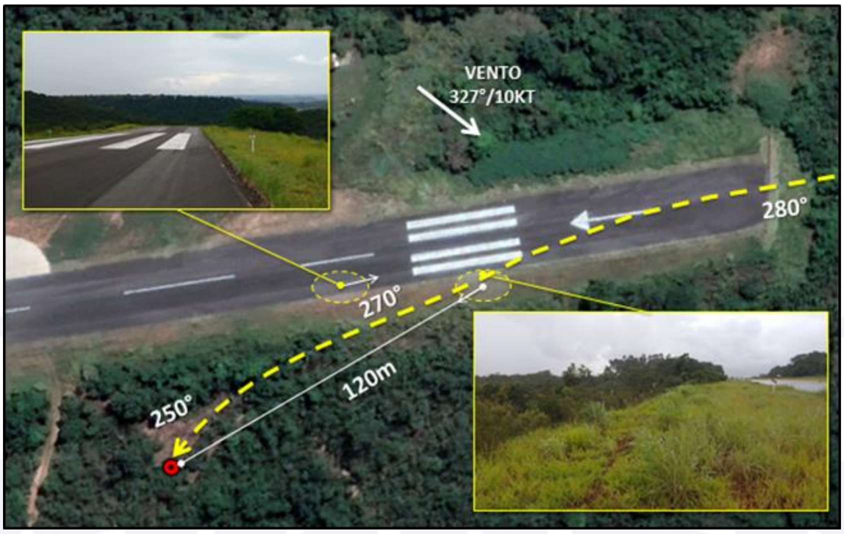

Figure 7 – Aircraft trajectory extracted from memory cards (map representation).

The wreckage distribution was of the concentrated type (Figure 8).

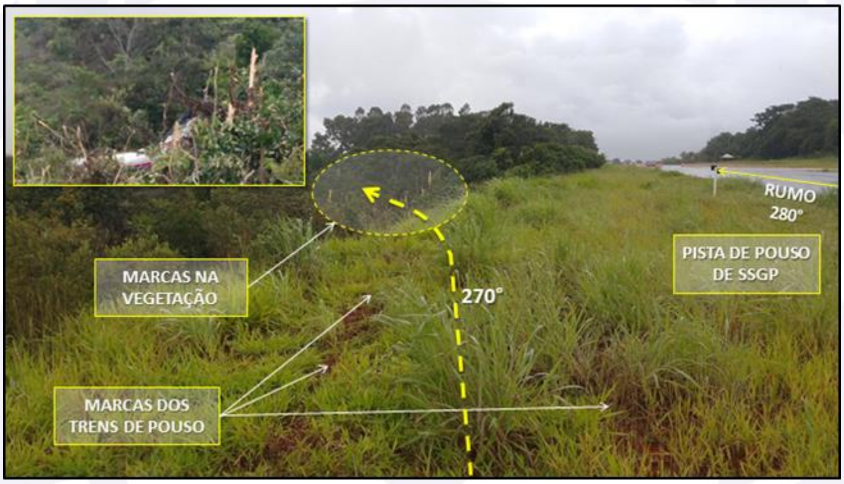

Figure 8 – View from the runway to the aircraft's final stop location.
Photo taken approximately 30 minutes after the event.

The landing gear, of the retractable type, was in the down position. The flaps were extended to the "LDG" (Landing – fully extended) position.

The elevator trim tabs were symmetrical and set in the nose-up direction, and the rudder trim was in the neutral position (Figure 9).

Figure 9 – View of parts of the aircraft after it came to a complete stop.

One found that the instrument panel sustained minimal damage from the impact, which allowed for the preservation and retrieval of data from the avionics.

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 PIC's performance.

1.13.2. Ergonomic information.

NIL.

1.13.3. Psychological aspects.

There was no evidence that psychological factors affected the pilot's performance, despite the flight being conducted in the presence of the aircraft owner, who was one of the passengers.

The pilot stated that he was aware of the meteorological conditions in the region and had performed some deviations during the descent. He declared that he felt comfortable operating the aircraft in Instrument Meteorological Conditions (IMC), and that during the occurrence flight, he experienced only the normal level of tension typical of that flight condition. He reported that there was no external pressure to complete the landing.

1.14. Fire.

There was no evidence of fire either in flight or after the impact.

1.15. Survival aspects.

The pilot and the passengers were able to evacuate the aircraft without sustaining any injuries.

1.16. Tests and research.

NIL.

1.17. Organizational and management information.

The aircraft and its operation were private, with no formal airline organizational structure. The pilot himself conducted the management of flight activities, and there was no operational oversight.

1.18. Operational information.

This was a private flight, operating under the requirements established by the Brazilian Civil Aviation Regulation nº 91 (RBAC-91).

The aircraft's basic operating weight was 2,048 kg (4,516 lb.), and it was fueled with 769 kg (961 L) of QAV-1 (Jet A-1). Adding the weight of the crew, passengers, baggage, and cargo items, the takeoff weight was 3,174 kg (6,997 lb.). The Maximum Takeoff Weight (MTOW) established by the manufacturer was 3,354 kg (7,394 lb.).

Based on the flight data retrieved from the aircraft, it was determined that the flight leg lasted 116 minutes and consumed approximately 350 kg of fuel.

The estimated landing weight at SSGP was approximately 2,823 kg (6,223 lb.). The Maximum Landing Weight specified by the manufacturer was 3,186 kg (7,024 lb.), and the aircraft's Center of Gravity (CG) was within the specified limits.

Therefore, the aircraft was within the manufacturer's specified weight and balance limits.

The cruise flight proceeded as planned, and descent was initiated from FL260 down to 1,000 ft. above field elevation (traffic pattern altitude). There were essential heading deviations instructed by ATC, and other deviations due to meteorological conditions, requested by the pilot.

The pilot reported having flown a wider pattern to allow for a longer final approach, in order to anticipate better and feel more comfortable during the approach. He entered directly on final for landing at SSGP, runway 28.

At 500 ft., he reported being stabilized, with landing configuration (gear down and flaps set to landing), approach speed (approximately 85 kt.), and all checklists completed.

He further stated that the wind was steady from the right, requiring rudder corrections and only minimal aileron inputs to avoid spoiler deployment, which would increase drag and cause some loss of lift. According to the pilot, this was a characteristic of the aircraft model.

Near touchdown, during the flare, he reported reducing engine torque and decreasing speed to approximately 70 kt., when he encountered a crosswind gust from the right. Upon experiencing a loss of lift, he applied more engine torque, more right rudder, and right roll input. Realizing he was no longer aligned with the runway centerline but rather to the left, he applied full power to initiate a go-around, during which a sharp yaw to the left occurred. From that moment on, the aircraft began striking vegetation until it came to a complete stop.

The analysis of the aircraft's flight parameters, obtained through avionics data extraction, indicated that during the final approach, there were no significant deviations from the glide path until the aircraft was exposed to the crosswind gust from the right.

According to the TBM700 *Pilot's Operating Handbook – Section 5 – PERFORMANCE*, the maximum demonstrated crosswind component for the model was 20 kt. The graphic representation of the wind component on final approach to SSGP runway, based on the data retrieved (wind from 327° at 10 kt), extrapolated to the forecasted maximum gust of 25 kt, is shown in Figure 10.

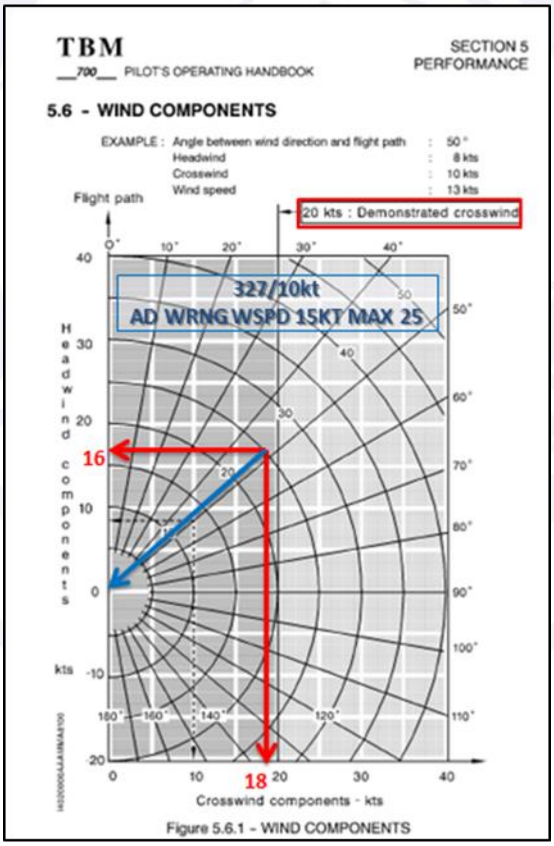

Figure 10 – Representation of the maximum wind component with direction 047° to the right and intensity of 25 kt.
Source: Adapted from the TBM700 *Pilot's Operating Handbook*.

The vector breakdown showed the potential presence of an 18-kt. crosswind component and a 16-kt. headwind.

1.19. Additional information.

In February 2014, the BEA, the French government agency responsible for air accident investigations, published a study on loss of control accidents involving Socata TBM700 aircraft, titled: *Loss of control on fast single-engine turboprop aircraft – Case of Socata TBM700* (BEA, 2014).

The study reviewed 36 accidents between 1990 and 2010, six of which involved loss of control due to left roll during final approach. In several cases, the aircraft deviated to the left of the intended flight path shortly before impact.

In general, in the six accidents analyzed, a speed lower than that specified in the flight manual for the selected configuration, combined with abrupt application of engine power for maximum acceleration, were concurrent conditions that led to loss of control involving a left roll.

The study cited a demonstration flight carried out during the investigation of a loss-of-control event. In that flight, some procedures not recommended in the flight manual were intentionally applied, such as failing to apply rudder correction following a rapid power increase.

The following observations were highlighted from that flight:

– tendency to initiate a left roll during stall; and

– tendency to roll to the left, in a controllable manner, during go-around maneuvers at speeds equal to or above 70 kt. and from a fully reduced engine torque or one set to 20%; the lower the speed, the more pronounced the rolling tendency.

The study emphasized that the left roll during stall is a recognized phenomenon associated with single-engine aircraft, and that the Socata TBM700 complied with federal regulations that limit the amount of left roll that may occur during a stall. The research suggested that additional pilot training could be beneficial in preventing similar accidents.

The *Pilot's Handbook of Aeronautical Knowledge* (FAA-H-8083-25C), published by the Federal Aviation Administration in its 2023 edition, *Chapter* 05: *Aerodynamics of Flight – Basic Propeller Principles*, states that:

"Torque" (the tendency of the airplane to turn to the left) is composed of four elements that cause or produce a twisting or rotating motion around at least one of the airplane's three axes. These four elements are:

1. Torque reaction from the engine and propeller;
2. Spiraling slipstream effect;
3. Gyroscopic action of the propeller; and
4. Asymmetric propeller loading (P-factor).

<u>TORQUE REACTION FROM THE ENGINE AND PROPELLER</u>

Torque reaction involves Newton's Third Law of Motion – for every action, there is an equal and opposite reaction. Applied to the aircraft, this means that as the engine shaft rotates, the propeller also spins and pushes air. According to Newton's Third Law, the air exerts an equal and opposite force on the propeller and engine shaft, generating both a thrust component and a tangential component around the propeller disc. Since both are fixed to the airframe, this interaction not only propels the aircraft forward but also produces a rolling (or rotational) tendency opposite to the direction of propeller rotation.

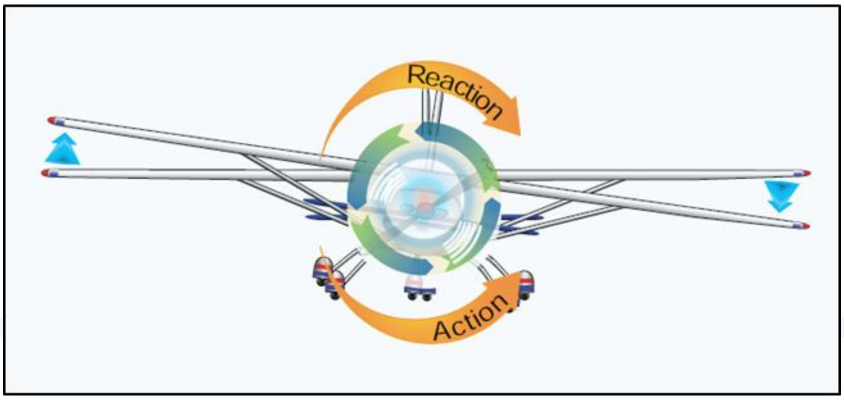

Figure 11 – Torque reaction.
Source: FAA-H-8083-25C.

When the aircraft is airborne, this torque acts around the longitudinal axis, tending to make the aircraft roll to the left (counterclockwise, opposite to the direction of propeller rotation). To compensate for this rolling tendency, several engineering solutions are employed, such as: designing the aircraft to generate more lift on the wing being pushed downward, offsetting the engine to neutralize the torque effect, among others.

Typically, aircraft design compensation factors are permanently set to counteract this force at cruise speed, since most of the flight time occurs during this phase. However, aileron trim tabs allow for additional adjustments at other speeds.

For example, when the aircraft wheels are on the ground during the takeoff roll, an additional yawing moment around the vertical axis is induced by the torque reaction. Since the left side of the aircraft is being pushed downward by torque reaction, a greater portion of the aircraft's weight is applied to the left main landing gear. This results in a greater normal force on the left wheel and, consequently, a greater friction force at that wheel, contributing to a yawing moment to the left around the aircraft's vertical axis.

The magnitude of this yawing moment depends on several variables, such as:

1. Engine size and power;
2. Propeller size and RPM;
3. Aircraft size; and
4. Ground surface condition.

This yawing moment during the takeoff roll is corrected by proper use of the rudder or rudder trim by the pilot.

SPIRALING SLIPSTREAM EFFECT

The high-speed rotation of the propeller generates a spiraling (helical) airflow. Under conditions of high propeller speed and low forward velocity (such as during takeoff and approach), this helical airflow becomes more compact and exerts lateral force on the aircraft's vertical stabilizer.

When this spiraling slipstream strikes the vertical fin, it produces a yawing moment around the aircraft's vertical axis.

The more compact the spiraling flow, the greater the force acting on the vertical stabilizer, and consequently, the more significant the yawing moment generated on the aircraft. However, as the forward airspeed increases, this helical airflow stretches out, and its effectiveness in producing a yawing moment diminishes.

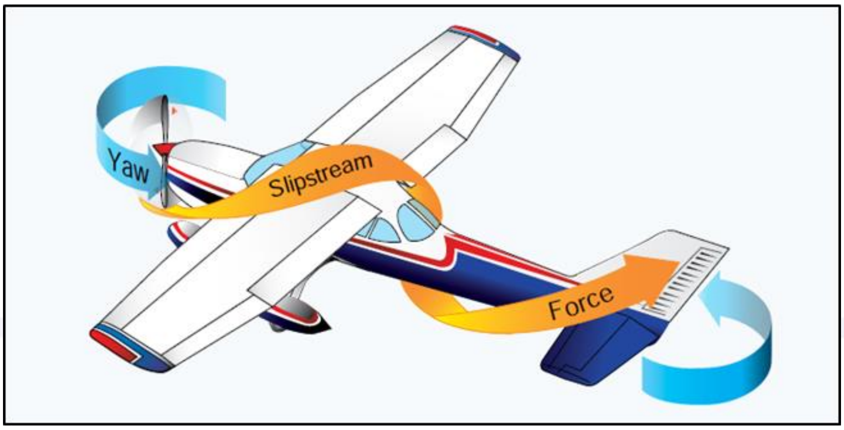

Figure 12 – Effect of spiraling slipstream.
Source: FAA-H-8083-25C.

It is the pilot's responsibility to apply proper corrective actions using the flight controls at all times

GYROSCOPIC ACTION

All practical applications of the gyroscope are based on two fundamental properties of gyroscopic action: rigidity in space and precession.

Precession is the resulting action, or deflection, of a spinning rotor when a deflective force is applied to its rim. In summary, when a force is applied, the resulting force manifests 90° ahead in the direction of rotation.

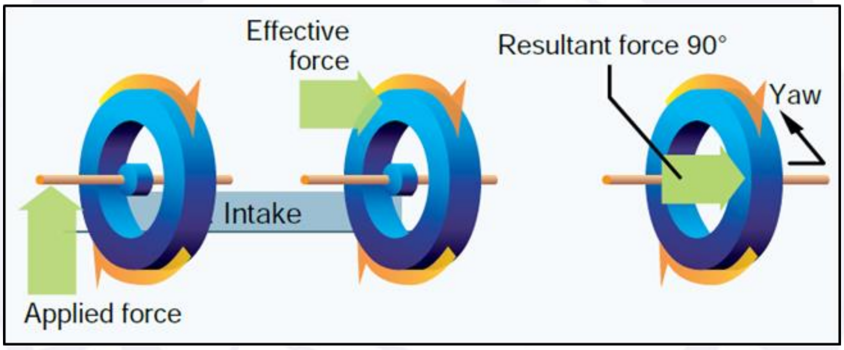

Figure 13 – Gyroscopic precession.
Source: FAA-H-8083-25C.

An aircraft propeller functions as a gyroscope. Whenever a force is applied to deviate the propeller from its plane of rotation, the resulting force acts 90° ahead in the direction of rotation and application, generating a pitching moment, a yawing moment, or a combination of both, depending on the point at which the force is applied.

A change in aircraft attitude has the same effect as applying a force to the top of the propeller's plane of rotation. The resulting force, acting 90° ahead, produces a yawing moment to the left around the vertical axis. The magnitude of this moment depends on several variables, one of which is the amount of force applied. Depending on where the force is applied, the aircraft may yaw to the left or right, pitch up or down, or experience a combination of pitch and yaw.

It can be stated that, as a result of gyroscopic action, any yaw around the vertical axis results in a pitching moment, and any pitch around the lateral axis results in a yawing moment.

To counteract the effect of gyroscopic action, the pilot must properly use the elevator and rudder to prevent undesired pitching or yawing.

ASYMMETRIC LOADING (P-FACTOR)

When an aircraft is flying with a high angle of attack, the mass airflow impacting the descending propeller blade is greater than that impacting the ascending blade.

This shifts the center of thrust to the right side of the propeller disc area, causing a yawing moment to the left around the vertical axis. This asymmetric loading is caused by the resultant velocity, which is generated by the combination of the rotational speed of the propeller blade and the horizontal airflow passing through the propeller disc. When the aircraft is flying at positive angles of attack, the right-hand blade (as seen from the rear), or the descending blade, moves through an area of higher resultant velocity than the left-hand, or ascending, blade. Since the propeller blade functions as an airfoil, increased velocity means increased lift. The descending blade thus produces more lift, tending to pull (yaw) the aircraft's nose to the left.

When the aircraft is flying at a high angle of attack, the descending blade experiences a higher resultant velocity, creating more lift than the ascending blade (Figure 14).

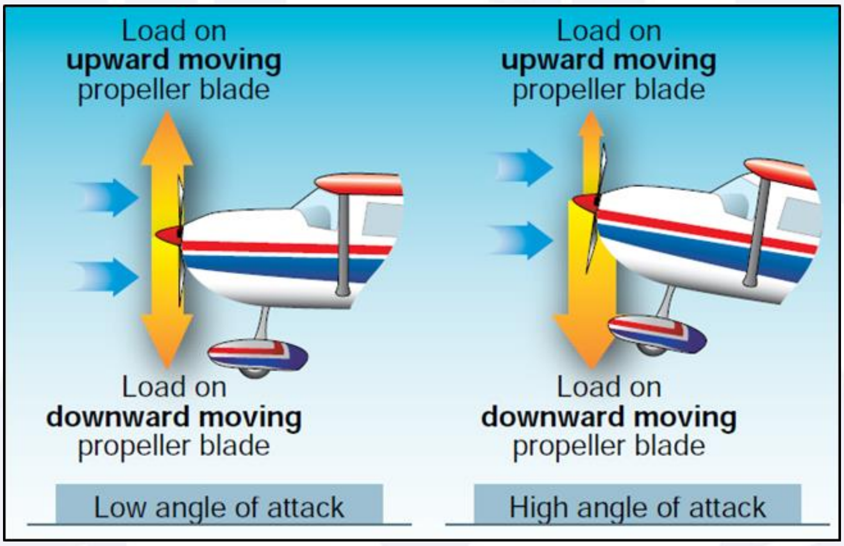

Figure 14 – Asymmetric loading (P-Factor).
Source: FAA-H-8083-25C.

The blade advancing into the horizontal airflow produces more lift, or thrust, shifting the thrust center toward that blade.

At smaller angles between the propeller shaft axis and the relative wind, this unbalanced thrust becomes proportionally smaller and continues to decrease until it reaches zero when the propeller shaft is exactly horizontal relative to the airflow (such as during cruise flight, for example).

The effects of each of the four torque-producing elements described above vary in magnitude with changes in flight conditions. In one phase of flight, one of these elements may be more prominent than the others. In another phase, a different element may dominate. The relationship among these values varies between aircraft, depending on factors such as exposed surface area and fuselage design, engine position and power, propeller configuration, and other aircraft-specific design features.

To maintain positive control of the aircraft under all flight conditions, the pilot must apply appropriate flight control inputs to compensate for these varying effects.

1.20. Useful or effective investigation techniques.

NIL.

2. ANALYSIS.

The flight involved in the occurrence was a private operation originating from SWFO and destined for SSGP, conducted for personal purposes and carried out in compliance with the provisions of RBAC 91.

During the approach to runway 28 at SSGP, with rain showers in the vicinity and wind gusts of up to 25 kt., a go-around was attempted at low altitude. During this maneuver, the aircraft touched down on the grassy area to the left of the runway and subsequently collided with vegetation ahead, coming to a complete stop.

Based on an estimation using the maximum forecasted wind gust for the region (25 kt.), the crosswind component for runway 28 at SSGP was found to remain within the demonstrated crosswind limit of up to 20 kt.

The information reported by the PIC was corroborated by data obtained from the avionics readout. For instance, it was noted that the aircraft's heading remained to the right of the runway heading throughout. Moments before the go-around, while still on final approach, there was a short period of lateral bank variation followed by negative pitch attitude, possibly indicating brief exposure to a wind gust.

According to the PIC's account, the sudden wind gust required stronger rudder input than aileron input, whereas typically, heading corrections due to wind variation would primarily involve aileron.

The pilot stated that he acted this way to avoid deployment of the wing spoilers, which would reduce lift; however, the aircraft's flight manual specifies that rudder input may also activate the spoilers in spoileron mode on the corresponding side, due to the coupling of yaw and roll movements just like aileron inputs. This reveals an inadequate assessment on the part of the pilot.

Since he had completed all required training for operating the aircraft, he was aware of the flight control characteristics and their responses. Therefore, training was not identified as a contributing factor, but rather piloting judgment.

Regarding the meteorological conditions, there was instability over the SSGP region, which could result in rain showers, restrictions on visual flight operations, and possible diversion due to the visual operation limits established for SSGP.

By nature, visual flight in proximity to meteorological instability or adverse weather conditions can lead to stimulus overload, resulting in delayed or selective perception and impairing the pilot's ability to recognize and anticipate environmental cues.

The application of maximum engine power, without the corresponding directional control input, may expose the aircraft to the combined effects of engine torque, gyroscopic precession, spiraling slipstream, and the P-factor (thrust vector displaced to the right).

These combined effects would result in a directional force causing deviation to the left, leading to a sudden yaw and runway excursion to the left side. This hypothesis is consistent with the initial actions taken, with the flight data retrieved from the avionics, and is further supported by the BEA publication that studied these factors in this specific aircraft model.

Variations in bank angle, pitch attitude, descent rate, and intensive flight control inputs during final approach caused by fluctuations in wind intensity are factors that may have led the aircraft to an unstabilized approach condition, followed by an unsuccessful go-around attempt.

Thus, it is hypothesized that the pilot experienced destabilization due to wind intensity fluctuations during short final. The decision to continue the approach, followed by exposure to another wind gust at a critical phase (low altitude and left of runway centerline), resulted in a delayed execution of the go-around procedure, demonstrating difficulty in perceiving, analyzing, and selecting appropriate alternatives for the situation.

Finally, the improper use of flight controls by the pilot led to loss of directional control and the aircraft veering off the side of the runway.

3. CONCLUSIONS.

3.1. Findings.

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

b) the pilot held valid MNTE and IFRA ratings;

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

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

e) the aircraft was within weight and balance limits;

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

g) the meteorological conditions were above the minimum required for the flight;

h) there was meteorological instability affecting the SSGP region;

i) an Aerodrome Warning with winds up to 25 kt. was in effect for SBBR;

j) a go-around was attempted near the ground and to the left of runway 28 at SSGP;

k) the aircraft touched down on the grassy area to the left of the runway, then on vegetation ahead, until it came to a complete stop;

l) the aircraft sustained substantial damage; and

m) the pilot and the four passengers were uninjured.

3.2. Contributing factors.

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

The significant weather, indicated with the proximity qualifier “vicinity” in the METAR for SBBR, encompassed the SSGP region and affected the aircraft’s stability on short final, requiring the pilot to perform additional control inputs compared to normal operating conditions.

- **Handling of aircraft flight controls – a contributor.**

The improper use of flight controls during heading correction on final approach - due to wind gusts - and the failure to effectively neutralize the aircraft’s rolling tendency during the go-around maneuver contributed to destabilization on final and to the unsuccessful go-around.

- **Piloting judgment – a contributor.**

The application of rudder to correct for lateral wind deviation, based on the belief that using aileron would result in loss of lift, reflected an inadequate assessment.

- **Perception – undetermined.**

It is possible that situational awareness was reduced due to the wind gust occurring near touchdown, where increased workload may have led to delayed or selective perception of the required action, in this case, the go-around procedure.

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

The decision to continue the approach, followed by exposure to another wind gust during a critical phase (low altitude and left of runway centerline), resulted in a delayed execution of the go-around procedure, highlighting difficulty in perceiving, analyzing, and selecting appropriate alternatives for the situation encountered.

4. SAFETY RECOMMENDATIONS

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

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

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

A-015/CENIPA/2020 - 01 **Issued on 09/04/2025**

Disseminate the lessons learned from this investigation to Civil Aviation Training Centers (CIAC) that provide theoretical and/or practical training for fixed-wing aircraft, in order to share with pilots the study on loss-of-control accidents involving fast single-engine turboprop aircrafts, prepared by the Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile (BEA), as well as the guidance contained in the Pilot's Handbook of Aeronautical Knowledge (FAA-H-8083-25C), published by the Federal Aviation Administration.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

None.

On September 4th, 2025.