COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A-128/CENIPA/2018

OCCURRENCE:	ACCIDENT
AIRCRAFT:	PP-SZN
MODEL:	C90GTI
DATE:	29JUL2018

FORMRFE 0124

NOTICE

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

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

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

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

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

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

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

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

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

SYNOPSIS

This is the Final Report of the 29 July 2018 accident involving the C90GTI King Air airplane, registration marks PP-SZN. The occurrence was typified as “[LOC-I] Loss of control in flight”.

During the descent procedure at SBMT (*Campo de Marte* Aerodrome, *São Paulo*, State of *São Paulo*), the aircraft had an issue with the landing gear position indicator lights.

After crossing the runway threshold on the fourth attempt to land at SBMT, before starting the flare, the airplane rolled around its longitudinal axis, lost control subsequently and collided with the ground.

The aircraft sustained substantial damage.

The pilot of the airplane suffered fatal injuries, two passengers were seriously injured, and the other four passengers received minor injuries.

Being the USA the State of aircraft design/manufacture, the NTSB (National Transportation Safety Board) designated an accredited representative for participation in the investigation of the accident.

TABLE OF CONTENTS

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

AD	Airworthiness Directive
ANAC	Brazil’s National Civil Aviation Agency
ANP	Brazilian National Agency for Petroleum, Natural Gas, and Biofuels
APP	Approach Control
ATC	Air Traffic Control
ATCO	Air Traffic Controller
ATZ	Aerodrome Traffic Zone
CA	Airworthiness Certificate
CB	Circuit Breaker
CBA	Brazilian Code of Aeronautics
CENIPA	Brazil’s Aeronautical Accidents Investigation and Prevention Center
CIV	Pilot Logbook
CMA	Aeronautical Medical Certificate
CVR	Cockpit Voice Recorder
DA	Airworthiness Directive
DECEA	Department of Airspace Control
EGPWS	Enhanced Ground Proximity Warning System
FCU	Fuel Control Unit
IAC	Civil Aviation Instruction
IAM	Annual Maintenance Inspection
IFR	Instrument Flight Rules
IFRA	IFR flight rating - Airplane
INVA	Habilitação de Instrutor de Voo - Avião
IS	Supplementary Instruction
LABDATA	Cenipa’s Flight Recorder Data Readout and Analysis Laboratory
METAR	Routine Meteorological Aerodrome Report
MLTE	Multi-Engine Land Airplane Class rating
NOTAM	Notice to Airmen
NSCA	Command of Aeronautics’ Norm
NTSB	USA’s National Transportation Safety Board
PAMA-SP	*Parque de Material Aeronáutico de São Paulo* (Brazilian Air Force Logistics Center located in *São Paulo*, State of *São Paulo*)
PIC	Pilot in Command
PLA	Airline Transport Pilot License – Airplane
PN	Part Number
PPR	Private Pilot License - Airplane

RBAC	Brazilian Civil Aviation Regulation
RBHA	Brazilian Aeronautical Certification Regulation
REA	Airplane Special Route
SACI	Integrated Civil Aviation Information System
SBMT	ICAO location designator - *Campo de Marte* Aerodrome, *São Paulo*, State of *São Paulo*
SCI	Fire-fighting Section
SIC	Second in Command
SIPAER	Aeronautical Accidents Investigation and Prevention System
SSVI	ICAO location designator - *Ângelo Ponzoni* Aerodrome, *Videira*, State of *Santa Catarina*
TMA-SP	*São Paulo* Terminal Control Area
TPP	Private Air Services Aircraft Registration Category
UTC	Universal Time Coordinated
VDC	Voltage Direct Current
VFR	Visual Flight Rules

1. FACTUAL INFORMATION.

Aircraft	**Model:** C90GTI **Registration:** PP-SZN **Manufacturer:** *Hawker Beechcraft*	**Operator:** Videplast Indust. de Embalagens Ltda.
Occurrence	**Date/time**: 29JUL2018 – 21:15 UTC **Location:** SBMT – *Campo de Marte* Aerodrome. **Lat.** 23°30'24"S **Long.** 046°38'02"W **Municipality – State:** *São Paulo – São Paulo*.	**Type(s):** [LOC-I] Loss of control - inflight

1.1. History of the flight.

At approximately 19:00 UTC, the aircraft took off from SSVI (*Ângelo Ponzoni* Aerodrome, municipality of *Videira*, State of *Santa Catarina*), bound for SBMT (*Campo de Marte* Aerodrome, *São Paulo*, State of *São Paulo*) in order to provide reserved transportation in favor of the operating company, with a pilot and six passengers on board.

During the approach for landing at the destination, there was a malfunction in the landing gear position indication lights. The airplane made three low passes over the runway, and during the attempt to land, rolled around its longitudinal axis, and crashed into the ground.

The aircraft sustained substantial damage.

The pilot suffered fatal injuries. Out of the six passengers, two suffered serious injuries and four of them were slightly injured.

1.2. Injuries to persons.

Injuries	Crew	Passengers	Others
Fatal	1	-	-
Serious	-	2	-
Minor	-	4	-
None	-	-	-

1.3. Damage to the aircraft.

The aircraft sustained substantial damage resulting from the impact with the ground and from the fire affecting the fuselage, engines, wings, empennage, and landing gear.

The propeller assemblies on both sides detached from the engines.

The right wing sustained significant deformation ranging from the wing tip to the wing root.

The forward section of the fuselage remained preserved, with lateral wrinkles and significant dents in the upper part of the left-hand side of the command cabin.

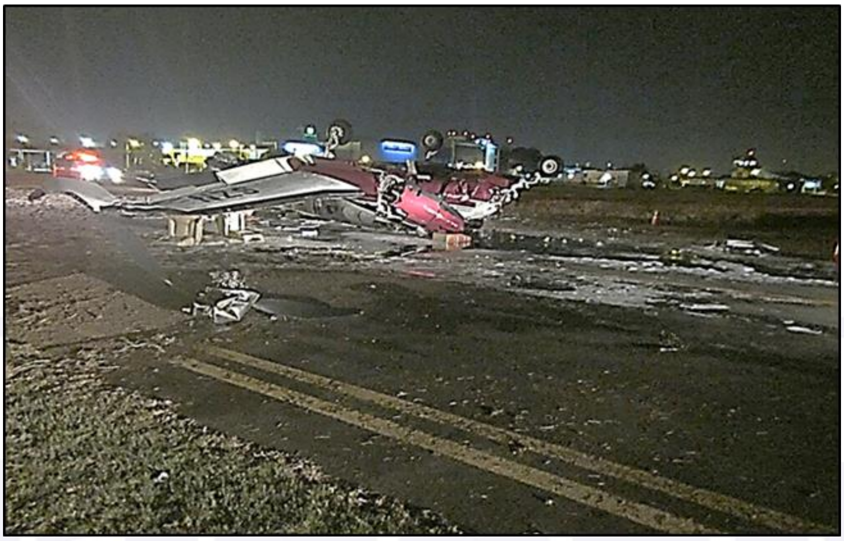


Figure 1 - Condition of the wreckage after the airplane came to a stop.

Figure 2 - View of the aircraft wreckage after removal from the accident site.

1.4. Other damage.

There was damage to the surface of an asphalt-sealed taxiway and to a few marker lights.

1.5. Personnel information.

1.5.1. Crew's flight experience.

Hours flown	
	PIC
Total	4.441:32
Total in the last 30 days	12:50
Total in the last 24 hours	00:00
In this type of aircraft	93:27
In this type in the last 30 days	12:50
In this type in the last 24 hours	00:00

RMK: Information on the hours flown obtained through records from the pilot's CIV (Digital Pilot-Logbook) of the ANAC's Integrated Civil Aviation Information System (SACI) and from records of the aircraft logbook. The physical CIV was not located.

The aircraft operator was did not specify the number of hours the pilot had flown in the PP-SZN airplane. In the aircraft logbook presented to the Investigation Committee, the hours flown in the PP-SZN airplane totaled 92 hours and 3 minutes. In the pilot's digital CIV, there were records regarding flights with the PR-TRO aircraft, which reached a total of 1 hour and 24 minutes.

The latest record in the digital CIV dated from 22 September 2017.

The first flight hour recorded in the PP-SZN logbook, containing the pilot's ANAC code, dated from August 2017.

The latest record in the aircraft logbook presented to the Investigation Committee dated from 22 July 2018 (relative to a flight from SBMT to SSVI).

1.5.2. Personnel training.

The Pilot in Command (PIC) did his the PPR Course (Private Pilot - Airplane) in 1990, but the place of training was not determined.

1.5.3. Category of licenses and validity of certificates.

The PIC held a PLA License (Airline Transport Pilot - Airplane) and valid ratings for MLTE (Multi-Engine Land Airplane), INVA (Flight Instructor - Airplane), and IFRA (Instrument Flight - Airplane).

1.5.4. Qualification and flight experience.

The PIC had been flying airplanes for 32 years and had worked for the aircraft operating company for 18 years.

He had operated multi-engine aircraft since 2007, accumulating experience in several aircraft models, including recent designs. In addition, he took flight simulator sessions in the USA when he operated an EMB-500 Phenom 100 aircraft, the type rating of which (EPHN) had expired in February 2015.

On 05 July 2017, he did en route training on a C90GTI aircraft of another operator, according to a record in his digital CIV, without any information about the type of training performed. From 15 August 2017 onward, he began operating the PP-SZN airplane.

On 22 September 2017, he took a proficiency test on a PA-34 *Seneca* airplane (PR-VGS) for revalidation of his MLTE rating.

His flights on class aircraft alternated between a PA-34 airplane (PP-VID, owned by the company, and which had an analogue panel) and a C90GTI airplane (PP-SZN, which had a glass cockpit panel).

He was qualified and experienced in this type of flight.

1.5.5. Validity of medical certificate.

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

1.6. Aircraft information.

The SN LJ-1910 model C90GTI King Air airplane was a product manufactured by Hawker Beechcraft in 2008. It was registered in the TPP Category (Private Air Services). The company acquired the airplane on 07 August 2017, as mentioned in the aircraft's Full Certificate.

The airplane had a valid CA (Airworthiness Certificate).

According to ANAC's Supplementary Instruction (IS) 43.9-003 Rev A, in effect at the time of the occurrence, the records in Part I of the airframe, engine, and propeller logbooks were out of date.

The aircraft's latest inspection (“Annual Maintenance Inspection - IAM”) took place on 21 November 2017. The airplane flew 144 hours and 42 minutes after the referred inspection. The airplane’s total flight time logged was 1,489 hours and 42 minutes.

The airplane was equipped with two PT6A-135A engines manufactured by Pratt & Whitney Canada. According to the engine logbooks, both the left engine (SN PCE-PZ0743) and the right engine (SN PCE-PZ0738) had 1,342 hours at the last maintenance action, which dated from 21 November 2017.

Hartzell Propeller Inc. manufactured the HC-E4N-3N propellers equipping the airplane. The left (SN HH-3200) and right (SN HH-3460) propellers had 1,342 total hours on the date of the last maintenance action.

According to the CA, the aircraft was capable of transporting eight people, being seven passengers and a pilot. As per the airplane’s certification, it required just a single pilot for operation.

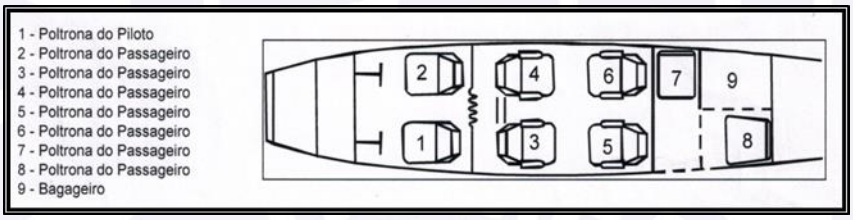


Figure 3 - View of the airplane’s seat layout.

General characteristics of the C90GTI King Air airplane.

The C90GTI King Air was a metal-framed, low wing, twin-engine, turboprop airplane featuring a pressurized cabin with a 30,000 ft. operational ceiling. It had a conventional empennage and retractable tricycle landing gear.

The main feature of this model was the introduction of a glass cockpit, which superseded the old conventional analog panels.

The primary flight surfaces consisted of ailerons, elevators, and rudder, responsible for roll, pitch, and yaw movements, respectively. The cockpit controls operated the surfaces by means of cables, pulleys, and rods.

The flap system consisted of four surfaces, two on each wing. Electrical control of the surfaces was performed by means of a position selector lever located on the central pedestal, which had three positions: UP, APPROACH, and DOWN. The surfaces were moved by means of an electric motor and actuators (Figure 4).

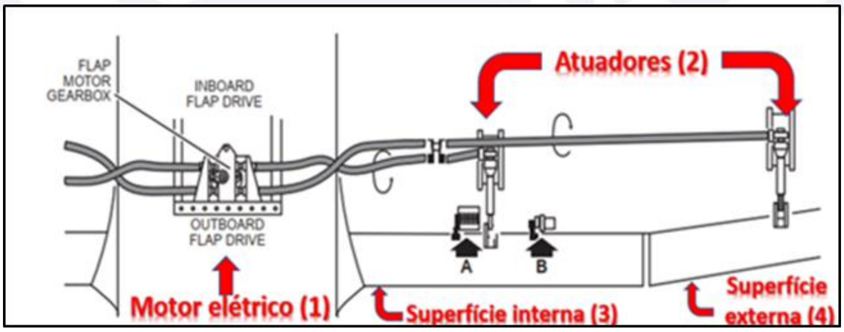


Figure 4 - Electric motor (1), actuators (2), internal surface (3), and external surface (4) of the Flap System.

The flap travel varied from 0% (UP) to 100% (DOWN), and its scale consisted of the 20, APPROACH, 40, 60, 80, and DOWN indications, which represented travel percentages.

The flap position selector was located on the pedestal, and the position indication was shown on an instrument on the panel above the lever pedestal (Figure 5).

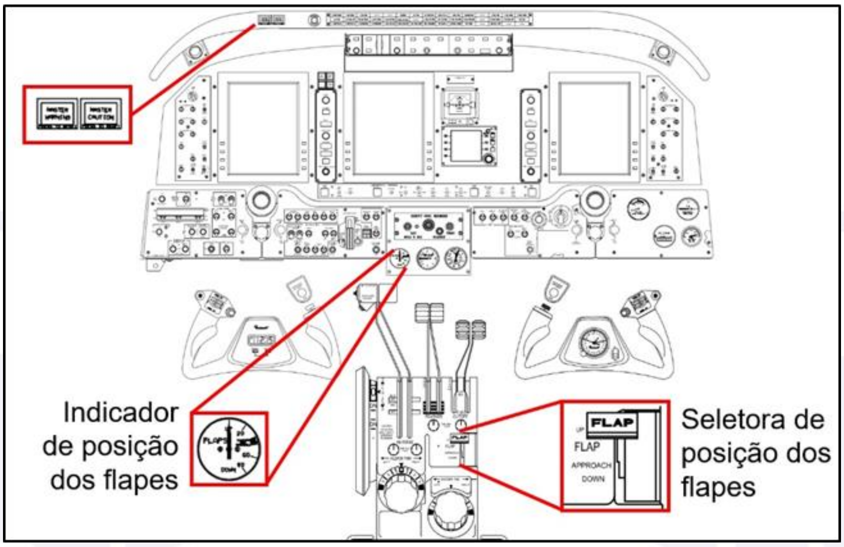


Figure 5 - Flap position selector and flap position indicator.

The main difference between the C90GT and the C90GTI models was the "glass cockpit" panel of the latter airplane model.

Landing gear assembly

The airplane was equipped with a retractable tricycle landing gear. The system used arms called *drag legs* that locked the gear in the fully extended position. The main landing gear legs were fitted with oil shock absorbers, and were attached to the aircraft structure by a pinned joint. The nose shock absorber was assembled with the nose landing gear control mechanism.

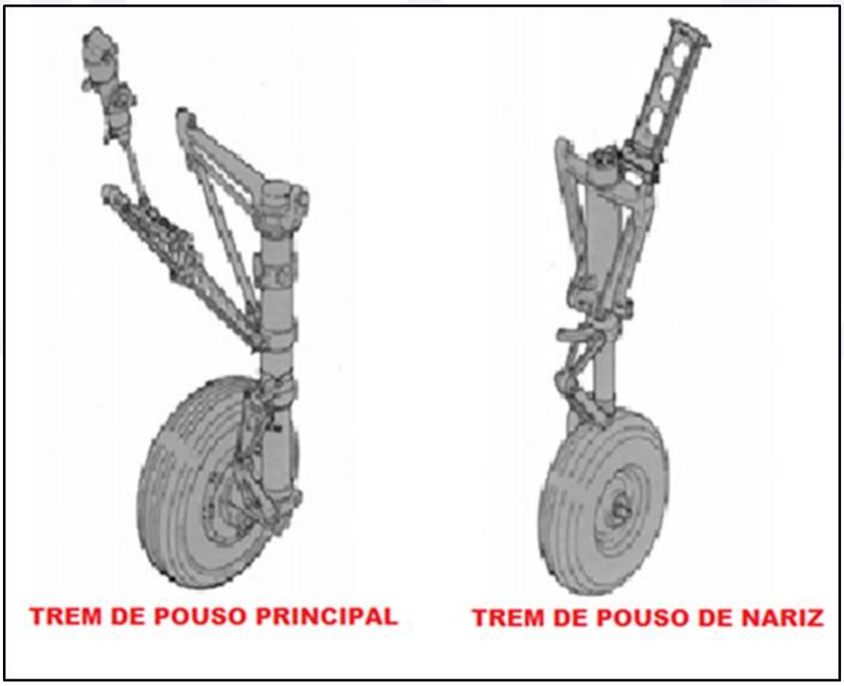


Figure 6 - Landing gear assembly.

The main and nose landing gears were extended and retracted by a hydraulic power pack in conjunction with hydraulic cylinders. The power pack was located forward of the main spar of the central section.

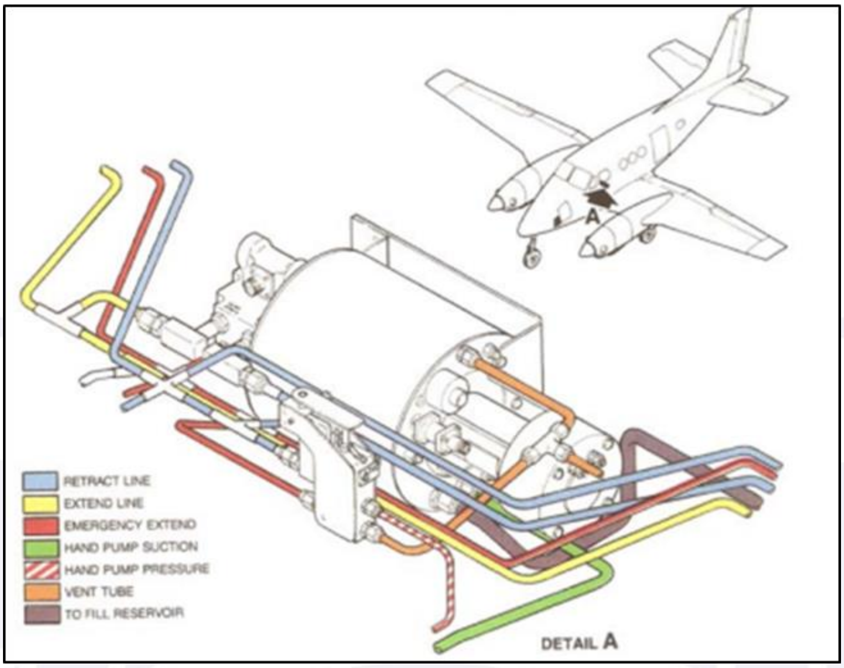


Figure 7 - Details of the power pack and its location.

A hydraulic actuator was located on each of the landing gear legs. The power pack consisted of:

- a hydraulic pump;
- a 28 VDC motor;
- a two-section hydraulic fluid reservoir;
- a screen filter; a landing gear select valve;
- a solenoid;
- a level sensor; and
- a retracted-gear pressure switch.

For emergency extension, the system had a mechanical pump, operated by means of a manual emergency extension lever.

Three hydraulic lines were provided for the actuators of the nose gear and main gear: one for normal extension and one for normal retraction, both from the power pack, in addition to one for emergency extension from the mechanical pump. The normal extension line and the emergency extension line were connected to the top of each hydraulic actuator, while the retraction line was mounted on the bottom of the actuators.

Both the nose gear and the main gear were hydraulically operated, and had an actuator on each leg. The normal control for extension and retraction was electric.

For emergency extension, the landing gear could be manually actuated by means of a lever (LANDING GEAR ALTERNATE EXTENSION) located on the aircraft floor, to the left of the cockpit central pedestal (Figure 8).

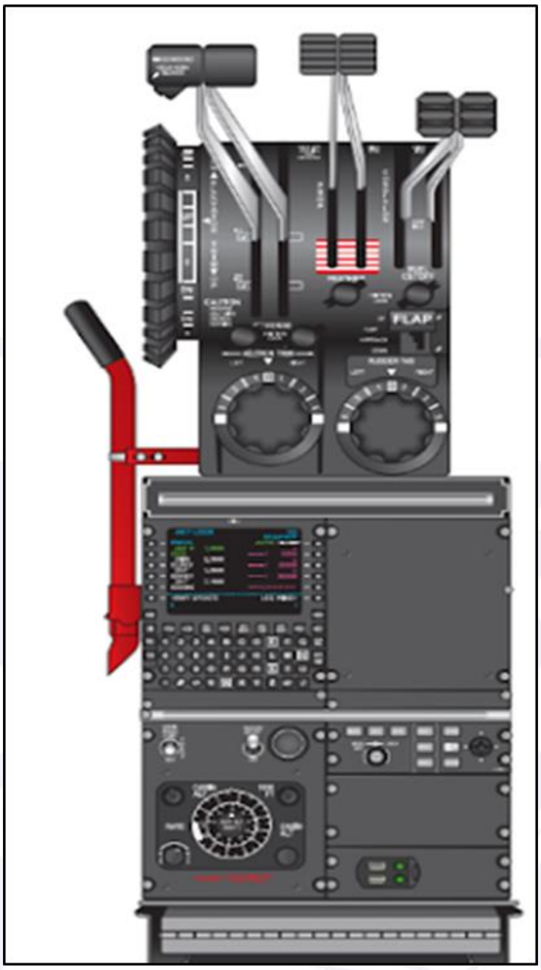


Figure 8 - Emergency actuation lever highlighted in red
(LANDING GEAR ALTERNATE EXTENSION).

In normal operation, the landing gear was controlled by means of the position selector lever. After the selector was moved to the UP or DOWN position, the pressurized hydraulic fluid acted on the faces of the hydraulic actuator pistons, resulting in the extension or retraction of the landing gear.

When the selector was moved to the down position, the gear moved downward and, upon reaching the fully extended and locked position, position switches were activated, triggering control relays that cut off the electric current supply to the hydraulic pump motor. The electric motor continued driving the pump until all three landing gear legs were down and locked.

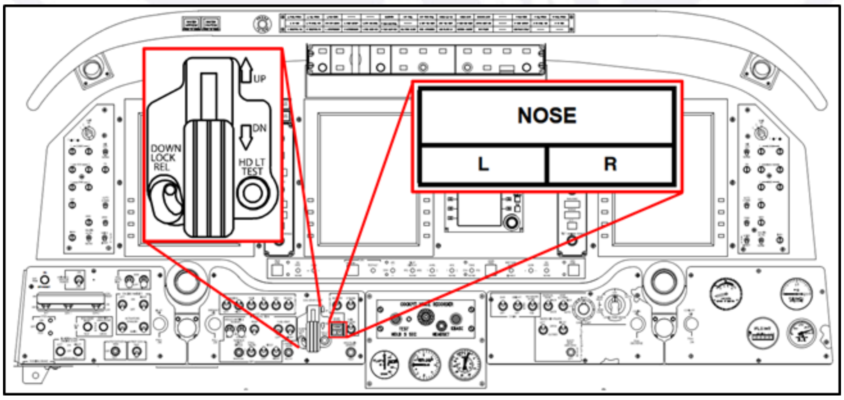


Figure 9 - Landing gear position selector and indicator lights.

When the red GEAR-IN-TRANSIT light turned off, the three green lights (NOSE/L/R) illuminated, indicating that the landing gear was in the down and locked position.

A solenoid located on the pump was energized when the landing gear was in the UP position, acting on the gear selector valve, allowing the system fluid to flow to the upper side of the gear. The gear selector valve remained in the DOWN position with the aid of pressure springs, and would only move to the UP position when energized.

The landing gear position indication was provided by a set of three lights (NOSE/L/R), on an indicator unit on the pilot's lower panel. Each light, when illuminated, indicated that the corresponding landing gear leg was down and locked. The absence of illumination, with the selector lever in the DOWN position, could indicate a transient or unsafe condition of the landing gear. The operation of the green position indicator lights could be tested by pressing the face of the indicator (PRESS TO TEST).

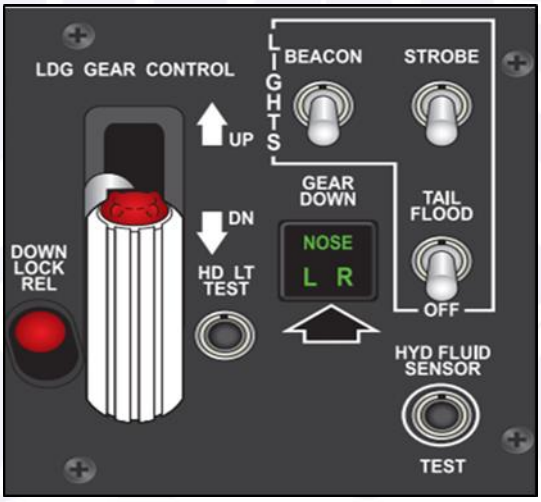


Figure 10 - Landing gear position selector and landing gear position indicator lights.

Two lights in a parallel circuit (red), located on the landing gear lever, would illuminate to indicate that the gear was in transit or unlocked (Figure 11) and would extinguish in the UP or DOWN positions. The red lights on the lever would also illuminate when the landing gear warning horn was sounding.

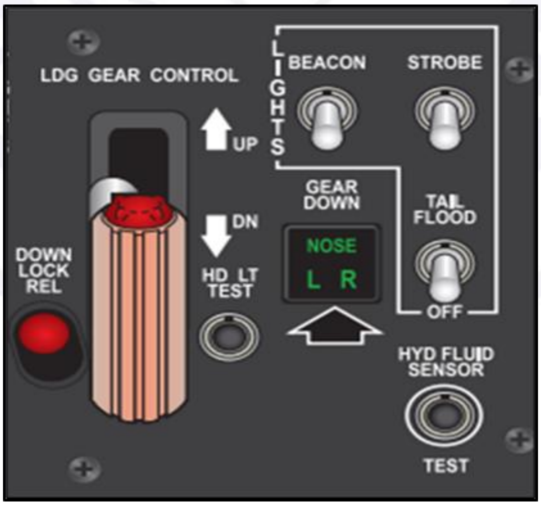


Figure 11 - Landing gear control lever handle (red light indicates landing gear in transit).

The red control lights could be checked by pressing the HD LT TEST button, located adjacent to the landing gear lever (Figure 12).

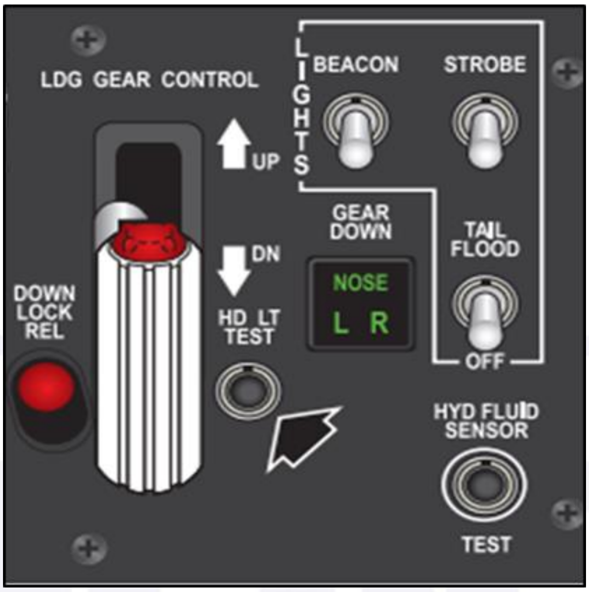


Figure 12 - HD LT TEST button used to check the red control lights on the landing gear lever.

When the landing gear assembly was actuated from the UP to DOWN position, the transit lights would illuminate and then extinguish as the drag brace of each landing gear leg engaged its respective downlock switch, signaling contact with the switch.

In this position, the switch would cut the circuit for the GEAR - IN - TRANSIT lights and complete the path for the DOWN POSITION LIGHTS with the lights in the down position. The down position switch on each gear also functioned as a system warning switch.

The GEAR - IN - TRANSIT lights indicated one or all of the following conditions of the landing gear:

- landing gear lever in the UP position and the aircraft on the ground with its weight on the landing gear;
- flaps in the UP or APPROACH position, one or both power levers reduced below approximately 79% +/- 2% N1, and one or more landing gear legs not down and locked;
- one or all landing gear legs not in the fully retracted position;
- the warning horn has been silenced and the engines are not operating below 79% +/- 2% N1; and
- the flaps are beyond the APPROACH position (36% or more) and one of the landing gear legs is not lowered.

The UP/DOWN and landing gear warning horn indication systems were completely independent. A malfunction in any one of them would not affect the others.

<u>Landing gear warning system</u>

The landing gear warning system was designed to alert the pilot that the landing gear was not down and locked during specific flight regimes. There were various alert modes, depending on the position of the flaps.

With flaps in the UP or APPROACH position, and one or both power levers retracted below 79% N1, the warning horn would sound intermittently, and the lights on the landing gear lever would illuminate.

The horn could be canceled by pressing the GEAR HORN SILENCE button located on the left engine power lever (Figure 13).

Figure 13 - Horn silence button of the landing gear configuration.

The lights on the landing gear lever, however, could not be called off. The system would reset when the power levers were advanced above 79% N1.

With the flaps beyond the APPROACH position and with the landing gear not locked down, the warning horn would sound and the lights on the landing gear lever would illuminate, regardless of the position of the power levers. It would not be possible to silence the horn or extinguish the lights.

Landing gear warning horn operation

LANDING GEAR POSITION	FLAPS	POWER / N1	HORN	SILENCER MODE
UP	UP	Less than 77% to 81%	No	Not Applicable
UP	UP	Less than 77% to 81%	Yes	Silence Button
UP	Approach	Less than 77% to 81%	Yes	Silence Button
UP	Beyond Approach	Any	Yes	Extend Landing Gear

Figure 14 - Table with the operating modes of the landing gear warning horn.

Manual extension of the landing gear

The manual extension of the landing gear was accomplished by operating an alternative lever located on the floor between the PIC's seat and the pedestal, which could be used when it was necessary to lower the gear in an emergency. The lever had re was an identification plaque with the text LANDING GEAR ALTERNATE EXTENSION.

The LANDING GEAR RELAY Circuit Breaker (located to the left of the landing gear lever) should be tripped, ensuring that the lever was in the DOWN position. Then, the lever should be removed from its compartment and pumped with alternate up and down movements.

The aircraft manual read that during the pumping cycles, in the down stroke of the lever, it should not be lowered beyond its safety clamp, as this would allow the pressure accumulated in the line during the manual pumping cycles to be drained. The movement should be continued until all three green lights illuminated.

After that, the lever should be returned to its original compartment. If one of the legs did not lock, the lever should not be stowed in its compartment; it should be kept in its upper position, instead.

If one of the conditions below occurred, the gear was likely not locked down, and, therefore, it was not a false indication:

- the respective landing gear annunciator illuminated when tested;
- the red light on the landing gear lever illuminated; and
- the warning horn sounded when one or both power levers were retarded below a certain value of N1.

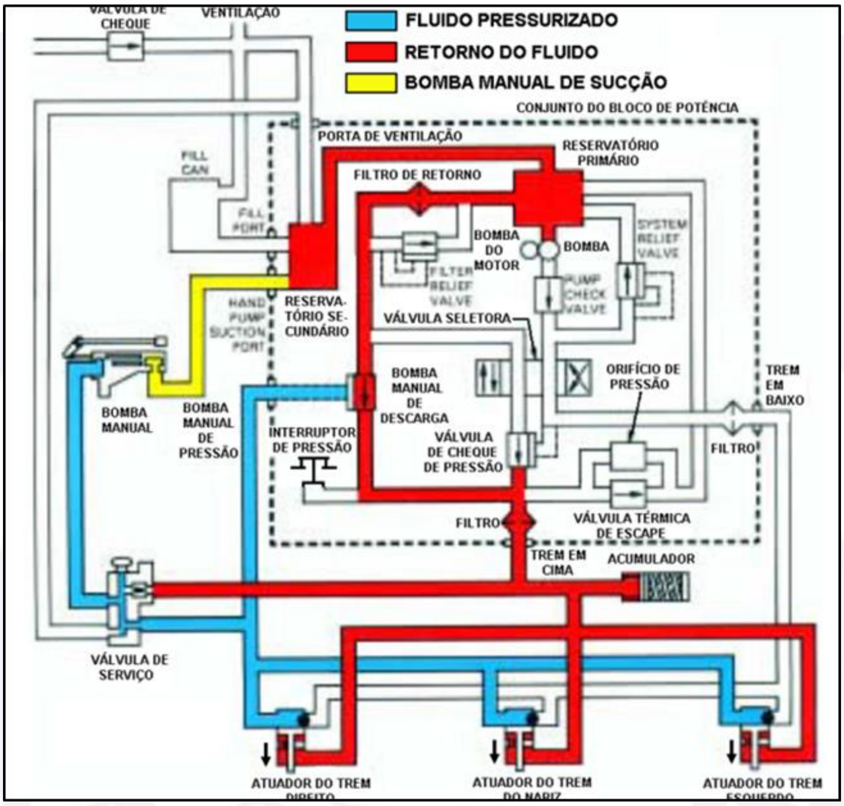


Figure 15 - Schematic diagram of the manual landing gear extension.

The Component Control Information Map presented - dated 21 November 2017 - regarding the PP-SZN airplane landing gear, contained the usage limits, data from the latest installation/overhaul, current data, expiration dates, and availability of the components. Shown in Figure 16, it was up to date at the time of the occurrence, without any expired items installed on the landing gear assembly.

AEROMECÂNICA LTDA PP-SZN 2
COM nº 0103-04/ANAC

ITEM CONTROLÁVEL		Parâmetro	LIMITES DO COMPONENTE			DADOS NA ÚLTIMA INSTALAÇÃO/REVISÃO				DADOS ATUAIS		VENCIMENTO	DISPONÍVEL	
Nome e	Fabricante	de	PRIMEIRO	Localização	VIDA	COMPONENTE			CÉLULA	DO COMPONENTE		VALORES DA	DO COMPONENTE	
Part Number	Serial Number	Controle	TBO	na Caderneta	LIMITE	TSOi/CSOi	TSNi/CSNi	DATA REV	TSNi/CSNi	TSO/CSO	TSN/CSN	CÉLULA	Vida Útil	Até Revisão
Landing Gear														
Trem pouso nariz	Hawker	CICLOS	8000	N/A	N/A	0,0	0,0	26/11/2014	1092,0	242	242	9092,0	N/A	7758,0
101-820029-31	07080801 ICT	DATA/DIAS	2190	N/A	N/A	0,0	0,0	26/11/2014	26/11/2014	1091	1091	24/11/2020	N/A	1099,0
Trem principal LH	Hawker	CICLOS	8000	N/A	N/A	0,0	0,0	26/11/2014	1092,0	242	242	9092,0	N/A	7758,0
90-810039-1	06230801 ICT	DATA/DIAS	2190	N/A	N/A	0,0	0,0	26/11/2014	26/11/2014	1091	1091	24/11/2020	N/A	1099,0
Trem principal RH	Hawker	CICLOS	8000	N/A	N/A	0,0	0,0	26/11/2014	1092,0	242	242	9092,0	N/A	7758,0
90-810039-2	06200801 ICT	DATA/DIAS	2190	N/A	N/A	0,0	0,0	26/11/2014	26/11/2014	1091	1091	24/11/2020	N/A	1099,0
Actuators (hydraulic) Nose Gear		HORAS	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C
11238002221		CICLOS	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C
Overhaul or replace if hydraulic fluid leaks are noted or if the lock indicator switch fails to operate properly.														
Actuators (hydraulic) Main Gear		HORAS	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C
903880005		CICLOS	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C
Overhaul or replace if hydraulic fluid leaks are noted or if the lock indicator switch fails to operate properly.														
Actuators (mechanical)		HORAS	N/A	N/A	N/A	NA	NA	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Overhaul or replace		CICLOS	NA	N/A	N/A	NA	NA	NA	NA	NA	NA	NA	N/A	N/A
Nota: Aeronave usa atuadores hidráulicos nos trens de pouso.														
Main gear wheels, bearings and tires		HORAS	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C
		DATA/DIAS	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C
*Note: Wheels with lose or missing tie bolts should be removed from the airplane, the tie bolts removed and the wheel halves dye penetrant inspection (Chapter 32-40-00, page 209)														
Nose gear wheels, bearings and tires		HORAS	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C
		DATA/DIAS	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C
*Note: Wheels with lose or missing tie bolts should be removed from the airplane, the tie bolts removed and the wheel halves dye penetrant inspection (Chapter 32-40-00, page 210)														
Nose gear retract and emergency		HORAS	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C
Extension chains (mechanical)		DATA/DIAS	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C
*Note: Replace the chains when allowable wear limits specified in Retract Chains Inspection and Replacement procedure in Chapter 32-30-00 are exceeded.														
Landing gear motor (mechanical)		CICLOS	8000,0	N/A	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	N/A
		DATA/DIAS	2190	N/A	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	O/C	N/A
*Note: This overhaul must is to coincide with the inspection of gearbox. APLICADO LJ1 THRU LJ 1062														
Landing gear retraction and extension		HORAS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Teflon hydraulic hoses		DATA/DIAS	3650	N/A	N/A	0,0	0,0	20/10/2008	15/04/2008	3507	3507	13/04/2018	N/A	143,0
Landing gear hydraulic system filter and		HORAS	1200,0		1200,0	0,0	0,0	26/11/2014	1080,0	262,0	262,0	2280,0	938,0	938,0
o-ring		CICLOS	1000		1000	0,0	0,0	26/11/2014	1092,0	242	242	2092,0	758,0	758,0
*Note: In addition to these frequencies, whenever a hydraulic component is replaced, this filter must be replaced after the system has been checked for operation.														
*Note: This filter must also, be replaced at the next inspection after the component replacement was made.														

Figure 16 - Page referring to the PP-SZN airplane's landing gear system in the Component Control Information Map.

Stall warning system

The PP-SZN airplane's stall warning system consisted of a vane transducer on the leading edge of the left wing, a warning horn mounted at the front of the right instrument panel, a stall warning light on the top center of the instrument panel, a heater element for the vane transducer, a circuit breaker (CB), and a transistor switch.

The stall warning light had a PRESS TO TEST system.

When the possibility of stall was imminent, aerodynamic forces moved the vane, causing the transistor switch to close the circuit for the warning horn and the stall warning light. This way, the horn sounded and the light illuminated.

The stall horn was activated at a speed of 5 to 12 kt above stall speed with flaps in the APPR position, and 8 to 14 kt above the stall speed with flaps fully extended.

Rudder Boost System

The Rudder Boost system (Figure 17) aided in maintaining directional control in the event of an engine failure or a large power difference between the engines. Two pneumatic servos were incorporated into the rudder control system, and could increase the action of its cables to help compensate for the asymmetric power.

During operation, a differential pressure switch measured the difference in bleed air pressure between the engines. If the bleed air pressure differential exceeded approximately 50 PSI of differential pressure, a signal from the differential pressure switch would cause the solenoid valve to actuate, and one of the servo actuators to be engaged.

The pressurized servo would then pull one of the rudder cables. Tension springs at the connection between the servos and the rudder cable prevented the cable from becoming slack when one or the other servo was actuated. A drop in bleed air pressure from the right engine would actuate the respective servo and cause the left pedal to move forward.

This system was only intended to compensate for asymmetric power. Trimming should be done exclusively using the trim tabs.

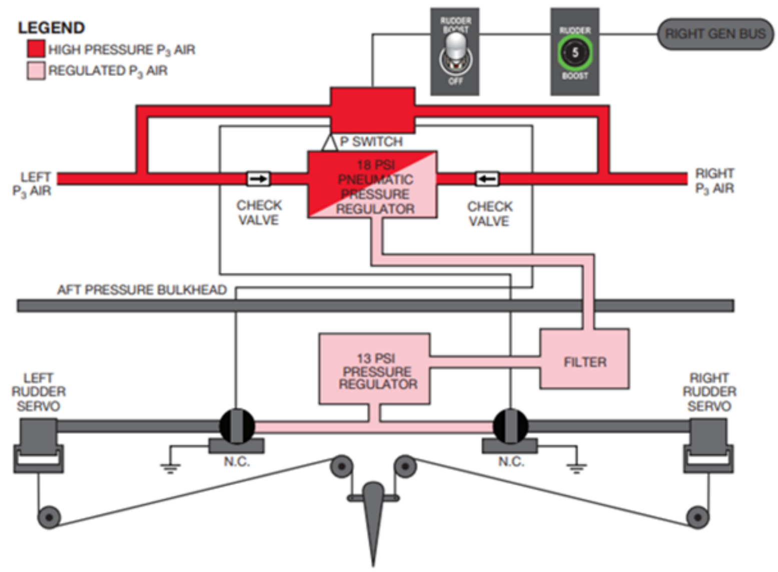


Figure 15-6. Rudder Boost System Diagram

Figure 17 - Diagram of the Rudder Boost System.

A Rudder Boost Switch located on the central console (Figure 18) was used for system control.

Figure 18 - Location of the Rudder Boost Switch.

In accordance with the manufacturer's manual, the switch should be in the RUDDER BOOST position before takeoff.

The system could be tested during taxi by reducing power on one engine to idle and advancing the power on the other engine until the difference in power and pneumatic pressure between them was sufficient to activate the RUDDER BOOST system. The corresponding pedal movement indicated that the system was working properly.

1.7. Meteorological information.

The routine Meteorological Aerodrome Reports (METAR) from SBMT contained the following information:

METAR SBMT 292000Z 29006KT 9000 NSC 28/08 Q1015=

METAR SBMT 292100Z 34003KT 7000 NSC 27/08 Q1015=

METAR SBMT 292200Z 01002KT 8000 NSC 25/09 Q1016=

One verified that the conditions were consistent with visual flights, with visibility of 7,000 meters and no significant clouds. The wind varied between 2 and 3 kt.

1.8. Aids to navigation.

All navigation and landing aids were operating normally while the aircraft was approaching the aerodrome.

1.9. Communications.

According to the transcripts of the communication audio between PP-SZN and the control agencies, it was verified that the PIC maintained radio contact with *São Paulo* Approach Control (APP-SP) and *Campo de Marte* Control Tower (TWR-MT), and that there were no technical abnormalities in the communication equipment during the flight.

The PP-SZN airplane's communications were conducted in a coordinated and clear manner, with nothing significant to report.

After passing “PERUS” position, coordination was established with APP-SP for the aircraft to contact the control tower of SBMT subsequently.

During the period between 20:26:56 UTC and 21:00:33 UTC, the PP-SZN airplane coordinated with TWR-MT throughout its descent up to the point of entering the final approach for the attempted landing, during which the accident occurred.

At 20:38:10 UTC, PP-SZN informed TWR-MT that it would perform a low pass over the runway, due to a visual warning regarding the landing gear position configuration, requesting that the Air Traffic Controller observe the condition of the left main landing gear. Radar images showed the low pass over the runway.

After the low pass (20:40 UTC), the ATCO informed the PIC that he obtained visual confirmation of the landing gear assembly (front and main) being down, but could not confirm if they were locked. Subsequently, the PIC informed that he would enter the traffic pattern and proceed to land.

Then, PP-SZN asked the ATCO if there was an area available to perform the emergency procedures.

The pilot of another airplane (PR-GCB, near position three of the aerodrome) reported over the frequency that, from his vantage point, the left main landing gear appeared not to be in the same position as the right main gear.

The ATCO informed that after the landing of another aircraft that was on approach, PP-SZN would be the only traffic in the pattern. At that point, the PIC decided to remain in the traffic circuit at 3,600 ft. and perform the procedures provided for extending the landing gear by means of the emergency system.

The control tower authorized PP-SZN to remain in the traffic pattern while they handled another aircraft that was about to take off. After the other airplane took off, the ATCO informed the PIC of PP-SZN that he was the only traffic in the circuit. The subject aircraft then informed that it would remain circling on the downwind leg until it could extend the landing gear using the emergency mode.

Subsequently, answering a question about his intentions, the pilot of PP-SZN informed the control tower that he would perform another pass at a slightly lower altitude, as the attempt to extend the landing gear in emergency mode was not proving effective. The ATCO responded, stating that the wind was calm and that the TWR team was already prepared for a second observation of the landing gear assembly.

After the second low pass, the ATCO reported that the main landing gear legs were seemingly symmetrical. The PP-SZN airplane then advised that it would proceed to land, as there were no further procedures to perform. The control tower acknowledged the message and inquired about the POB and the remaining fuel. The PIC stated that there were seven people on board and that he had two hours and fifteen minutes of fuel endurance. He also informed that he would perform a touch-and-go but would not complete the landing cycle.

Then, the control tower asked the pilot if he could maintain altitude so as not interfere with helicopter traffic. The PIC replied that he was still trying to lower the landing gear and managing other matters, but would return to the agreed altitude of 3,600 ft.

After that, the ATCO asked the PIC if he had any flammable material on board the airplane. The PIC answered that he did not and that he was beginning the approach for the touch-and go procedure. The control tower granted him the pertinent clearance and informed that the wind was calm.

After the touch and go, PP-SZN reported that the aircraft behavior was normal while in contact with the runway surface and that he thought the indication light issue was only due to a faulty light bulb. The control tower responded, informing him that the ground crew was ready to support the landing. The controller also mentioned that the tower control staff would be available in case the pilot deemed it necessary to perform another low pass.

The PIC reported that he had run a little on the runway with the landing gear in contact with the tarmac and the aircraft had behaved appropriately. He further stated that he would proceed to land and, if he sensed anything unusual, he would perform a go-around; otherwise, he would commit to the final landing.

Following that, the ATCO instructed PP-SZN to enter the downwind leg and report on the final approach. Then, the crew of a similar aircraft on the frequency asked the controller about a possible recommendation for a light test to the pilot of PP-SZN. In the sequence, the control tower asked PP-SZN if they had copied the message regarding the light test.

Speaking directly with the PIC of PP-SZN, the pilot of the other King Air aircraft provided instructions for replacing the light to check its functionality, and then communicated the settings regarding the flaps and thrust lever settings that should be used to confirm the position of the landing gear by means of the landing gear warning horn.

After implementing the recommended settings, the PIC reported that the warning horn did not sound, and the pilot of the other aircraft indicated that he could proceed to land. After establishing final contact, PP-SZN reported to the controller that he would proceed with the final landing.

TWR-MT requested confirmation from the PP-SZN airplane that the necessary checks had been performed. After receiving confirmation, the controller informed that the wind was 320° at 04 knots. The PIC of PP-SZN thanked him.

That was the last recorded transmission from the aircraft to TWR-MT.

1.10. Aerodrome information.

It was a public/military aerodrome managed by INFRAERO. It operated VFR (Visual Flight Rules) during day- and night-time.

The aerodrome had an asphalt-sealed runway with thresholds 12/30, measuring 1,600 m x 45 m, at an elevation of 2,371 ft.

One verified that there were no reports in the NOTAMs of any infrastructure condition that could restrict operations at SBMT.

1.11. Flight recorders.

The aircraft was equipped with a PN 2100-1010-00, SN 000546991 FA 2100 CVR (Cockpit Voice Recorder), manufactured by L3 Harris Technologies, capable of recording the audio from the last 30 minutes of flight (Figure 19).

Figure 19 - Image of the CVR of the PP-SZN airplane.

The CVR system consisted of a cockpit voice recorder, a control unit, an area microphone, and an impact switch. Electrical power for the recorder was supplied by means of the Triple Fed Bus. The recorder and the impact switch were located in the rear avionics compartment, behind the pressure bulkhead.

Data for the CVR was supplied by four sources:

- Cabin Pager (capturing what the PIC and SIC transmitted through it);
- SIC audio (capturing what the SIC heard and transmitted through the lip-phone, handheld microphone, or oxygen mask microphone);
- PIC audio (what the PIC heard and transmitted through the lip-phone, handheld microphone, or oxygen mask microphone); and
- area microphone.

The area microphone, responsible for capturing open audio in the cockpit, was located in the CVR control unit positioned on the subpanel above the throttle pedestal (Figure 20).

Figure 20 - CVR control unit installed.

The Investigation Committee analyzed the information contained in the voice recorder.

The equipment operated normally and contained data related to the occurrence flight. The information found also allowed for a spectral analysis of engine noise and identification of the alarms emitted by the aircraft.

From the pilot's voice, no signs of tension or stress were observed that could indicate the existence of abnormalities in the aircraft systems during the en-route flight and in the descent procedure toward the destination aerodrome.

The Investigation Committee noticed changes in the pilot's voice, indicating a certain level of anxiety, which started when the landing gear position indicator system signaled an abnormality in its operation.

The PIC did not utter any expression indicating the existence of an abnormal situation with the engines or flight controls that could compromise the handling of the aircraft.

In respect to the CVR, in accordance with the Brazilian Aeronautical Certification Regulation n° 91, in force at the time, the installation of this equipment was required for multiengine jet aircraft that had a maximum passenger configuration of six or more seats, and for which two pilots were required by certification requirements or operational rules.

Thus, since the airplane in question did not require two pilots for operation in accordance with certification requisites or operational rules, the installation of the CVR was not mandatory.

1.12. Wreckage and impact information.

Video footage aired by the media and some videos provided to the Investigation Committee showed that the aircraft lost altitude in an uncontrolled trajectory.

The distribution of the wreckage was linear.

Several witnesses positioned in different spots (Figure 21) observed the final approach, the crossing of threshold 30, and the first impact.

Figure 21 - Sketch from the final approach to the threshold of runway 30 SBMT and the positions of the observers.

The first impact, on the upper side of the fuselage, occurred with the aircraft nearly in a 180-degree left bank position, with the landing gear extended, followed by the impact of the right engine and the onset of flames due to the friction of the fuselage with the ground (Figure 22).

Figure 22 - Cuts in the asphalt made by the propeller blades of the right engine.

The wreckage was only released by the firefighters for the initial action of the investigators on the afternoon of 30 July 2018, after completion of all the salvage work.

The right wing, left wing, empennage, and landing gear remained attached to the structure of the airplane. The damage was observed mainly on the right wing and on the right side of the fuselage, where the flames were more intense.

Figure 23 - Aspect of the wreckage after removal of the airplane from the accident site.

Both engines remained secured in their mounts; however, the left propeller separated due to the rupture in the reduction gearbox upon impact with the ground, with this gearbox being found at a distance of 40 meters from the aircraft (Figure 24).

Figure 24 - Aspect of the engines and position of the landing gear after the impact.

After completing the final approach for landing on runway 30 of SBMT, the aircraft collided with the ground on the asphalt-sealed taxiway "ALPHA", approximately 60 meters off the runway centerline and 95 meters longitudinally from the aiming point of the threshold in use. The impact of most of the fuselage with the ground occurred with the aircraft already inverted.

The collision was witnessed by the control tower operators, by military personnel from the *São Paulo* Aeronautical Material Park (PAMA-SP), aerodrome firefighters, airport administration staff, bystanders, and by one of the closed-circuit electronic surveillance cameras of one of the aerodrome's concessionaires.

The landing gear was in the extended position. The flaps, on both the left and right wings, were deployed to the same extent. The trim surfaces of the elevators were symmetrical and positioned in a nose-down direction.

The power, propeller, and fuel levers were in the forward position; however, this may not reflect their condition at the time of impact due to the possible movement during the aircraft's impact or during the extraction of the occupants, given that the final configuration of the cockpit was considerably small, with little space for internal movement.

Figure 25 - Position of the levers and elevator trim tab.

The elevator trim position indicator was in a position corresponding to UP (nose up), according to Figure 25.

Although the flap-position selector lever was damaged by the impact, one noted that it was set to the APPROACH position, corresponding to evidence observed on the wing surfaces.

The right circuit breaker panel was broken and dislodged from its housing. It showed eleven circuit breakers tripped and three missing, possibly due to the high temperature from the flames and/or the significant energy absorbed by the fuselage upon impact with the ground (Figure 26).

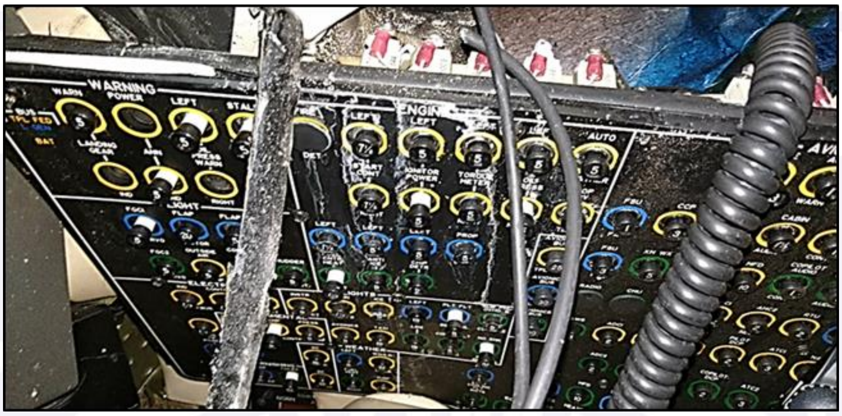


Figure 26 - Circuit breaker panel on the right hand side.

The tripped circuit breakers supplied electrical power to the following systems:

- Oil Press (WARN) - tripped;
- Stall (WARN) - tripped;
- Power (WARN) - missing;
- Power (WARN) - INS - tripped;
- Landing Gear (WARN) - missing;
- Oil Press (WARN) right - missing;
- Engine / Ignitor Power Right - tripped;
- Fuel Center Heat Right - tripped;
- Flight FGC2 Servo - tripped;
- Electrical / Environmental Temp - tripped;
- Furnishing Toilet - tripped;
- Lights / PLTFLT / Side PNL - tripped;
- Lights / No SMK / FSB & Reading – tripped; and
- Engine / Oil Press Right - tripped.

The RUDDER BOOST SYSTEM control switch was in the “OFF” position; however, it may have been subject to movement during the evacuation of the occupants (Figure 27).

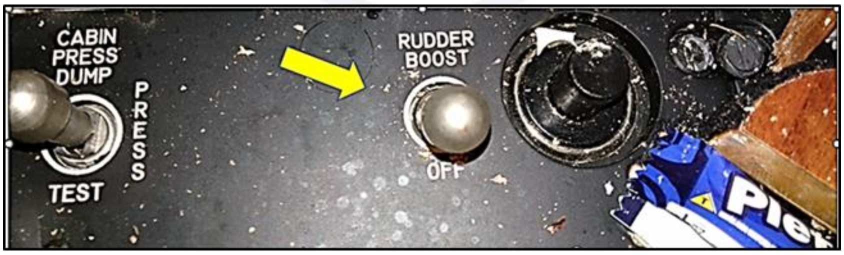


Figure 27 - Position of the Rudder Boost System switch, as found amid the wreckage.

During the analysis of the airplane, the Investigation Committee found the copy of a page of the Pilot Training Manual (Manual Land Gear Extension procedure) in the cockpit.

FlightSafety International

KING AIR C90GTi/C90GTx PILOT TRAINING MANUAL

MANUAL LANDING GEAR EXTENSION

A hand pump handle, placarded "LANDING GEAR ALTERNATE EXTENSION" (Figure 14-15), is located on the floor between the pilot's seat and the pedestal. The pump is located under the floor, below the handle, and is used when emergency extension of the gear is required.

LANDING GEAR ALTERNATE EXTENSION

1. REMOVE HANDLE FROM SECURING CLIP AND PUMP.

2. AFTER ALL THREE GREEN INDICATOR LIGHTS ARE ILLUMINATED AND FURTHER RESISTANCE IS FELT, SECURE HANDLE IN STOWED POSITION.

Figure 14-15. Landing Gear Alternate Extension Placard

To engage the system, pull the LANDING GEAR RELAY circuit breaker (Figure 14-16), located below and to the left of the LDG GEAR CONTROL switch handle on the pilot's sub-panel, and ensure that the LDG GEAR CONTROL handle is in the DN position. Remove the pump handle from the securing clip, and pump the handle up and down until the green NOSE-L-R gear-down indicator lights illuminate and further resistance is felt. Place the handle in the fully down position and secure in the retaining clip.

Figure 14-16. Landing Gear Relay Circuit Breaker

WARNING

If for any reason the green GEAR DOWN lights do not illuminate (e.g., in case of an electrical system failure or in the event an actuator is not locked "down"), continue pumping until sufficient resistance is felt to ensure that the gear is down and locked. Do not stow pump handle. The landing gear cannot be manually retracted in flight.

WARNING

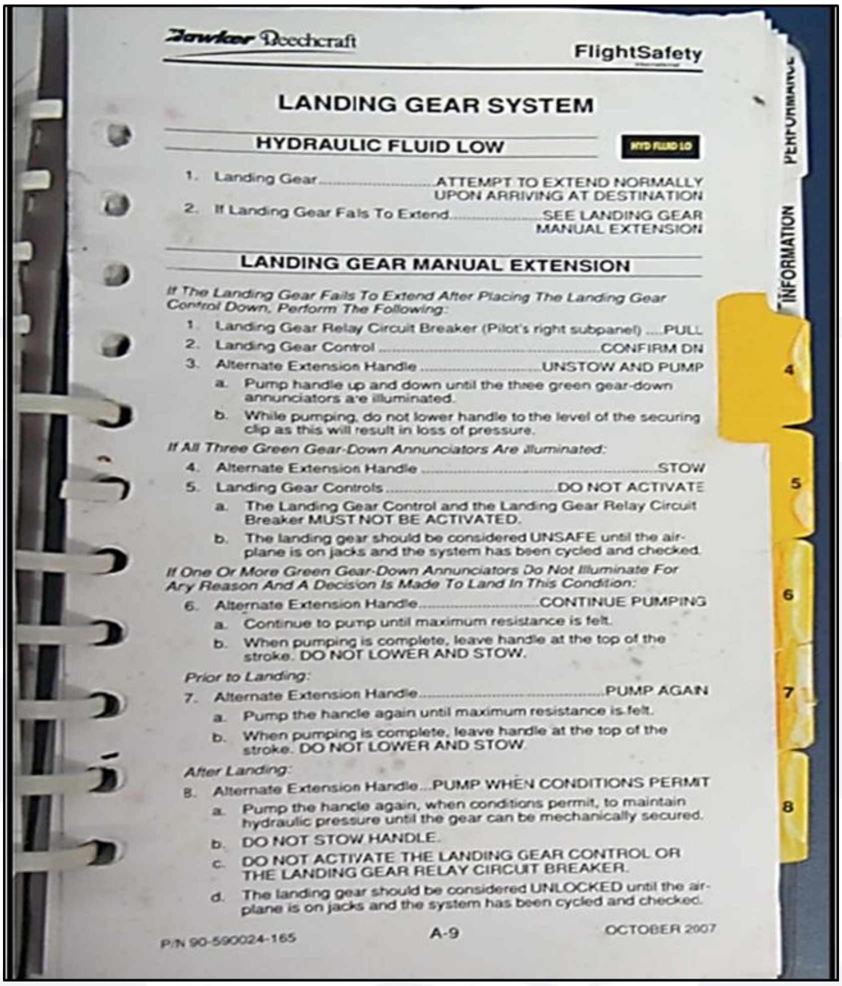
After a manual landing gear extension has been made, do not move any landing gear controls or reset any switches or circuit breakers until the airplane is on jacks.

After a practice manual extension of the landing gear, the gear may be retracted hydraulically by pushing the LANDING GEAR RELAY circuit breaker in and moving the LDG GEAR CONTROL handle to the UP position.

14 LANDING GEAR AND BRAKES

Figure 28 - Copy of a page the manual found by the Investigation Committee on the left side of the cockpit.

The original aircraft manual and checklists were also located; however, it was not possible to determine which checklist/manual the PIC used by during the emergency, since they were together with various items found on the floor of the aircraft.



Hawker Beechcraft FlightSafety

LANDING GEAR SYSTEM

HYDRAULIC FLUID LOW — HYD FLUID LO

1. Landing Gear......................ATTEMPT TO EXTEND NORMALLY UPON ARRIVING AT DESTINATION
2. If Landing Gear Fails To Extend.................SEE LANDING GEAR MANUAL EXTENSION

LANDING GEAR MANUAL EXTENSION

If The Landing Gear Fails To Extend After Placing The Landing Gear Control Down, Perform The Following:

1. Landing Gear Relay Circuit Breaker (Pilot's right subpanel) ....PULL
2. Landing Gear Control ....CONFIRM DN
3. Alternate Extension Handle ....UNSTOW AND PUMP
   a. Pump handle up and down until the three green gear-down annunciators are illuminated.
   b. While pumping, do not lower handle to the level of the securing clip as this will result in loss of pressure.

If All Three Green Gear-Down Annunciators Are Illuminated:

4. Alternate Extension Handle ....STOW
5. Landing Gear Controls ....DO NOT ACTIVATE
   a. The Landing Gear Control and the Landing Gear Relay Circuit Breaker MUST NOT BE ACTIVATED.
   b. The landing gear should be considered UNSAFE until the airplane is on jacks and the system has been cycled and checked.

If One Or More Green Gear-Down Annunciators Do Not Illuminate For Any Reason And A Decision Is Made To Land In This Condition:

6. Alternate Extension Handle..........................CONTINUE PUMPING
   a. Continue to pump until maximum resistance is felt.
   b. When pumping is complete, leave handle at the top of the stroke. DO NOT LOWER AND STOW.

Prior to Landing:

7. Alternate Extension Handle..........................PUMP AGAIN
   a. Pump the handle again until maximum resistance is felt.
   b. When pumping is complete, leave handle at the top of the stroke. DO NOT LOWER AND STOW.

After Landing:

8. Alternate Extension Handle...PUMP WHEN CONDITIONS PERMIT
   a. Pump the handle again, when conditions permit, to maintain hydraulic pressure until the gear can be mechanically secured.
   b. DO NOT STOW HANDLE.
   c. DO NOT ACTIVATE THE LANDING GEAR CONTROL OR THE LANDING GEAR RELAY CIRCUIT BREAKER.
   d. The landing gear should be considered UNLOCKED until the airplane is on jacks and the system has been cycled and checked.

P/N 90-590024-165 A-9 OCTOBER 2007

Figure 29 - Original aircraft manual located on the left side of the cockpit.

1.13. Medical and pathological information.

1.13.1. Medical aspects.

According to interviews, the pilot had no health problems, and there was no evidence of physiological or incapacitating factors that could have affected his performance.

1.13.2. Ergonomic information.

NIL.

1.13.3. Psychological aspects.

The PIC belonged to the third-generation of pilots in the family; both his grandfather and father had also been pilots. He had been a pilot for twenty-eight years and had worked at the company for eighteen years.

According to reports from friends and family, he was a person who did not tolerate his own mistakes. For this reason, he was meticulous in studying the manuals of the aircraft he operated.

During the investigation, based on the pilot's study materials, it was possible to observe that he had a unique profile regarding the organization and study of the aircraft manuals. At an interview, a close acquaintance of the pilot even reported that his actions during flights were always in accordance with the recommendations of the manufacturers' manuals.

According to colleagues and supervisors who were familiar with his work style, he was diligent, meticulous, and strict regarding the maintenance of the aircraft he flew. During operations, he usually followed all the procedures outlined in the checklist.

The PIC was autonomous in his operational decisions, did not experience pressure at work, and was listened to and respected by the company's management. According to family members, his work routine was considered "calm," as he shared flights with another pilot from the company.

He did not use controlled medications, underwent regular health check-ups, and engaged in daily physical activity to manage his weight. He was not in the habit of consuming alcoholic beverages, did not smoke, and slept well.

On the day of the flight, he was well, had slept adequately the previous night, and did not report any complaints to his family. He left home around 2 p.m. local time and arrived at the hangar an hour before the flight, as was his usual routine.

According to reports, the PIC was in a very serene and happy period of his life, financially stable, and without any personal issues that could interfere with his professional performance.

<u>Reports from the passengers</u>

According to accounts from the passengers, the flight had been scheduled in advance for the afternoon of Sunday so that they could arrive in São Paulo still during daytime, as they preferred not arriving at SBMT at night.

They reported that the flight was uneventful, that the PIC was relaxed, and that one of the passengers had asked to sit in the front of the cockpit because it was a scenic flight for him, a beautiful flight.

During the approach to SBMT, the passenger seated in the right seat of the cockpit signaled to the others that there was a problem with the landing gear, as one of its lights was not illuminating.

According to the accounts, the PP-SZN airplane remained in the traffic pattern while the pilot contacted TWR-MT several times and consulted the aircraft manual. The PIC started the procedure for manual landing gear deployment, and as he became rather tired, the passenger in the right seat assisted with the pumping. A third passenger, who was watching the process, stood up and helped with the manual deployment procedure.

After completion of the procedure, the pilot reported that he would perform a low flyby to verify whether the tower could confirm that the gear was down. The controller said that the gear was in the extended position, but that he could not confirm the locking. The passengers reported that they remained concerned, but did not express their concern to the pilot.

After performing a new traffic pattern, the PIC informed that he would conduct a touch-and-go maneuver to "check if the landing gear was locked." According to the passengers, at that moment, the aircraft proceeded for landing at a higher-than-normal speed and added that the "atmosphere grew increasingly tense." They reported that during the touchdown they felt that the landing gear was secure and that the manual deployment had worked. They then felt the plane sway slightly and ascend at high speed.

The pilot subsequently initiated a third traffic circuit and informed the TWR that he would proceed with the landing. At a certain point, he removed his headset and instructed the passengers to read the emergency exit window instructions.

The passengers said that, as the airplane was in the descent, they felt it moving at high speed and swaying from side to side. One of them mentioned hearing the stall alarm, and immediately afterward, they noticed the engines revving up to full throttle. Suddenly, they could not determine their altitude above the ground, felt a lateral acceleration, and experienced the airplane spinning, after which they saw nothing else.

1.14. Fire.

There was no evidence of fire in flight. Images provided to the Investigation Committee captured the moment of final approach and impact, confirming the absence of fire in flight (Figure 30).

Figure 30 - Images of the airplane in flight without evidence of fire before the impact with the ground.

The fire started after the airplane impacted the ground, and followed the trajectory of the aircraft, spreading to the wings, fuselage, and engines.

Figure 31 - Dynamics of the impact and the onset of fire.

1.15. Survival aspects.

Immediately after the aircraft came to a complete stop, the firefighters of SBMT, already alerted by the control tower, began the procedures to extinguish the flames and rescue the passengers and pilot.

The aircraft ended up in an inverted position. The main door was deformed by the impact, making it impossible to open. The emergency exit on the right side was also affected by the twisting of the fuselage.

The passengers reported not recalling whether the evacuation of the aircraft had taken place through the emergency exit or through the windows that broke at the impact. The fuselage did not need to be cut by the rescue team.

The reopening of the aerodrome was only possible eighteen hours after the accident.

The seat belts and harnesses remained intact after the impact. The pilot's harness was cut by the rescue team.

According to reports from passengers at interviews, the seat belts were essential for them to remain in their seats during the impact.

The pilot and the passenger seated on the right in the cockpit were also restrained by their seat belts and were removed from the aircraft by rescuers.

1.16. Tests and research.

<u>Spectral sound analysis of the CVR data</u>

In order to obtain the maximum amount of information from the audio recorded by the CVR, an analysis was conducted at the CENIPA's Labdata (Flight Recorder Data Readout and Analysis Laboratory) aiming to gather information from the spectral reading of the sound.

A spectrum is a graphical representation that shows the decomposition of a signal into its frequency components. In the context of sound, the sound spectrum is a representation of an audio sample, illustrating the distribution of energy or intensity across different frequencies. Typically, this representation is displayed as a graph that relates the acoustic power or pressure (measured in decibels) to frequency (measured in Hz, or kHz).

The analysis was performed by means a graphical comparison between the sound frequencies normally emitted by the aircraft during a standard flight, with those recorded by the PP-SZN airplane's CVR, allowing the identification of the conditions present in the aircraft during the accident flight.

In order to define the sound frequencies and amplitudes to be used as a standard, one used recordings made in flight with a similar aircraft, which had the same configuration as the accident aircraft.

The analysis indicated that there were cycles of extension and retraction of the landing gear assembly. From the beginning of the last CVR recording, the analysis also showed that the first extension of the landing gear took place at 5 minutes and 10 seconds. Then, at 7 minutes and 10 seconds, there was an indication of gear retraction, and at 7 minutes and 20 seconds, a new extension. By relating these sounds to the pilot's recorded phraseology, one can infer that he was on the first approach.

At 11 minutes and 10 seconds, there was another retraction, which took place after the first low pass; a new extension only occurred at 13 minutes and 40 seconds, referring to the landing gear extension by means of the emergency system.

In the sound signatures of the propellers, one was able to observe that the rotational frequencies of both propellers coincided throughout the flight, with a slight variation noted at the end of the recording period. Figure 32 shows only one line for the NP of both engines, indicating that there was no difference between them; if there had been any difference, two lines would have been displayed.

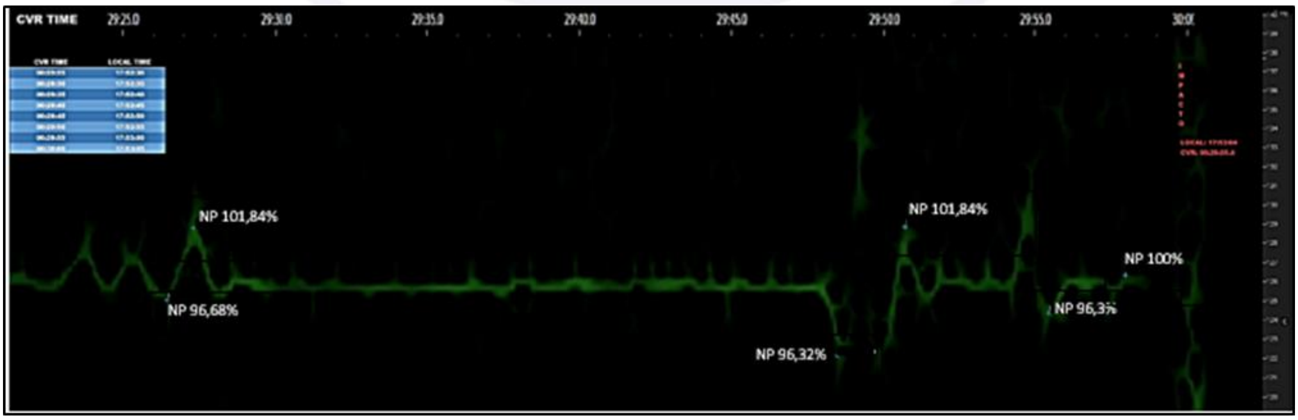


Figure 32 - Variation of the propeller rotational frequencies indicated in the spectrum.

Subsequent analyses allowed the identification of the following indicative sounds during the final minutes:

- altitude alert;
- stall warning;
- pilot's speech; and
- sound of impact.

Technical examination of the engines.

- Right engine.

During the disassembly of the right engine (model PT6A-135A, SN PCE-PZ0738), no evidence of lack of lubrication was observed. The examined bearings showed no damage or characteristics indicative of poor lubrication. There was no metal contamination in the chip detectors or in the return oil filter of the reduction gearbox.

Figure 33 - View of the engine and right propeller, showing the blades with forward bending.

The Fuel Control Unit (FCU) sustained damage resulting from the impact, which made functional bench testing unfeasible. It is important to note that the connections of the pneumatic and fuel lines that could be verified showed appropriate torque and were correctly secured.

The engine presented signs of intense rubbing between the compressor turbine blades and the segmented ring, and all the blades had fractures. The blade fragments left marks when they detached and were centrifuged. The engine diaphragm, in its correct position, also showed intense rubbing. Such marks indicate that the engine was operating normally at the time of the impact.

The power turbine also had rubbing marks, and some of the stator vanes were broken. One also observed that all the blades on the turbine rotor disk detached or broke near the root, and were found inside the exhaust duct.

- Left engine.

The left engine (model PT6A-135A, SN PCE-PZ0743), showed internal less intense marks in comparison to those found on the right engine, but it also exhibited severe damage resulting from the impact and action of the fire.

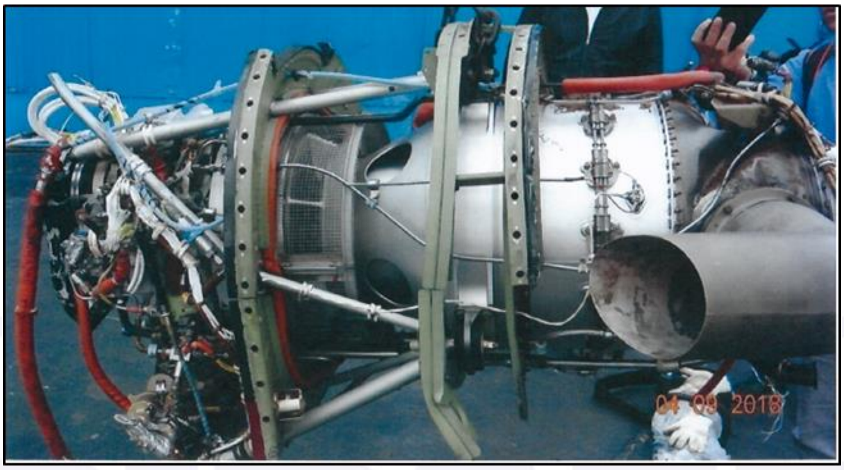


Figure 34 - View of the right side of the left engine.

One analyzed the chip detectors of the reduction gearbox and accessory box, as well as the filters of the engine's fuel and lubrication systems. No metal shavings or contaminants were found that could have affected the operation of the engine.

The fuel filters were clean. Fuel was present inside them and no metal shavings were detected. No evidence of overheating was found in the fuel pump. The gears and their respective bushings looked as if they were new. The FCU was analyzed and had damage resulting from the impact, which made functional bench testing unfeasible. The connections of the pneumatic and fuel lines were also inspected, and were found to be locked and with the correct torque.

The roots of the rotor blades of the compressor turbine showed less intense rubbing marks, when compared to the right engine. The blades were intact, not causing damage to the segmented ring. No rubbing marks and/or damage were found on the thermocouples of the power turbine diaphragm. Some blades broke halfway along their length, and the remaining blades exhibited deformation.

Thus, the results of the tests led one to conclude that both engines were in operation and developing power at the time of impact.

Technical examination of the fuel.

The fuel sample (approximately 2 liters from the left wing of the airplane) was sent for physico-chemical tests, and compared with the standards established in the Technical Regulation 6/2009 of the National Agency for Petroleum, Natural Gas and Biofuels (ANP).

The fuel underwent physic-chemical tests for appearance, corrosivity, flash point, specific gravity, and distillation.

The samples were clear, clean, and free of undissolved water and solid materials, within the limits established by the ANP and international agencies.

CARACTERÍSTICAS	Regulamento Técnico ANP Nº 6/2009	AMOSTRA ASA ESQUERDA	
		1	2
1. Aspecto	(#)	(*)	(**)
2. Corrosividade ao Cobre (2 h/100 °C)	1 (máx.)	1	1
3. Ponto de Fulgor TAG (°C)	40 (mín.)	42 ± 1	42 ± 1
4. Massa Específica a 20 °C (kg/m³)	771,3 a 836,6	794,0 ± 0,1	794,0 ± 0,1
5. Destilação			
Ponto Inicial de Ebulição (P.I.E.) (°C)	anotar	148,1 ± 1,9	148,3 ± 1,1
10 % evaporado (°C)	205 (máx.)	166,2 ± 0,8	163,4 ± 0,9
50 % evaporado (°C)	anotar	187,8 ± 0,9	188,9 ± 1,2
90 % evaporado (°C)	anotar	231,0 ± 1,5	232,0 ± 1,2
Ponto Final de Ebulição (P.F.E.) (°C)	300 (máx.)	261,9 ± 3,2	263,4 ± 0,9
Resíduo (% volume)	1,5 (máx.)	1,3 ± 0,5	1,0 ± 0,5
Perda (% volume)	1,5 (máx.)	0,5 ± 0,5	0,5 ± 0,5

Figure 35 - Result of the fuel sample analysis.

Landing gear assembly.

Specialists of the Investigation Committee conducted analyses of the landing gear assembly on two separate occasions.

The first analysis took place while the aircraft was still at the accident site and in its final resting position. The main landing gear was extended and locked; however, the nose landing gear was out of its normal position, showing a forward displacement due to the deformation that the aircraft's front structure following the impact with the ground.

Figure 36 - Position and condition of the landing gear assembly after the final stop.

After clearance granted by the firefighters and the completion of the initial investigation action by the team of investigators, as well as the authorization for access by other public forces, the aircraft removal process began.

Figure 37 - Aircraft repositioning process.

When the airplane returned to its normal position, it was possible to note that the main landing gear assembly, which was down and locked, supported the weight of the aircraft.

The nose landing gear partially retracted into its housing compartment after receiving the weight of the airplane during the process of repositioning the aircraft in normal configuration with the landing gear down. (Figure 38).

Figure 38 - Moment at which the nose landing gear returned to its housing.

The landing gear system assembly and the gear-position indicator lights underwent testing.

One observed that both indicator lights for the nose landing gear were in good working order.

Figure 39 – Testing the lights of the nose landing gear position indicator.

The left and right main landing gear position indicator lights were not functional during the bench test.

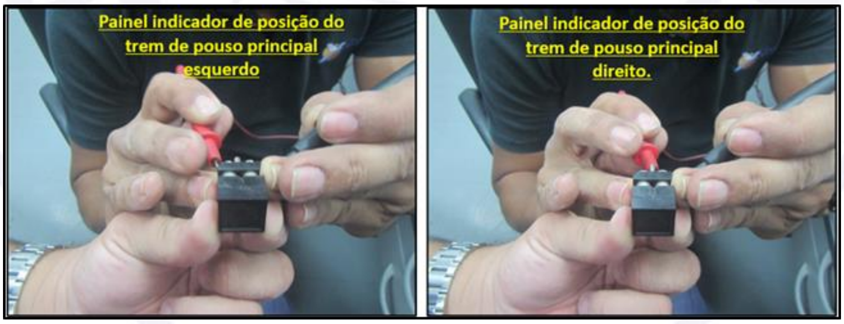


Figure 40 - Bench test of the main landing gear position indicator lamps.

The respective lights were sent for laboratory testing, and showed fracture characteristics typical of breakage when the lights are off (Figure 41).

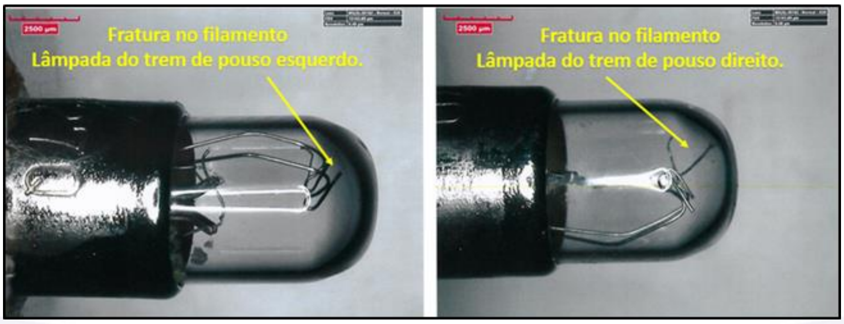


Figure 41 - Laboratory test of the lamps.

The tests and research showed that the nose landing gear position-indicator lights were functional, whereas the main landing gear indicator lights were not functional prior to the accident.

1.17. Organizational and management information.

The operator of PP-SZN airplane was a group active in the packaging market. The company conducted aviation activities directly related to its own benefit.

The process of hiring the pilots followed selection criteria and was coordinated by the most senior pilot on the team, aiming to contract pilots deemed technically reliable by the company.

The PIC's prior experience, before flying the PP-SZN airplane, was as a crew member for the same operator, piloting jet-engine aircraft (Phenom 100 - ANAC check in 2014 - owned by the company and sold on 26 NOV 2015), as well as some other models of single-engine and multi-engine aircraft.

Among the working teams, a pleasant and cooperative interpersonal relationship predominated, which positively influenced the processes of communication, especially with regard to activity planning. Despite this, the specific operation model (of a private character) often required flexible planning.

The operator regularly sent the airplane for services at specialized maintenance organizations selected by the pilots. A pilot from the operator’s staff was usually assigned to oversee the services performed by the maintenance organizations. This oversight was partial and did not constitute a formal procedure established by the operator.

Flights could be performed with the presence of only one pilot or, sometimes, with the inclusion of a Second-in-Command (SIC) pilot but there was no criterion defined for the flights that might require the presence of a second pilot.

Management activities were delegated to the pilots, including matters concerning aircraft maintenance. Services were performed after approval granted by the operator. One observed that there was no previously established work routine.

According to the data obtained, the PIC expressed interest in undergoing flight simulators training to maintain his technical proficiency. In the year prior to the accident, inquiries were made to a flight simulator-training center; however, there was no confirmation that the training was conducted, as it was not required for the aircraft's category of operation.

1.18. Operational information.

It was a flight transporting members of the airplane’s operating company. The flight was being conducted in accordance with the requirements established in the RBHA-91, in effect at the time, and was crewed by a single pilot.

The PIC operated frequently at SBMT, having completed approximately twenty-two legs, either arriving or departing from that location in the twelve months prior to the accident.

The flight plan submitted followed the usual pattern, with a scheduled departure from SSVI at 19:00 UTC. The airplane would fly under VFR at FL135 through visual corridors, and then would descend toward the destination aerodrome. The estimated en-route time was 1 hour and 45 minutes, with a declared fuel endurance of four hours.

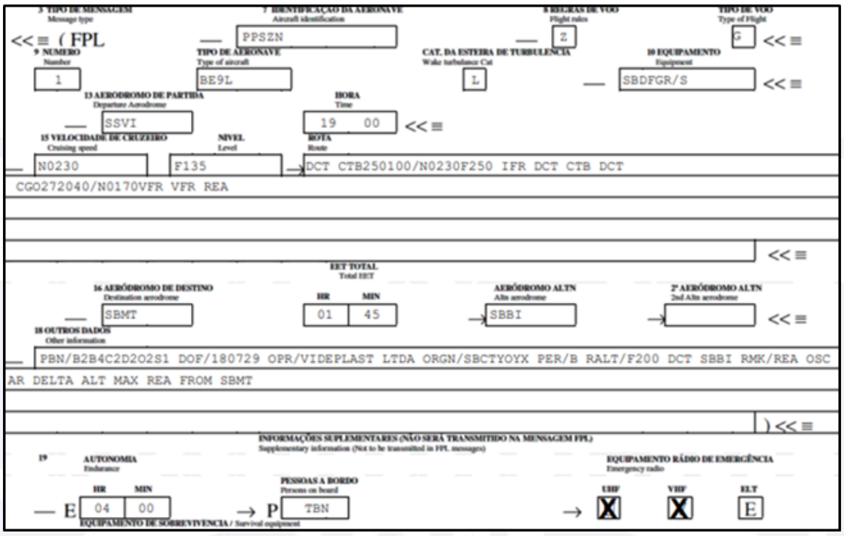


Figure 42 - Aircraft data and planned route as per the Flight Plan filed.

<u>Development of the flight</u>

The PIC performed all the procedures related to aircraft preparation, weather analysis, and the planned route. According to reports, during the start-up procedures, he did not mention any abnormalities with the aircraft.

The flight manual specified the following approach speeds for normal landing, in accordance with the weight of the aircraft:

NORMAL LANDING APPROACH SPEED	
LANDING WEIGHT LBS	**KNOTS**
10.100	102
9600	101
8000	99
7000	99

Based on the approximate weight of the loaded baggage, people on board, and fuel, it was estimated that the PP-SZN airplane's weight was in the range of 8,000 pounds (3,628 kg) to 9,600 pounds (4,082 kg). Thus, the speeds that should have been used on the final approach ranged from 99 to 101 kt.

According to the coordination between the PP-SZN airplane and the ATC agencies, as well as the observation of radar displays of *São Paulo* Terminal Control Area (TMA-SP), one noted that the departure from the origin, the cruise flight, and the descent into SBMT proceeded without abnormalities.

At 20:26 UTC, the image shows the moment when PP-SZN entered the REA (Airplanes' Special Route) controlled by TMA-SP 2, shortly after passing *Vargem Grande* position.

Highlighted in green, the transponder's Alpha mode with code 3314 activated, and just below, the altitude from the Charlie mode, indicating 4,600 ft. Next, the radar-calculated ground speed of around 200 kt., and the heading of 071° (Figure 43).

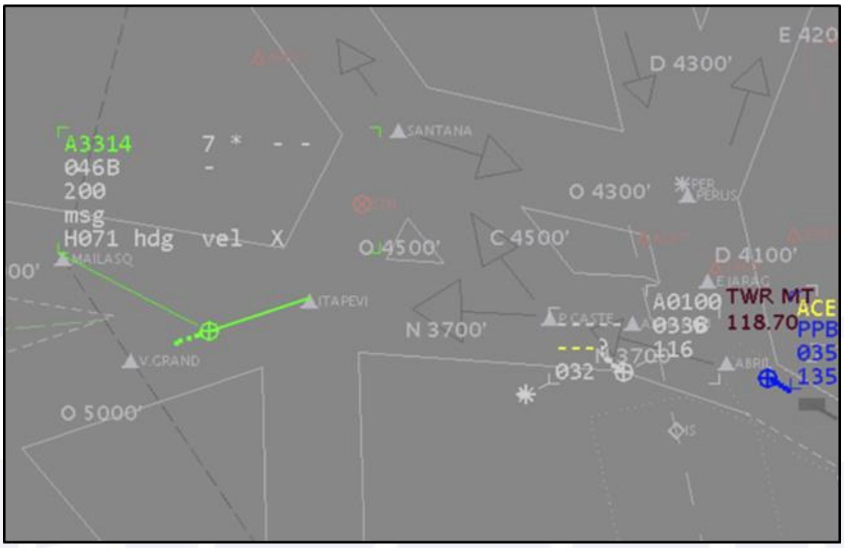


Figure 43 - Data from PP-SZN in the TMA-SP 2 at 20:26 UTC.

At 20:29 UTC, the aircraft appeared on the radar screen with its track already correlated with the assigned transponder code, remaining in the REA near *Santana* position, in the municipality of *Santana de Parnaíba*, State of *São Paulo*. The data block indicated an altitude of 4,600 ft., with a radar-calculated ground speed of around 180 kt., and a course of 024° (Figure 44).

Figure 44 - PP-SZN data in the TMA-SP 2 at 20:29 UTC,
with the airplane’s radar track correlated.

At 20:34 UTC, the airplane entered the Traffic Zone of SBMT (ATZ-MT) after passing vertically over *ABRIL* position, indicating an altitude of 3,600 ft., a ground speed of around 169 kt., and a course of 157° (Figure 45).

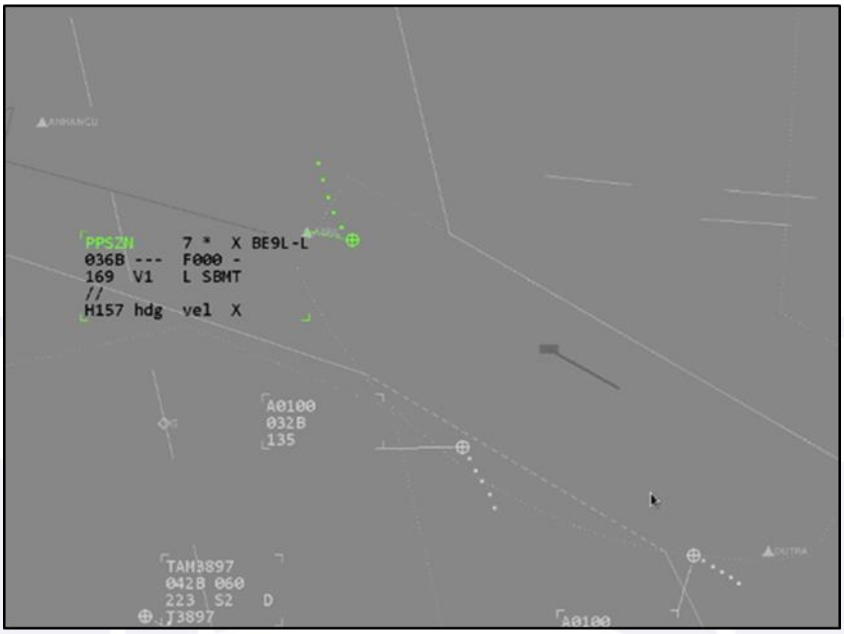


Figure 45 - PP-SZN data in the ATZ-MT at 20:34 UTC.

At 20:36 UTC, the radar image showed PP-SZN on the downwind leg for runway 30 of SBMT for the first approach, indicating an altitude of 3,700 ft., a ground speed of around 130 kt., and a course of 122° (Figure 46).

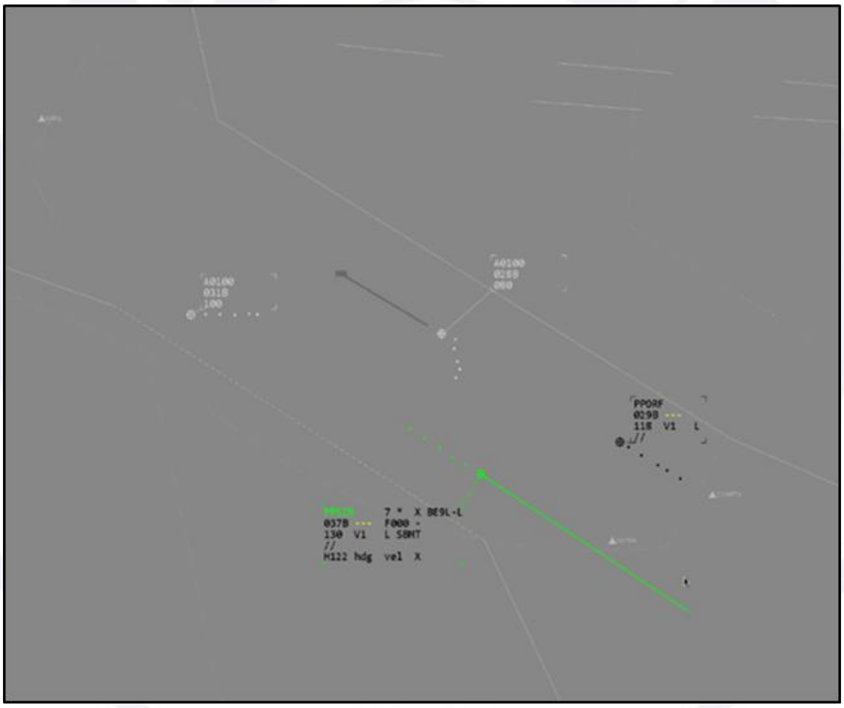


Figure 46 - PP-SZN data on the downwind leg of SBMT at 20:36 UTC.

At 20:38 UTC, the radar image showed the airplane on the short final for runway 30 of SBMT, at a speed of 94 kt., an altitude of 2,600 ft., and a course of 301° (Figure 47).

Figure 47 - PP-SZN data on the short final of
SBMT at 20:38 UTC.

At 20:40 UTC, the radar showed the airplane executing its first go-around procedure from the runway 30 of SBMT (Figure 48).

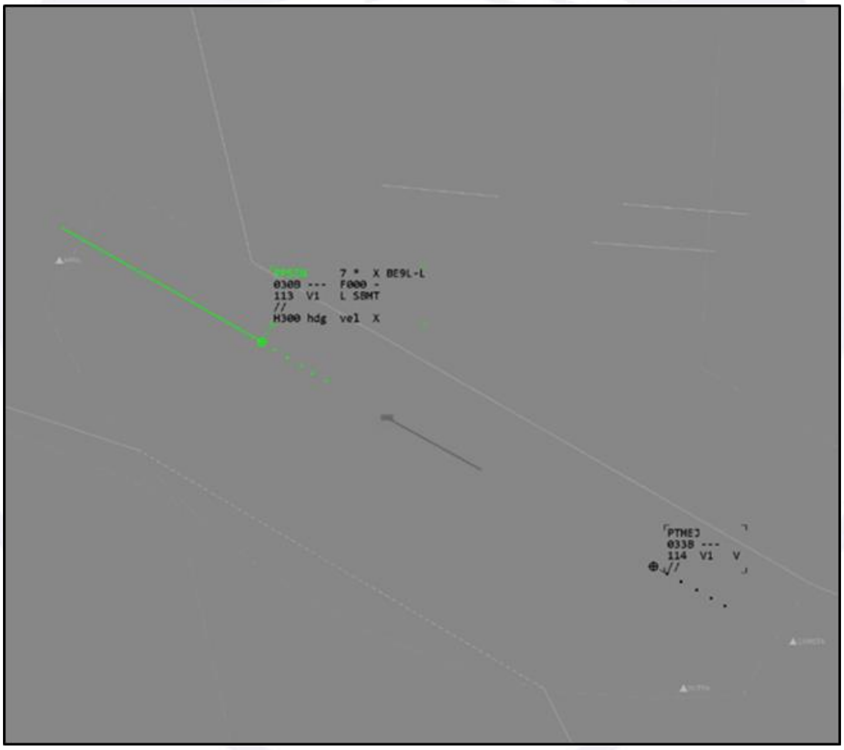


Figure 48 - Radar image of the PP-SZN airplane
on its first go-around at SBMT.

At 20:43 UTC, the radar captured the image of the PP-SZN airplane entering the downwind leg for runway 30 of SBMT for the second time (Figure 49).

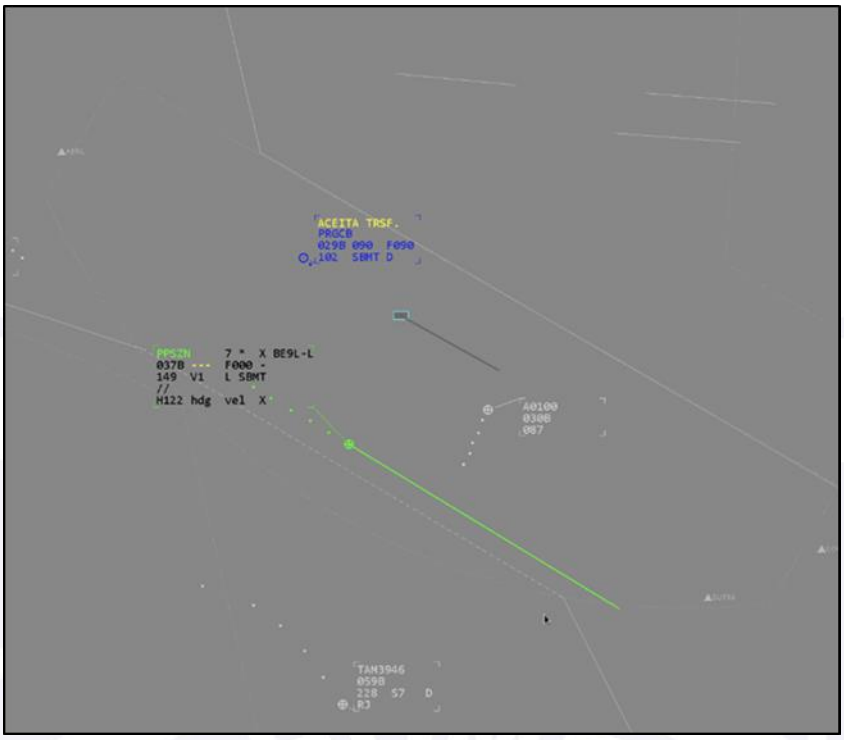


Figure 49 - Radar image of the PP-SZN airplane joining the downwind leg at 20:43 UTC.

At 20:45 UTC, the radar image showed the PP-SZN entering the final approach for runway 30 of SBMT for the second time, at a speed of 99 kt. (Figure 50).

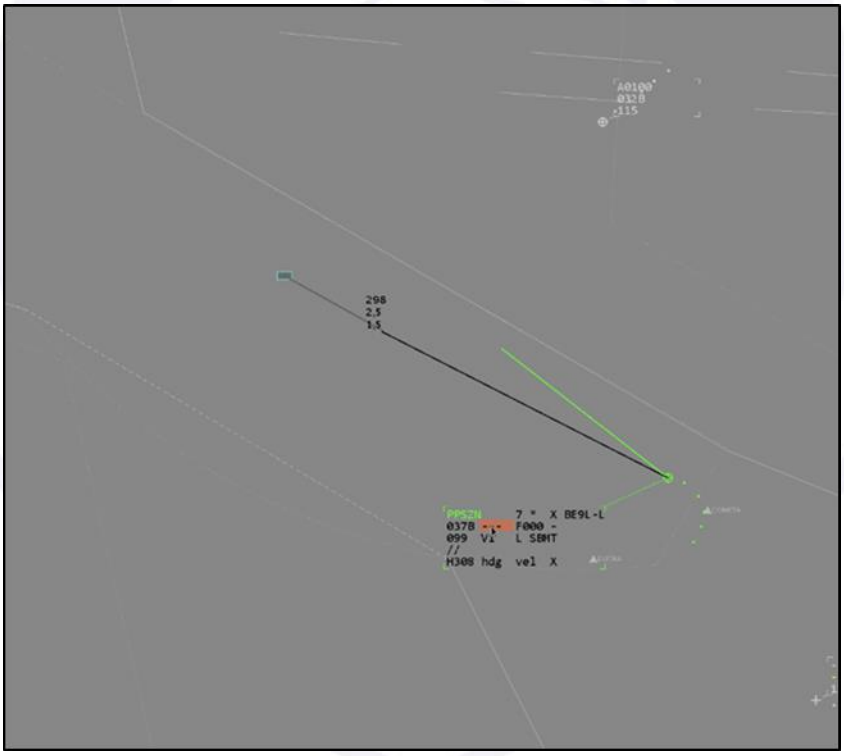


Figure 50 - Radar image of the PP-SZN airplane recorded at 20:45 UTC, showing the aircraft entering the final approach for the second time.

At 20:48 UTC, the radar showed the PP-SZN airplane on the downwind leg for runway 30 of SBMT for the third time (Figure 51).

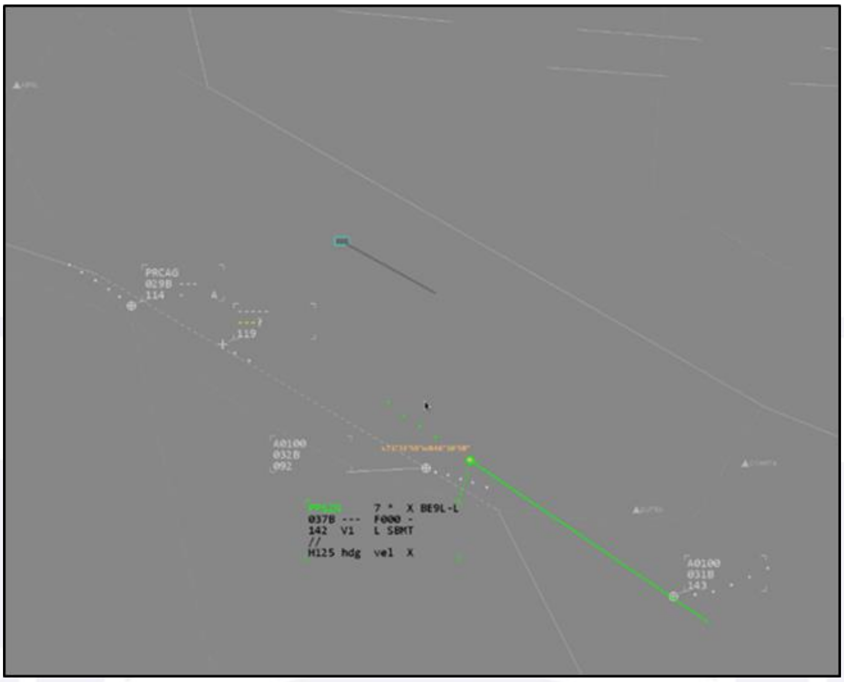


Figure 51 – Radar image of the PP-SZN airplane
on the downwind leg for the third time.

At 20:50 UTC, the radar image showed the PP-SZN airplane on the short final for runway 30 of SBMT at a speed of 142 kt. due to the touch-and-go maneuver that the PIC informed ATC that he would execute (Figure 52).

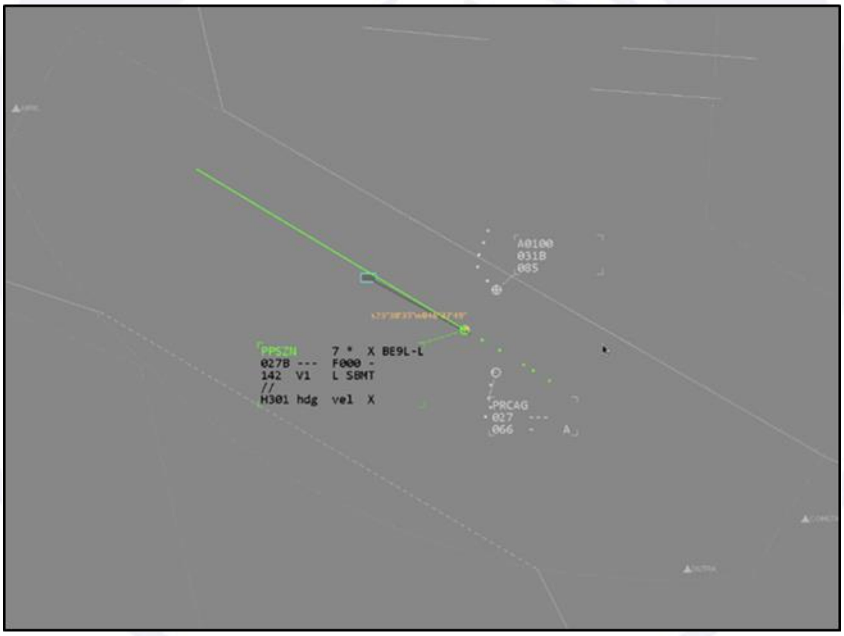


Figure 52 – radar image of PP-SZN on the final leg of
SBMT at a speed of 142 kt.

At 21:00:13 UTC, the aircraft performed a new traffic pattern as in the previous situations, and the radar image showed the PP-SZN airplane on the short final for runway 30 of SBMT at a speed of 84 kt. (Figure 53).

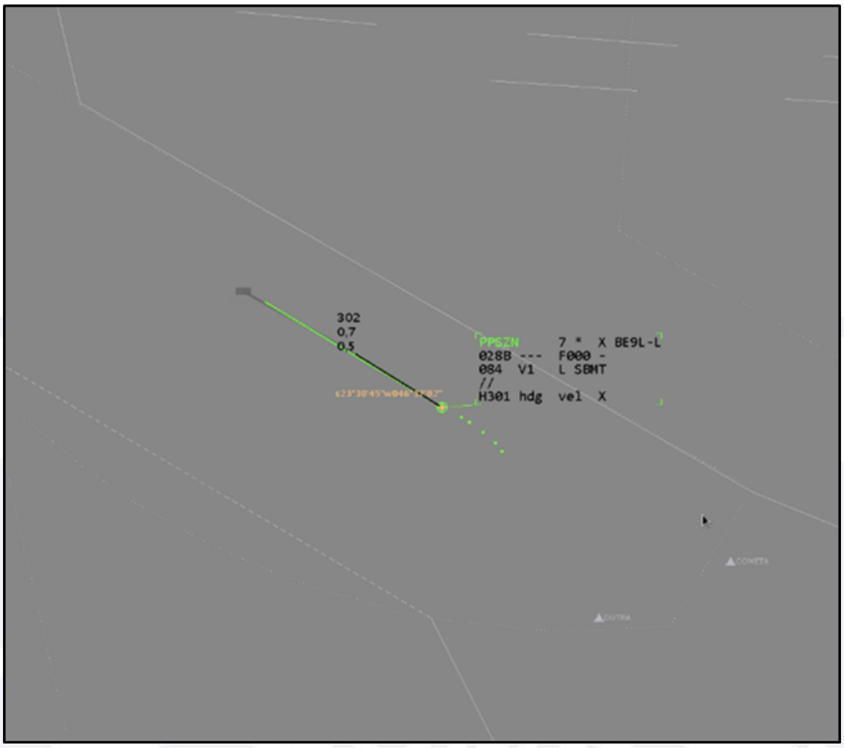


Figure 53 – Radar image showing the PP-SZN airplane on the final approach to SBMT at a speed of 84 kt.

At 21:00:21 UTC, the radar image shows a deviation to the left of the approach axis at a distance of approximately 0.5 NM to the threshold 30 of SBMT (Figure 54)

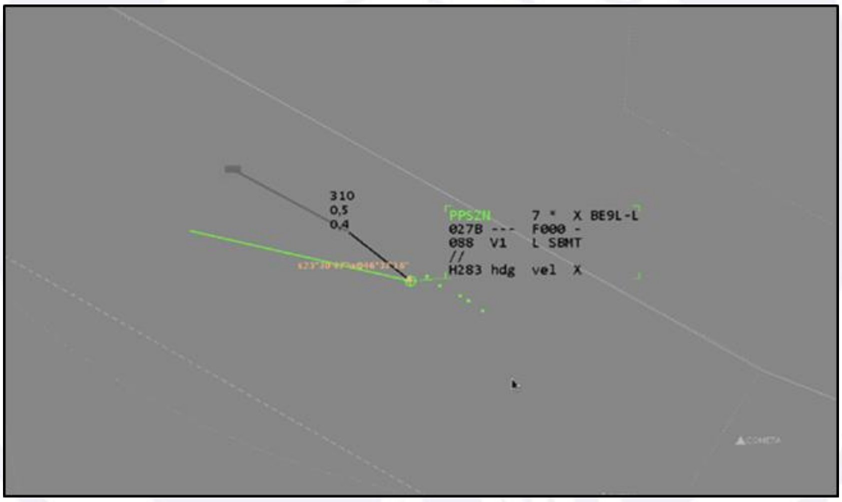


Figure 54 – Radar image showing a deviation to the left of the runway axis.

At 21:00:33 UTC, the radar shows the last image of the correlated radar track of the PP-SZN airplane, with the aircraft at a distance of 0.4 NM to the threshold of runway 30 of SBMT, slightly to the left of the approach axis at a speed of 88 kt. (Figure 55).

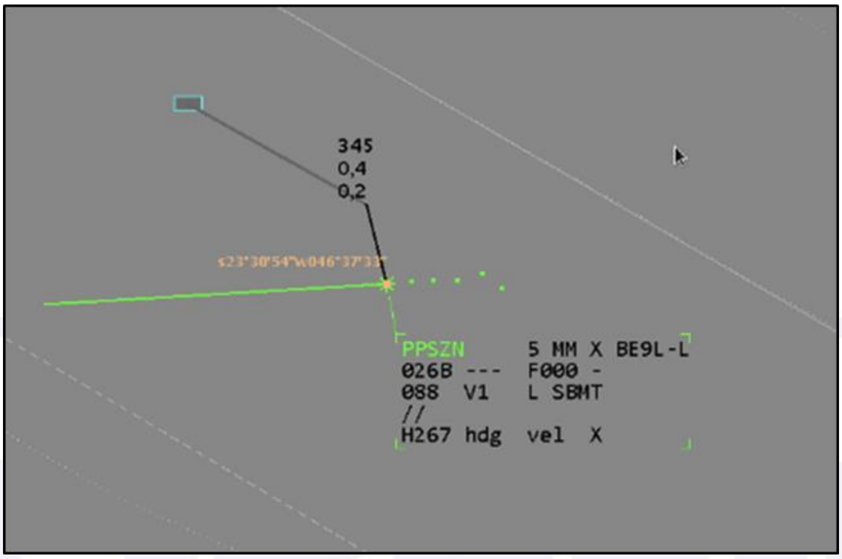


Figure 55 - Image of the last presentation with the airplane's radar track.

Based on data retrieved from the CVR, it was observed that during some approaches, the rate of descent increase significantly, triggering a Sink Rate alert. This alert was possibly suppressed by the pilot through the EGPWS (Enhanced Ground Proximity Warning System) equipment, or addressed by operational adjustments to the aircraft.

Up until the first final approach, when the landing gear was lowered, neither the pilot nor any other occupant of the aircraft noticed anything unusual. The PIC informed the ATCO that the landing gear was down and locked. However, during the pre-landing check, he observed that the confirmation light indicating the left landing gear down-and-locked status was not illuminated.

The PIC promptly called the control tower, requesting clearance for a low pass over the runway to have the landing gear inspected.

After completing the low pass and receiving confirmation from the control tower that the landing gear was down, the PIC decided to re-enter the traffic pattern and proceed with landing. At this point, the pilot on the ground, operating aircraft PR-GCB near position 3, reported via radio that the left main landing gear appeared to be in a different position than the right main gear.

Following this, the PIC requested clearance to proceed to an area where he could attempt to extend the landing gear extension using the emergency system provided by the manufacturer. The control tower responded, informing him that his airplane was the only one in the traffic pattern.

While in the traffic pattern, the PIC received assistance via radio from a King Air pilot on the same frequency. The pilot suggested the possibility of replacing the unlit bulb to verify the integrity of the panel’s indication. The recordings revealed that the PIC initiated the process of replacing the bulbs and instructed the passenger in the right seat to assist. However, it remains unclear whether the bulbs were actually replaced.

Before confirming the completion of the bulb checks, the pilot of the other aircraft suggested that PIC verify whether the warning horn would sound with the flaps in the full position. The PIC responded that the flaps were already fully extended and the horn was not sounding.

It was then suggested that the PIC retract the flaps and reduce the throttles. Upon performing these actions, he reported that the horn still did not sound. Both pilots concluded that the issue was limited to the landing gear indication light. The PIC then informed that he would proceed with the landing.

Standard profile to be performed - Flight Safety International Manual

Page 26 of the manual provided to the Investigation Committee outlined the approach profile to be followed by the aircraft under normal operating conditions and in visual approach conditions.

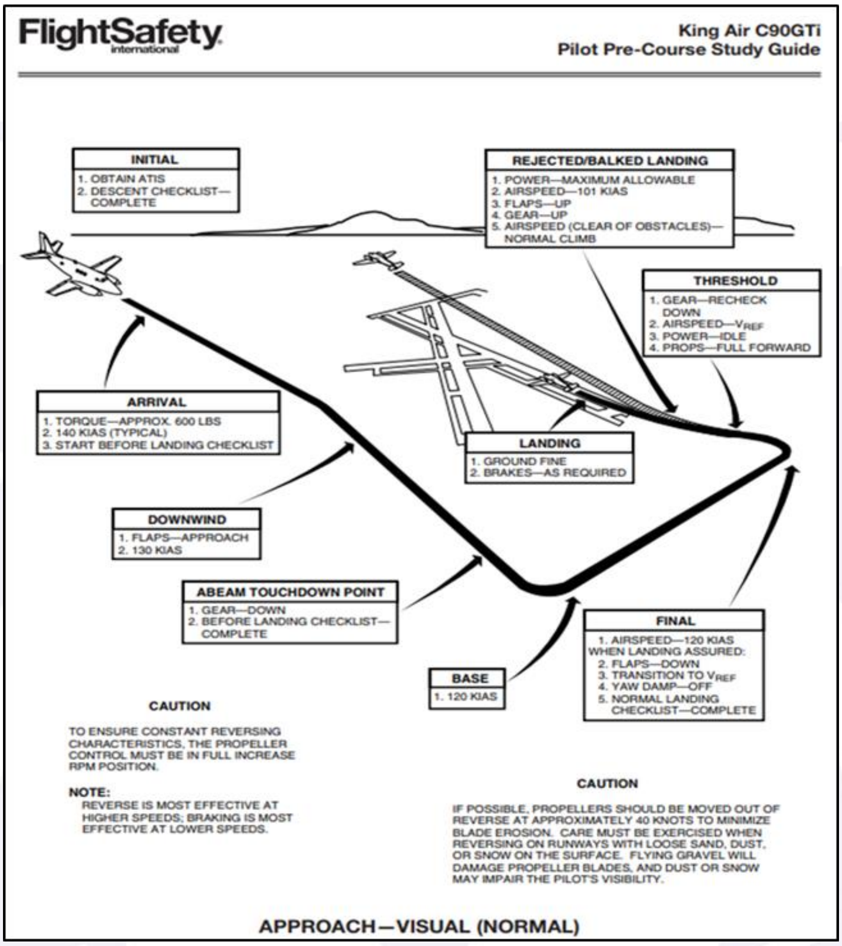


Figure 56 - Approach profile and configurations in a visual flight circuit.

The pre-landing checklist was read only during the first approach. On subsequent approaches, it was observed that the PIC was primarily focused on communications with the controller, air traffic, and the on condition of the landing gear.

1.19. Additional information.

Considerations regarding the recording of experience in the Individual Pilot Logbook (CIV) for civil aviation pilots.

According to Civil Aviation Instruction nº 3203 (IAC-3203), dated 19 May 2002, the CIV served as the legal document for verifying pilots' flight hours when operating aircraft under the requirements of the Brazilian Civil Aviation Regulation nº 91 (RBAC-91). Flight hours were to be recorded in the CIV in accordance with the different types of licenses.

On 01 December 2011, the ANAC published IS 61-001, Revision "A", which outlined procedures for the online flight experience declaration, referred to as Electronic CIV, whose objective was:

> to provide all pilots with procedures for demonstrating the flight experience required for the issuance and/or revalidation of licenses or ratings, or for ensuring compliance with the requirements of sections 61.65, 61.67, 61.95, 61.97, 61.115, 61.117, 61.173, 61.185 and 61.187 of the RBHA-61, or any RBAC superseding it, through the online declaration of flight experience.

The electronic flight hour declaration represented a significant advancement in recording and verifying pilots' experience for obtaining licenses and ratings, as all records were stored in a centralized database, enabling rapid and accurate information processing.

However, the primary method of record keeping remained the physical logbook, and in practice, the use of the electronic CIV was limited to training and evaluation flights. In the case of the pilot of the PP-SZN airplane, the digital CIV did not include entries for all the flight hours completed. As the physical logbooks were not located, this made it verifying and proving the pilot's experience challenging.

Directional Control in Light Twin-Engine Aircraft.

It is worth highlighting certain aspects of operating light twin-engine aircraft, particularly those related to directional control. At this juncture, a few key considerations should be noted.

The equilibrium of a rigid body is achieved when the sum of forces and moments acting around its center of gravity (CG) equals zero. In other words, the forces and moments cancel each other out, resulting in balance. Consequently, the forces of the lift, thrust, drag, and weight must be balanced around the aircraft's lateral, longitudinal, and vertical axes.

The knowledge of aerodynamics and flight control gained and applied in single-engine aircraft must be adapted and applied as pilots transition to flying twin-engine aircraft.

For propeller-driven aircraft, whether single or twin-engine, it is important to highlight some effects resulting from the engine-propeller interaction, as outlined in the Airplane Flying Handbook (FAA-H-8083-3C):

- Torque Effect;
- P-Factor;
- Gyroscopic Effect; and
- Spiraling Slipstream.

The Torque Effect is the direct application of Newton's third law, which states that for every action, there is an equal and opposite reaction. The torque produced by the engine and transmitted to the propeller (action), causes the propeller to rotate the surrounding air in a specific direction and intensity. In response, the air exerts an equal but an opposite reaction on the propeller, creating a torque moment on the aircraft. This results in a rolling tendency around the torque axis, in the direction opposite to the propeller's rotation.

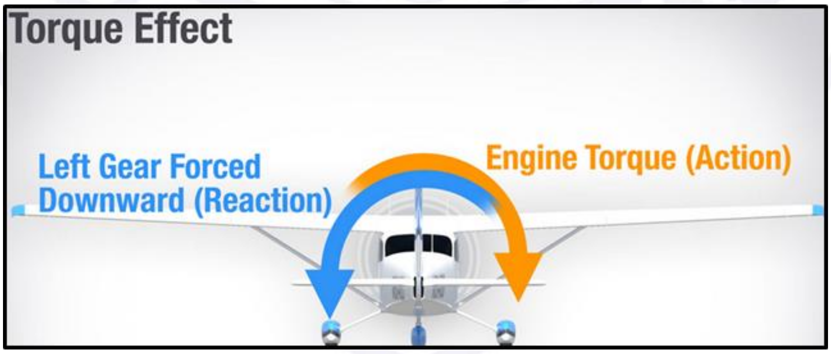


Figure 57 - Torque effect acting on a single-engine propeller-driven aircraft.
Source: image from the website www.boldmethod.com.

When the aircraft's angle of attack – and consequently the propeller's angle of attack – increases, the blades on the descending side of the rotation disk experience a higher angle of attack compared to those on the ascending side, thereby generating more thrust. This causes the resultant thrust vector to shift toward the side of the propeller disk with the descending blades.

This effect creates a yawing moment on the aircraft, causing it to rotate around the vertical axis. To counteract this, the pilot must apply a correction to the flight controls, accounting for a phenomenon known as the “P-Factor”.

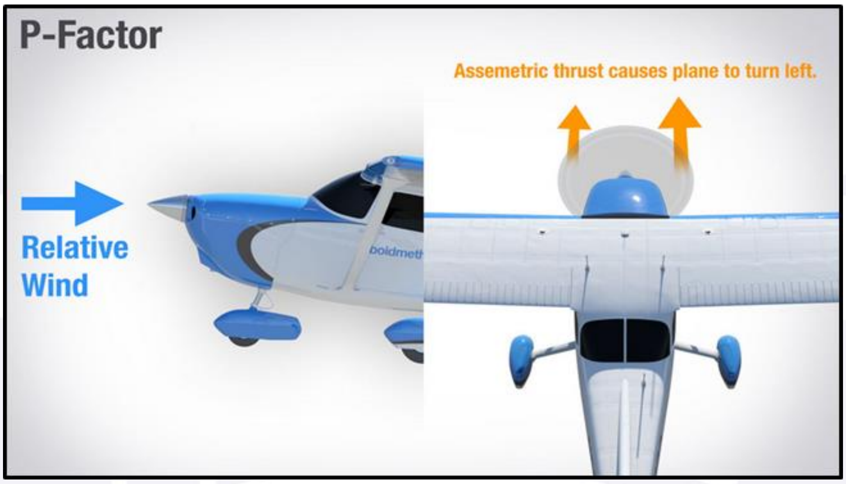


Figure 58 - “P-Factor” creating thrust asymmetry in a single-engine propeller-driven aircraft. Source: image from the website www.boldmethod.com.

The Gyroscopic Effect is a physical phenomenon observed in propeller-driven aircraft engines due to the rotational motion of the propeller. When a propeller is spinning, it behaves like a gyroscope, resisting changes to the direction of its axis of rotation. This effect, stemming from the conservation of angular momentum, can have a significant impact on the aircraft’s maneuverability.

When a force is applied to the propeller's axis of rotation, gyroscopic precession causes the reaction to occur ninety degrees ahead in the direction of rotation. This can influence the aircraft's attitude, particularly during abrupt maneuvers. As a result, a vector is generated with components that can create a rolling moment around the aircraft's longitudinal axis, opposite to the direction of the propeller's rotation, and/or a yawing moment around the vertical axis.

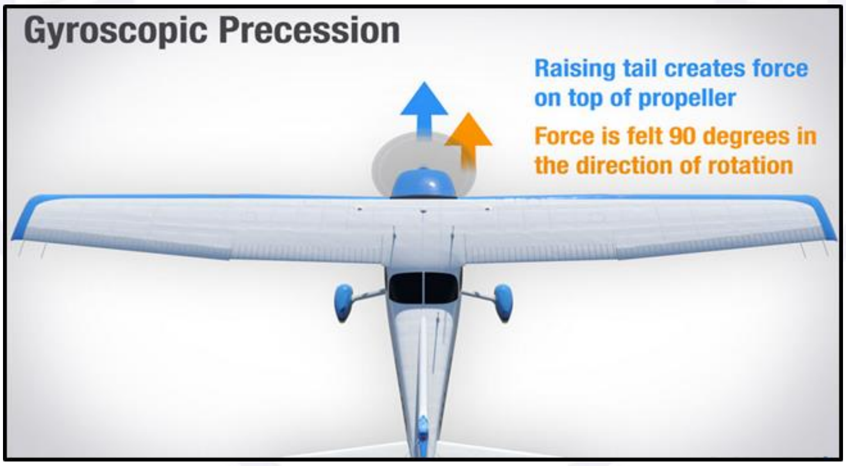


Figure 59 - Figure indicating the force component that appears during the Gyroscopic Effect. Source: image from the website www.boldmethod.com.

The Spiral Slipstream effect typically generates fewer reactions compared to the other effects mentioned but is more pronounced in single and twin-engine aircraft. According to Jeppesen (2007), when the propeller spins at high speed in a clockwise direction with low forward speed, such as during takeoff, it creates an accelerated rotational airflow. When this accelerated airflow wraps around the fuselage in a spiral pattern and reaches the aircraft’s vertical stabilizer, it induces a yawing tendency around the airplane’s vertical axis.

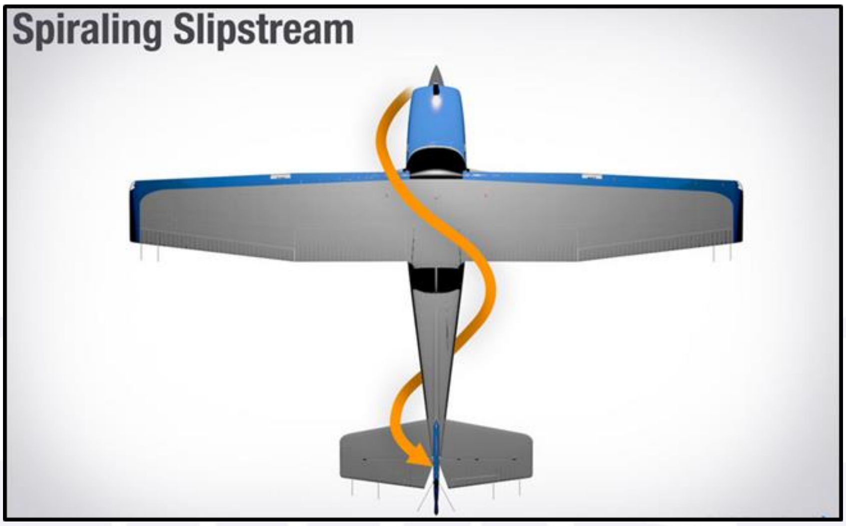


Figure 60 - Figure showing the Spiraling Slipstream and the tendency to yaw after impact of the flow on the vertical tail of the aircraft. Source: image from the website www.boldmethod.com.

Basically, during straight and level flight at a constant speed with the aircraft stabilized, the forces and moments acting on the aircraft are balanced. In twin-engine aircraft, however, there are two parallel thrust-force vectors, one on each wing, rather than a single vector aligned with the longitudinal axis as in single-engine aircraft. (Figure 61).

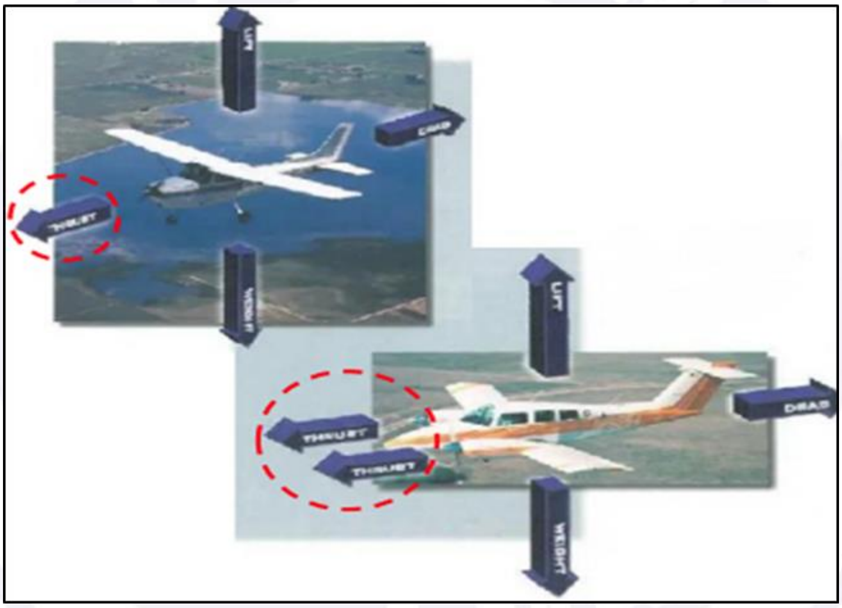


Figure 61 - Similarity of the forces acting on single-engine and twin-engine aircraft. Source: Multi-Engine Manual, Jeppesen, 1996.

The same effects caused by the engine-propeller interaction, as described for single-engine aircraft, also occur in twin-engine aircraft. These effects influence the flight dynamics and require continuous adjustments by the pilot to maintain the aircraft's stability and control.

With advancements in design concepts, manufacturers have adopted various standards for equipping the engines of twin-engine propeller-driven aircraft. The most commonly adopted approach involves mounting the engines on the aircraft's wings, with propellers that can rotate either in the same direction or in opposite directions (known as counter-rotating).

The purpose of designing counter-rotating engines is to eliminate the condition of a "critical engine" in the event of an engine failure. However, this does not apply to this report, as it was determined that both engines were operational.

In aircraft with clockwise-rotating propellers, the most commonly used configuration in twin-engine designs and also present in the case of the PP-SZN airplane, the Torque Effect generates a reaction that tends to roll the aircraft to the left around the longitudinal axis.

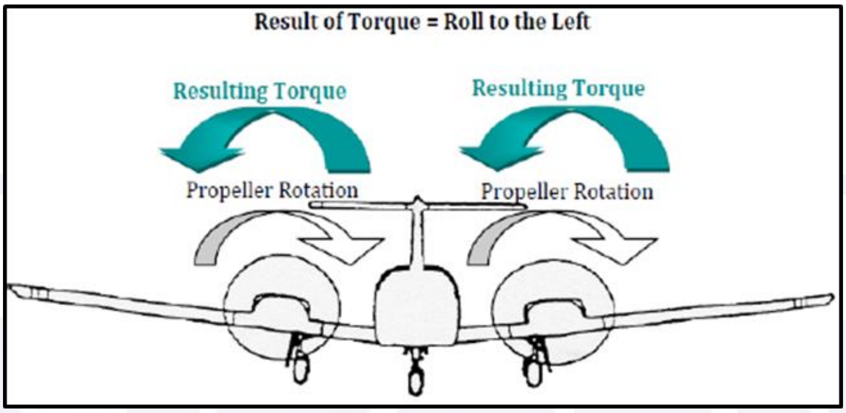


Figure 62 - Resultant of Torque Effect for twin-engine aircraft with propellers rotating in a clockwise direction.
Source: Embry-Riddle Aeronautical University, 2009.

As the aircraft's angle of attack increases, the "P-Factor" becomes apparent, creating a yawing tendency to the left around the vertical axis.

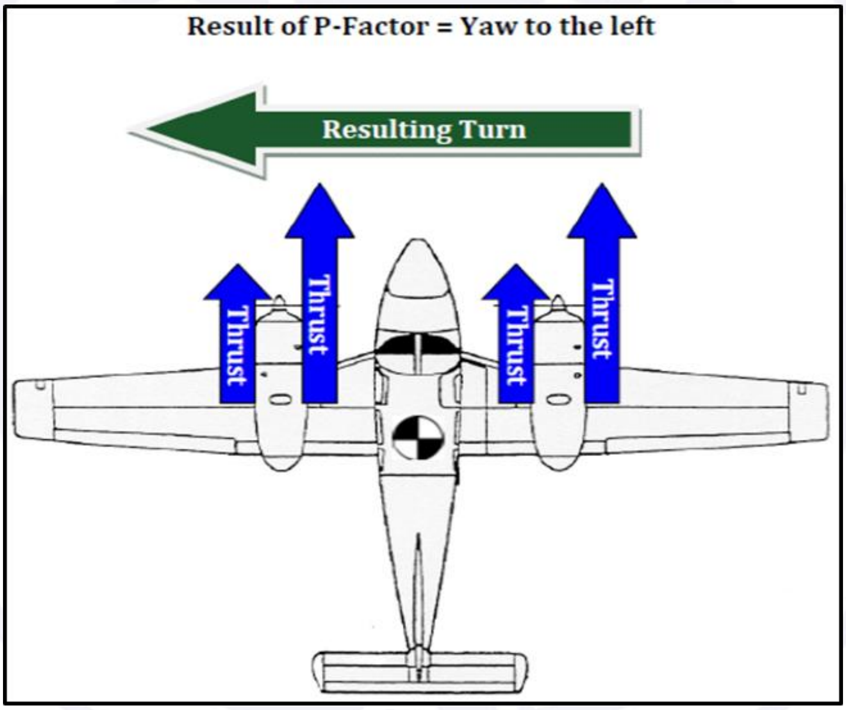


Figure 63 - Resultant of the "P-Factor" for a twin-engine aircraft with propellers rotating in a clockwise direction.
Source: Embry-Riddle Aeronautical University, 2009.

Similar to what happens in single-engine aircraft, gyroscopic precession in a twin-engine with clockwise-rotating propellers can occur during abrupt flight control movements capable of generating an inertial effort, with yawing and left-rolling components.

As is the case in single-engine aircraft, the consequence of spiraling slipstream in twin-engine aircraft with clockwise-rotating propellers will be a tendency to yaw to the left.

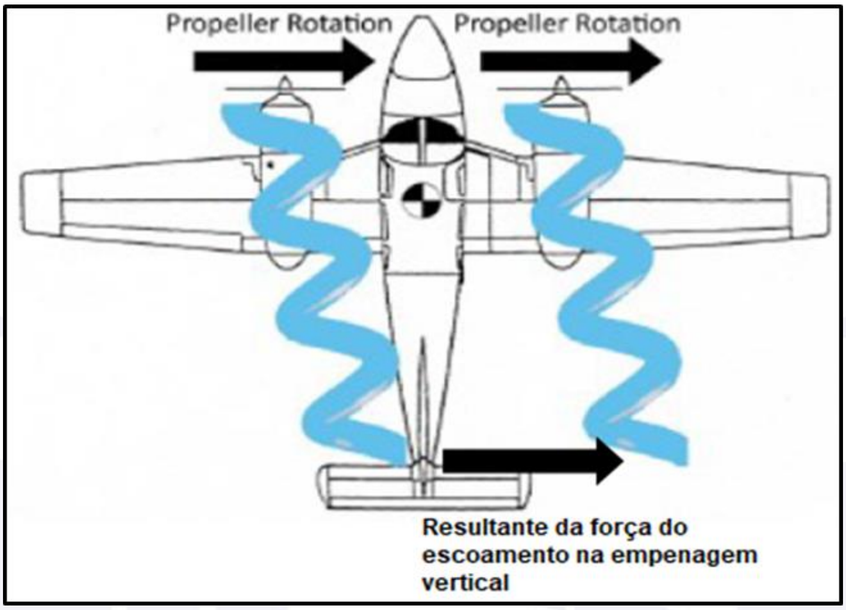


Figure 64 - Resultant of the Spiraling Slipstream for a twin-engine with propellers rotating clockwise. Source: adapted from Embry-Riddle Aeronautical University, 2009.

The direction of propeller rotation in a twin-engine aircraft plays an important role in the forces that will affect the aircraft's directional stability. Early in training, both in the classroom and during flight training in a single-engine aircraft, the student pilot becomes aware of the effects of torque, and learns how to counteract them by means of the rudder pedals. These tendencies become more pronounced in conventional twin-engine aircraft, in which both engines rotate in the same direction.

Information on *stall* and *spin* in the King Air series aircraft.

The aircraft manufacturer issued a publication containing a compilation of topics related to the operational safety in the family of King Air aircraft (King Air Series Safety Information).

Among other pieces of information, the referred publication stated that entering a spin condition could not occur unless a stall occurred first.

SPINS

A major cause of fatal accidents in general aviation airplanes is a spin. Stall demonstrations and practice are a means for a pilot to acquire the skills to recognize when a stall is about to occur and to recover as soon as the first signs of a stall are evident. IF A STALL DOES NOT OCCUR - A SPIN CANNOT OCCUR. It is important to remember, however, that a stall can occur in any flight attitude, at any airspeed, if controls are misused.

Figure 65 - Excerpt from the Beechcraft King Air Series.
Source: Safety Information Manual.

Additionally, the manual provided general information on the conditions for entering a spin in twin-engine aircraft, addressing the fundamentals for preventing and recovering from this condition, emphasizing that pilots should prevent entering this condition at all costs, as the aircraft would become uncontrollable.

When entering a stall, if there is a force resulting of yaw and/or roll around the vertical and longitudinal axes, respectively, the aircraft enters a spin condition if flight controls are not immediately applied to correct the attitude and recover from the stall. In other words, if the recovery procedures are delayed, the aircraft may quickly enter a rolling and yawing motion, potentially even inverting.

Tunnel vision.

The term "tunnel vision", when used in aviation, represents situations where the pilot's attention is focused on a single detail of the operation, while other aspects related to operational safety are neglected – in other words, prioritizing one procedure at the expense of the other ones.

1.20. Useful or effective investigation techniques.

NIL.

2. ANALYSIS.

The C90GTI King Air airplane (registration marks PP-SZN) was registered in the Private Public Transport (TPP) Registration Category and had been operated by *Videplast Indústria de Embalagens Ltda.* since 07 August 2017.

The pilots normally carried out all tasks related to the management of the airplane's maintenance after approval granted by the operator (owner of the airplane).

According to the maintenance records, the airframe, engine, and propeller logbooks were out of date in their Part 1; however, the primary maintenance records in Part 2, as well as the Airworthiness Directives, were up to date.

In the wreckage analysis, eleven tripped circuit breakers were found. However, the characteristics of the damage and deformation of the circuit breaker panel suggest that they had tripped due to both the aircraft's impact with the ground and the heat generated by the fire.

Regarding the integrity of the primary and secondary flight controls: the interviews and the CVR data indicated no abnormalities during the operation of the aircraft that could have interfered with control authority.

Relatively to the engines, the analysis of their components and the damage characteristics indicated that they were operating normally at the time of the impact. Witnesses of the accident reported hearing both engines running.

Thus, no evidence was found of any system or component failure or malfunction in the airplane that could have affected either performance or control in flight.

The examination of the landing gear indicator lights showed that the two lights related to the nose landing gear were operational; however, the indicator lights of the left and right main landing gear indicator were non-functional and displayed breakage characteristics while in the off state.

Upon analyzing the event as a whole, one sees that the left landing gear light was already off (burned out) before the impact, rendering the PIC unsure as to the real position of the gear. This situation was consistent with the other pieces of evidence; however, it was not possible to determine when the right landing gear light burned out, and there is no reference to a lack of indication for that gear. In the wreckage of the aircraft, one confirmed that all landing gear struts were down and locked.

As for the RUDDER BOOST SYSTEM control switch, although it was found in the OFF position, one considered that it might have been moved after the accident, when the pilot was removed from the command cabin. If the switch had been intentionally placed in that position by the PIC, the lack of the system would not have influenced the accident, as it was determined that both engines were operating.

The pilot had been working for the company for 18 years and, due to his performance, had the trust and respect of the directors. He operated frequently at SBMT, having completed approximately twenty-two legs, arriving at or departing from that location in the twelve months prior to the accident.

According to the pilot's theoretical and practical training history, verified through interviews with people close to him, as well as his experience with both the airplane and the aerodrome (SBMT), no qualification issues were found that would indicate deficiencies in the operations conducted by the pilot.

According to accounts from friends and family, he was a person who did not tolerate personal errors, and for this reason, he was usually meticulous in studying the manuals of the aircraft he flew.

The PIC had autonomy in operational decision-making, was not under pressure, and had a work routine considered "calm", as he alternated flights with another pilot from the company.

According to interviews, the PIC had no health issues and was in a very serene and happy period of his life, with no reports of personal problems that could have interfered with his performance during the flight that led to the accident.

On 28 July 2018, the PIC submitted the flight plan, with a scheduled departure time of 19:00 UTC.

On the accident flight, a passenger occupied the right seat in the cockpit, a transport configuration authorized both by the manufacturer and by the Regulatory Agency.

It was not possible to determine whether, due to the need to transport all passengers, the company dispensed with a second pilot on this flight. Although the aircraft was certified for single-pilot operation, having a second pilot would have enhanced operational safety by reducing the individual workload, especially on flights with adverse weather conditions or those requiring emergency management, which was a condition experienced by PP-SZN.

Regarding flight preparation, one found that there were no reports of any infrastructure conditions at SBMT registered in NOTAMs that might restrict operations at the aerodrome.

The weather information for the region of the destination aerodrome indicated conditions favorable for visual flights.

The takeoff took place at the scheduled time, and no abnormalities were observed during the climb, cruise, or approach within the São Paulo terminal area (TMA-SP).

Between 20:40:05 UTC and 20:44:33 UTC, the PP-SZN airplane coordinated its entire descent with TWR-MT (Campo de Marte control tower) until entering the final approach for landing.

Radar images recorded the aircraft at a speed of 94 kt on the short final of runway 30 at SBMT.

At 20:45:02 UTC, PP-SZN informed TWR-MT that it would perform a low pass over the runway because the left landing gear lock confirmation light had not illuminated, requesting the ATC controller to observe the condition of the gear assembly. The radar images confirmed the low pass of the airplane over the runway.

After the low pass of the airplane at 21:00 UTC, the controller informed that the landing gear assembly was down, but he could not confirm the locking of the gear struts. The PIC then informed that he would proceed with the landing.

After the response from the control tower, the pilot, still unsure about the landing gear status (locked), requested an area to attempt to extend it by means of the emergency system.

The pilot of another aircraft (PR-GCB), who was near position three at SBMT, reported over the frequency that, from his vantage point, the left main landing gear did not appear to be in the same position as the right main gear. This observation likely reinforced the PIC's decision to extend the landing gear using the emergency system.

The fact that he was the only traffic at the aerodrome likely made the PIC comfortable enough to remain in the traffic pattern around the airfield. Thus, he remained in the traffic at 3,600 ft. in order to perform the procedures for landing gear extension using the emergency system.

From the CVR recordings, it became clear that the pilot had difficulty handling the lever for the manual landing gear extension system. Interviews with the passengers also indicated that the procedure caused fatigue for the PIC, with two passengers alternately taking over the task involving the system.

Convinced that all procedures had been completed and that there was nothing else to do, the PIC informed ATC that he would perform a touch-and-go procedure to verify whether the actions taken had achieved the goal of locking the landing gear.

During the circuit, the pilot asked the passengers to familiarize themselves with the doors and emergency exits.

The flight profile in the traffic circuit performed by the aircraft followed practically the same pattern, with slight speed variations. One aspect that drew the Investigation Committee's attention was the PIC's decision to perform a touch-and-go on the third pass. Even after noticing that the entire landing gear assembly had supported the weight of the aircraft, he executed another go-around, possibly due to being at a speed higher than the one prescribed for decelerating the aircraft on the available remainder of the runway.

About five minutes after completion of the touch-and-go procedure, the PIC exchanged some information with the pilot of another King Air airplane that was on the same frequency, and conducted system tests as directed by this latter pilot. Convinced that the landing gear assembly was locked down, he informed the controller that he would proceed with the final landing, re-entering the downwind leg of the aerodrome’s traffic circuit with the landing gear down but without indication of locking.

Recordings indicated that between the first low pass over the runway and the final approach that led to the accident, the pilot showed signs of apprehension, denoting an emotional state compatible with stress.

The pilot's described profile indicated a characteristic of not tolerating personal errors and being meticulous in his actions. He likely performed various traffic circuits as a way of ensuring that the landing gear was down and locked, aiming to prevent the consequences of a landing with a malfunctioning gear. This reflected difficulties in his thought process, leading to improvisation of procedures.

The radar display showed the PP-SZN airplane at 0.4 NM from the runway 30 threshold, slightly to the left of the approach axis at a speed of 88 kt.

By focusing all his attention on the issue of the landing gear indicator light, the PIC may have neglected other procedures due to selective perception or "tunnel vision".

Since the PIC did not have simulator training, he may not have acquired the appropriate skills to carry out procedures related to emergency management.

Despite the wreckage analysis not revealing any failure that could have compromised the aircraft's performance and/or controllability, one noted that a final approach was conducted at a speed close to the stall speed.

After the stall warning horn sounded, it is possible that the PIC incremented engine power, advancing the throttles quickly in order to prevent entering a stall condition. With this sudden throttle increase, the torque effect, combined with the “P-Factor”, Gyroscopic Effect and spiraling slipstream, may have contributed to an increased tendency for yaw and/or roll to the left.

Based on both the analysis of the flight data and the accounts provided by the passengers, the occurrence of the stall warning and other alarms was confirmed in the moments preceding the aircraft's wing roll. The delayed recognition of these signals may have led to the loss of control at low altitude, making it impossible for the pilot to avoid the outcome of the situation.

It is possible that the controls were not applied adequately to counteract the effects and maintain controlled flight, resulting in an abrupt left bank of the aircraft and entry into a spin condition due to stall.

3. CONCLUSIONS.

3.1. Findings.

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

b) the PIC held valid ratings for MLTE (Multi-Engine Land Aircraft) and IFRA (Instrument Flight - Airplane);

c) the PIC was qualified for experienced in this type of flight;

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

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

f) the records of the airframe, engine, and propeller logbooks were not up date;

g) the weather conditions were favorable for the flight;

h) there were no abnormalities during the takeoff, climb, cruise flight, and descent of the aircraft;

i) on the first approach attempt, there was no panel indication that the left landing gear had locked down;

j) the first approach attempt was aborted, and a low pass was conducted to allow the TWR to visually verify the condition of the left landing gear strut;

k) an aircraft on the ground reported over the frequency that the PP-SZN airplane’s left main landing gear strut seemed to be in a different position from the right landing gear strut;

l) PP-SZN performed a second pass over the runway and received confirmation from ATC that all landing gear legs were down, but they could not verify the locking;

m) after the second go-around, still in the traffic pattern, the PIC performed the procedures for extending the landing gear using the emergency system;

n) two passengers assisted in performing the manual gear extension procedure due to the physical fatigue of the PIC;

o) still in the traffic pattern, PP-SZN received verbal assistance from the crew of another King Air aircraft that was on the frequency;

p) after performing the landing gear check procedures and being confident that the landing gears were locked, the PIC informed ATC that he would perform a touch-and-go procedure;

q) during the climb, after the touchdown on the runway followed by a go-around, the pilot reported that the aircraft remained supported on the landing gear assembly after the touchdown and that he would perform another circuit for the final landing;

r) the PIC instructed the passengers to check the position and operation of the emergency exits;

s) on the fourth traffic pattern, after crossing the runway threshold, the aircraft rolled to the left around its longitudinal axis and crashed into the ground;

t) the aircraft suffered substantial damage; and

u) the PIC received fatal injuries, two of the passengers suffered serious injuries, and the other four were slightly injured.

3.2 Contributing factors.

- **Attitude – undetermined.**

The pilot's described profile indicated a characteristic of not admitting personal mistakes and being meticulous in his actions. He likely performed multiple traffic circuits as a way to ensure that the landing gear had locked down, aiming to avoid the consequences of landing with a faulty landing gear, which reflected challenges in his way of thinking, leading to the improvisation of procedures.

- **Training – undetermined.**

Since the PIC had no simulator training, he may not have acquired the necessary skills for performing the procedures related to the management of the emergency.

- **Emotional state – undetermined.**

The contribution of a state of tension and stress, due to overload, cannot be disregarded, considering that the PIC faced the need to perform a landing with the possibility of the main landing gear retracting, with his superiors on board, as well as the potential damage to the aircraft as a consequence.

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

It is likely that improper use of the flight controls during the final approach allowed flight at speeds close to stall speed. Furthermore, it is possible that the controls were not adequately applied to counteract the effects and maintain controlled flight, leading to a sudden left roll of the aircraft and entry into a spin condition resulting from the stall.

- **Piloting judgment – a contributor.**

Despite being qualified and certified to operate the airplane, there was no adequate assessment of the malfunction and procedures to be adopted during the situation encountered.

- **Perception – undetermined.**

By focusing all his attention on the landing gear indicator light issue, the PIC may have neglected other procedures due to selective perception or "tunnel vision".

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

There was an inadequate judgment caused by fixation on solving the landing gear indication failure, which affected the analysis and choice of better alternatives for the conditions presented.

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):

A-128/CENIPA/2022 - 01 **Issued on 04/08/2025**

Disseminate the lessons learned from this investigation to MLTE rating holders aiming at encouraging them to reappraise their training on aircraft limitations and emergency procedures, with particular emphasis on the workload required by an aircraft during emergencies, especially in single-pilot operations.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

None.

On April 8th, 2025.