COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A-013/CENIPA/2017

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PR-SOM**
MODEL:	**C90GT**
DATE:	**19JAN2017**

NOTICE

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

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

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

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

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

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

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

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

SYNOPSIS

This is the final report of the 19 January 2017 accident with the C90GT aircraft, registration PR-SOM. The accident was classified as “Loss of Control In-Flight”.

During the second approach attempt to land at the Paraty Aerodrome, RJ, the aircraft flew into a region under restricted visibility conditions, which caused the pilot to lose visual contact with the terrain references, leading to loss of control and the impact of the aircraft against water.

The aircraft was destroyed.

The pilot and the four passengers perished at the accident site.

An Accredited Representative of the NTSB (National Transportation Safety Board), from the United States of America (State where the aircraft was manufactured); and an Accredited Representative of the TSB (Transportation Safety Board), from Canada (State where the engine was manufactured) were designated for participation in the investigation.

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GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ANAC	Brazil's National Civil Aviation Agency
ANN	Annunciator System
AOM	Aircraft Operating Manual
APP-SP	Approach Control - São Paulo
ATC	Air Traffic Control
ATS	Air Traffic Services
ATZ	Aerodrome Traffic Zone
BIMTRA	Air Traffic Movement Database
CA	Airworthiness Certificate
CB	Cumulonimbus
CENIPA	Aeronautical Accident Investigation and Prevention Center
CFIT	Controlled Flight Into Terrain
CIV	Pilot´s Flight Logbook
CMA	Aeronautical Medical Certificate
CMV-CW	Curitiba Weather Monitoring Center
CPTEC	Weather Forecasting and Climate Studies Center
CRM	Corporate Resource Management
CSMU	Crash Survivable Memory Unit
CVR	Cockpit Voice Recorder
DA	Decision Altitude
DE	Spacial Disorientation
DECEA	Airspace Control Department
E	East
EADI	Electronic Attitude Direction Indicator
EGPWS	Enhanced Ground Proximity Warning System
EHSI	Electronic Horizontal Situation Indicator
ELT	Emergency Locator Transmitter
EPTA	Telecommunications and Air Traffic Services Provider Station
FAP	Pilot´s Evaluation Sheet
FIR-CW	Curitiba Flight Information Region
FPDAM	Flight Procedure Design and Airspace Management
GAMET	General Aviation Meteorological Information
GEIV	Special Inflight Inspection Group
GND-MT	Campo de Marte Ground Control
GOES	Geostationary Operational Environmental Satellite
GPS	Global Positioning System
HBV	Brazilian Daylight Saving Time
HSI	Horizontal Situation Indicator
IAM	Annual Maintenance Inspection
ICA	Command of Aeronautics' Instruction
ISA	International Standard Atmosphere

IFR	Instrument Flight Rules
IFRA	Instrument Flight License - Airplane Category
IMC	Instrument Meteorological Conditions
INMET	Meteorology National Institute
INSPAC	Civil Aviation Inspector
INSPSAU	Health Inspection
INVA	Flight Instructor Qualification - Airplane Category
LABDATA	Flight Data Recorders Read-out and Analysis Laboratory
MDA	Minimum Descent Altitude
METAR	Aerodrome Routine Weather Report
MFD	Multi-Function Display
MLTE	Airplane Multiengine Land (AMEL)
N	North
NE	Northeast
NM	Nautical Miles
NOTAM	Notice to Airmen
NTSB	National Transportation Safety Board
NuHFASP	São Paulo Air Force Hospital Nucleus
PCM	Commercial Pilot License - Airplane Category
PF	Pilot Flying
PLA	Airline Pilot License - Airplane Category
PM	Pilot Monitoring
PN	Part Number
POH	Pilot’s Operating Handbook
PPR	Private Pilot License - Airplane Category
QNE	Standard Pressure at Sea Level (1,013.2 h Pa)
QNH	Reduced Pressure at Sea Level by the Vertical Gradient of the Standard Atmosphere
RADAR	Radio Detection And Ranging
RBAC	Brazilian Civil Aviation Regulation
RBHA	Brazilian Aeronautical Homologation Regulation
RMI	Radio Magnetic Indicator
RNAV	Area Navigation
RPM	Rotations per minute
S	South
SBKP	ICAO location designator - Viracopos Aerodrome / Campinas, SP
SBMT	ICAO location designator - Campo de Marte Aerodrome / São Paulo, SP
SBRJ	ICAO location designator - Santos Dumont Aerodrome / Rio de Janeiro
SBSJ	ICAO location designator - São José dos Campos Aerodrome / SP
SDAG	ICAO location designator - Angra dos Reis Aerodrome / RJ
SDIH	ICAO location designator - Irohy Farm Aerodrome / Biritiba Mirim, SP
SDTK	ICAO location designator - Paraty Aerodrome / RJ
SIGMET	Significant Meteorological Information
SIGWX	Significant Weather

SN	Serial Number
TCU	Towering Cumulus
TGL	Touch and Go Landing
TMA-SP	São Paulo Terminal Control Area
TPP	Aircraft registration category of private air service
TS	Thunderstorm
TSB	Transportation Safety Board
TWR-MT	Campo de Marte Aerodrome Control Tower
UTC	Coordinated Universal Time
VFR	Visual Flight Rules
VSI	Vertical Speed Indicator
W	West
ZCOU	Humidity Convergence Area

1. FACTUAL INFORMATION.

Aircraft	**Model:** C90GT **Registration:** PR-SOM **Manufacturer:** Beechcraft - Textron Aviation	**Operator:** Emiliano Empreendimentos e Participações Hoteleiras Sociedade Ltda
Occurrence	**Date/time:** 19JAN2017 - 15:44 (UTC) **Location:** Paraty Bay **Lat.** 23°12'11"S **Long.** 44°41'06"W **Municipality – State:** Paraty - RJ	**Type(s):** Loss of control in-flight **Subtype(s):** NIL

1.1 History of the flight.

The aircraft took off from Campo de Marte Aerodrome, SP (SBMT), to the Paraty Aerodrome, RJ (SDTK), at 13:01 (HBV) with one pilot and four passengers on board.

During the approach procedure to land in SDTK, in restricted conditions of visibility, the aircraft crashed into the sea in Paraty Bay.

The aircraft was destroyed.

All occupants suffered fatal injuries.

1.2 Injuries to persons.

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

1.3 Damage to the aircraft.

The aircraft’s right wing was separated inboard of the right engine nacelle and the tail cone was separated in a position near to the leading edge of the horizontal stabilizers.

The tip of the left wing was deformed back and forth.

Both engines detached from the wings.

The front section of the fuselage remained relatively undamaged, with wrinkles on the sides and a significant kneading on top of the cockpit.

The damages observed on the left side of the fuselage were manually made during rescue operations.

Figure 1 - Condition of the aircraft at the time of lifting.

1.4 Other damage.

Nil.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Hours Flown	
	Pilot
Total	7.464:55
Total in the last 30 days	07:45
Total in the last 24 hours	00:00
In this type of aircraft	2.924:00
In this type in the last 30 days	07:45
In this type in the last 24 hours	00:00

N.B.: Data regarding flight experience were based on the records of the Pilot´s Flight Logbook (CIV), as well as on the records of the Air Traffic Movement Database (BIMTRA) and on the consultation of relatives.

1.5.2 Personnel training.

The pilot took the Private Pilot course - Airplane (PPR) at *Aeroclube de Bragança Paulista*, SP in 1987.

He obtained the Commercial Pilot License - Airplane (PCM) in 1988. In 1991, he started to fly as a flight instructor at Aeroclube de São Paulo, SP.

In 1994, the pilot began operating multi-engine aircraft and, from 1999 on, he started flying Beechcraft 90 series aircraft (C90).

In 2000, he obtained an Airline Pilot License - Airplane (PLA).

1.5.3 Category of licenses and validity of certificates.

The pilot held a PLA license, as well as a valid technical qualification certificate for Airplane Multiengine Land (MLTE / AMEL), in addition to being IFR-rated in airplanes.

1.5.4 Qualification and flight experience.

The pilot was 55 years old. He was a pilot for thirty years and operated multiengine aircraft on private flights (under the rules of the Brazilian Regulation of Aeronautical Homologation number 91 - RBHA-91) since 1994, accumulating the experience of 2,924 hours in Beechcraft 90 series aircraft, especially on the C90A and C90GT models, since March 2000.

He operated the PR-SOM C90GT aircraft since 2010 and had the Paraty, RJ aerodrome as a frequent destination. In the twelve months prior to the accident, he performed 33 flights to SDTK.

He periodically revalidated his qualifications and his last Pilot Assessment Sheets (FAP) contained the following observations, recorded by the respective Civil Aviation Inspectors (INSPAC):

- On 18OCT2011, he performed the revalidation exam for C90GT (BE90) type qualification and for aircraft instrument flight license (IFRA).

  He performed the exercises and procedures provided, under normal flight conditions, as well as simulated emergencies, with proficiency.

  He performed precision (ILS) and non-precision (VOR) IFR procedures, and visual traffic patterns, followed by touch and go in SBSJ.

  Pilot able for Beech type qualification.

  He made the IFR route navigation circuit from SBMT to SBSJ.

  He performed precision (ILS) and non-precision (VOR) IFR approach procedures, followed by touch and go in SBSJ.

  He presented a good use of the aircraft's commands, as well as good flight instruments crosschecks.

  Good standardization of operational procedures.

  Pilot able for IFR qualification.

- On 24AUG2012, he carried out the revalidation for BE90 type qualification and for IFRA.

  The pilot was evaluated for revalidation of BE90 type qualification and IFRA en route with "Y" flight plan from SBRJ to SBSJ, and then from SBSJ to SBMT, where it was possible to evaluate the CRM and was trained the normal maneuvers and simulated emergencies. The pilot showed good piloting technique, good flight planning and good CRM. Pilot considered able.

- On 22MAR2013, he performed the revalidation for B300 type.

  The pilot was evaluated for revalidation of type qualification in local and en route flights, where he presented good performance, with good planning, good CRM and good knowledge. Pilot considered able.

- On 02OCT2013, he performed the revalidation for BE90 type qualification and for IFRA.

  Satisfactory flight.

  "NA" items not compatible with the type of evaluation performed.

  Satisfactory Oral exams (ICA 100-12 / BE90).

  Safe operation and safe control of the aircraft in its various configurations.

- On 07OCT2014, he performed the revalidation for BE90 type qualification and for IFRA.

  Items 18, 25, 26, 27, 36, 37, 38, 39, 50, 51, 54, 55, 57, 58 and 59 performed only in simulator.

  Items 40 and 73: aircraft operated only single pilot.

  Items 45, 46 and 48: not performed due to air traffic and the proficiency presented in the accomplishment of item 47.

It was performed 01 departure procedure in the visual corridor (VRF special route) for SBSJ. Due to a GEIV aircraft carrying out an inspection, after some hold patterns, the flight continued to SBKP.

A RNAV procedure was performed in SBKP with a go-around procedure in (at) MDA.

He performed 01 normal landing and 01 simulated single-engine landing, all safe and in the center of the runway.

The pilot demonstrated flight safety and proficiency in the operation of the aircraft at all stages of the flight, including simulated emergency situations.

- On 30SEPT2015, he performed the revalidation for the BE90 type qualification and for IFRA.

Issues related to single-engine performance and emergencies had been addressed.

He operated as PF and PM.

Maneuvers and simulated emergencies performed with satisfactory profiles.

Stabilized approaches, safe touches.

Safe IFR profiles.

- On 15OCT2016, he performed the revalidation for IFRA qualification and, according to new requirements that were established by the National Civil Aviation Agency (ANAC) for the operation of the C90GT, he also carried out the revalidation of the MLTE qualification.

Examination as required in RBAC 61.197 (MLTE / IFR) 61.225.

The commander demonstrated good knowledge of the manual and limitations of the aircraft with number of hits greater than 95%. He was instructed to use the weight contained in the weighing chart to fill out the weight and balancing form, although he was aware of where to locate each information in the AOM.

He performed the procedures according to the manual and made good use of the checklist.

He used the callouts properly during takeoff and was instructed to use them during landing, especially in anticipation of altitude before DA.

Safe maneuvers, curves, landing and go-around procedures.

Further familiarization with RNAV navigation is recommended, although he corrected / managed the flight when aircraft automation did not behave as expected.

Flight IFR satisfactory.

- On 02DEC2016, he carried out the revalidation of flight instructor qualification (INVA).

Documentation, planning, theoretical preparation and briefing; presented good preparation.

A local SDIH flight was carried out for INVA revalidation purposes, being executed: maneuvers, TGLs, simulated emergencies and other planned phases; the instructor was proficient in the various stages of the flight, demonstrating good preparation, safety and ability to teach; instructor considered fit for the activity.

1.5.5 Validity of medical certificate.

The pilot had first class Aeronautical Medical Certificate (CMA) in the Airline Pilot Category (PLA), valid until 26APR2017.

1.6 Aircraft information.

The aircraft with the registration PR-SOM, serial number LJ-1809, model C90GT - King Air, was manufactured in 2006 by Beech Aircraft Corporation - Textron Aviation. The aircraft was registered in the category of Private Air Services (TPP) and operated by *Emiliano Empreendimentos e Participações Hoteleiras Sociedade Ltd*., since May 2010.

The Airworthiness Certificate (CA) of the aircraft was valid until 12APR2022.

According to the CA, the aircraft was capable of carrying eight people and was certified to operate with only one pilot.

General Features of the King Air C90GT Aircraft.

The King Air C90GT was a steel structure aircraft with a pressurized cabin, 30,000ft operating ceiling, low wing, twin-engine turbo-propel with conventional empennage, and retractable tricycle landing gear.

Both, the nose landing gear and the main landing gear were hydraulically operated and had an actuator on each one of them. The normal command for extension and retraction was electric. Landing gears could also be manually operated via a lever located on the aircraft floor to the left of the cockpit center pedestal.

The primary flight surfaces consisted of ailerons, elevators and rudders, responsible for the rolling, pitching and yawing movements, respectively. The cabin controls operated on the surfaces by means of cables, pulleys and rods.

The ailerons and elevators were commanded through the control stick. Pedals on the aircraft floor performed the rudder commands. All pilot and co-pilot commands were interconnected.

The aircraft was equipped with elevator compensator, electrically controlled by switches on both sticks, and manually by a wheel located on the left of the center pedestal. The electric control could be disabled by setting the ELEV TRIM switch to the OFF position. The position display of the elevator compensator was integrated with the manual control.

Aileron and rudder compensators had manual controls installed on the center pedestal. The position indication of each surface was integrated with the control device. Figure 2, adapted from the Pilot's Operation Handbook (POH), March 2007 review, shows the location of the compensator controls and indicators.

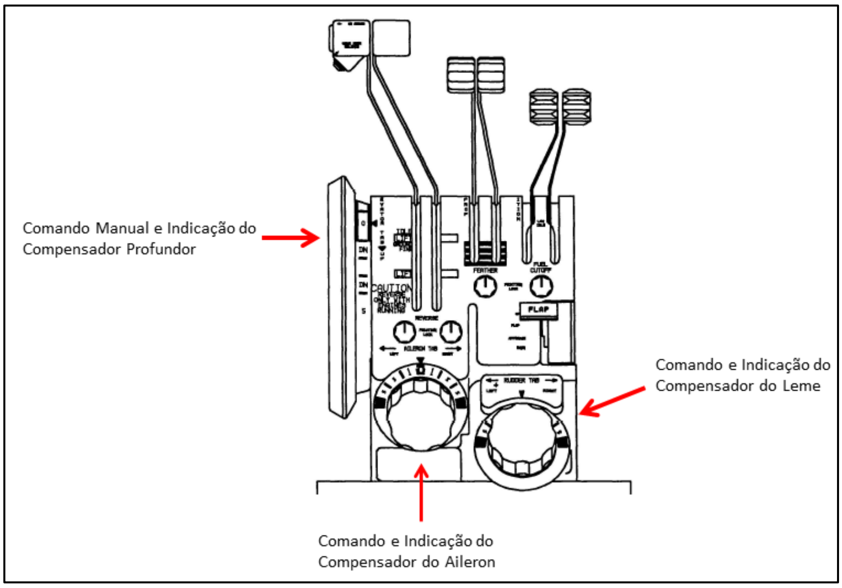

Figure 2 - Location of the control devices and indication of the elevator, aileron and rudder compensators on the central pedestal (Adapted from POH).

The aircraft had a system of aid to the directional control for the cases of failure in one of the engines or in case of great asymmetry of power between them. This system was called Rudder Boost. Such system compared the pressure difference between the bleed air from the two engines and, if the pressure differential was greater than a given reference value, the system would act to compensate for the yaw tendency generated by the asymmetric power. The performance of the Rudder Boost could be noticed by a movement of the rudder control pedals.

The flap system consisted of four surfaces, two on each wing. The surfaces were electrically controlled through a lever on the central pedestal, which had three positions: UP, APPROACH and DOWN; and were moved through actuators, shafts and electric engine (Figure 3).

The position of the flaps was shown in a gauge on the instrument panel, above the throttle pedestal.

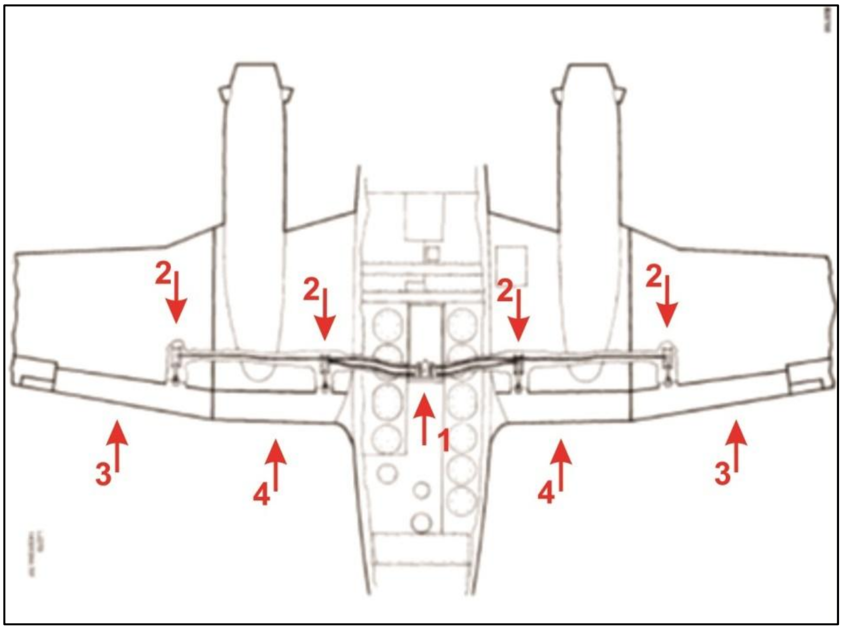

Figure 3 - Flap system. Electric engine (1), actuators (2), outer surfaces (3) and inner surfaces (4).

Enhanced Ground Proximity Warning System (EGPWS).

The PR-SOM was equipped with an Enhanced Ground Proximity Warning System (EGPWS). The main functions of this system were to provide situational warning to the crew of the presence of obstacles and proximity to the ground.

EGPWS received information from the Global Positioning System (GPS), non-corrected barometric pressure and external air temperature, and it also had a database of terrain, obstacles and tracks.

For the issuance of warnings, the system compared the aircraft's trajectory with information from the terrain database, known obstacles and the distance to known runways.

The EGPWS had a protection mode, related to high rates of descent. This mode issued the "Sink Rate" warning based on the flight altitude and the rate of descent of the aircraft. If the aircraft entered a more critical condition, the "Pull Up" warning would be issued.

When the equipment detected a hazardous condition related to terrain or obstacles, at a distance of approximately one minute ahead of the aircraft, the warnings "Caution

Terrain, Caution Terrain" or "Caution Obstacle, Caution Obstacle" were issued. Additionally, the message "Thread Area" was displayed on the Multi-Function Display (MFD), in order to increase the situational awareness of the pilot in relation to the presence of obstacles that would represent risks to the flight.

Some pushbuttons on the aircraft panel were part of the EGPWS system, through which it was possible to perform tests on its alarms and inhibit all visual and auditory warnings of the system (TERR INHB).

Figure 4 - EGPWS alarm panel.

The system also allowed the visualization of terrain and obstacle data in the MFD, which showed the height of the elevations in relation to the aircraft through a color pattern where the green indicated elevations below and red indicated elevations above the aircraft (Figure 5).

Figure 5 - MFD of the same model of the PR-SOM aircraft, selected in terrain mode, and displaying the EGPWS information.

The EGPWS manual included the following warning in its "limitations" chapter:

> The EGPWS is a Situational Awareness tool and an alert and warning device. Not to be used for aircraft navigation.

<u>Altitude Alert</u>

The aircraft was equipped with an Altitude Alert Part Number (PN): 10379-11-01. This equipment compared the altitude shown on the pilot's altimeter with the altitude selected on the equipment itself.

The Altitude Alert had an amber warning light located on the front of the equipment, which was lit and remained on when the aircraft was in the 200 to 1,000ft altitude range above or below the selected altitude. Every time the aircraft entered this altitude discrepancy range, a two-second sound warning was issued.

<u>Revisions and Maintenance Inspections</u>.

The PR-SOM's airframe and engine logbooks records were up-to-date until the date of its last Maintenance intervention performed.

The aircraft had 1,157.8 total flight hours, according to the "hour meter" (Figure 6).

Figure 1 - "Hour meter" of the PR-SOM aircraft.

The aircraft was equipped with two PT6A-135A engines, manufactured by Pratt & Whitney Canada. According to the engine logbooks, the left engine (SN: PCE-PZ0395) and the right engine (SN: PCE-PZ0396) had the same number of hours of operation as the last maintenance action.

Hartzell Propeller Inc. manufactured the propellers that equipped the aircraft; model HC-E4N-3N. The left propeller (SN: HH-2734) and the right propeller (SN: HH-2732) had the same number of hours of operation of the engines.

According to the records of the propeller logbook, on 12APR2016, the Phases 3 and 4 (400 hours) inspections were performed, according to the aircraft maintenance program. In conjunction with these inspections, the Annual Maintenance Inspection (IAM) and the renewal of the aircraft's CA were performed. These maintenance services were performed at the CONAL shop in Sorocaba, SP.

The aircraft had flown 84 hours and 30 minutes between the last maintenance intervention and the date of the occurrence. During this period, there were some items that should have been inspected, but had no records of compliance, such as:

- ELT (Emergency Locator Transmitter) Battery, due date 01AUG2016;

- Charging test, and recharging (if necessary) of the Standby Power Supply Battery (backup battery), due date 09OCT2016;

- Lead Acid Battery recharge, due date 11JUL2016; and

- Check of the oil inlet protection screen of the Scavenge pump of the Engine Accessories Box, due date 09OCT2016.

1.7 Meteorological information.

In the synoptic surface analysis from 12:00 (UTC) of 19JAN2017, a light blue Humidity Convergence Zone (ZCOU) was observed over the southeastern region of Brazil. A band of organized cloudiness and intense rainfall precipitations characterize this meteorological phenomenon.

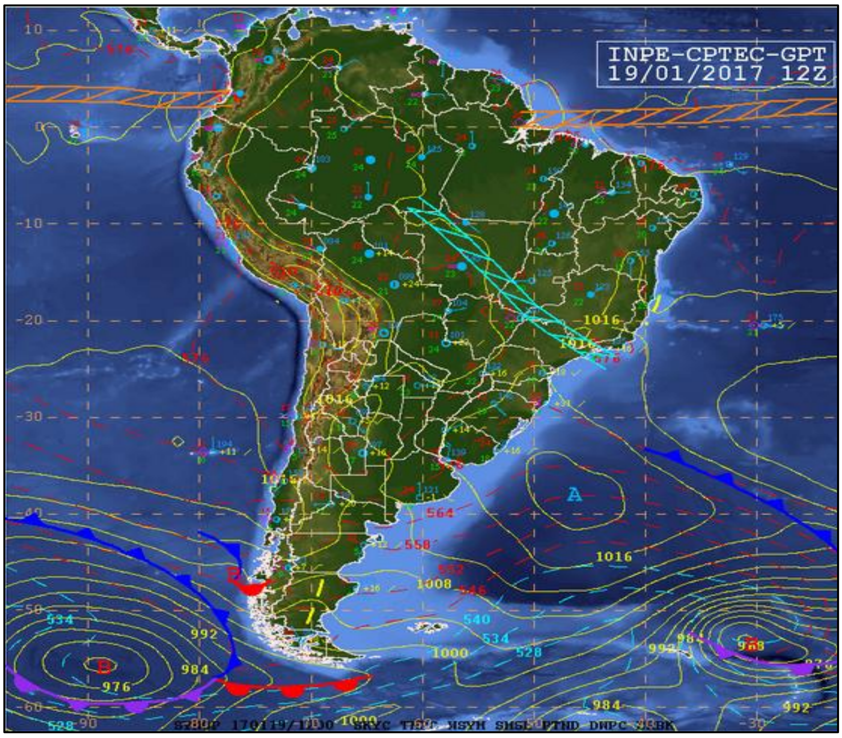

Figure 7 - Synoptic analysis of 19JAN2017 (Source: CPTEC).

The forecast of significant time (SIGWX chart) from 12:00 (UTC), of 19JAN2017, with projections in the period from 09:00 (UTC) to 15:00 (UTC), indicated the presence of cloudy weather with clouds at 1.200ft, constituting a ceiling with possibility of continuous rain, and the presence of Towering Cumulus (TCU) type clouds, according to Figure 8.

The General Aviation Meteorological Information (GAMET) prepared by the Curitiba Weather Monitoring Center (CMV-CW) contained the following information:

SBCW GAMET VALID 191200/191800 SBGL- SBCW CURITIBA FIR/SECTORS 04 AND 11 BLW FL100 SECN I SFC VIS : 15/18 4000M TSRA/RA SECTOR 4 SIGWX : 15/18 ISOL TS SECTOR 4 MT OBSC : MAR AND MANTIQUEIRA SIG CLD : ISOL EMBD CB AND TCU 2500/ABV 10000FT AGL SECTOR 04 SECN II PSYS : NIL WIND/T : S04 2000FT VRB/10KT PS24 5000FT VRB/10KT PS18 10000FT 340/10KT PS09 S11 2000FT 010/15KT PS26 5000FT 360/15KT PS19 10000FT 360/15KT PS10 CLD : SCT/BKN CUSC 1500/5000FT AGL AND SCT/BKN ACAS 8000/ABV 10000FT AGL FZLVL : ABV 10000FT AGL MNM QNH : 1008HPA VA : NIL=

The GAMET valid between 12:00 and 18:00 (UTC) on 19JAN2017 provided for the formation of Cumulonimbus (CB) clouds, with thunderstorms (TS), restricted visibility at 4,000 meters in sector 4 (corresponding to the region of Paraty, RJ) due to rainfall and the forecast of obscured mountains at Serra do Mar and Serra da Mantiqueira.

The CMV-CW issued the Significant Meteorological Information (SIGMET) number nine, valid between 15:10 and 18:10 (UTC) on 19JAN2017:

SBCW SIGMET 9 VALID 191510/191810 SBCW - SBCW CURITIBA FIR SEV ICE FCST WI S2330 W04656- S2012 W04320- S2440 W04058- S2805 W04450 - S2330 W04656 FL140/220 STNR NC=

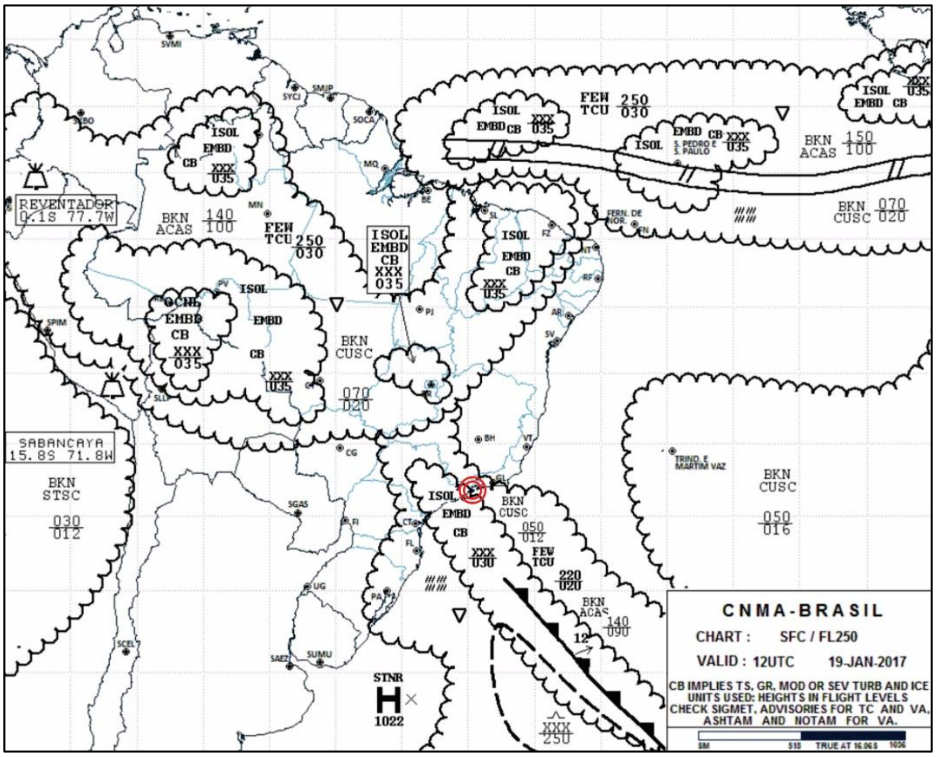

Figure 8 - SIGWX chart of 19JAN2017, 12:00 UTC, highlighting the region of Paraty, RJ (highlighted in red circles).

SIGMET cautioned against a severe, stationary, unchanging layer of ice between levels FL140 and FL220 on the area of the accident.

The enhanced Geostationary Operational Environmental Satellite (GOES 13) images showed an increase and displacement of the cloud band over the region of Paraty, RJ, from 14:00 to 16:00 (UTC).

In the image of 14:00 (UTC), the region of the city of Paraty, RJ, (highlighted in red circles) appeared without intense formations (Figure 9).

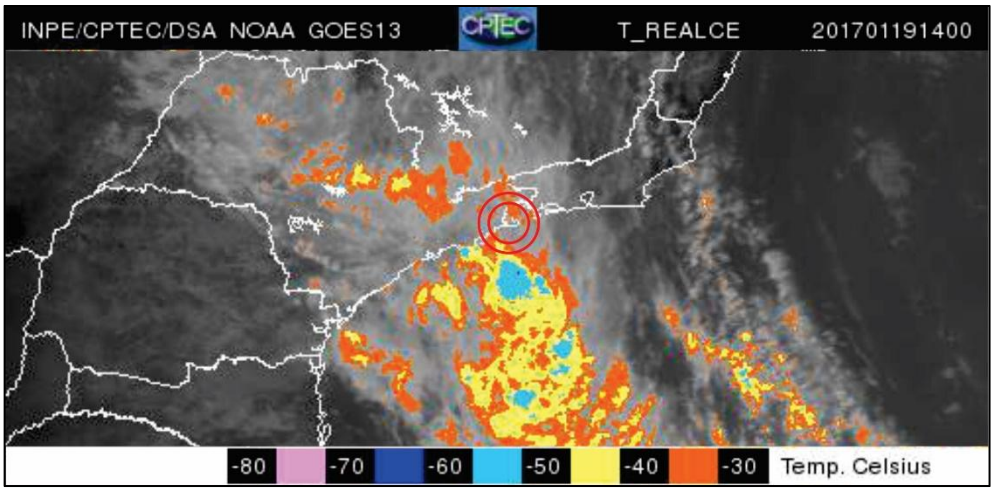

Figure 9 - GOES 13 image, highlighted from 19JAN2017 at 14:00 (UTC).

At 15:00 (UTC), the image showed cloud formations getting intense over the Paraty region (Figure 10).

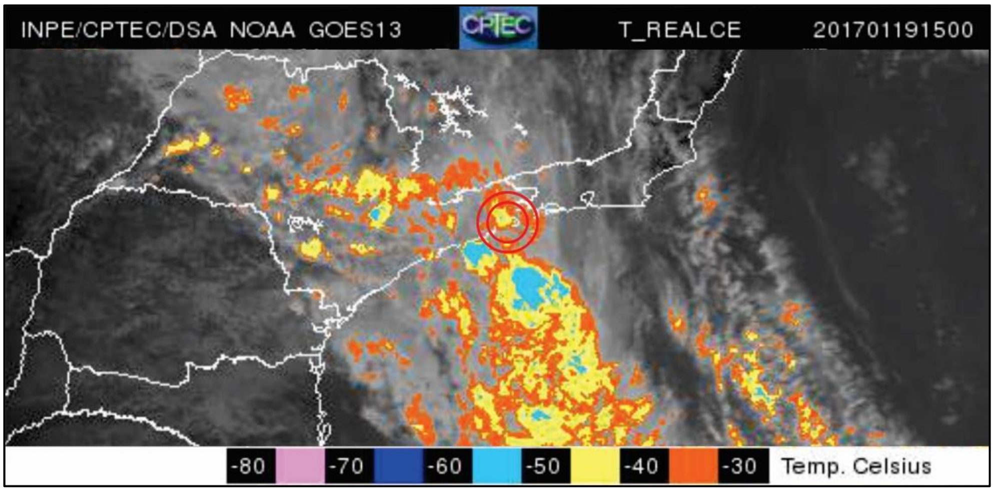

Figure 10 - GOES 13 image, highlighted from 19JAN2017 at 15:00 (UTC).

At 16:00 (UTC), cloud formations with CB and TCU characteristics intensified over the region (Figure 11).

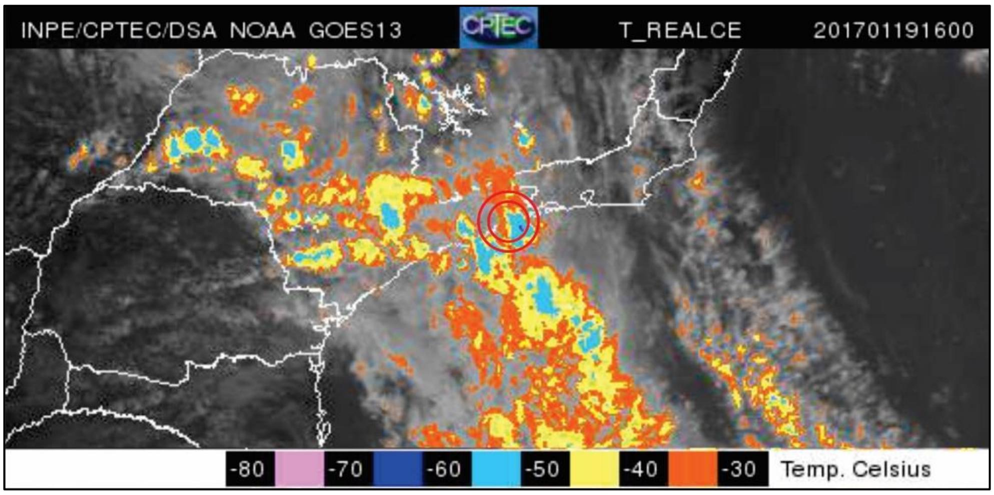

Figure 11 - GOES 13 image, highlighted from 19JAN2017 at 16:00 (UTC).

The Meteorological RADAR located in Petrópolis, RJ (Pico do Couto), recorded the rainfall precipitation potential of the Paraty region, RJ, using color scale images, which could range from zero to one hundred millimeters per hour (mm / h).

The sequence of images, from 15:06 to 15:56 (UTC) on 19JAN2017, shows the presence of precipitable water over the region of Paraty, RJ, and demonstrates the evolution of the rainfall precipitation conditions. The red circles indicate the position of the city of Paraty, RJ (Figure 12 to Figure 17).

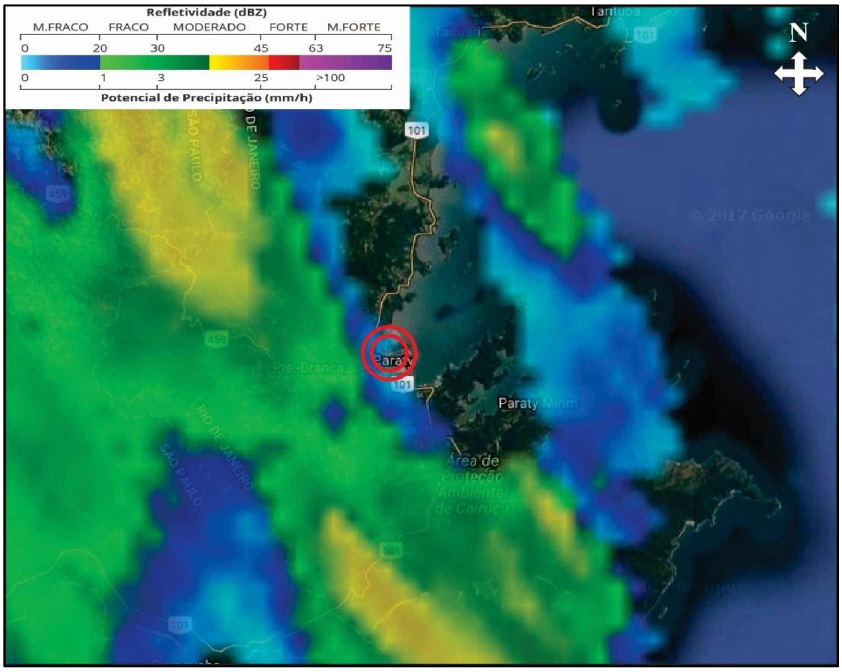

Figure 12 - Meteorological RADAR image from Pico do Couto at 15:06 (UTC).

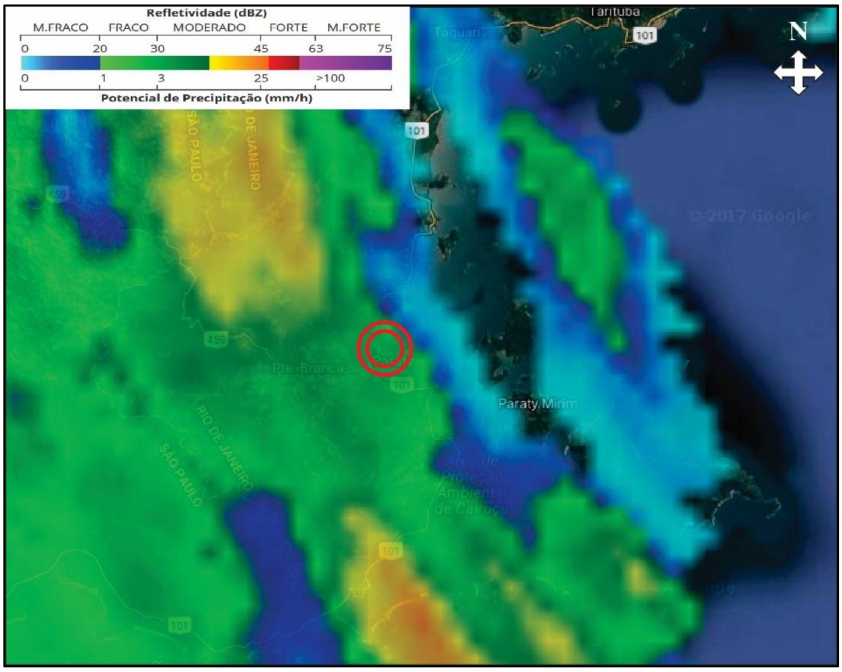

Figure 13 - Meteorological RADAR image of Pico do Couto at 15:16 (UTC).

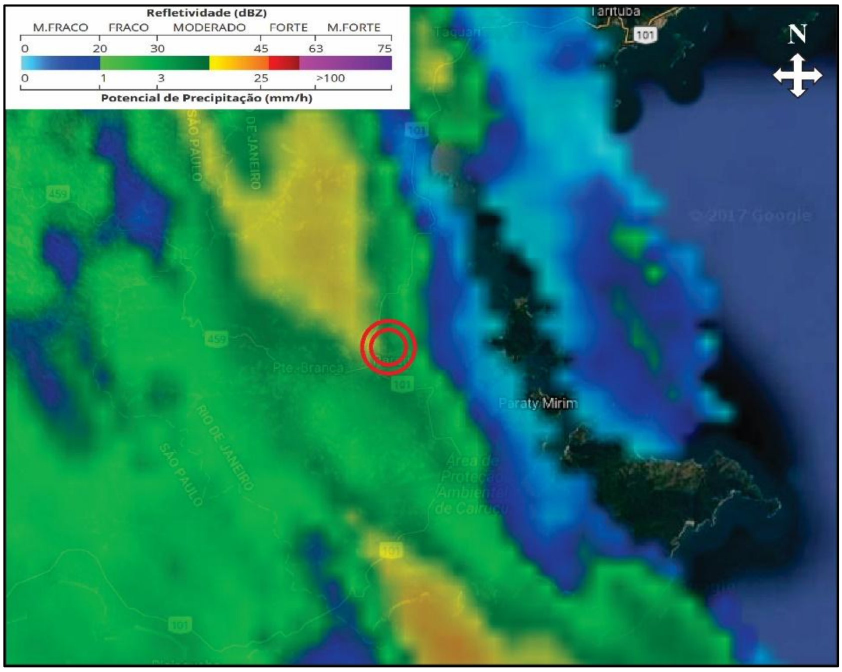

Figure 14 - Meteorological RADAR image of Pico do Couto at 15:26 (UTC).

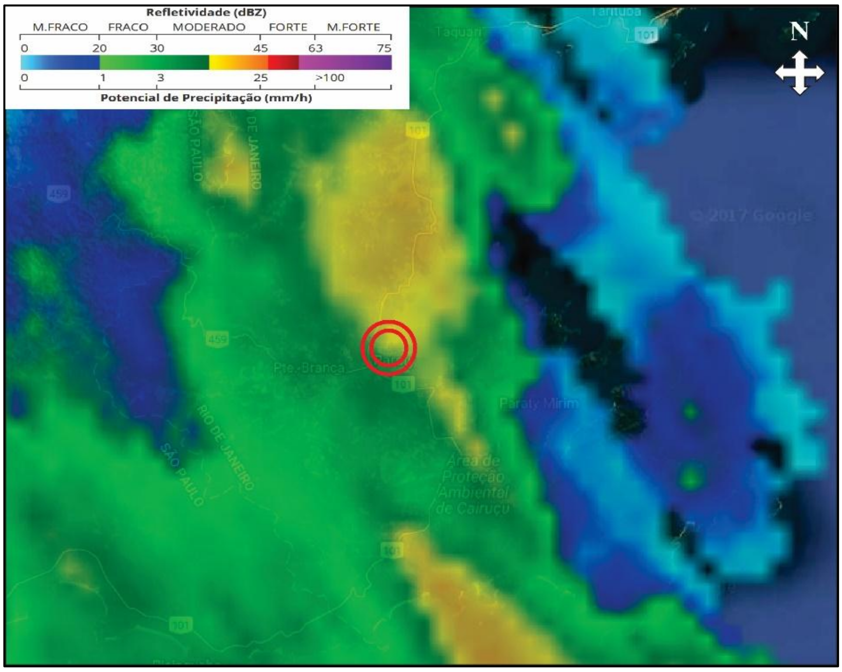

Figure 15 - Meteorological RADAR image of Pico do Couto at 15:36 (UTC).

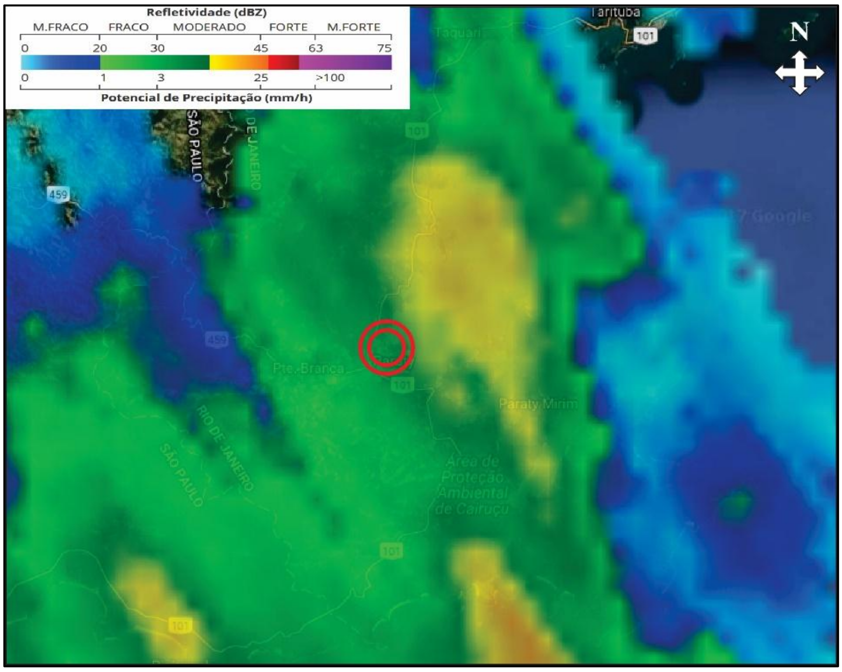

Figure 16 - Meteorological RADAR image of Pico do Couto at 15:46 (UTC).

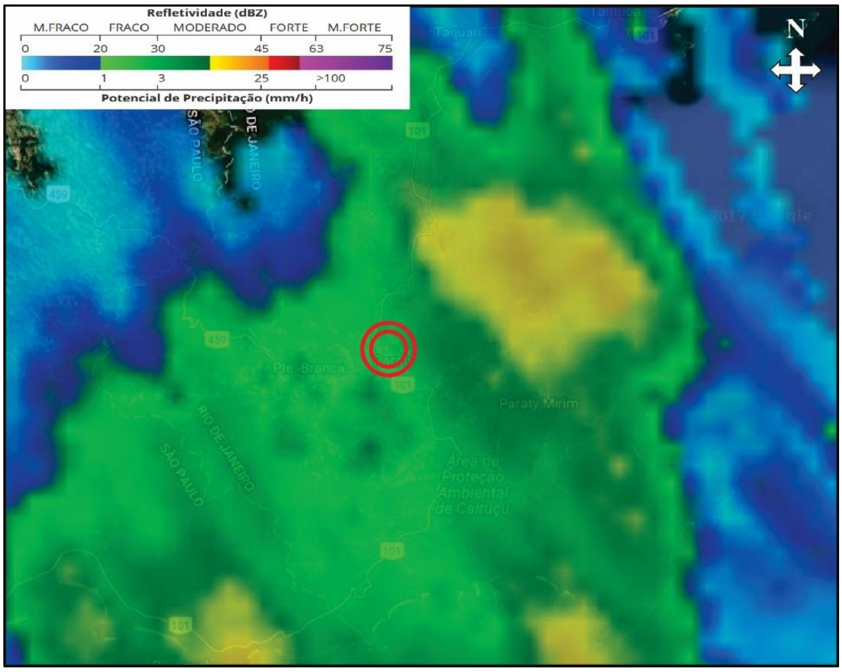

Figure 17 - Meteorological RADAR image of Pico do Couto at 15:56 (UTC).

It was verified the existence of well developed TCU and CB cloud formations on the region of the accident. The convective formations were dynamic and intensified with south-easterly displacement.

It stands out the image generated at 15:46 (UTC), about two minutes after the impact of the aircraft, when it is observed a potential rainfall precipitation of 25 mm/h on the Paraty Bay.

Due to the lack of Meteorological Aerodrome Report (METAR) at the Paraty Aerodrome, RJ, the Investigation Team searched for information from the National Institute of Meteorology (INMET) for the weather data between 15:00 and 16:00 (UTC), referring to an automatic weather station.

It should be noted that such information is the result of the direct reading of an automatic equipment, representing raw data that has not undergone any treatment and is not intended for the provision of air traffic services (Figure 18).

Consulta Dados da Estação Automática: Paraty (RJ) Fechar

Observação: Estes são dados brutos e sem consistência com o único objetivo de deixá-los disponíveis de forma imediata.

Data Inicial: 19/01/2017 Data Final: 20/01/2017 Nova Pesquisa Download de Dados

Data	Hora	Temperatura (°C)			Umidade (%)			Pto. Orvalho (°C)			Pressão (hPa)			Vento (m/s)			Radiação	Chuva
	UTC	Inst.	Máx.	Mín.	Inst.	Máx.	Mín.	Inst.	Máx.	Mín.	Inst.	Máx.	Mín.	Vel.	Dir. (°)	Raj.	(kJ/m²)	(mm)
19/01/2017	00	23.9	24.9	23.9	91	91	90	22.3	23.2	22.3	1012.7	1012.9	1011.4	3.2	263	5.0	-1.85	12.0
19/01/2017	01	22.6	23.8	22.5	93	93	91	21.4	22.2	21.4	1013.9	1013.9	1012.7	2.2	246	7.0	0.171	39.6
19/01/2017	02	22.8	22.8	22.5	94	94	93	21.7	21.7	21.4	1013.9	1014.1	1013.8	1.8	269	3.8	-1.71	5.8
19/01/2017	03	22.4	22.9	22.4	94	94	94	21.3	21.8	21.3	1013.5	1013.9	1013.5	2.3	249	4.2	-0.76	7.2
19/01/2017	04	22.5	22.6	22.3	94	94	94	21.5	21.6	21.3	1012.8	1013.5	1012.8	0.2	259	3.9	-2.02	3.4
19/01/2017	05	22.5	22.6	22.4	94	94	94	21.4	21.5	21.3	1012.3	1012.8	1012.3	0.9	270	1.6	-1.83	2.0
19/01/2017	06	22.5	22.5	22.4	94	94	94	21.4	21.5	21.4	1011.5	1012.3	1011.5	0.2	238	1.6	-0.61	0.2
19/01/2017	07	22.3	22.5	22.2	94	94	94	21.2	21.4	21.1	1011.2	1011.5	1011.2	0.9	260	1.5	-2.69	0.0
19/01/2017	08	22.1	22.4	22.1	94	94	94	21.1	21.3	21.1	1011.2	1011.2	1011.1	0.9	248	2.0	-2.54	0.0
19/01/2017	09	22.3	22.3	22.1	94	94	94	21.3	21.3	21.1	1011.8	1011.8	1011.2	1.0	186	2.3	20.18	0.2
19/01/2017	10	22.9	22.9	22.3	93	94	93	21.8	21.8	21.2	1012.7	1012.7	1011.8	1.1	290	2.3	133.2	0.0
19/01/2017	11	23.3	23.3	22.8	93	93	93	22.1	22.1	21.6	1013.6	1013.6	1012.7	0.3	326	2.3	210.4	0.0
19/01/2017	12	24.9	24.9	23.3	90	93	90	23.1	23.3	22.1	1014.0	1014.0	1013.6	0.3	212	1.2	827.8	0.0
19/01/2017	13	28.1	28.1	24.9	80	90	80	24.3	24.3	23.1	1013.9	1014.1	1013.9	0.3	82	2.0	1942.	0.0
19/01/2017	14	29.3	29.3	28.0	68	80	68	22.8	24.4	22.7	1013.9	1014.0	1013.9	1.5	18	3.4	2392.	0.0
19/01/2017	15	29.3	29.5	28.8	63	68	62	21.6	22.5	21.0	1013.7	1013.9	1013.7	1.1	30	2.8	1991.	0.0
19/01/2017	16	23.6	29.2	23.6	88	88	63	21.5	22.0	20.9	1014.3	1014.5	1013.7	0.5	276	5.5	339.4	10.8
[illegible]	17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19/01/2017	18	25.1	26.2	25.1	84	88	82	22.2	23.3	22.2	1013.7	1013.7	1013.5	1.7	157	4.6	984.2	0.6

Figure 18 - Data from the meteorological station of Paraty, RJ (Source: INMET).

The Automatic Meteorological Station recorded atmospheric pressure measurements ranging from 1, 013.7 to 1, 014.5 hPa in the interval between 15:00 and 16:00 (UTC), winds of 0.5 to 1.1m/s with gusts of up to 5.5m / s and cumulative rainfall of 10.8mm.

Aiming at an approximate measurement of the horizontal visibility present in the region, at the time of the accident, the Investigation Team used the images recorded by a security camera (Camera 4 Dome Heliponto). In addition were adopted some points on the ground (Referência 1,510m; Referência 2,875m; Referência 5,320m) which were used as reference distance for the determination of the visual range, according to Figure 19.

The figure also illustrates the position of the Paraty Aerodrome, RJ, and the position of the aircraft wreckage (red circle and white letters).

Figure 19 - Relative positions of the Aerodrome, of the camera and the distance references seen in the recorded images.

The camera images recorded the times without the adjustment of the Brazilian Daylight Saving Time, so it is necessary to add three hours to determine the time of generation of the images in the Coordinated Universal Time (UTC) used in aviation.

In the image generated at 15:01:03 (UTC), SBMT aircraft take-off time, it is possible to visualize all the elevations adopted as references for distances of 1,510m, 2,875m and 5,320m (Figure 20).

In the image generated at 15:46:27 (UTC), about two minutes after the estimated time of the accident, the presence of rain with restriction of visibility is verified. At this point, it is possible to observe, with some difficulty, only the reference of 1,510m (Figure 20).

Figure 20 - Comparison of the visibility conditions at the aircraft crash site in two moments: on the left - takeoff time, and on the right - two minutes after the accident.

For aeronautical purposes, visibility is defined as the greatest distance at which an object of appropriate size can be seen and identified when observed against a bright background.

In this way, it was verified that the horizontal visibility estimated in the region of the Paraty Bay was restricted to 1,500m, due to the rain.

1.8 Aids to navigation.

Nil.

1.9 Communications.

According to the transcripts of the recordings, it was verified that the pilot maintained integral radio contact with ATC, and that there was no technical abnormality of communication equipment during the entire flight.

The PR-SOM communications with the Ground Control and the Campo de Marte Control Tower, as well as the Approach Control - APP-SP were performed in a coordinated and clear manner, without there being anything significant to report.

During the descent, APP-SP cleared the aircraft to perform coordination-free frequency communications. After that, the PR-SOM made the initial call on the coordination frequency, informing that it was flying from SBMT to SDTK and that it was in the south sector, crossing 7,000ft.

Another aircraft, which had taken off from the Angra dos Reis Aerodrome, RJ (SDAG), to the SBMT, made the call on the coordinating frequency and reported that it was crossing 5,300ft upwards, flying towards SDTK vertical position.

The PR-SOM pilot replied that he was crossing 5,500ft and that he would make a left turn to enter the "base leg" of the SDTK traffic pattern.

After the coordination, the pilots exchanged some information regarding the weather conditions of SBMT.

The PR-SOM pilot reported on entering SDTK's "Echo" sector that he was crossing 3,800ft.

Upon reaching the vertical of SDTK, the pilot of the other aircraft reported that position at 6,500ft, stating that he would be tuning the coordination frequency of the visual corridors (VFR special routes).

Upon entering the final approach, the PR-SOM pilot reported the position, informing that he crossed 1,500ft.

A minute and nine seconds later, he reported that he was in SDTK's "Echo" sector, waiting for the rain to stop and visibility to improve.

Three minutes and thirty-one seconds later, the pilot reported that he was rejoining the final to runway 28 of SDTK, with landing gear lowered and locked. This was the last transmission, until the impact of the aircraft.

1.10 Aerodrome information.

The Aerodrome was public, administered by the Paraty City Hall, RJ, and operated under visual flight rules (VFR) in daytime.

The runway was made of asphalt, with thresholds 10/28, dimensions of 700 x 23m, with elevation of 10ft.

The northeast (NE) and east (E) sectors of the Aerodrome were predominantly comprised of the Paraty Bay.

The Indaiá Mountain was located in the west (W) section of the Aerodrome, with elevations reaching up to 6,099ft. Both the North sector (N) and the South sector (S) presented elevations ranging from 1,000 to 2,900ft, within a radius of 3NM from the center of the runway.

The threshold 28 was located 590m from the banks of the Paraty Bay and determined a final approach bow in the bay-continent direction.

The approach axis for threshold 28 had the highest terrain area of up to 950ft within a 5NM radius. At 1.5NM from the threshold, the runway 28 shaft was free of any natural obstacle, comprising, for the most part, the Paraty Bay.

Figure 21 - View from the final to the SDTK threshold 28.

1.11 Flight recorders.

According to RBHA-91, the installation of the Cockpit Voice Recorder was required for turbine-powered multi-engine aircraft with a maximum configuration for passengers with six or more seats, demanding two pilots for the approval requirements or an operational rule.

Therefore, because two pilots were not required for the C90GT model, both by type approval requirement and by operational rule, the CVR installation was not mandatory for the PR-SOM aircraft.

Although not mandatory, it was found during field investigation that the aircraft was equipped with a Honeywell CVR, PN: 2100-1010-00 and SN: 000402988.

Thus, immediately after recovering the CVR, the work to read the voice data of the equipment began.

Once the aircraft was submerged in salt water, the investigation team preserved the CVR so that it could be delivered to the CENIPA’s Flight Data Recorders Read-out and Analysis Laboratory (LABDATA) for opening, cleaning and drying.

By separating the Crash Survivable Memory Unit (CSMU) from the chassis, it was noted that there was no penetration of liquid in the memory and no physical damage to the recorder, such as kneading, twisting or submission at great pressures.

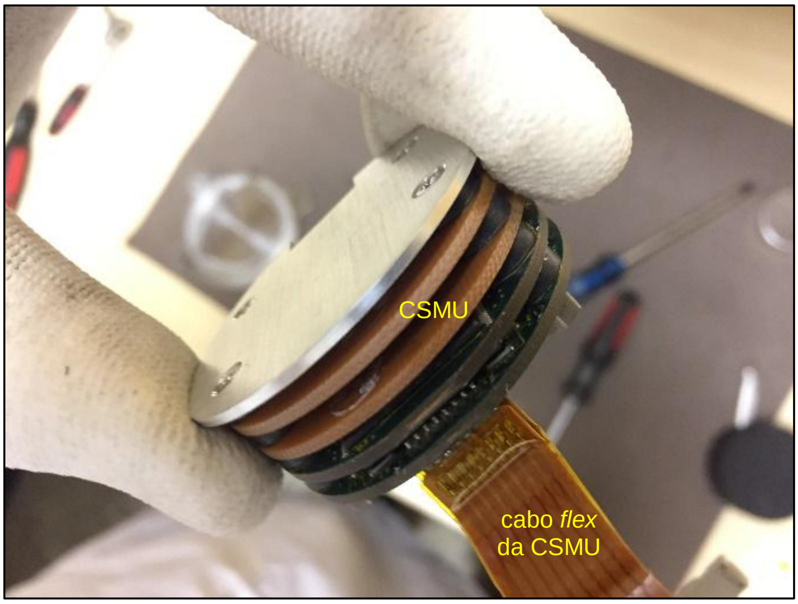

Figure 22 - Condition of the CSMU when removed from the CVR.

After that a CSMU flex cable replacement service was performed, it was possible to successfully read the last thirty-one minutes and four seconds of audio, according to the requirements of the recorder.

1.12 Wreckage and impact information.

The fuselage of the aircraft was taken out of the water in the early evening of 22JAN2017, after the rescue of the bodies of the occupants of the aircraft.

The right wing was sectioned at the inner section level of the right motor nacelle and fragmented into several pieces. The left wing was fixed to the aircraft and the damage was mainly observed on the leading edge of the outermost sections.

Most of the impact damage was concentrated on the right side of the aircraft, while the damage observed on the left side of the fuselage resulted from the rescue actions of the accident victims.

The position of the aircraft's fuselage was altered by boats in an attempt to rescue survivors, and its initial position could be defined by means of a scanner mapping of the marks left at the bottom of the sea (Figure 23).

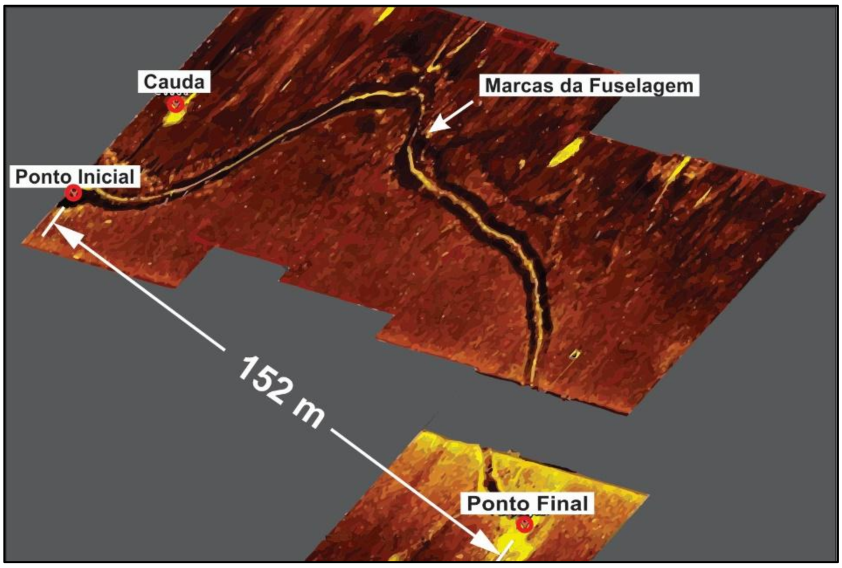

Figure 23 - Mapping of the marks left by the fuselage at the bottom of the sea.

The empennage set separated from the fuselage during impact dynamics, as well as the two engines that were launched forward due to inertial and impact forces.

The left propeller was found fixed to the respective engine. However, the right propeller and its reduction box separated from the right engine, being found at 145.72m from this. At that site, there were also fragments of the aircraft associated with the right wing.

Figure 24 - Left engine and propeller.

Figure 25 - Right engine and propeller.

The force of resistance resulting from the impact of the right wing against the water generated a moment in its center of gravity, causing the aircraft to turn and the damages observed in the fuselage (Figure 26).

Figure 26 - Right side view of the aircraft after its removal from the sea.

The larger mass components were thrown forward, projecting a magnetic bow corresponding to 042 ° (Figure 27).

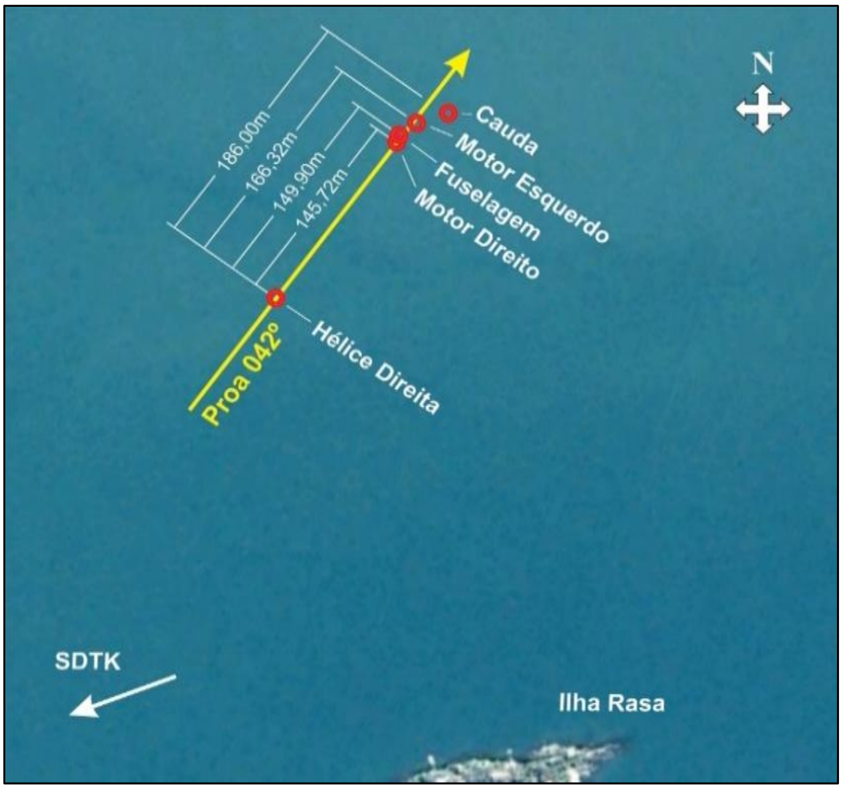

Figure 27 - Distribution of the aircraft wreckage at the bottom of sea.

The left main landing gear and the nose landing gear were in the above locked position, corresponding to that of the control lever on the aircraft panel (Figure 28).

Figure 28 - Left landing gear positions and
the control lever (red arrow).

The internal and external surfaces of the flaps of the left wing were deflected in an intermediate position, corresponding to 15°. The flap lever in the cabin was in the APPROACH position (Figure 29).

Figure 29 - Position of flaps and control lever (red arrow).

The power, propeller and fuel levers were advanced. The elevator compensator was in a position corresponding to UP 4.5, while the aileron and rudder compensators were in a neutral position.

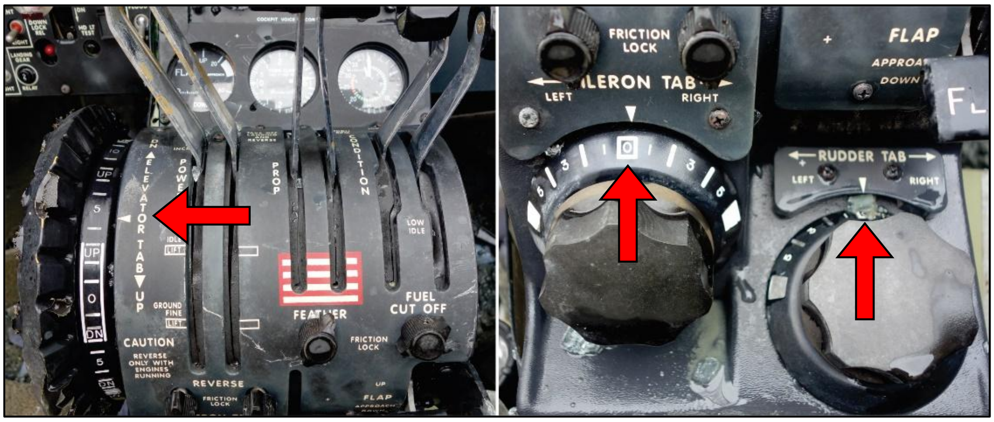

Figure 30 - Positions of the levers and the compensators.

It was found that the Instrument panel of the left station had no damage due to the impact of the aircraft (Figure 31).

The EGPWS panel was with the Terrain Inhibit pushbutton pressed (TERR INHB).

The airspeed indicator had no visible markings that could indicate the speed of the aircraft at the time of impact.

Regarding the Vertical Speed Indicator (VSI), it suffered water action and it was locked in the position of 1,200ft/min, without a reliable reading.

The Radio Magnetic Indicator (RMI) indicated the magnetic bow corresponding to 035°.

The electronic altimeter, the Electronic Attitude Direction Indicator (EADI) and the Electronic Horizontal Situation Indicator (EHSI) were de-energized, so there were no indications on those instruments.

The propeller synchronization switch (PROP SYN) was in the OFF position.

Figure 31 - Left-hand station instrument panel.

On the instrument panel of the right station (Figure 32), it was found that, similar to the panel of the left station, the airspeed indicator and the VSI had no readings indicating the aircraft's flight parameters at the time of impact.

The altimeter was set at 1013 hPa (QNE setting) corresponding to the en-route flight setting, while the artificial horizon had no visible markings that could indicate the attitude of the aircraft at the time of impact.

The HSI indicated the magnetic bow corresponding to 030°.

Figure 32 - Right-hand station instrument panel.

The right circuit breaker panel was broken in its upper left corner and had a crack in its lower right. It presented four disarmed circuit breakers (Figure 33).

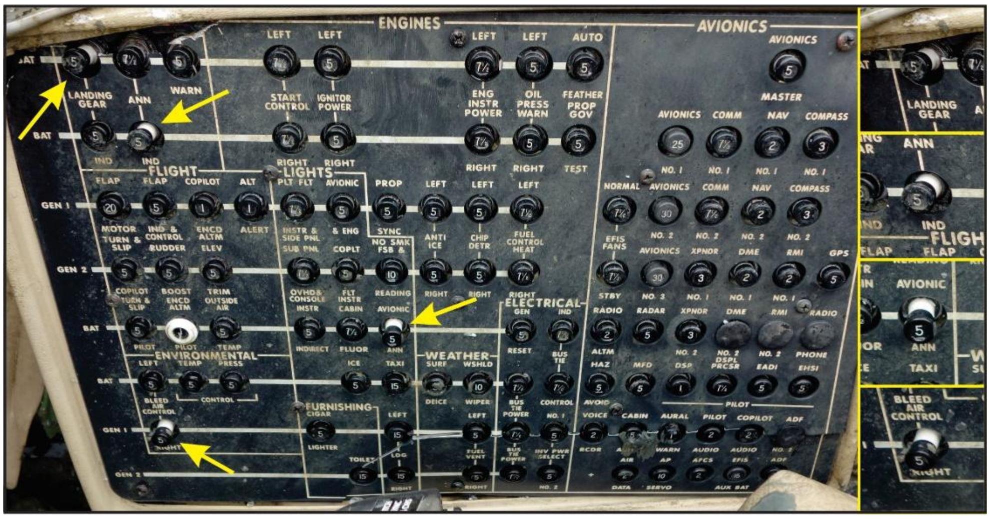

Figure 33 - Panel of circuit breakers on the right side. On the right, the disarmed circuit breakers (yellow arrows) are highlighted.

Disarmed circuit breakers supplied power to the following systems:

- Landing Gear (WARN) - related to the landing setup warnings when the landing gear was in the up position.
- Annunciator System (IND) - related to the anti-ice warnings (Right Engine Anti-Ice Control, Left Engine Anti-Ice Control and Pitot Anti-Ice), to the Inverters warnings and to the Pressurization Control.
- Avionic (ANN) - related to avionics controls lighting system.
- Bleed Air Control (Right) - related to the right engine pressurization and ventilation system of the aircraft.

The left circuit breaker panel remained undamaged and did not have any circuit break disarmed (Figure 34).

Figure 34 - Left circuit breaker panel.

The fuel control panel (Figure 35) had the left fuel quantity display locked on a position corresponding to 900lb. The right instrument was in a position that corresponded to a reading when it is de-energized.

The fuel control panel had the switches in the following positions:

- Trans Pump Override Left - Auto
- Boost Pump Left - On
- Transfer Test - Neutral
- Fuel Quantity Total / Nacelle - Neutral
- Trans Pump Override Right - Auto
- Boost Pump Right - On
- Crossfeed - Auto

Figure 35 - Fuel control panel.

The positions of the fuel panel switches corresponded to the positions expected for a normal flight condition.

1.13 Medical and pathological information.

1.13.1 Medical aspects.

The pilot had the first-class Aeronautical Medical Certificate (CMA) in the Airline Pilot category (PLA), valid.

According to the latest Health Inspection (INSPSAU), held at the São Paulo Air Force Hospital Nucleus (NuHFASP) on 26APR2016, the pilot was physically and mentally healthy, with indication of use of corrective lenses.

The pilot has always performed the INSPSAU regularly, as provided in the current regulations.

In all inspections carried out since 14FEB1985, he obtained the opinion "Able" or "Able for the purpose for which it is intended"

From 1988 on, there were indications of treatment with "use of corrective lenses" for visual changes (H52.0, hypermetropia, H52.2, astigmatism and H52.4, presbyopia). From 2000 on, the medical exams has presented a hearing loss (H90) diagnosis without significant repercussions and without indication of treatment.

According to information collected in post-accident interviews, the pilot never commented on any health problem. He did not smoke or drink, did not use any medication, showed no signs of stress or fatigue. He was not seen as a stressed person, being considered quite focused and professional.

According to reports from people close to him, the pilot always slept and woke up early, having at least eight hours of sleep a night. Likewise, there was no change in the routine performed during the 48 hours prior to the accident.

There was no evidence of alcohol in the pilot's blood. In the same way, the toxicological tests performed after the accident did not detect the presence of pharmacological or toxically active substances that could have interfered with his in-flight performance.

Spatial Orientation

Under normal conditions, the human being is able to determine, with precision, his spatial orientation. To do so, it uses information provided by three specialized sensory systems:

- the visual system, which provides 80% of orientation information;
- the vestibular system, related to the inner ear (semicircular canals, responsible for angular acceleration information, and otolithic organs responsible for linear acceleration and gravity information), which contributes 10% of the information; and
- the proprioceptive system (receptors located in the skin, muscles, tendons, ligaments and joints), which contributes another 10%.

Through specialized sensory receptors, these three systems constantly collect information that is transmitted to the central nervous system, where they are integrated and processed, creating a spatial orientation model that, under normal conditions, it is highly reliable. This model determines the position of the body in relation to a fixed system of coordinates that has as reference the Earth (horizontal) and the gravity (vertical).

These so complex and important systems, were not "designed" to operate in the three-dimensional environment of flight. Flight movements dramatically increase the risk of Spatial Disorientation (DE), given the physiological limitations of human orientation systems. Under these circumstances, guidance can be maintained with the aid of instruments.

In situations where visual references are poor or absent, such as in bad weather or at night, up to 80% of normal orientation information can be lost, with the remaining 20% being in charge of the vestibular and proprioceptive systems. Under these conditions, these two systems each, contribute 50% of the orientation information. However, they are less accurate and more prone to illusions and misinterpretations. This becomes especially relevant in the three-dimensional environment of flight, and explains the various types of illusion a pilot can experience.

In this way, the lack of good visual references deprives the human being of most of the information about his orientation. Therefore, most disorientation events are associated with a lack of visual references, such as instrument meteorological conditions (IMC) and night flights.

On the earth's surface, orientation is generally limited to two axes of motion (forward or backward and left or right). In aviation, the altitude dimension is added, which significantly changes the experiences perceived by the visual and vestibular systems. For this reason, the complex movements of the flight environment increase the probability of occurrence of spatial disorientation by exposing the physiological limitations of the normal systems of orientation of the human being.

Spatial Disorientation

In general, Spatial Disorientation is the misperception of the position and movement of the body in space.

With regard to aeronautical accidents, Spatial Disorientation is defined as "occurrence in which the pilot in command enters into confusion in the interpretation of the attitude of the aircraft, whether or not entering into an abnormal attitude."

Changes in linear acceleration, angular acceleration, and gravity are detected by receptors in the vestibular and proprioceptive systems and are compared in the brain with visual information. Any difference or discrepancy between the sensorial stimuli coming from the visual, vestibular and proprioceptive systems can cause a sensorial incompatibility, being able to produce illusions and lead to Spatial Disorientation.

Therefore, illusion is a false impression of reality, or misperception of something that exists objectively. The illusions are divided into two major groups:

- vestibular illusions, and
- visual illusions.

With respect to the accident involving the PR-SOM aircraft, conditions were found that favored the occurrence of the following types of illusion:

a) vestibular illusion by excess of "G" force.

This type of illusion is a complex phenomenon because it involves multiple stimuli in the vestibular system. In practice, it happens when the pilot makes a curve with a load factor greater than 1G and looks back into the curve. In this condition, the pilot experiences the sensation that the angle of inclination is reducing.

During 2G curves, a pilot may experience an apparent decrease in tilt angle of at least 10 to 20 degrees. To maintain the desired angle, the pilot tends to apply more inclination, leading to a significant increase of the initial inclination. This can result in loss of altitude and / or stall.

This type of illusion is potentially dangerous, especially if it occurs on flights at low altitude and at high speeds, due to the limited time available to recognize and recover from the illusion.

b) Visual illusion of homogeneous terrain.

This type of illusion is characterized by the false perception of height (above the real) when flying over a terrain with few details (or poor in characteristics) like water, dark areas, sand or snow.

False perception of height results from the feeling of "ground floating in space" due to lack of terrain features, such as the presence of objects of known size.

The more distant objects are the less visual angle to perceive them (due to size and distance). Thus, the characteristics of the terrain provide not only information on the horizontal distance, but also on the height.

In this type of illusion, the pilot's inability to estimate his height above the ground is due to the lack of focal and environmental visual signals, as a consequence of the constancy of the sizes and shapes observed in a terrain devoid of objects of known size.

Due to the false perception of being above the desired height, the pilot tends to start a descent, which can lead to a significant loss of altitude.

In addition to the illusions, situations such as: overload of work in the cabin, stress, adverse weather conditions, alternation between visual and instrument flight, as well as lack of adequate training, can also contribute to the process of spatial disorientation.

1.13.2 Ergonomic information.

Nil.

1.13.3 Psychological aspects.

<u>Individual and psychosocial information relating to the pilot.</u>

According to reports from people of his acquaintance, the pilot was considered caring and considerate, but very reserved.

Friends, family members and co-workers reported that the pilot did not usually share his problems or complain about adverse situations. Even in the family environment, he kept himself calm and reserved.

According to the information obtained, the pilot considered himself a shy, anxious person who did not like to make mistakes. He praised punctuality and was displeased with situations of delay.

He had a good relationship with the people of his personal and professional life. Although reserved, he was known by many of the pilots operating from SBMT. According to the reports obtained, he always treated others with courtesy and sympathy.

Since 2002, he was a pilot for the Grupo Emiliano, in an exclusive dedication. In most cases, the flights had the purpose of transporting the PR-SOM owner on personal travel.

According to reports from people of owner´s acquaintance, he was seen as a person with an imposing attitude. Often he expressed himself firmly and sometimes carried himself roughly. Despite this posture, there were no reports of any problem in the professional relationship between the pilot and the owner.

On flying days, the pilot used to arrive in the hangar in advance to transmit the flight plan, to fuel the aircraft, and to perform pre-fly inspection.

On the day before the occurrence, the owner personally called the pilot. Usually the secretary made the flight schedules.

The flight was scheduled for the morning period at 13:30 (UTC), however, one of the passengers arrived late, causing delay of an hour and thirty minutes in the takeoff.

According to information, the delay of one of the passengers bothered the owner. There were no reports of the pilot's reaction to the delay. However, it is known that the pilot was familiar with this situation, since eventually, the owner was also late for flights.

There were times when the pilot waited in the hangar, for hours, without expressing dissatisfaction with the delay. According to the information obtained from people close to the pilot, waiting was seen as part of his work, as he considered delays as a feature of the executive aviation.

Considerations about SDTK operations conducted by PR-SOM pilot.

Traffic patterns for landing in SDTK occurred under VFR rules; however, there was an unofficial IFR chart for landing procedure in the aerodrome. According to reports, some pilots used this chart as an auxiliary resource during approach and landing procedures.

According to reports from people who operated with the PR-SOM pilot, despite the existence of this unofficial procedure, he did not make use of this resource.

It was found that the pilot used to consult only basic information, such as the METAR from nearby locations. He also consulted with people that were familiar with SDTK to get their opinion on cloud-layer conditions and visibility.

Due to the frequency of flights to SDTK, the pilot was already accustomed to different operating conditions at that Aerodrome. Other pilots who were interviewed and also operated in the region, considered it possible that he had already performed some operations in adverse weather conditions. However, according to the perception of these interviewees, the pilot would avoid very critical adverse conditions that could compromise flight safety.

According to the data obtained, during the years that he worked for the operator, there were no situations in which the pilot had failed to perform the flight according to the schedule.

The owner, although described as an imposing and demanding person, did not intervene in the conduct of the flight. According to the reports obtained, he usually kept himself involved with conversations or readings throughout the flight.

However, during the descent to SDTK traffic pattern, it was common for the pilot to fly over an operator property's side, with a slight deviation from the trajectory. According to people who have already flown with the pilot, this over flight routinely occurred on flights to that location, as it was a request from the owner himself.

During the investigation process, there were reports that the pilot had already done go around procedures during approach to SDTK. In addition, he advised other pilots about how to perform a go-around procedure in that Aerodrome.

According to the interviewees, the pilot expressed that the best profile to be followed would be to "keep the aircraft level in a right turn, flying over Paraty Bay, in order to avoid inadvertent entry in instrument meteorological conditions (IMC) and thus avoid collision against elevations."

Considerations about the group of pilots operating on SDTK

It was common for many pilots operating from SBMT to perform flights to SDTK, which led to the formation of an informal group of pilots operating in that region.

The experience accumulated by the PR-SOM pilot over the years conferred professional recognition on both the operator and other pilots flying in the region. For these reasons, he was considered a reference.

After an accident in SDTK, in 2016, this group of pilots had the initiative to hold a meeting. The objective was to discuss issues relating to the safety of operations in the locality. On that occasion, due to experience, the PR-SOM pilot was invited to share his knowledge with others.

The event did not include the participation of external members of the group and did not count on the presentation of lectures or discussions focused on flight safety, but it was characterized as an opportunity to exchange experiences, with exclusive focus on the operation in SDTK.

In general, the concern of the pilots with the operation in the locality focused on the meteorological conditions, since Paraty, RJ, was located in a region subject to climatic instability. According to the interviewees, cloud formations and temporary rains were familiar to the residents, visitors and pilots, being a characteristic of the region.

At that time, some possibilities for improvements were discussed, such as the installation of cameras at the Aerodrome to view weather conditions, via the Internet.

There were no reports that the unofficial procedure for the IFR operation in SDTK was discussed during the meeting. However, as a way to try to increase the safety of operations at that Aerodrome, it was proposed to adopt unofficial ceiling levels and visibility of operation, in order to discourage flights under unfavorable conditions.

In order to deal with weather issues, pilots consulted information available on aeronautical meteorology sites, as well as people working at the Paraty Aerodrome or other pilots who had eventually landed in the area.

In some cases, even with prior knowledge of less favorable weather conditions in SDTK, some pilots decided to take off, assess conditions during flight, and then decide to proceed or return to SBMT. Although some interviewees reported not to act in such a way, this group of pilots considered this practice safer.

Beginner pilots usually make flights accompanied by a more experienced pilot before performing operations by themselves in Paraty, RJ, in order to settle with the region. Some parameters and reference points were taught, but each one developed its own standard of operation.

<u>Considerations about the executive aviation, according to the perception of pilots operating in the region of Paraty, RJ</u>.

Flight in the single pilot condition, common in executive aviation, was very common among pilots operating in SDTK. According to the interviewees, under these conditions, the pilot had no one to share decision-making on takeoff or judgment of en-route conditions.

Furthermore, according to this perception, they pointed out that, although the pressure to perform flights varied according to the employer's profile, it was difficult for the pilot's decision to be questioned when it came to issues related to flight safety.

The reports, however, indicated a collective perception that on some occasions the pilot himself might feel pressured to make a flight. In that case, they reported personal situations or other colleagues’ situations who postponed the decision to cancel the flight; made unsuccessful landing attempts, even after checking the unfavorable landing conditions; and, in some situations, concluded the operation despite the critical conditions.

1.14 Fire.

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

1.15 Survival aspects.

The first attempt to rescue the victims was carried out by people who were on boats near the crash site.

The aircraft was almost totally submerged, leaving the back of the left side and the left wing tip out of the water. The main door was deformed and partially submerged, making it impossible to open it. The emergency exit on the right side was completely submerged.

According to reports, there was a survivor in the back of the aircraft who was asking for help. There was an attempt to open a hole in the fuselage to insert an oxygen hose, to assist the survivor's breathing; however, there was no response after the insertion of the hose.

The fuselage needed to be cut by the rescue team, and the removal of the bodies was only possible twelve hours after the accident.

Belts and suspenders remained intact after impact. The rescue team cut the pilot's suspenders. It was not possible to confirm whether passengers were using their seat belts at the time of the accident.

The anatomical pathological tests confirmed that all the occupants of the aircraft had death due to multi-trauma because of the forceful action, due to the impact of the aircraft against the water.

1.16 Tests and research.

Spectral sound analysis of CVR data

With the objective of extracting as much information as possible from the CVR, an analysis was carried out at the National Transportation Safety Board (NTSB), followed by LABDATA technicians, who aimed to obtain data from spectral sound reading.

This analysis was performed by comparing the graphic information of standard sound frequencies normally emitted by the aircraft in relation to those recorded by the CVR, allowing the measurement of the parameters presented by the aircraft during the flight that culminated in the accident.

For the definition of the standard sound frequencies, it was used information supplied by the aircraft manufacturer, by the engine manufacturer, and recordings made in flight with a C90GT aircraft, which had the same configuration as the crashed aircraft.

The analysis pointed out that, at 15:37:12 (UTC), there was an audible tone with a duration of 0.384 seconds. When compared to the aircraft manufacturer's data, it was found that the tone had a spectral characteristic similar to the stall alarm. However, the aircraft was descending, crossing 5,100ft, and with ground speed recorded in the air traffic control RADAR corresponding to 197kt.

Signatures of the strong sound of the propellers were heard and observed through the spectrum, which coincided with approximately 1,900 RPM over the recorded period. Through both auditory observation and spectral analysis, it was observed that the frequencies of rotation of both propellers coincided throughout the flight, with a small variation observed at the end of the recording period.

At 15:42:41 (UTC) the beginning of a small speed differential between the propellers was observed. At the end of the recording, one of the propellers was at 1,875 RPM and the other at 1,950 RPM. The spectral analysis, however, did not allow defining to which engine each rotation was associated with (Figure 36).

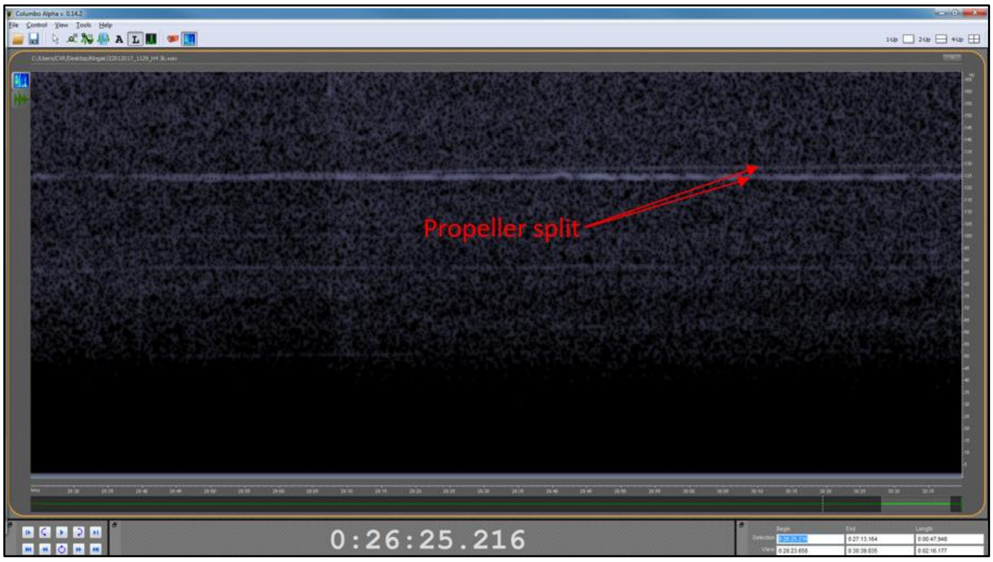

Figure 36 - Small detachment of the frequencies of the propellers rotation indicated in the spectrum.

When comparing the graphical information of the recording of another C90GT aircraft in relation to the information of the accident flight, the parameters of Figure 37 were obtained. Comparison of the data revealed lines that characterized the movement of the landing gear of the PR-SOM aircraft.

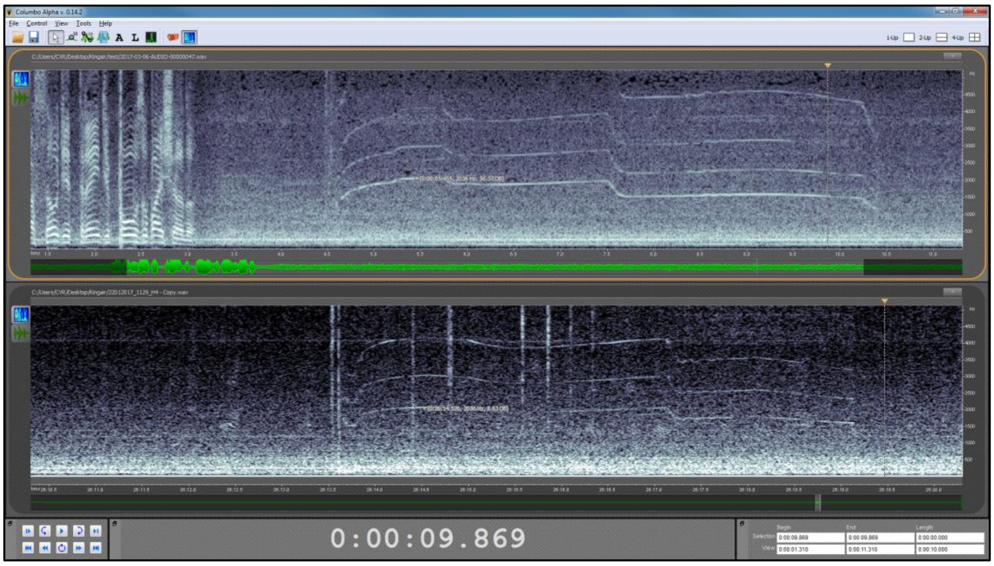

Figure 37 - Comparison between flight spectra with another C90GT aircraft (top image) and crash flight (bottom image).

Thus, it was possible to identify the landing gear at retraction at 15:40:23 (UTC) and 15:44:12 (UTC).

Subsequent analyzes made it possible to identify the following parameters during flight:

- EGPWS Sink Rate callout at 15:39:49 (UTC);
- Similar sound to altitude alert at 15:43:23 (UTC); and
- Strong impact sound at 15:44:27 (UTC).

The flap extension and retraction sounds were not audible or observable in the CVR spectral analysis. This may have occurred mainly due to the prevalence of extra noise coming from the aircraft in flight.

The spectral signatures of the engine compression stages were present, but did not allow an analysis with an adequate level of reliability.

It was not possible to confirm the presence or absence of rainfall precipitation noises.

Analysis of voice, speech and language parameters

The flight data recorded in CVR were submitted to biometric identification, performed from the analysis of voice, speech and language of the pilot. A specialist in causal nexus analysis between changes in vocal parameters and occupational activity conducted the exam.

For the establishment of the voice standard and conduction of the comparative analyzes, audio files that recorded the pilot's spontaneous speech in relation to the PRSOM CVR audio were used.

This analysis was based on the concept that the emotional state influences the speaker, causing variations resulting from the physiological responses elicited in the individual by the emotions. These changes, in turn, cause variations in breathing, phonation and articulation, processes directly related to speech.

It is emphasized that emotions are produced from an automatic cognitive assessment of the individual on external and internal events considered relevant to their interests and needs. They are also characterized by a high degree of synchronization of almost all the subsystems of the organism (cognitive, motivational, physiological and motor).

According to the data obtained, no interaction was observed between the pilot and the other passengers during the last thirty minutes of flight.

By means of the spectrographic image, there were excerpts in which the pilot presented a rate of normal elicitation to slightly increased (6 to 6.8 síl/sec) and high F0 (fundamental frequency).

In addition to these acoustic parameters, it was observed an acute pitch for the male pattern and in comparison with the pilot's own pattern, incoordination of the pneumophonoarticulatory (alteration in coordination between breathing and articulation). Likewise, vocal quality was tense throughout the flight, accentuating itself in the passage shown, and in this section, the voice was slightly shaky.

It is important to point out that the pilot presented himself breathless during the whole flight, and there was a moment of accentuation in the section of Figure 38

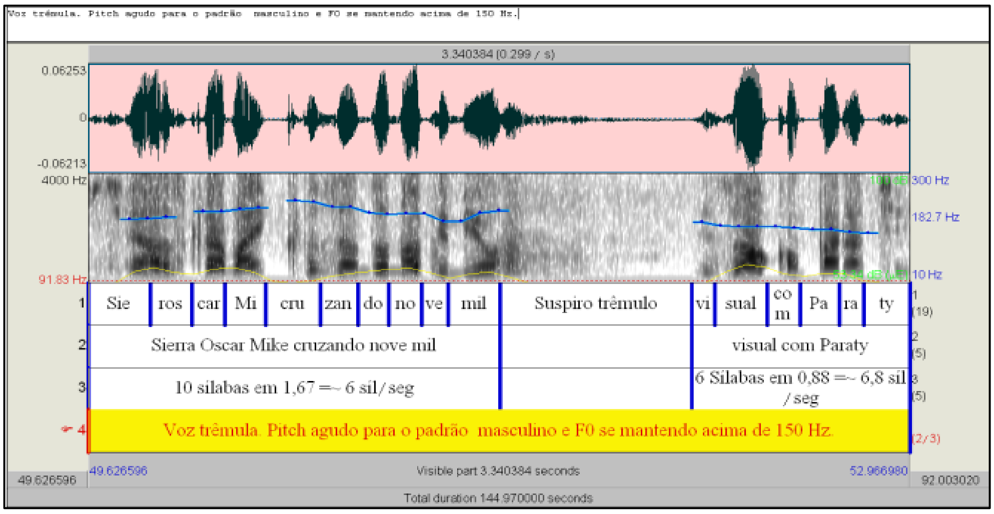

Figure 38 - Excerpt from the pilot’s dialog with APP-SP at 15:32:18 (UTC).

In the penultimate verbalization recorded before impact, it was reported in the phonics that the pilot would wait for the rain to stop, keeping 1,300ft (Figure 39).

At that moment, the pilot presented normal elocution rate, normal articulation rate for slightly increased, high F0, acute pitch, pneumophonoarticulatory incoordination, tense vocal quality, breathless speech, and voice trembling. In this section, these characteristics were more accentuated than previously demonstrated.

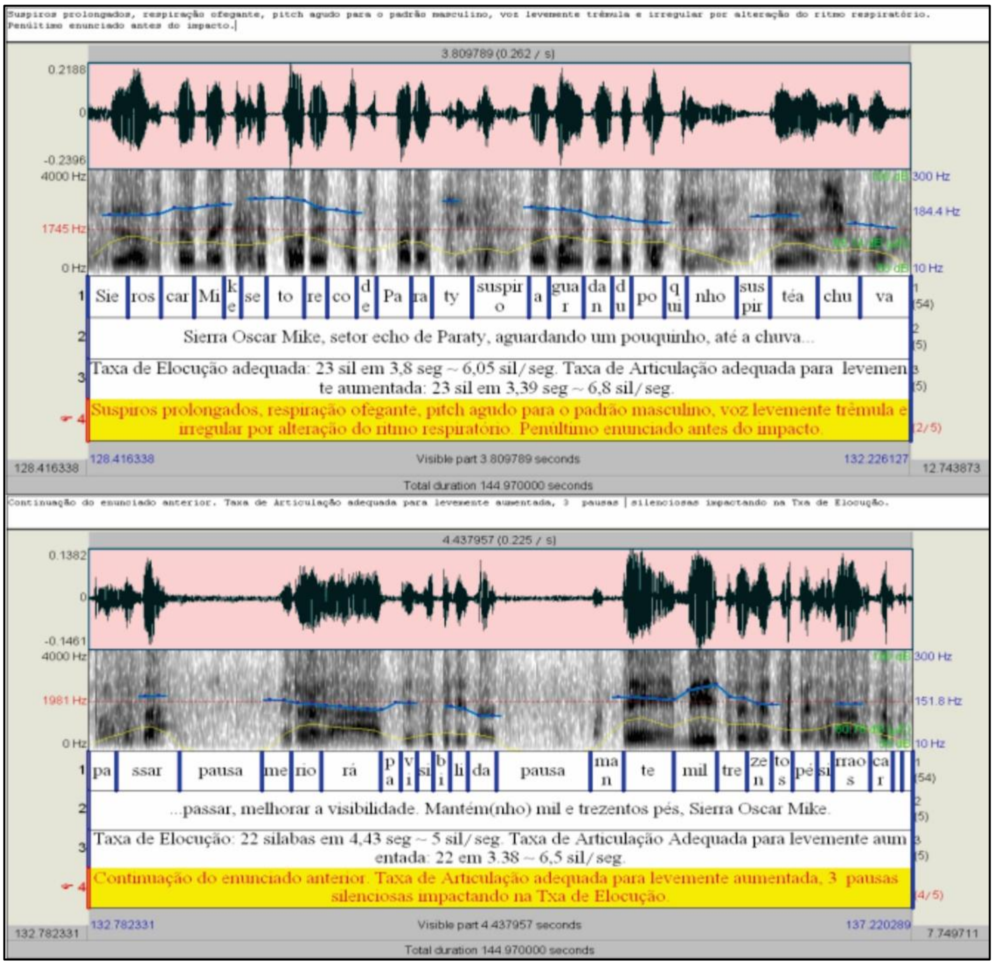

Figure 39 - Excerpt from the pilot's communication on the coordination frequency at 15:40:37 (UTC).

Thus, considering the scientific studies on the methodology of acoustic and clinical parameters to evaluate the expression of emotions, it was possible to infer that the pilot had traces of apprehension/worry and anxiety, ranging to fear, especially in the instant immediately before impact.

No evidence of fatigue or drowsiness was found by analyzing voice, speech, and language of the pilot in the audio files of the day of the accident, nor alterations consistent with the use of narcotic substances of the central nervous system.

Likewise, there were no shouts or any emissions indicative of the panic situation of the pilot or the passengers before the impact.

<u>Extraction of data from the EGPWS</u>

The aircraft was equipped with an EGPWS Honeywell model PN: 066-01175-2102, SN: 1337.

Although the EGPWS did not meet the certification requirements for data recording or impact survival, it was made an attempt to extract possible information recorded in the moments prior to the PR-SOM accident.

One design feature of this EGPWS relates to its ability to record GPS-based data relating to the conditions identified by the equipment at the time that proximity with the terrain alerts were issued.

Thus, the EGPWS created a flight history that contained the data relating to twenty seconds before and ten seconds after each caution/warning issued by the equipment (Figure 40).

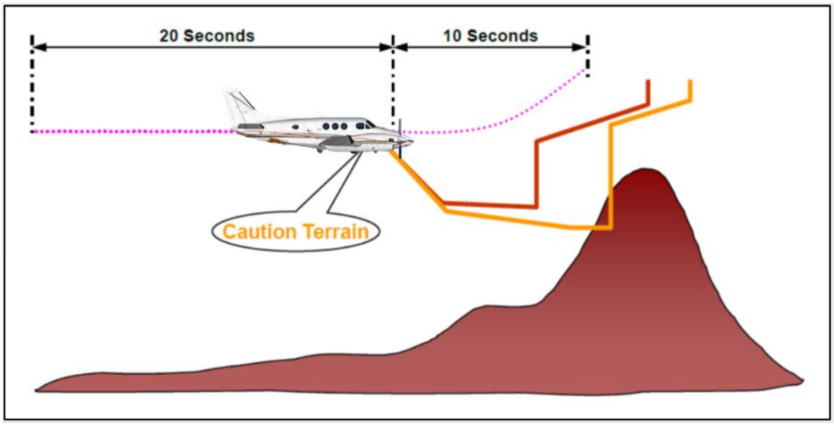

Figure 40 - Illustration of EGPWS data recording logic.

In this way, the Investigation Team preserved the EGPWS and the components that could have recorded information from the accident flight were segregated for data extraction at the manufacturer's facilities.

The data extraction was performed successfully and it was verified that the equipment had recorded information from four issued alerts, which corresponded to the flight of the accident, being:

- Sink Rate at 15:39:49 (UTC);
- Terrain Caution / Terrain Warning at 15:42:55 (UTC);
- Terrain Warning at 15:43:23 (UTC); and
- Runway Field Clearance Floor at 15:43:39 (UTC).

At 15:39:51 (UTC), the TERR INHB pushbutton was pressed, inhibiting subsequent visual and audible warnings to the pilot. Such alerts, however, remained recorded in the EGPWS memory.

The Terrain Caution, Terrain Warning, and Runway Field Clearance Floor alerts had their recording intervals partially overlapped. It was found, after the de-recording, that there was one minute and forty-six seconds of recorded data relating to the flight of the accident.

Examination of flight controls, flaps and landing gear.

Cables, rods, bellcranks mechanically actuated the primary flight controls of the C90GT aircraft, and their design characteristics did not allow determining positions at impact. Thus, the tests carried out were aimed at verifying the conditions of continuity of the components of the flight commands.

It was observed that the control cables showed signs of oxidation due to contact with salt water and exposure to the ambient atmosphere.

Figure 41 - Overview of the central quadrant on the aircraft floor with oxidation signs on the control cables of the primary surfaces and the compensators.

The continuity of the aileron control was verified from the movement of any of the control yokes located in the cabin of the pilots. The command was reproduced, passing through the central quadrant on the floor of the aircraft until each of the points of rupture in the wings.

The control cables of the right aileron had, at the breaking point, an overload fault characteristic, consistent with impact forces.

Regarding the left aileron control cables, they had a rupture at the place where the rescue teams performed the separation of the left wing to transport the wreckage.

From the breakpoints mentioned above, it was found that the control cables were intact up to the aerodynamic surfaces of the wings and that there was no sign of any condition that could interfere with their performance.

Regarding the compensation on the bearing shaft, the C90GT had a single compensating surface, located on the left wing. The aileron compensator had an actuator that allowed the measurement of its extension for position determination.

The tests showed that the deflections of the actuator of the aileron compensator corresponded to the indications of the cabin, which, after lifting the aircraft, had a control position in neutral.

Regarding the elevator and rudder controls, it was observed that the controls applied to the control yokes and pedals were reproduced to the point where the tail was broken.

Near the point of rupture, pulleys and fractured fixtures were observed, both in the fuselage section and in the tail area. The observed damages had characteristics of overload due to the impact forces. No conditions were observed that could interfere with the authority of the elevator and rudder controls of the aircraft.

Figure 42 - Elevator control cables.

The position indicator of the compensator in the cabin, after lifting the aircraft, had a position equivalent to 4,5° UP. The measurement of the left and right actuators of the elevator compensator, however, corresponded to a position between 0 ° and 5 ° DOWN and were not reliable due to the possibility of movement due to the impact.

The position indicator of the rudder compensator had a position equivalent to neutral, while the actuator measurement corresponded to the fully deflected position to the left. The measurements of the positions of the actuators were considered unreliable due to the damages caused by the impact and the movement of the wreckage.

Regarding the Rudder Boost actuating cylinders, it was not possible to determine if this system was acting on the rudder surface at the moment of impact.

The flap system of the aircraft consisted of four actuators, two on each wing. The measurement of these actuators corresponded to a deflection of 15°.

In relation to the landing gear, it was observed that all the legs and the selector were with their actuators in positions that corresponded to the up position.

Technical examination of the engines.

The left engine, model PT6A-135A SN: PCE-PZ0395, presented scuff marks between the compressor turbine vanes and the segmented ring and, more markedly, friction marks between the power turbine and the engine diaphragm. The friction marks are the result of the contact between the rotating parts of the engine and the parts that have been deformed as a result of the impact forces. Such marks are indicative that the engine had normal operation at the time of impact.

The gearbox and accessory box filters; fuel system and engine lubrication filters were analyzed. No filings or contaminants have been found that could affect the operation of the engine.

The exhaust duct of the left engine contained salt. Such deposit represents an indication that the engine was running at impact, as the heated exhaust, in contact with seawater, caused the water to evaporate, leaving only the deposited salt.

The right engine, model PT6A-135A SN: PCE-PZ0396, had characteristics similar to the left engine. Among the differences observed, the propeller rupture, along with the second stage of reduction, is outstanding. The bending marks in the turbine region of the compressor were lighter than those observed in the left engine, but the bending marks on the power turbine were well characterized.

In the same way, no filings or contaminants were found in the gearbox and accessory box smoke detectors, as well as in the fuel and engine lubrication system filters, which could indicate a malfunction.

The salt deposit was observed in the right engine exhaust duct, similar to that observed in the left engine.

Thus, the test results concluded that both engines were in operation at the time of impact. However, the characteristics of the damages verified did not allow determining the level of power developed by the engines.

1.17 Organizational and management information.

The PR-SOM registration aircraft had, as operator, the Emiliano Empreendimentos e Participações Hoteleiras Ltda. This organization did not have other aircraft and did not perform activities directly related to aviation.

The aircraft was used privately (according to its category) for the transportation of the owner. Since its acquisition, the aircraft has been operated by the same pilot.

The flights performed by the pilot occurred, in the great majority, in the condition of single pilot, that is, with the aircraft being manned by only one pilot. On some occasions, there were flights accompanied by co-pilot, which was indicated by the pilot himself. There was, however, no definite criterion for flights, which might require the presence of a co-pilot.

According to the information obtained, because it was an aircraft whose operating requirements established the minimum crew of a pilot, there was no interest of the operator in hiring a co-pilot.

Management activities were delegated to the pilot, including aircraft maintenance issues. The services were performed after the approval of the operator.

It was observed that there was a previously established work routine. Flight frequency consisted, for the most part, of short-haul flights on weekends, from SBMT to SDTK, and vice versa.

This routine was common to most of the pilots operating on the SBMT-SDTK route, as there were many operators who owned homes and/or participated in leisure activities in Paraty, RJ, at weekends. Due to this reality, the operators tended to value the pilots who fulfilled the flights, even in unfavorable meteorological conditions.

According to the data obtained, the PR-SOM pilot showed interest in flight simulators training sessions, in order to maintain his technical proficiency. In the years 2014 and 2015, consultations were made to a flight simulators training center, however, there was no confirmation about the accomplishment of this kind of training. Likewise, there were no records of flight simulator training at ANAC.

Such trainings were not required for the category of the aircraft operation.

1.18 Operational information.

Preparation for flight.

The flight plan was presented at 10:35 (UTC) through telephone to the São Paulo Aeronautical Information Center.

The plan followed the commonly adopted profile, planning to take off from SBMT at 13:30 (UTC), and followed a route where it would initially fly under VFR flight rules during the climb via visual corridors (VFR special routes) and then make the transition to IFR flight.

He planned to fly on the FL150 until reaching DORLU position, where he would make the descent and make a new rule change for VFR, proceeding with bow to the destination Aerodrome. It estimated a time in route of 35 minutes, with declared flight autonomy of four hours and thirty minutes.

In the flight plan, four people were present on board, but this information did not correspond to the actual number of five people (Figure 43). Such information was not rectified during communications with ATC.

The aircraft was fueled on 19JAN2017 at 11:57 (UTC) with 500 liters (865 lb.) of JET A-1.

Due to the lack of fuel in SDTK, it was found that the pilot routinely planned to comply with SBMT-SDTK and SDTK-SBMT steps, without fueling in SDTK, filling up wing tanks before SBMT take-off.

With regard to aeronautical information, it was found that the Notice to Airmen (NOTAM) for the locality of SDTK did not report any information concerning the condition or modification of the aeronautical facility, service or procedure.

Development of the flight.

The pilot requested the authorization of the flight plan to the ground control at 14:49 (UTC). The take-off took place at 15:01 (UTC).

According to the coordination of the PR-SOM with the Air Traffic Control (ATC) and observation of the RADAR views of the Terminal Control Area (TMA-SP), it was observed that the take-off of SBMT and the ascent to FL150 occurred without abnormalities.

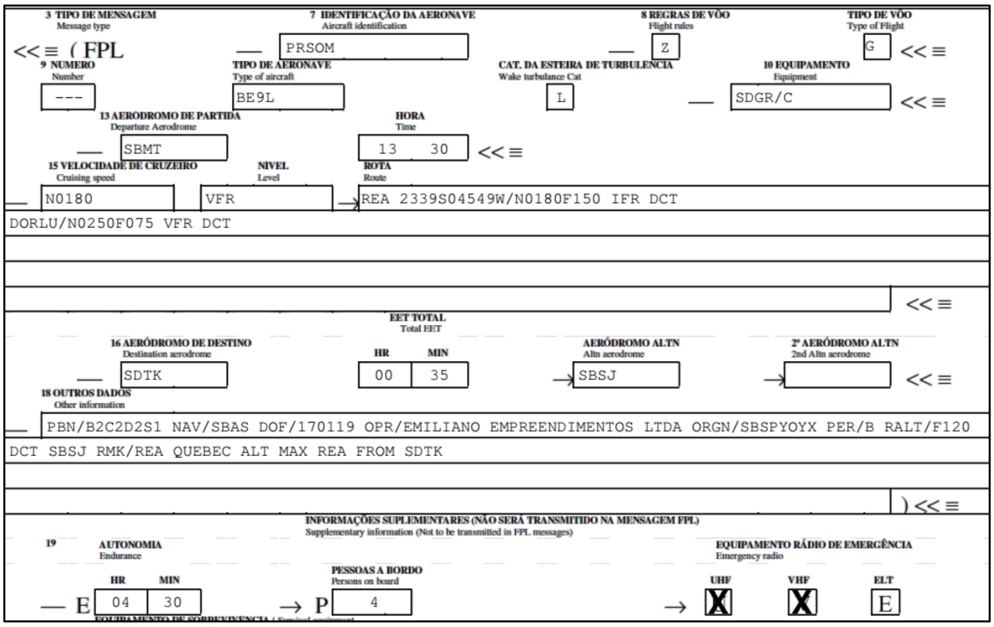
3 TIPO DE MENSAGEM / Message type: <<≡ (FPL
7 IDENTIFICAÇÃO DA AERONAVE / Aircraft identification: PRSOM
8 REGRAS DE VÔO / Flight rules: Z
TIPO DE VÔO / Type of Flight: G <<≡
9 NUMERO / Number: ---
TIPO DE AERONAVE / Type of aircraft: BE9L
CAT. DA ESTEIRA DE TURBULÊNCIA / Wake turbulance Cat: L
10 EQUIPAMENTO / Equipment: SDGR/C <<≡
13 AERÓDROMO DE PARTIDA / Departure Aerodrome: SBMT
HORA / Time: 13 30 <<≡
15 VELOCIDADE DE CRUZEIRO / Cruising speed: N0180
NIVEL / Level: VFR
ROTA / Route: REA 2339S04549W/N0180F150 IFR DCT
DORLU/N0250F075 VFR DCT
<<≡
EET TOTAL / Total EET
16 AERÓDROMO DE DESTINO / Destination aerodrome: SDTK
HR 00 MIN 35
AERÓDROMO ALTN / Altn aerodrome: SBSJ
2º AERÓDROMO ALTN / 2nd Altn aerodrome: <<≡
18 OUTROS DADOS / Other information:
PBN/B2C2D2S1 NAV/SBAS DOF/170119 OPR/EMILIANO EMPREENDIMENTOS LTDA ORGN/SBSPYOYX PER/B RALT/F120
DCT SBSJ RMK/REA QUEBEC ALT MAX REA FROM SDTK
) <<≡
INFORMAÇÕES SUPLEMENTARES (NÃO SERÁ TRANSMITIDO NA MENSAGEM FPL) / Supplementary information (Not to be transmitted in FPL messages)
19 AUTONOMIA / Endurance: E HR 04 MIN 30
PESSOAS A BORDO / Persons on board: P 4
EQUIPAMENTO RÁDIO DE EMERGÊNCIA / Emergency radio: UHF X VHF X ELT E

Figure 43 - Aircraft and planned route data fields.

At 15:25 (UTC), the PR-SOM requested the descent and left deviation of the route to Approach Control (APP-SP). The APP-SP authorized it to descend to the FL110, to make the deviations and requested that the aircraft report for the modification of the flight rules from IFR to VFR.

At 15:28:36 (UTC), the PR-SOM reported crossing FL130 and requested the change of flight rules for VFR.

From that moment on, the APP-SP confirmed the modification of the flight rules, leaving the descent below the FL110 at the pilot's discretion, informed the reference pressure adjustment (QNH) of the São José dos Campos Aerodrome, SP (SBSJ), of 1,018 hPa, and asked to report when crossing 9,000ft.

At 15:32:18 (UTC), the aircraft reported to APP-SP that it was crossing 9,000ft and that it was visual with Paraty, RJ. Subsequently, the APP-SP authorized the PR-SOM to continue performing air traffic coordination in the "free frequency".

After being cleared by the APP-SP, it was verified that the aircraft proceeded in descent towards northeastern direction, according to the APP-SP RADAR visualization (Figure 44).

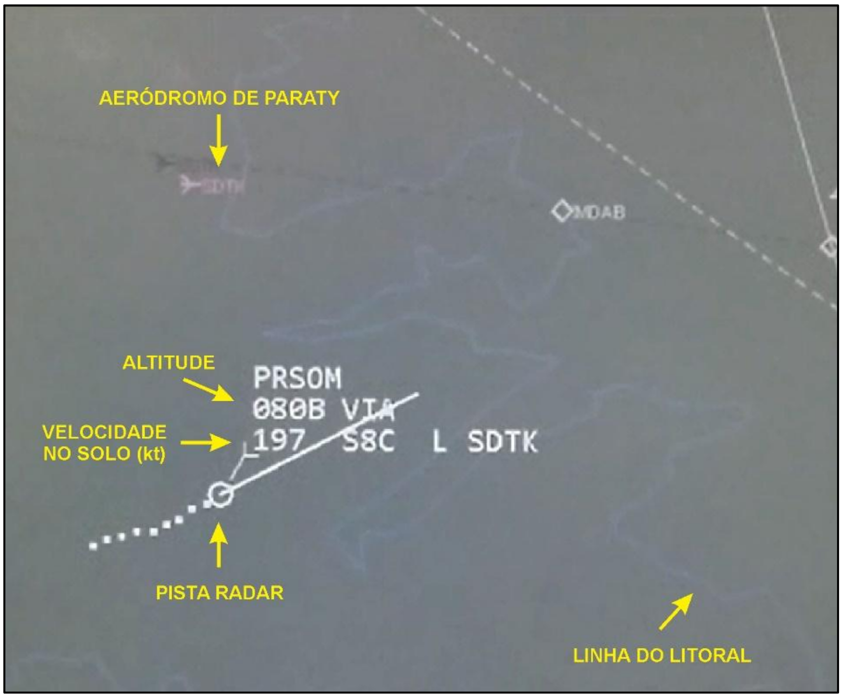

Figure 44 - APP-SP RADAR image recorded at 15:34:45 (UTC).

During the descent, according to CVR audio, the PR-SOM performed a traffic coordination with another aircraft that had taken off from the Angra dos Reis Aerodrome, RJ (SDAG), and was flying to SBMT (Figure 45).

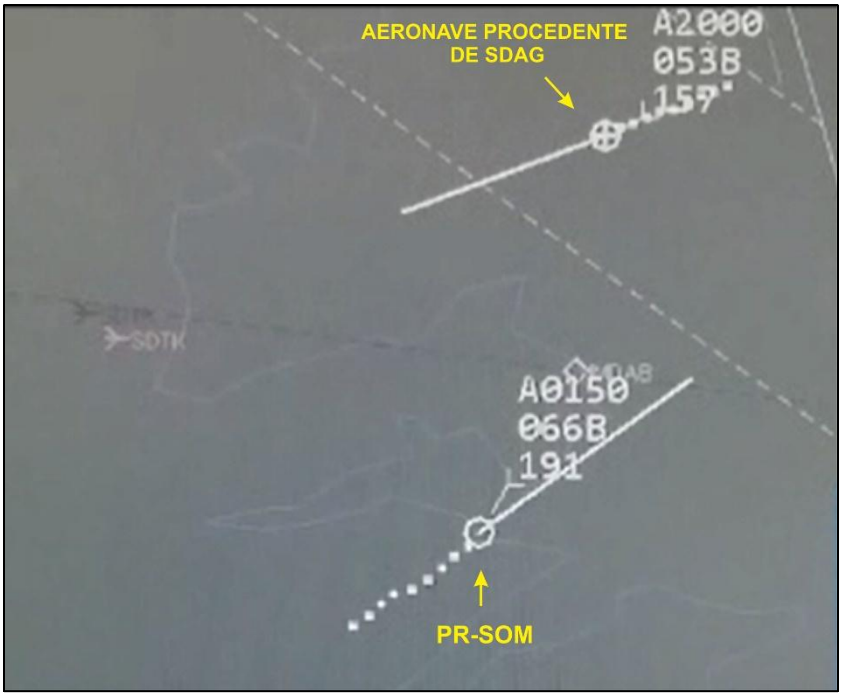

Figure 45 - APP-SP RADAR image recorded at 15:36:18 (UTC).

According to reports from people of his acquaintance, it was found that the pilot usually performed a flight path that tangentiated an area owned by the aircraft operator, during the descent to join the final approach and landing in SDTK.

On the day of the accident, the RADAR images of the APP-SP observed that the descent was performed, in relation to the property, according to the constant trajectory in Figure 46.

Figure 46 - Trajectory of the descent of the PR-SOM in relation to the ownership of the aircraft operator (illustrative image).

The PR-SOM continued to descend with the bow of the Paraty Bay and reported that it was in the sector "Echo" of the aerodrome, crossing 3,800ft.

When it reached 3,200ft, it made a left turn, still descending, reaching 2,300ft (Figure 47).

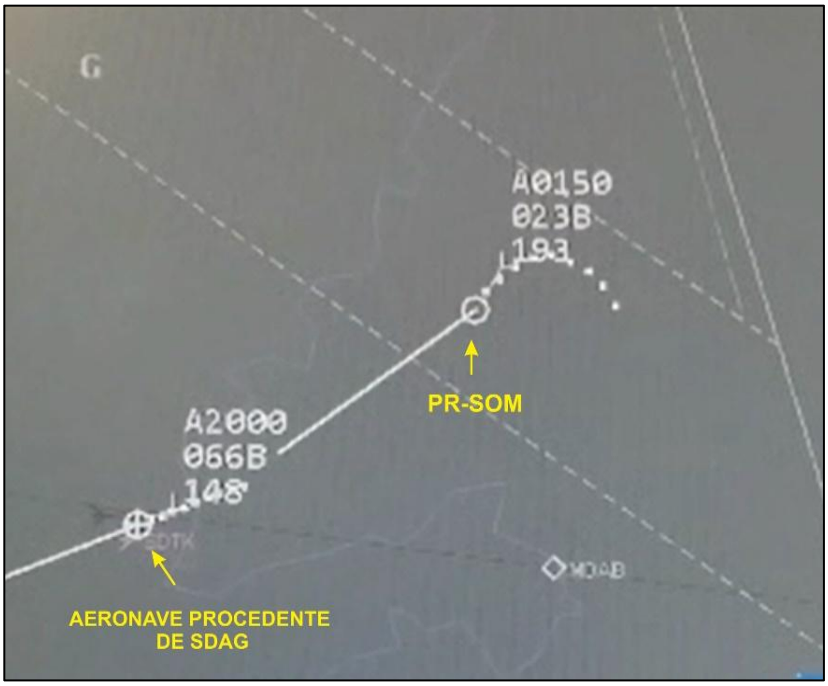

Figure 47 - RADAR image of APP-SP registered at 15:38:44s (UTC).

The aircraft then proceeded South and, as it approached the coast, made a right turn until it reached the SDTK Aerodrome, reporting that it was entering the approach to runway 28, crossing 1,500ft (Figure 48).

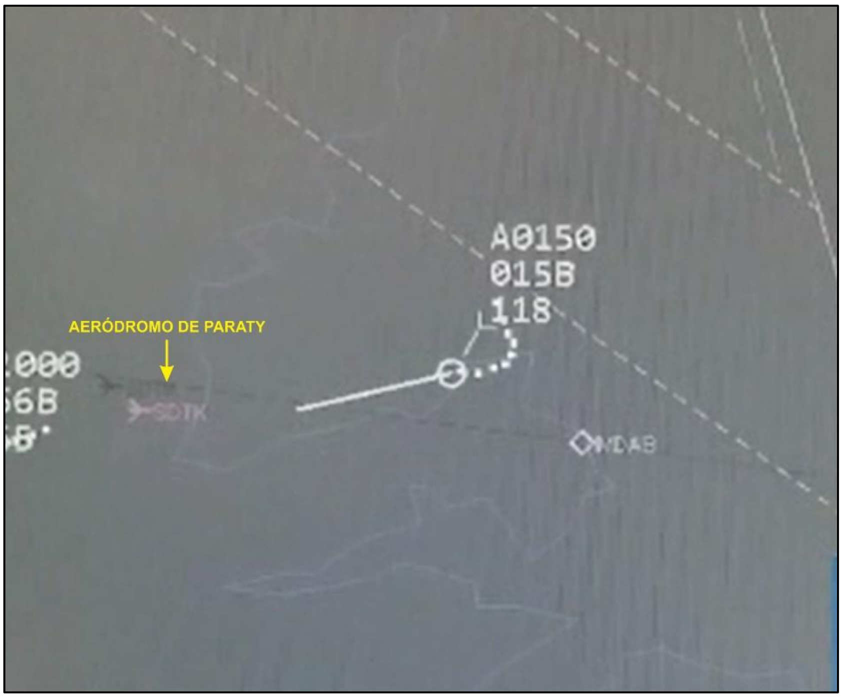

Figure 48 - APP-SP RADAR image recorded at 15:39:52 (UTC).

When synchronizing the data provided by APP-SP RADAR with the terrain information of the Paraty Aerodrome region, it was verified that the aircraft followed a descent profile according to the reconstruction shown in Figure 49.

Figure 49 - Reconstruction of the descent profile of the aircraft, according to the RADAR air traffic control data.

According to the data extracted from the aircraft's EGPWS, synchronized with the CVR audio, it was verified that, at the moment that the pilot reported the approach to runway 28, the aircraft passed over the tip of Paraty Bay, which had elevation of approximately 500ft.

The landing gear was lowered when the aircraft was at 1,570ft altitude. Subsequently, there was a significant increase in the rate of descent (2,000ft/min), resulting in a Sink Rate alert which was inhibited by the pilot in the EGPWS equipment.

At 15:39:45 (UTC), at the end of the first trajectory recorded by the EGPWS, the aircraft was at 890ft altitude, with 161kt of ground speed and bow 234°

Figure 50 - Aircraft trajectory profile during the first approach attempt, according to aircraft EGPWS data.

After 35 seconds of the Sink Rate alert, the landing gear was retracted and the pilot reported: "*Sierra Oscar Mike setor echo de Paraty, aguardando um pouquinho, até a chuva passar, melhorar a visibilidade. Mantém mil e trezentos pés, Sierra Oscar Mike*" ("Sierra Oscar Mike sector echo of Paraty, waiting a little until the rain to stop, improve visibility. It maintains one thousand and three hundred feet, Sierra Oscar Mike") (sic).

About two minutes and ten seconds after landing gear was retracted in the first approach attempt, the landing gear was extended again and the EGPWS registered the aircraft, skirting the tip of Paraty Bay in a gentle descent from 740ft.

The pilot reported that he was "re-entering" the final of Paraty, with landing gear down and locked.

At 15:43:56 (UTC), at the end of the second trajectory recorded by EGPWS, the aircraft was at 270ft height, with 121kt ground speed and 236° bow.

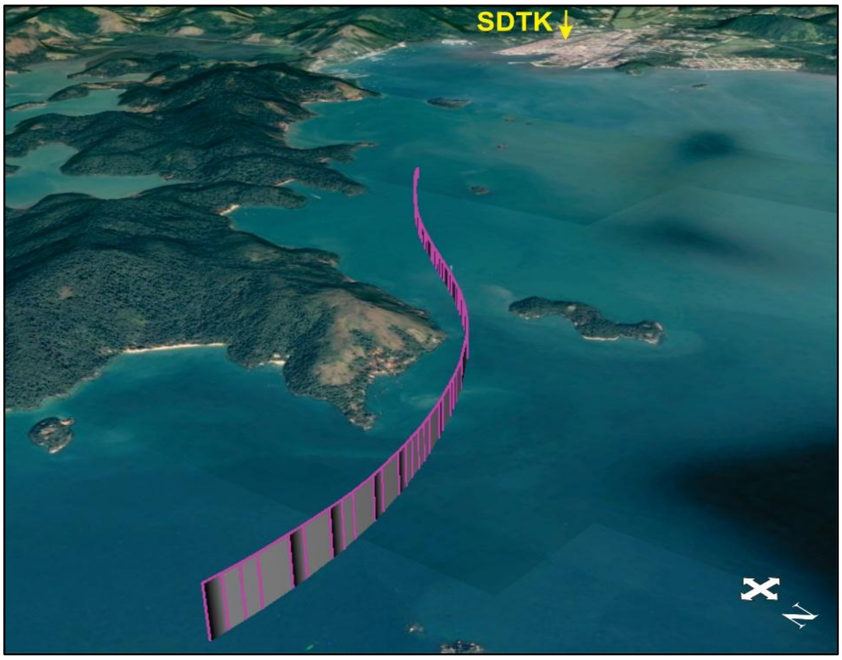

Figure 51 - Aircraft trajectory profile during the second approach attempt, according to the EGPWS data of the aircraft.

By combining the data from the last position recorded by the EGPWS, with the bow of the aircraft at the time of impact, with the recorded audio in the CVR and with the reports of observers, the Investigation Team has elaborated a mathematical model that describes an estimated trajectory of the aircraft. In this estimated flight path, it was possible to infer flight parameters and the sequence of events until the moment of the impact (Figure 52).

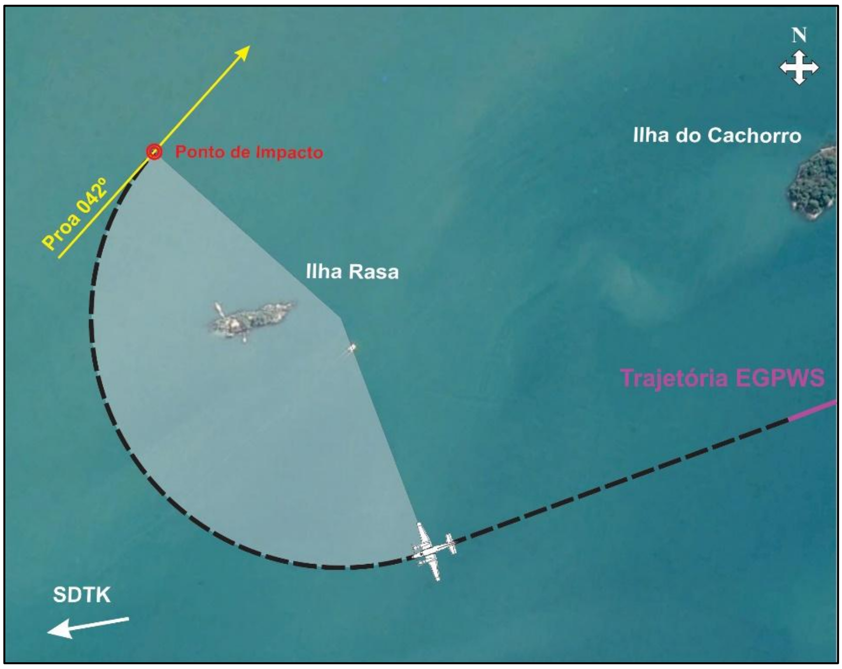

Figure 52 - Estimated aircraft trajectory between the last position recorded in the EGPWS and the point of impact.

The mathematical model adopted assumes a constant curve at the moment of impact, and the flight time of 31s from the last point recorded in the EGPWS. Thus, it is estimated that the aircraft started the curve at approximately 15:44:06 (UTC).

The landing gear was retracted at 15:44:12 (UTC), according to analysis of the audio of the CVR.

During the curve, the average speed was estimated to be 120kt and the bank angle varied around 38°, resulting in an average load factor of 1.27G.

According to reports from observers, the aircraft had a large tilt of wings to the right at the moment of impact.

1.19 Additional information.

Air traffic rules required for operation in SDTK.

The Paraty Aerodrome had an Aerodrome Traffic Zone (ATZ) that comprised parts of the airspace around SDTK, within which the special requirements for air traffic protection were applied.

This ATZ was located within the Flight Information Region of Curitiba (FIR-CW) in class "G" airspace and extended from ground level up to 1,500ft altitude.

On flights in class "G" airspace, traffic separations were performed by pilots through continuous bilateral communications and were not subject to ATC authorizations. In this type of airspace, the flight information service was only provided when feasible.

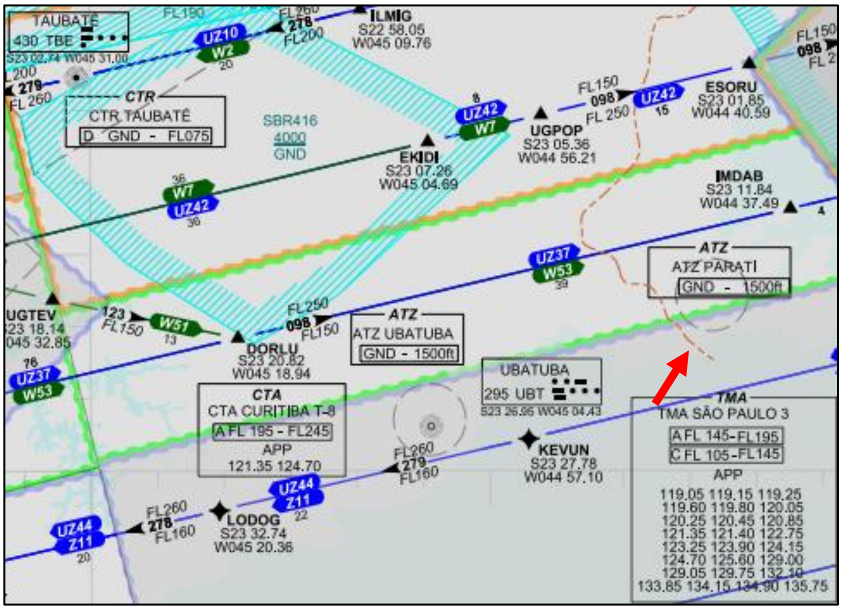

Figure 53 - Detail of the ATZ Paraty's location in the FIR-SBCW, indicated by the red arrow, seen on a route chart.

Since the operation at the SDTK Aerodrome was restricted to daytime VFR rules and that it did not have an Air Traffic Services body (ATS) for the provision of flight information service, pilots should observe the rules of air traffic required for this type of operation. They are described in the Command of Aeronautics' Instruction number 100-12 "Rules of the Air" (ICA 100-12).

According to ICA 100-12, of 17OCT2016, the visual flight rules were described as follows:

> 5 VISUAL FLIGHT RULES
>
> 5.1 GENERAL CRITERIA
>
> ...
>
> ...
>
> 5.1.3 Except as authorized by the ATC to serve a special VFR flight, VFR flights may not land, take off, enter ATZ or the traffic pattern of such aerodrome if:
>
> (a) the ceiling is less than 450 m (1500 ft.); or
>
> b) the horizontal visibility is less than 5 km.
>
> 5.2 RESPONSIBILITY OF THE PILOT
>
> It shall be incumbent upon the pilot in command of an aircraft in flight VFR to arrange his own separation from obstacles and other aircraft through the use of sight, except in Class "B" airspace, where the separation between aircraft is the responsibility of the ATC , however, the provisions of 4.2.1.
>
> 5.3 CONDITIONS FOR PERFORMING FLIGHT VFR
>
> ...
>
> 5.3.1 DAYTIME PERIOD
>
> 5.3.1.1 The departure, destination and alternate aerodromes shall be registered or approved for daytime VFR operation.
>
> 5.3.1.2 Prevailing meteorological conditions at departure, destination and alternate aerodromes during take-off or landing operations shall be equal to or greater than the minimums established for VFR flight.

<u>Unofficial instrument approach procedure</u>.

During the investigation, it was found that there was an unofficial instrument approach procedure, called "Paraty 1 ARR", which was used by pilots to perform descents under reduced visibility conditions at the SDTK Aerodrome (Figure 54):

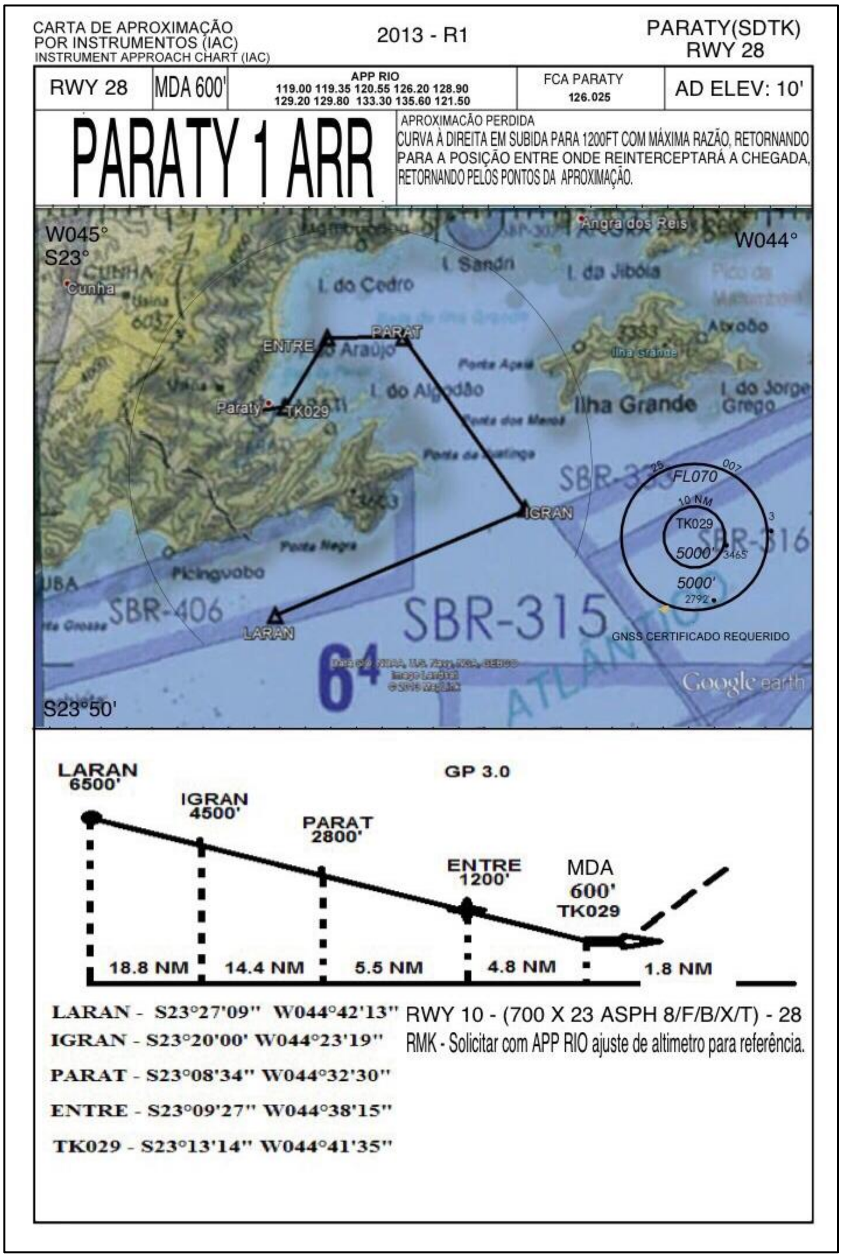

Figure 54 - Unofficial procedure "Paraty 1 ARR".

Despite the fact that the pilot did not carry out the "Paraty 1 ARR" procedure, it should be pointed out that this type of procedure must be prepared by specialized technicians and in accordance with international safety standards.

An instrument approach procedure consists of a series of predetermined maneuvers, with specific protection against obstacles, to a position in which the holding patterns or obstacle free margin criteria are applied en route.

In order to verify the deficiencies of the unofficial procedure in relation to international standards, an evaluation was made using the Flight Procedure Design and Airspace Management (FPDAM) tool as shown in Figure 55.

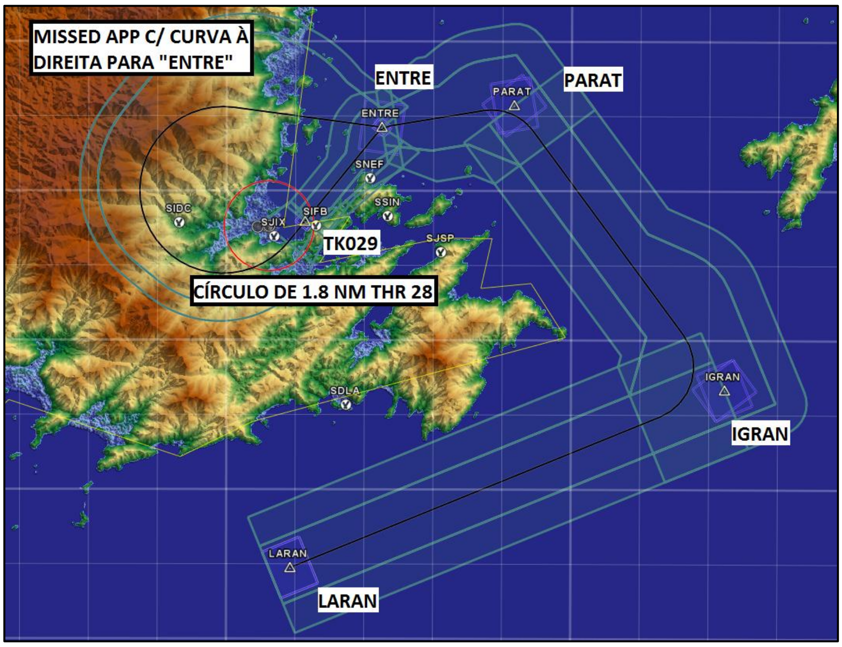

Figure 55 - Analysis of the unofficial procedure *"Paraty* 1 ARR" with the use of the FPDAM tool.

The evaluation pointed out that the procedure "Paraty 1 ARR" had several deficiencies, highlighting the most critical parameters, as follows:

- the change of direction between two initial approach trajectories was higher than the 90° limit (found 105°);
- the intermediate approach segment intercepted the final approach segment, through a fly-by curve, at an angle above the 30° limit (found 41.43°);
- the angle formed between the final approach segment and the runway alignment exceeded the limits for direct approach by 15° for aircraft categories A and B, and by 30° for aircraft categories C, D and E (found 45, 83°);
- the gradient of climb in the missed approach, based on the altitude values in the chart and the lack of indication of minimum value to be used by the crews, was lower than the minimum of 2.0% (found value of 0.65%), ;
- the Minimum Descent Altitude (MDA) value of 600ft displayed on the chart was less than the value found by analyzing obstacles in the final approach segment (1,010ft);
- the evaluation of the missed approach segment resulted in several terrain violations, suggesting MDA of 5,920ft, in disagreement with the MDA indicated in the chart (600ft); and
- the Minimum Sector Altitude (MSA) assessment resulted in minimum altitudes of 7,900ft and 7,100ft, above the existing MSA in the chart (FL070 and 5,000ft).

Thus, in finding that the unofficial procedure "Paraty 1 ARR" did not meet a series of minimum safety limits, it was concluded that its use represented intolerable risks to air operations.

Other accidents occurred in the region of Paraty, RJ and *Angra dos Reis*, RJ

Thirteen (13) accidents occurred in the region of Paraty and Angra dos Reis, RJ, during the ten-year period prior to the accident involving the PR-SOM aircraft.

From this total, it can be observed that six accidents were related to meteorological conditions, with three occurrences classified as Controlled Flight Into Terrain (CFIT), two as "Caused by Meteorological Phenomena in Flight" and one as "Spatial Disorientation", according to Table 1.

REGISTRATION	DATE	PLACE	CLASSIFICATION
PT-YGB	15JAN2008	Angra dos Reis	Others
PR-IPO	30APR2008	Angra dos Reis	Spatial Disorientation
PR-MES	12JUN2009	Angra dos Reis	Runway incursion
PP-AFM	12OCT2009	Angra dos Reis	Runway run off
PT-OPR	30JAN2011	Paraty	Caused by Meteorological Phenomena in Flight
PT-MAB	12JUL2012	Angra dos Reis	CFIT
PP-LOS	31AUG2012	Angra dos Reis	Others
PP-PFC	27DEC2012	Angra dos Reis	Abrupt landing
PR-EAG	10NOV2013	Paraty	CFIT
PU-WFA	22AUG2014	Angra dos Reis	Caused by Meteorological Phenomena in Flight
PU-TOF	18SEPT2015	Angra dos Reis	Engine Fail In-Flight
PP-LMM	03JAN2016	Paraty	CFIT
PT-MMP	10SEPT2016	Angra dos Reis	Runway run off

Table 1 - Accidents in the region of *Paraty*, RJ and *Angra dos Reis*, RJ, in the ten years prior to the accident with the PR-SOM aircraft.

The study of these occurrences classified as "CFIT" and "Spatial Disorientation" reveals common points, in which the operation in meteorological conditions of ceiling and/or visibility below those required for the flight under VFR is highlighted, leading the pilots to lower situational awareness or loss of control of the aircraft.

Change of aircraft classification C90GT from "Type" to "Class" Airplane Multiengine Land (MLTE).

Aircraft classified as "Type" are those that have more complex certification characteristics and require specific training for their operation, while aircraft classified as "Class" comprise a general group of less complex aircraft with similar characteristics of propulsion, flight or landing.

On 23APR2016, ANAC promoted a review of the definition of "Type" aircraft, when the C90GT aircraft had its classification changed from "Type" to "Class" MLTE.

The change in aircraft classification, however, did not imply a change in the training requirements for its operation, with the possibility that they could be fulfilled through instruction with qualified instructors, and not requiring instruction in flight schools or training centers.

In the case of the PR-SOM pilot, he obtained his "Type" rating according to the established before the change, and carried out his last revalidation in the same crashed aircraft, on 10OCT2016, according to the new rule for aircraft "Class".

Despite this transition, it was also verified that there was no change in the requirements for revalidation of qualification, which were fulfilled by the pilot.

Altitude adjustment considerations for aerodrome VFR operation without ATS unit

When transferring an aircraft in change from IFR rules to VFR rules, to landing in locations without ATS, the altimeter adjustment was reported for the last sector in which the aircraft made contact with APP-SP. During the descent of the PR-SOM, the sector adjustment reference was SBSJ, which indicated a pressure of 1,018 hPa.

According to information collected from an INMET automatic weather station (Figure 18), located in Paraty, RJ, atmospheric pressure ranged from 1,013.7 to 1,014.5 hPa in the interval from 15:00 to 16:00 (UTC). Such station, however, was not intended to provide information for aeronautical use.

In order to convert the pressure values (in hPa) to altitude values (in feet), the International Standard Atmosphere (ISA) model was considered.

Thus, it was found that the difference between the altimeter setting for the SBSJ Aerodrome in relation to the setting recorded at the Paraty meteorological station, RJ, would result in an altitude indication of approximately 100 to 120ft above that predicted for the SDTK Aerodrome.

1.20 Useful or effective investigation techniques.

Nil.

2. ANALYSIS.

The King Air C90GT aircraft (PR-SOM) was registered in the category of Private Air Services (TPP) and was operated by Emiliano Empreendimentos e Participações Hoteleiras Sociedade Ltda., since May 2010.

The pilot performed all tasks related to aircraft maintenance management, after approval of the operator (aircraft owner).

According to the maintenance records, the airframe, propellers and engine logbooks records were up to date. The last inspection of the aircraft, the Annual Maintenance Inspection (IAM) type, was completed on 12APR2016, having flown 84 hours and 30 minutes after inspection and valid until 12APR2017. The Certificate of Airworthiness (CA) was valid until 12APR2022.

Despite the finding that all scheduled aircraft maintenance was up to date, it was found that there were some items without inspection records such as Emergency Location Transmitter (ELT) battery, reserve battery, lead-acid emergency battery, and the Oil Intake Protection Screen Check of the Accessory Box return pump.

Despite the absence of such records, no discrepancies associated with such items were identified that resulted in malfunction of any aircraft system.

In the analysis of the wreckage, there were four circuit breakers off: The Landing Gear (WARN), Annunciator System (IND), Avionic (ANN) and Bleed Air Control (Right). However, the damage and deformation characteristics of the circuit breaker panel suggest that they have gone off due to the impact. It should be noted that such circuit breakers were not associated with systems that could affect the aircraft performance.

The sound spectral analysis of the CVR data showed that, at 15:42:41 (UTC), there was a small speed differential between the propellers, when one of them started to have a rotation equivalent to 1,875 RPM and another 1,950 RPM.

This rotation differential, of the order of 75 RPM, was not significant with respect to a change of performance of the aircraft and, likewise, was not configured as evidence of engine malfunction. The most likely hypothesis for this differential is that there has been an involuntary shift of the position of one of the propeller levers during the second rush.

Regarding the integrity of the primary and secondary flight commands, no failure of continuity of the cables was observed that could interfere with the command authority.

Regarding the engines, the analyzes of their components and the characteristics of the damages indicated that they operated normally at the moment of impact.

Thus, no conditions of failure or malfunction of systems and/or components of the aircraft that could have affected its performance or its control in flight were evidenced.

The pilot had been flying for 30 years and had an Airline Pilot License (PLA), accumulating 7,464 hours and 55 minutes of total flight time, of which 2,924 hours were on Beechcraft 90 aircraft series, mainly on C90A and C90GT models.

The Pilot´s Evaluation Sheet (FAP), regarding his qualification revalidations of the last six years, did not present any comment that indicated an operational deficiency. In that period, there were no records of the pilot training in a simulator, which was not required for the registration category and rules of operation of the aircraft.

The pilot operated frequently at the Paraty, RJ, (SDTK) Aerodrome, having made 33 flights to that locality in the twelve months prior to the accident. All these flights were performed on the PR-SOM aircraft.

This experience accumulated by the pilot gave him professional recognition, so he was considered a reference among the group of pilots operating in the region of Paraty, RJ.

The familiarity with the region, as well as the recognition received from the operator and other pilots may have given the pilot a higher self-confidence to fly in that locality, despite the possibility of changes in the weather conditions in the region.

According to the history of practical and theoretical training, verified during the revalidation of the qualifications, as well as his experience, both in the aircraft and in SDTK, there were no qualification issues that indicated deficiencies in the operations conducted by the pilot.

In all health inspections carried out since 14FEB1985, the pilot obtained the opinion "Able" or "Able for the purpose for which it is intended". Despite the indication of the use of corrective lenses, from 1988 on, and of hearing loss (without significant repercussions), as of 2000, he did not present any physiological or pathological limitation that restricted his performance in aerial activity.

According to reports, the pilot did not use any medication and had no change in his routine in the 48 hours before the accident.

The technical analysis of voice, speech and language parameters, based on data from the Cockpit Voice Recorder (CVR), did not identify signs of fatigue, drowsiness or changes compatible with the use of narcotic substances of the nervous system central. The toxicological tests carried out after the accident also failed to detect the presence of pharmacological or toxic active substances as well as alcohol in the blood of the pilot that could have interfered in his performance in flight.

Thus, there were no changes from a medical point of view that could result in impairment of the in-flight pilot performance.

On 19JAN2017, the pilot presented the flight plan at 10:35 (UTC) with take-off scheduled for 13:30 (UTC).

With regard to flight preparation, it was found that there was no reporting recorded in Notice to Airmen (NOTAM to the SDTK location) of any Aerodrome infrastructure condition that would restrict operation at the location.

The meteorological information for the Paraty region indicated conditions favorable to visual flight, with the possibility of worsening in the weather due to continuous rainfall and the presence of Towering Cumulus (TCU) clouds.

Fueling was made at 11:57 (UTC), with enough fuel to comply with the steps of SBMT-SDTK and SDTK-SBMT, without refueling in SDTK.

The route planned for the flight was the same as the pilot routinely adopted, which provided for departure under visual flight rules (VFR) during the climb, via visual corridors (VFR special routes), and the transition en route to instrument flight rules (IFR). During the descent, he planned a new rule change for VFR, proceeding with bow from the destination Aerodrome.

Due to the delay in the arrival of one of the passengers, there was a delay of one hour and thirty minutes in the takeoff. This made the owner uncomfortable, because although he was late, he did not usually wait for the takeoff. However, it is not known how the pilot reacted to this uncomfortable situation of the owner.

The takeoff occurred at 15:01 (UTC) and no abnormalities were observed during the climb to FL150.

At 15:25 (UTC), the PR-SOM requested the descent and a deviation to the left of the route to São Paulo Approach Control (APP-SP). There was coordination for the modification of the IFR rules for VFR, and the reference pressure adjustment (QNH) of the São José dos Campos Aerodrome, SP (SBSJ), of 1,018 hPa was reported. Afterwards, APP-SP transferred the aircraft to coordination-free frequency for landing on SDTK.

According to the RADAR images, it was verified that the descent profile carried out by the PR-SOM coincided with the reports of other pilots, who informed that the pilot executed a trajectory that tangentiated an area owned by the aircraft operator.

When synchronizing the air traffic control RADAR data with the Meteorological RADAR images from Pico do Couto, it was verified that, at 15:36 (UTC), the aircraft was descending, crossing 6,600ft (Figure 56), and performed a trajectory consistent with deviations from an area of rain located on the Paraty Bay.

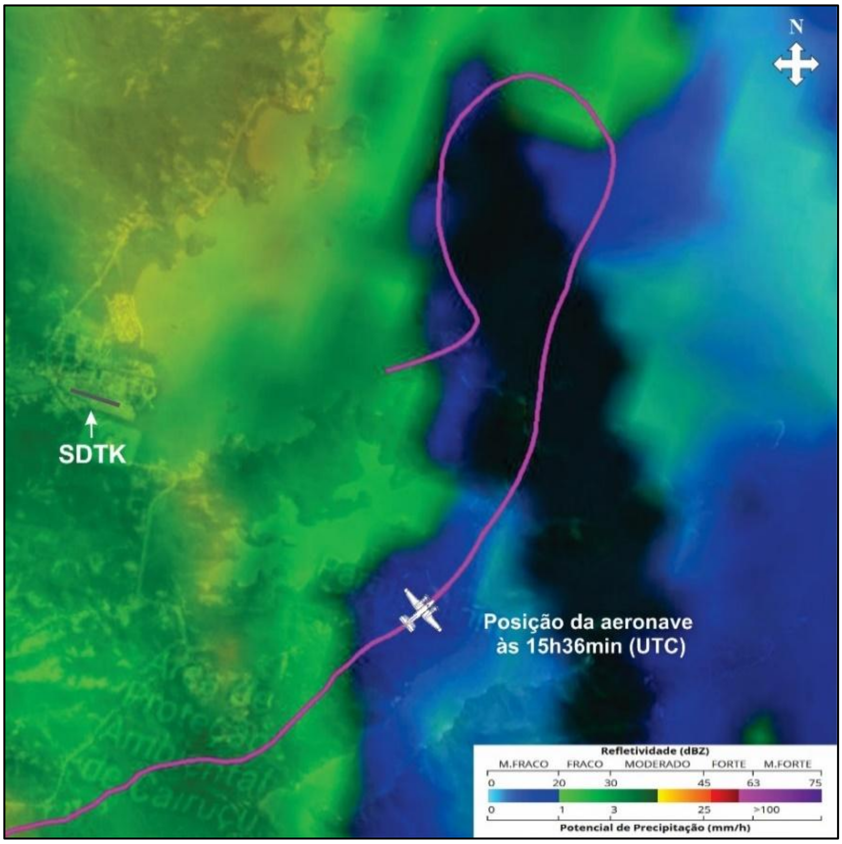

Figure 56 - PR-SOM descent trajectory in relation to meteorological formations recorded at 1536 (UTC) by Meteorological RADAR.

At that moment, the PR-SOM pilot was coordinating traffic with another aircraft that had taken off from the Angra dos Reis Aerodrome, RJ (SDAG), to SBMT. The communications between the aircraft did not reveal any abnormality or conflict of air traffic that could have interfered in the performed flight profile.

After making a left turn in descent over the sea, the aircraft proceeded, still in descent, with south bow and, approaching the coastline, made a right turn, until fly towards SDTK Aerodrome. At that moment, the pilot reported that he was entering the final leg approach to runway 28, crossing 1,500ft.

Thereafter the landing gear was extended and there was a significant increase in the rate of descend (2,000ft/min) followed by a Sink Rate alert (high sink rate). After this alert, the pilot pressed the TERR INHB pushbutton on the EGPWS panel, causing all system visual and audible warnings to be inhibited.

In the sequence, the pilot canceled the approach, retracting the landing gear and reported on the frequency of coordination: "*Sierra Oscar Mike setor echo de Paraty, aguardando um pouquinho, até a chuva passar, melhorar a visibilidade. Mantém mil e trezentos pés, Sierra Oscar Mike*" ("Sierra Oscar Mike sector echo of Paraty, waiting a little until the rain to stop, improve visibility. It maintains one thousand and three hundred feet, Sierra Oscar Mike") (sic).

The aircraft flight path, after the first landing attempt, was not detected by RADAR and there were no data records recorded in the EGPWS.

About two minutes and ten seconds after landing gear was retracted on the first approach attempt, the landing gear was extended again and the EGPWS recorded the aircraft flight path, skirting the tip of Paraty Bay in a gentle descent from 740ft. At that moment, the pilot reported that he was "re-entering" the SDTK final leg, with landing gear down and locked.

The short time elapsed between the pilot's verbalization (of which he would wait for the rain) and the beginning of the second approach attempt denoted that he gave up waiting for better weather conditions.

In analyzing the possible motivations that would have led the pilot to make a new approach, in adverse weather conditions for operation under VFR, it is necessary to evaluate the pilot profile and its relationship with the aircraft owner.

It was found that the owner did not interfere in the conduct of the flights, although he sometimes acted in a harsh and demanding way. In addition, no communication between the pilot and the owner indicating otherwise was recorded in the CVR.

With regard to the pilot, it was observed that he always excelled by the faithful accomplishment of his activities. According to the reports, there were no occasions when he had reported impediments to completing a flight in accord with his initial planning.

Considering the characteristics of the executive aviation and the profile of the pilot, it is possible that throughout his professional career he has developed a self-imposed pressure aimed at fulfilling the planned flights, leading him to accept conditions below the minimum limits required for the type operation.

The go-around procedure made after the first attempt to approach and the verbalization that he would wait for the improvement of the meteorological conditions indicated that, initially, the pilot had identified the conditions that prevented the approach to the landing.

Analysis of the pilot's voice, speech, and language parameters showed that he was tense at that time of the flight. The variations observed in his emotional state indicated that, even after leaving the adverse condition generated by the rain and heading to the sector "Echo", the pilot was still anxious, having presented emotional traits that varied from apprehension to fear.

The circumstances of that flight, which had delayed and irritated the owner, as well as the profile of the pilot who avoided conflicts, may have raised his level of anxiety. Such a scenario may have led the pilot to seek alternatives to complete the flight in order to meet the owner´s wishes.

Thus, the emotional state in which the pilot was found may have influenced his decision to make a new approach and try another profile, different from the first one, although there was no improvement in the weather.

According to the trajectory recorded by EGPWS, at the end of the second approaching attempt, at 15:43:55 (UTC), the aircraft was at 270ft height, with 120kt ground speed and 235° bow.

At 15:44:26 (UTC), the CVR recorded a strong impact sound and interrupted the recording.

When synchronizing the EGPWS data with the Meteorological RADAR images from Pico do Couto at 15:46 (UTC), recorded about one minute and thirty-four seconds after the impact time, there was rain with rainfall potential 25mm/h, covering the region of the trajectory recorded in the EGPWS and the location of the impact of the aircraft (Figure 57).

The analysis performed on the images of a security camera, positioned in the region where the impact of the aircraft occurred, estimated that the horizontal visibility, recorded at 15:46 (UTC), was 1,500m.

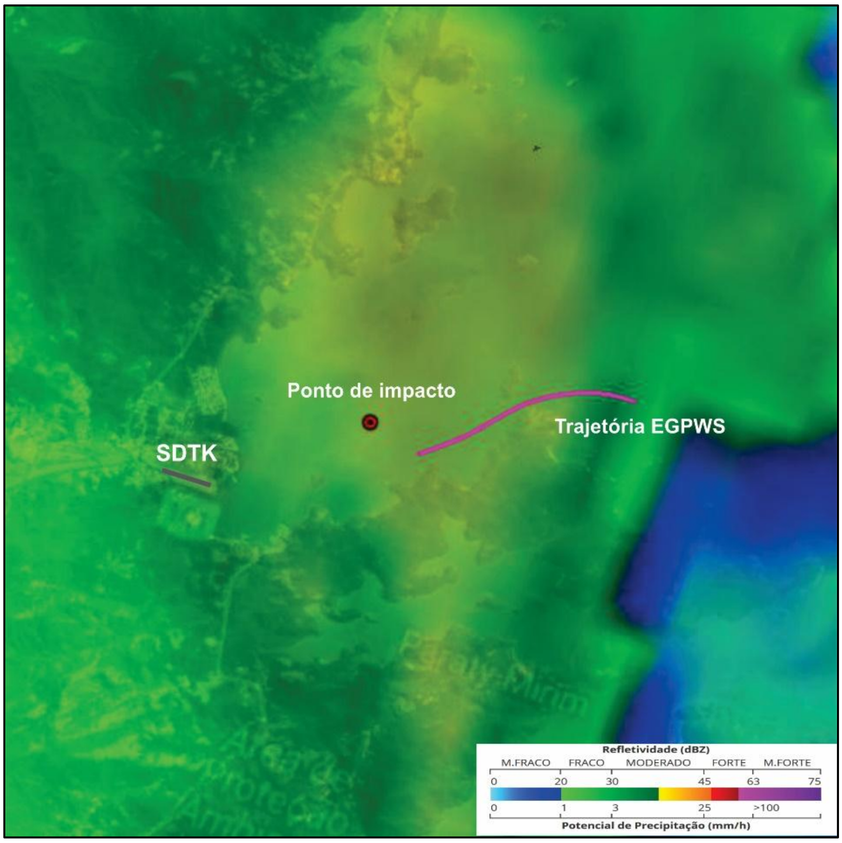

Figure 57 - Trajectory of the second attempt of landing of the aircraft, in relation to the meteorological formations registered at 1546 (UTC) by Meteorological RADAR.

The SDTK Aerodrome allowed only operations under VFR flight rules and landing and take-off operations under instrument flight conditions are not possible.

According to the Command of Aeronautics' Instruction number 100-12 (ICA 100-12) "Air Rules", minimum ground visibility of 5,000m and 1,500ft ceiling were required for operation under VFR. Thus, it was found that, at that time, there were no minimum visibility conditions required for landing and take-off operations.

As there was no aeronautical station with altimeter adjustment information for SDTK, the altimeter adjustment was reported for the last sector in which the PR-SOM made contact with APP-SP, that is, the adjustment of the São José dos Campos Aerodrome, SP (SBSJ), which corresponded to 1,018 hPa.

It was verified that the pressure measured in the automatic (non-aeronautical) meteorological station of Paraty, RJ, ranged between 1,013.7 and 1,014.5 hPa in the interval between 15:00 and 16:00 (UTC). Thus, if the pilot were using the SBSJ setting, the instrument he would have an inaccuracy of about 100 to 120ft above actual altitude.

When considering that there was no aeronautical information of adjustment in SDTK, the altimeter could not be used as reference for the flight in low altitude, since the flight under VFR required that it was conducted with visual references.

Despite these considerations, the fact that the right station altimeter is set at 1,013 hPa suggests that the pilot may not have used the 1,018 hPa setting.

By associating visibility information of the region with the trajectory of the second attempt to approach and land the aircraft, it was verified that the visual field of the pilot was restricted and with few visual references of the ground that could allow his orientation.

This condition worsened, even more, in the final part of the EGPWS trajectory, when the pilot's visual range did not allow the identification of references at the front and he decided to make a right turn (Figure 58).

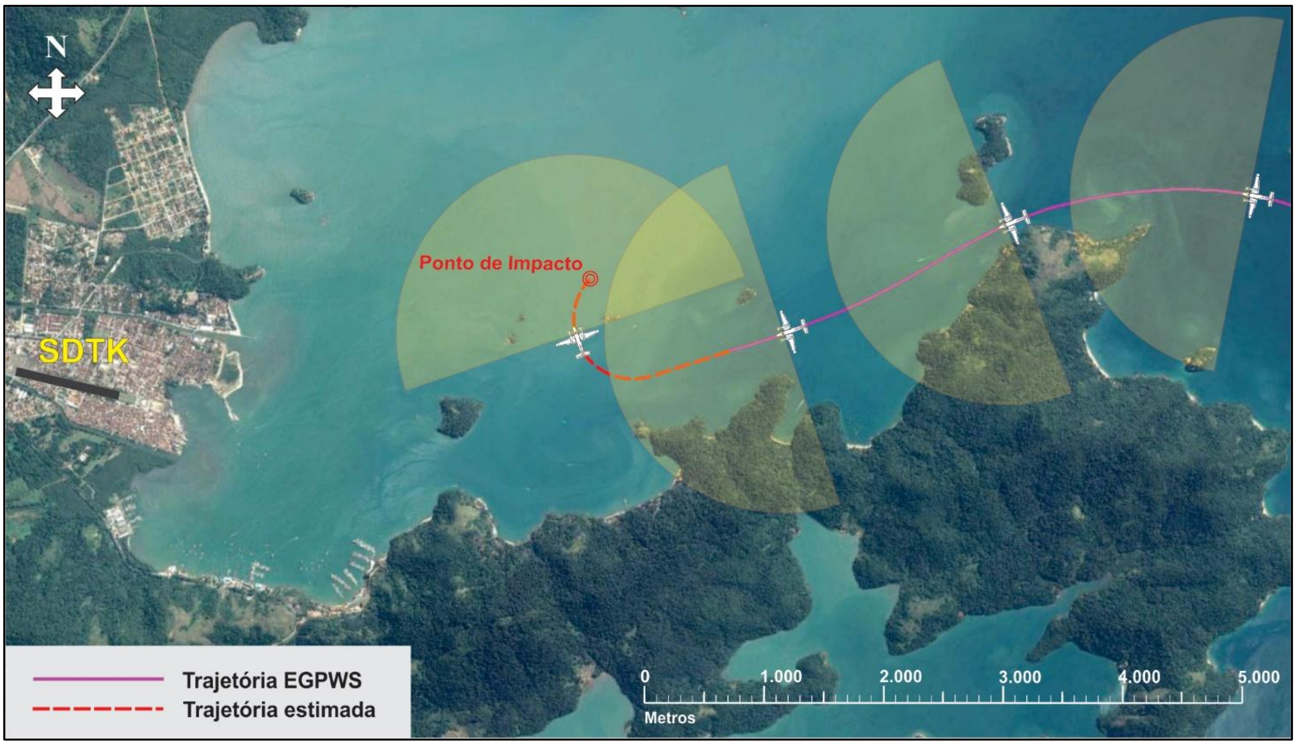

Figure 58 - Illustration of the pilot's visual range (estimated at 1,500m), in relation to the aircraft's trajectory (the aircraft is off-scale).

According to the Investigation Team´s calculations, the curve started at approximately 15:44:06 (UTC), and the landing gear was retracted at 15:44:12 (UTC), suggesting that the go-around cockpit procedures were carried out simultaneously with the run of the curve.

By performing the curve with a medium load factor of 1.27G (sufficient value to stimulate semicircular orientation channels), at the same time the pilot made head movements, due to the need to observe his trajectory, to seek visual references or (such as the landing gear lever, for example). He may have experienced a feeling that the bank angle (lateral inclination) was decreasing.

Considering that slope and "pull" variations may easily have involved load factors that have reached 2G, this sense of decreased bank angle may have reached up to 20 degrees.

With this vestibular illusion by excess of "G", to maintain the desired angle, the pilot may have applied more inclination, causing an excessive increase of the initial bank angle. This condition of great inclination of the aircraft is consistent with the report of observers who witnessed the impact of the aircraft against the water.

At the beginning of the right turn, the aircraft began to fly over a region on homogeneous terrain (water), where there was no relief that could provide focal and environmental visual signals, and that allowed the pilot to estimate its height in relation to water.

Thus, it was found that the fact that the aircraft was flying at low altitude over water (about 270ft height) might have favored the phenomenon of visual illusion of homogeneous terrain, resulting in a false perception of height, above the real. This illusion may have induced the pilot to allow a descent of the aircraft.

It was found that during the landing attempts, the pilot presented traces of apprehension, anxiety and fear, indicating an emotional state compatible with signs of stress. Studies have shown that stress can interfere with pilot perception and contribute to spatial disorientation.

Thus, the low visibility conditions, the low height curve over the water, added to the pilot's stress and also to the wreckage conditions, which did not show any fault that could have compromised the performance and/or controllability of the aircraft, lead to the conclusion that the pilot most likely had a spatial disorientation that led to the loss of control of the aircraft.

Regarding the culture of the pilots' group operating in the region of Paraty, RJ, it was observed that, although they expressed concern about flight safety issues, the work culture fostered among them favored informality, to the detriment of requirements for the VFR operation.

This fact could be verified by the existence of an unofficial chart for operation in SDTK. This procedure did not meet a series of minimum safety requirements and therefore its use implied risks to the operation in that locality.

It should be noted that the characteristics of executive aviation demanded the need for pilots to adapt to the routine and the interests of operators, which sometimes led to the development of external or self-imposed pressures, which could lead to a reduction of the safety margin of flights.

In addition, it was common for operators, possibly for ignorance of the minimum requirements of operation in SDTK, to value the pilots who made the landing even in adverse weather conditions.

Thus, it was verified that the values shared by both the operators and the group of pilots interfered in the perception and the adequate analysis of the risks involved in the operations.

The recurrence of accidents in that region, with similar characteristics to the PR-SOM accident, shows that such a culture existed for several years, without the awareness of pilots and operators.

With respect to the PR-SOM accident, it can be concluded that this culture influenced the decision-making of the pilot, who, despite of finding adverse conditions and his emotional state in the situation experienced, opted to insist on the landing attempt.

3. CONCLUSIONS.

3.1 Facts.

a) The pilot had valid aeronautical medical certificates (CMA);

b) the pilot´s Airplane Multiengine Land Qualification (MLTE) and Instrument Flight Qualification (IFR) were valid;

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

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

e) the airframe and engine logbooks records were updated;

f) it was not evidenced any condition of failure or malfunction of the systems and/or components that could have affected the aircraft flight performance or control;

g) there were no medical changes in the period prior to the accident that could have affected the performance of the pilot in flight;

h) the present culture, at the time, valued the pilots who made the landing even in adverse weather conditions;

i) there was a delay of one hour and thirty minutes in the take-off due to the delay in the arrival of one of the passengers, fact that annoyed the aircraft owner;

j) meteorological information, observed before the take-off time, indicated conditions favorable to the visual flight, with the possibility of worsening in the weather due to continuous rainfall and the presence of TCU in the region of Paraty, RJ;

k) there were no abnormalities during takeoff, climb, en-route flight and descent procedures;

l) the SDTK aerodrome allowed exclusively operations under VFR flight rules;

m) on the first approach attempt, the landing gear was extended and there was a significant increase in the rate of descent, followed by a Sink Rate alert;

n) the first approach attempt was canceled and the pilot informed that he would wait for the rain to stop and the visibility to improve;

o) there was rain with rainfall potential of the order of 25mm/h, covering the Paraty Bay region;

p) the horizontal visibility, recorded by a security camera, located in a helipad of the Paraty Bay, was equivalent to 1,500m;

q) there were indications that the pilot was tense during the approach attempts;

r) about two minutes and ten seconds after the landing gear was retracted, on the first approach attempt, the aircraft started a new attempt;

s) the visual field of the pilot was restricted and with few visual references of the ground that could allow his correct orientation;

t) the flight conditions encountered by the pilot favored the occurrence of vestibular illusion due to excess of "G" and visual illusion of homogeneous terrain;

u) there was loss of control and the aircraft impacted against the water, with wide bank angle (lateral inclination);

v) the aircraft was completely destroyed; and

w) all occupants suffered fatal injuries.

3.2 Contributing factors.

- **Adverse meteorological conditions - a contributor**

At the moment of the impact of the aircraft, there was rain with rainfall potential of 25mm/h, covering the Paraty Bay region, and the horizontal visibility was 1,500m. Such horizontal visibility was below the minimum required for VFR landing and take-off operations.

Since the SDTK aerodrome allowed only operations under VFR flight rules, the weather conditions proved to be impeding the operation within the required minimum safety limits.

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

The weather conditions present in SDTK resulted in visibility restrictions that were impeding flight under VFR rules. In this context, the accomplishment of two attempts to approach and land procedures denoted an inadequate evaluation of the minimum conditions required for the operation at the Aerodrome.

- **Disorientation - undetermined**

The conditions of low visibility, of low height curve on the water, added to the pilot stress and also to the conditions of the wreckage, which did not show any fault that could have compromised the performance and/or controllability of the aircraft, indicate that the pilot most likely had a spatial disorientation that caused the loss of control of the aircraft.

- **Emotional state - undetermined.**

Through the analysis of voice, speech and language parameters, variations in the emotional state of the pilot were identified that showed evidence of stress in the final moments of the flight. The pilot's high level of anxiety may have influenced his decision to make another attempt of landing even under adverse weather conditions and may have contributed to his disorientation.

- **Tasks characteristics - undetermined**

The operations in Paraty, RJ, demanded that pilots adapt to the routine of the operators, which was characteristic of the executive aviation. In addition, among operators, possibly because of the lack of minimum operational requirements in SDTK, the pilots who landed even in adverse weather conditions were recognized and valued by the others.

Although there were no indications of external pressure on the part of the operator, these characteristics present in the operation in Paraty, RJ, may have favored the pilot's self-imposed pressure, leading him to operate with reduced safety margins.

- **Visual illusions - undetermined.**

The flight conditions faced by the pilot favored the occurrence of the vestibular illusion due to the excess of "G" and the visual illusion of homogeneous terrain. Such illusions probably had, consequently, the pilot's sense that the bank angle was decreasing and that he was at a height above the real. These sensations may have led the pilot to erroneously correct the conditions he was experiencing.

Thus, the great bank angle and the downward movement, observed at the moment of the impact of the aircraft, are probably a consequence of the phenomena of illusions.

- **Work-group culture - a contributor.**

Among the members of the pilot group that performed routine flights to the region of Paraty, RJ, there was a culture of recognition and appreciation of those operating under adverse conditions, to the detriment of the requirements established for the VFR operation. These shared values promoted the adherence to informal practices and interfered in the perception and the adequate analysis of the risks present in the operation in SDTK.

4. SAFETY RECOMMENDATION.

A measure of preventative/corrective nature issued by a SIPAER Investigation Authority or by a SIPAER-Link within respective area of jurisdiction, aimed at eliminating or mitigating the risk brought about by either a latent condition or an active failure. It results from the investigation of an aeronautical occurrence or from a preventative action, and shall never be used for purposes of blame presumption or apportion of civil, criminal, or administrative liability.

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

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

A-013/CENIPA/2017 - 01 Issued on: 16/01/2018

Disseminate the lessons learned from the aeronautical accident investigation with the PR-SOM aircraft as regards the need to foster an executive aviation culture where compliance with minimum operating requirements is valued.

A-013/CENIPA/2017 - 02 Issued on: 16/01/2018

Review the existing requirements to emphasize, during the civil pilot training, the characteristics and risks arising from illusions and spatial disorientation to aerial activity.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

None.

On January 16th, 2018.