COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A - 025/CENIPA/2013

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PP-AJV**
MODEL:	**C90A**
DATE:	**03 FEB 2013**

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 item 3.1, 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 3 February 2013 accident with the C90A aircraft, registration PP-AJV. The accident was classified as "caused by inflight weather phenomenon".

Thirty-five minutes after takeoff, the ATC units lost radar contact with the aircraft.

The aircraft was found the next day in an agricultural area.

All the aircraft occupants had perished in the crash site.

Accredited representatives, one from the National Transportation Safety Board (USA) and another from the Transportation Safety Board (Canada) were designated for participation in the investigation.

CONTENTS

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ACC-CT	Area Control Center - Curitiba
ANAC	Brazil’s National Civil Aviation Agency
ATC	Air Traffic Control
CA	Airworthiness Certificate
CENIPA	Aeronautical Accident Investigation and Prevention Center
CG	Center of Gravity
CINDACTA	First Air Defense and Air Traffic Control Integrated Center
CIV	Pilot’s Flight Logbook
CMA	Aeronautical Medical Certificate
CMV-CW	Meteorological Surveillance Center - Curitiba
CPTEC	Weather Forecast and Climate Studies Center
CVR	Cockpit Voice Recorder
DCTA	Department of Science and Aerospace Technology
FAA	Federal Aviation Administration
FIR-CW	Flight Information Region - Curitiba
FL	Flight Level
FMS	Flight Management System
IAE	Institute of Aeronautics and Space
IAM	Annual Maintenance Inspection
IFR	Instrument Flight Rules
IFRA	Type Technical Qualification / IFR (Airplane)
IMC	Instrument Meteorological Conditions
INFRAERO	Brazilian Airports Infrastructure Enterprise
INPE	National Institute for Space Research
NTSB	National Transportation Safety Board
PCM	Commercial Pilot (Airplane category)
PPH	Private Pilot (Helicopter category)
PPR	Private Pilot (Airplane category)
SBLO	ICAO location designator – *Londrina* aerodrome
SBMG	ICAO location designator – *Maringá* aerodrome
SBMT	ICAO location designator - *Campo de Marte* aerodrome
SBSP	ICAO location designator – *Congonhas* aerodrome
TSB	Transportation Safety Board (Canada)
UTC	Universal Time Coordinated

1. FACTUAL INFORMATION.

Aircraft	**Model:** C90A **Registration:** PP-AJV **Manufacturer:** BEECHCRAFT	**Operator:** Z. AIR Investimentos e Participações LTDA.
Occurrence	**Date/time:** 03FEB2013 / 22:10 (UTC) **Location:** Água do Miranda Farm **Lat.** 22º43'33"S **Long.** 050º24'48"W **Municipality – State:** Cândido Mota – São Paulo State	**Type(s):** Caused by meteorological phenomenon in flight

1.1 History of the flight.

The aircraft took off from SBMG at 21:37 UTC on a passenger transport flight destined for SBSP, with a pilot and four passengers on board.

The pilot filed an IFR flight plan (FL210) via telephone. It was a night-time flight, and the prevailing weather conditions en route were IMC.

Approximately 35 minutes after takeoff, the ATC units with jurisdiction over the area lost radar contact with the aircraft.

The next day, the aircraft was found totally destroyed in a rural area.

1.2 Injuries to persons.

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

1.3 Damage to the aircraft.

The airplane was destroyed.

1.4 Other damage.

None.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Hours Flown	
	Pilot
Total	Unknown
Total in the last 30 days	24:30
Total in the last 24 hours	02:05
In this type of aircraft	441:45
In this type in the last 30 days	24:30
In this type in the last 24 hours	02:05

N.B.: The pilot's Flight Logbook (CIV) was not found. The approximate amount of hours flown by the pilot was obtained from cross-checking the computerized data provided by the National Civil Aviation Agency (ANAC) and the control of movements of the accident aircraft in SBMT, this latter provided by the INFRAERO.

1.5.2 Professional formation.

It was not possible to trace the pieces of information relative to the flying school attended at by the captain. However, the commission verified that he earned his Private Pilot license (Airplane category) on 19 February 1991 and his Commercial Pilot license (Airplane category) on 14 February 2012.

1.5.3 Category of licenses and validity of certificates.

The aircraft captain had a valid technical qualification of BE90 aircraft. His airplane IFR rating had expired in January 2013, despite the validity of his theoretical IFR test done at the ANAC.

1.5.4 Qualification and flight experience.

The pilot was not qualified for the type of flight proposed in his flight plan (due to an expired IFR rating).

1.5.5 Validity of medical certificate.

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

1.6 Aircraft information.

The aircraft (serial number LJ-1647) was manufactured by Beechcraft in 2001.

The airworthiness certificate (CA) was valid.

The airframe, engine, and propeller logbooks were not found. However, after a consultation with the workshop responsible for the aircraft maintenance, the commission verified that all the records were up-to-date.

The last inspection of the aircraft (Annual Maintenance Inspection) was done on 23 August 2012 by CONAL workshop. The aircraft had 3,137 flight hours on that date.

Notwithstanding these pieces of information, the investigation commission verified that the pilot used to switch off the aircraft hour-meter in order to mask the amount of hours flown. Thus, it is not possible to guarantee that the inspections, overhauls, and other maintenance services were being carried out within the deadlines prescribed by the legislation in force and by the manufacturer.

1.7 Meteorological information.

The synoptic chart of the region of the accident shows the presence of a cold front with moderate to high intensity over the Curitiba FIR (FIR-CW). According to meteorological information, the axis of the cold front activity extended from Ponta Porã (State of Mato Grosso do Sul) to the coast line of the States of Paraná and Santa Catarina.

There was a large area with clouds in multiple layers, associated with active thunderstorms, affecting the States of Paraná and São Paulo. The sectors 9 and 10 of the FIR-CW were affected by the presence of storm cells, mainly along the north area of those sectors, where the city of Assis is located.

From the analysis of the SIGW (Significant Weather Chart), utilized graphically for describing the meteorological conditions, it was observed that the multiple layer nebulosity was associated with cumulus clouds.

All the sectors were being monitored by the Surveillance Meteorological Center of Curitiba (CMV – CW) associated with the Curitiba Area Control Center (ACC-CT). The CMV-CW job was to exercise continuous surveillance of the existing weather conditions capable of affecting flight operations within the FIR-CW.

For that purpose, the ACC-CT issued a SIGMET (*Significant Meteorological Information*) relative to the observed/forecast meteorological conditions en route that affect the safety of aircraft in flight. Such information contained data relative to the area of activity of phenomena such as: turbulence, thunderstorms, icing, and squall line, together with the direction of movement of the front.

03/02/2013	**SBCW**	**031940-2300Z**	**SBCW CURITIBA FIR EMBD TS FCST WI S2233 W05547- S2028 W05440 - S1857 W05227 - S2220 W04903 - S2325 W04952 - S2359 W05524 - S2233 W05547 TOP FL400 MOV ENE 06KT NC**

Figure 1 – SIGMET in the FIR-CW: embedded thunderstorms, and tops at FL400.

From the analysis of the winds aloft charts relative to FL180 and 240 (closer to FL210, the one utilized by the accident aircraft), it was observed a predominance of a 35kt-wind in a direction compatible with the SIGMET.

The predominant temperature for the region of the accident was -16°C at FL240 and -5°C at FL180. By means of simple interpolation, the values obtained for FL210 were around -10°C / -11°C.

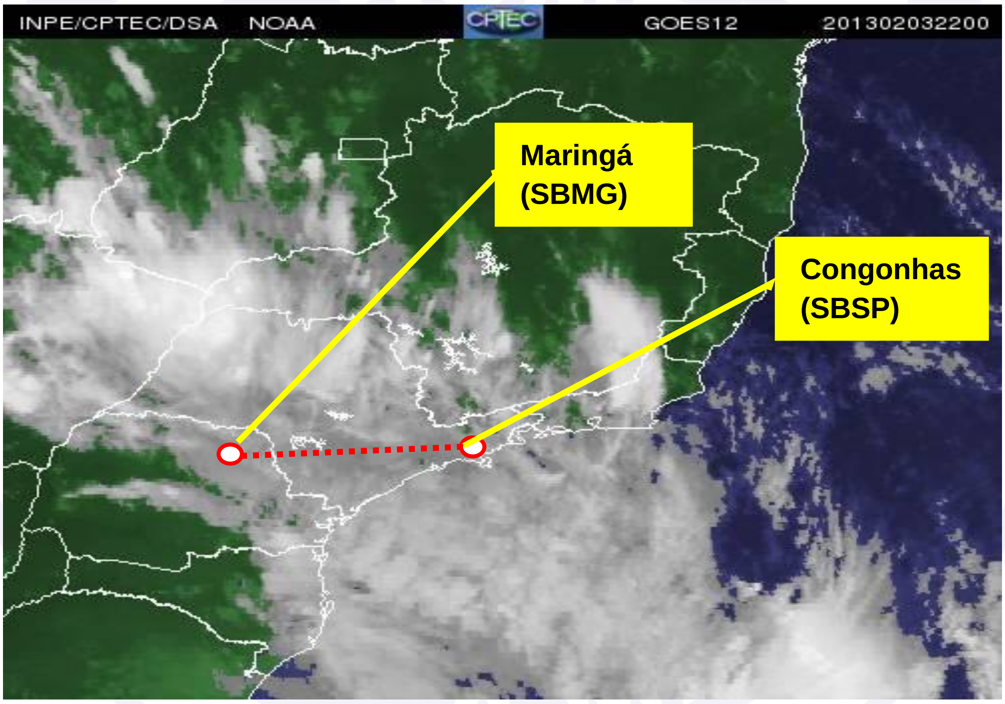

Figure 2 – Satellite image of the front over the Southern and Southeastern regions of Brazil – 22:00 (UTC).

According to a radiosonde measurement taken in SBLO (4 February 2013, 00:00 UTC) two hours after the occurrence, it was possible to observe that between 400 and 300 hPa of atmospheric pressure, corresponding to the flight level utilized by the accident aircraft, there was proximity between the temperature and dew point values, favoring the existence of icing.

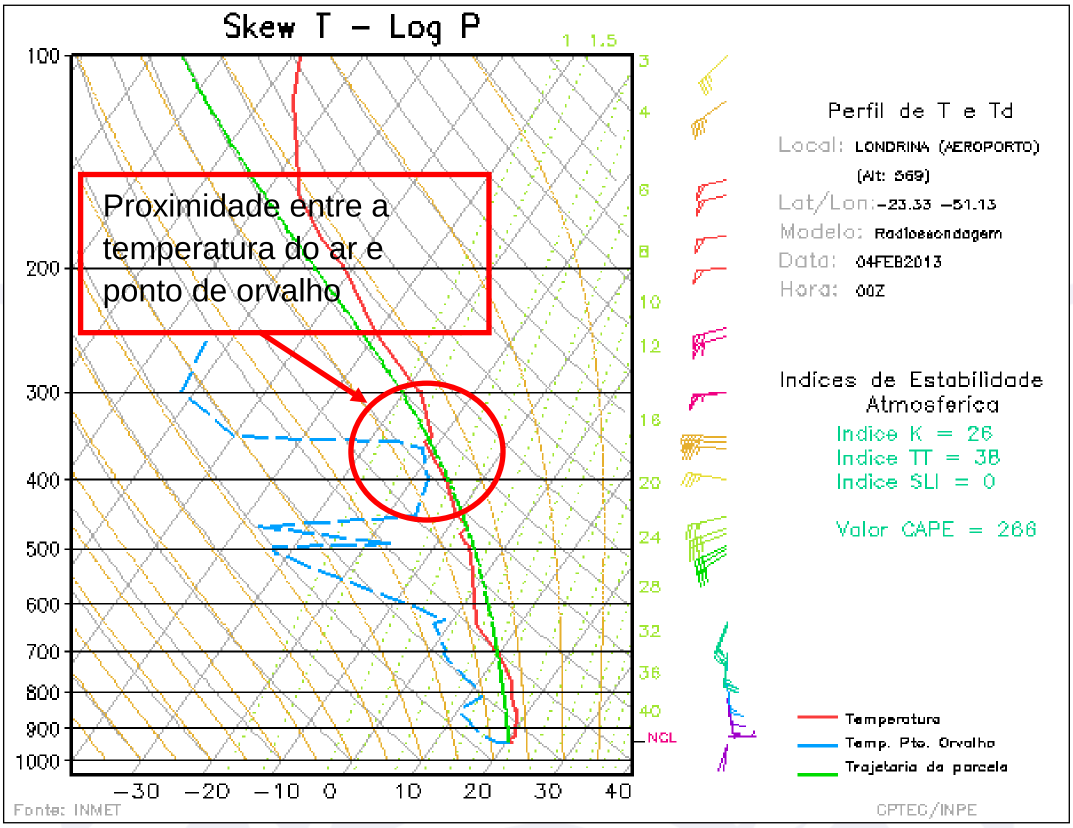

Figure 3 – Radiosonde measurement in SBLO – 00:00 (UTC) – 04FEB2013.

By consulting studies and specialized publications of meteorological content (*Aircraft Icing Avoidance and Protection* – NTSB-SR-81-1 and *Pilot`s Handbook of Aeronautical Knowledge* – FAA – H – 8083-25A), it was possible to go deeper in the study of cumulus clouds and their relation with ice build-up on the structure of aircraft.

Similarly to any other type of clouds, cumulus clouds result from condensation of water vapor in suspension in the atmosphere. Such clouds may contain a lot of humidity inside during their development.

For ice to build up on the structure of an aircraft, there are several meteorological and aerodynamic contributing factors. The most important ones are: presence of water in liquid state, temperature, size of water drops in suspension, as well as size and speed of the object colliding with the water drops.

The most important meteorological factor is the presence of water. The volume of ice which accumulates on the structure of the aircraft is directly proportional to the volume of water in the form of drops. When there is water in the form of vapor, snow or ice crystals, it does not normally adhere to the aircraft structure.

The second most important factor is temperature. It directly affects icing in itself, and ice will build up on the aircraft fuselage. The vast majority of icing events occur between the temperatures of 0°C and -15°C. When the temperature of the external air is below -20°C, ice build-up is a rare event, inasmuch as the “water” component has a tendency to solidify.

If one considers a standard loss gradient of 2ºC per 1,000ft of climb, it is possible to see that such conditions are normally encountered around FL200, leading this altitude to be known to the aeronautical community as *freezing level*.

Nevertheless, it is worth stressing that this gradient is merely an engineering standard for the calibration of altimeters, that is, the planning of the flight has to be done with reference to the winds aloft charts and other aids which promote an opportune knowledge of the real temperature conditions at the flight levels of interest.

The size and speed of the aircraft surfaces also have influence on the ice build-up. In a simplified manner, the thicker the surface of impact (mainly airfoils) is, the lesser the probability of ice formation. The higher the speed of the surface is, the higher the probability of ice formation. However, a flight at a reduced speed is not indicated for reducing the probability of icing at the levels aforementioned. Reduced speeds are associated with higher angles of attack and, consequently, a higher exposure of the aircraft wing area has the potential to form ice on its structure.

Thinner components or thinner surfaces are prone to ice accumulation more easily. Therefore, there is high probability that the leading edges on the empennage (vertical and horizontal stabilizers) will accumulate ice before the leading edges of the wings will do.

Also, in relation to ice build-up on the aircraft structure, the weight of the ice, when accumulated in flight, is around 50 pounds per cubic foot. In contrast, even small additions of ice on the leading edge of the airfoils may reduce the maximum coefficient of lift in up to 30%.

The worst effect to lift is caused by the first deposits of ice. Paradoxically, a later increase of the size the ice accumulated on these surfaces has a reduced effect. Thus, the angle of attack at which the aircraft stalls is diminished. In this case, the stall speed will be higher, as well as the probability of entering an inadvertent stall while turning.

The drag coefficient has an effect that is opposite to the one produced by the lift coefficient. In other words, drag increases as more ice forms on the aircraft airfoils, and can reach a value that is twofold, or even threefold, the original one produced by those surfaces. By inference, more power will be required from the engine to maintain a level flight. One has also to take into consideration that the efficiency of the propeller blades can be degraded by the accumulation of ice, if the aircraft is not equipped with anti-ice devices or if they are inoperative.

Roll control can be degraded if ice forms on the wings ahead of the ailerons. Pitch control is also deteriorated if there is ice on the leading edges of the empennage and wings, affecting the aerodynamic flow on the aircraft empennage.

The irregular texture of even a thin layer of ice on the leading edges of the horizontal stabilizers may deteriorate their effectiveness to the point of making the aircraft stall even before the very wings have stalled, resulting in loss of pitch control.

Therefore, unless there is a provision to the contrary in the manual of the aircraft manufacturer, the utilization of anti-ice or de-ice systems is expressly recommended, whenever one notices that ice is forming on these surfaces, or when icing conditions are present..

1.8 Aids to navigation.

Nil.

1.9 Communications.

The aircraft climb to FL210 was made in accordance with the clearance issued by the ATC units. After passing FL110, the aircraft continued direct to Bauru (São Paulo State). ACC-CT coordinated the PIRA2 IFR arrival for the approach to SBSP. No request was made by the pilot concerning an update of meteorological information.

The investigation commission had access to all radio communications between ATC units and the aircraft. The takeoff clearance was coordinated by the pilot. All the other communications were done by the female passenger sitting in the cockpit (copilot seat).

1.10 Aerodrome information.

Not applicable.

1.11 Flight recorders.

The aircraft was equipped with an A100S Cockpit Voice Recorder (CVR) manufactured by L3 Communications (P/N S100-0080-00 and S/N 000137440).

Despite the damage sustained by the component, it was possible to retrieve the last 30 minutes of flight, in which there were communications between the aircraft and ATC units, the ambient sound captured by the microphone installed in the cockpit, as well as the communications between the pilot and the female passenger, who was sitting in the copilot seat.

It was observed that, during the climb of the aircraft to flight level FL210, the pilot occasionally talked with the passengers.

Shortly before the aircraft had leveled off, the female passenger sitting in the right seat asked the pilot to request FL230 or FL250 from ACC-CT, so as to avoid flying in the clouds existing at FL210. The pilot disagreed, stating that the aircraft was too heavy to continue climb to a higher level.

The female passenger insisted, for feeling that one of the passengers of the back seats was upset to fly inside the clouds, and for seeing that at FL230 or FL250 they would fly clear of the clouds. The pilot replied that he would maintain FL210 for a further half an hour, with the objective of burning more fuel and then become able to climb to FL230. The female passenger commented that in half an hour they would probably be out of the clouds.

It was observed that, shortly after the aircraft had leveled off, the rotation of the propellers was adjusted to 1,850 RPM. No reference to any checklist could be noticed during the whole flight. At the beginning of the recordings (initial climb), the pilot only checked whether the aircraft pressurization was in accordance with the required parameters.

Upon completion of the climb, and 7 minutes before the loss of control, the female passenger informed about the presence of ice. It was not possible to confirm if such comment was made because she saw ice on the windshield or on the aircraft wings.

Approximately two minutes before loss of control, and after ACC-CT defined the IFR arrival in SBSP (PIRA2), it was possible to notice a concern relative to the insertion of the arrival in the Flight Management System (FMS), located on the central console of the aircraft.

Thirty seconds before the end of the recording, two audio warnings were heard (identified as coming from the stall horn - intermittent for almost 10 seconds) and also a warning of abandonment of the pre-selected FL210. The comments made by the pilot in the cockpit indicated that he did not know what was going on with the aircraft.

During the final 20 seconds, an intense noise was heard, associated with the increase of the aerodynamic flow passing around the aircraft.

Never, in the midst of the inflight loss of control, was it observed any deliberate reduction of engine power.

There were not any audio warnings concerning either disengagement of the autopilot or overspeed.

The stress sustained by the fuselage structure after the loss of control was probably responsible for activating an impact switch and disconnected power to the CVR.

1.12 Wreckage and impact information.

The aircraft wreckage was found in a soybean plantation in the municipality of Cândido Mota, State of São Paulo. There was no indication of impacts prior to the crash. There were electric lines in the area in back of the aircraft without any signs of damage.

The left engine, the right wing tip, the directional rudder, and the horizontal stabilizers were found in a 1,000-meter radius circular area around the fuselage. The four propeller blades of each engine, in spite of the deformations sustained at the impact with the ground, were still connected to their respective cubes.

The direction to which the aircraft was pointing indicated a magnetic heading of 080º.

The rescue teams had to cut off the front part of the aircraft in order to remove the bodies of the pilot and the passenger from the cockpit.

Figure 4 – Crash site.

Figure 5 – Aspect of the torsion of the fuselage to the right.

1.13 Medical and pathological information.

1.13.1 Medical aspects.

No evidence was found that problems of physiological nature or incapacitation could have affected the flight crew performance.

1.13.2 Ergonomic information.

Nil.

1.13.3 Psychological aspects.

<u>Individual information</u>

The pilot had only recently been qualified in the type of aircraft (less than one year). His qualification costs had been paid by his employer. He used to perform administrative functions for the company operating the aircraft, and flew private flights in favor of his boss.

He was described by acquaintances as charismatic, studious, methodical and organized. He passed the image of a responsible and experienced pilot.

According to information provided by persons who were with the pilot and passengers moments before the flight, all of them seemed to be relaxed.

According to accounts, the pilot did not show any signs of being tired or overworked at the time of the accident. He felt professional fulfillment, and was well within the family.

The pilot's wife was the passenger sitting in the copilot's seat, and was wearing crew clothing. According to information collected at interviews, the couple habitually flew together, although the wife did not have any aeronaut license or technical qualification.

During the flight, the pilot gave instructions to this female passenger on a few occasions. The CVR recording showed that she did the radiotelephony communication on certain phases of the flight.

According to a copilot who had flown with the captain, he used to be more cautious than bold during operations, and would make the necessary deviations in adverse meteorological conditions.

However, this same copilot affirmed not having had access to the aircraft logbook on the flights he had flown with the captain, and that the logbook would never stay onboard the aircraft. The copilot also said that when composing the crew with him, the captain never complied with the aircraft checklist, to the point of saying that he did not need to do that and would teach him how to do everything based on memory.

Another copilot, still under training, who flew as a free-lancer with the captain, also reported that this latter would even make use of a type of memory checklist nicknamed “seven killers”, which was probably developed by the very captain. According to reports, he had peculiar operational habits which he had acquired while flying, and was not used to adopting procedures prescribed in manuals.

Psychosocial information

The pilot had a good relationship with his family and showed to be always available to the persons who contacted him.

At work, he had an excellent relationship with his mates. He was described by his peers as a communicative person, always happy and in good mood.

According to information, the pilot trusted his employer, who, in turn, had confidence in his work, either as a pilot or manager of the issues related to the aircraft.

From the CVR recording, it was possible to identify a climate of disagreement in some dialogs between the captain and the female passenger sitting next to him. However, it was not possible to determine whether the interaction difficulties were due to the flight itself or to personal issues.

The pilot spent some time talking with a passenger sitting in a back seat, explaining technical details of the flight. Apparently, he wanted to create a friendly environment.

The female passenger, working as an assistant for the captain, also showed concern with the well-being of the client, who seemed to be afraid of flying. She drew the captain’s attention to the subject.

1.14 Fire.

No signs of inflight fire.

1.15 Survival aspects.

Nil.

1.16 Tests and research.

The research was carried out in the premises of an ANAC-certified workshop in Sorocaba, São Paulo State, in the presence of the investigators and DCTA engineers.

According to the Technical Report issued by the Department of Science and Airspace Technology (DCTA), the fracture surfaces found in the parts showed aspects that were characteristic of “failure due to overload”.

The root of the two leading edges of the horizontal stabilizer, which separated in flight, showed signs of compression. It was possible to notice, on both sides of the lower portion of the horizontal stabilizer and directional rudder, small fractures in the coating and significant marks from a material of dark pigmentation.

The inboard ends of the aircraft horizontal stabilizer were covered by surfaces of black rubber seal. The marks found on the base of the vertical stabilizer led to the belief that they were a result of the impact sustained by the sections of the horizontal stabilizer at the moment of detachment.

The PT6A-21 *Pratt & Whitney* engines of the aircraft were analyzed in detail at the manufacturer headquarters in Sorocaba. A team of specialists under the supervision of an aeronautical engineer of the DCTA Institute of Aeronautics and Space (IAE) presented a Technical Report of the aircraft power plant investigation.

According to the technical report, the left engine was operative, but was not developing power at the moment of the impact with the terrain. This indicated that the wing/engine assembly detached from the aircraft while it was still in the air. The propeller of the left engine showed evidence of non-rotation at the moment of impact.

Figure 6 – Right side of the assembly formed by the horizontal stabilizer and directional rudder.

Figure 7 - Left side of the assembly formed by the vertical stabilizer and directional rudder.

The right engine was operational and developing power at the moment of impact with the ground, as indicated by the severe internal damage sustained. In relation to the propeller of this engine, there were deformations and kneads without a specific pattern, which might at first be (a wrong) indication of lack of power. Such hypothesis, however, was ruled out on account of the evidence observed, which allowed affirming that the engine was developing medium to high level power.

The Ice Protection System installed in the aircraft met the requirements of the American authority and primary certifier of the aircraft, the Federal Aviation Administration (FAA), for flights under known icing conditions. Nevertheless, and in accordance with the description contained in the very flight manual of the aircraft, the referred certification was based on tests performed under natural and simulated icing conditions, with exclusion of the more severe ones, capable of eventually exceeding the Ice Protection System capacity and/or jeopardizing, in an unacceptable manner, the aircraft performance.

The manual did not forbid flying under icing conditions different from those tested. However, it explained that the crew should be ready to divert immediately, if the ice build-up became dangerous.

This system had pneumatic devices, known as de-ice boots, installed in the leading edges of the wings, horizontal and vertical stabilizers. There was also electrical heating for the internal layer of the windshield (in layers), Pitot tube, propellers, engine inertial separators, stall warning device, and fuel ventilation. The exhaustion gases were also used for maintaining the air inlets of the turbine compressor free of ice.

The aircraft also had lights in the external cowlings of the engine nacelles capable of illuminating the wing leading edges for a contingent identification of ice on those surfaces, mainly at night.

For the operation of both the pilot's and copilot's windshield heaters, two switches located on the pilot's lower right panel, could be moved to the NORMAL position (upward), allowing heating the secondary areas of each associated windshield, and HI (downward), allowing heating the primary areas of each associated windshield, in addition to OFF in the central position. Each switch had to be raised in order to overcome a dent when moved to the HI position. Such dent would prevent an inadvertent selection of that position, when changing the switch from NORMAL to OFF.

For the operation of the de-ice boots, a switch (spring loaded type), also located on the pilot's lower right panel, could be momentarily moved to one of two positions: SINGLE (upward), allowing automatic alternate filling of the wing boots (for six seconds), and vertical stabilizer boots (for four seconds), and MANUAL (downward), allowing filling all boots simultaneously, for the time the switch was manually maintained in that position. With the switch at the central position, the system was turned off.

An electric source was necessary for filling the boots. The loss of such source would cause a vacuum pump to maintain the boots stuck to the leading edges.

The aircraft training manual provided by the aircraft operator read that an ice layer of ½ inch could be allowed to form before starting operation of the de-ice boots, in order to prevent thin ice from breaking and get stuck to the boots instead of dispersing in flight. If this ice got stuck, the subsequent filling cycles might create an ice layer beyond the leading edge contours protected by the boots, rendering the ice removal process ineffective.

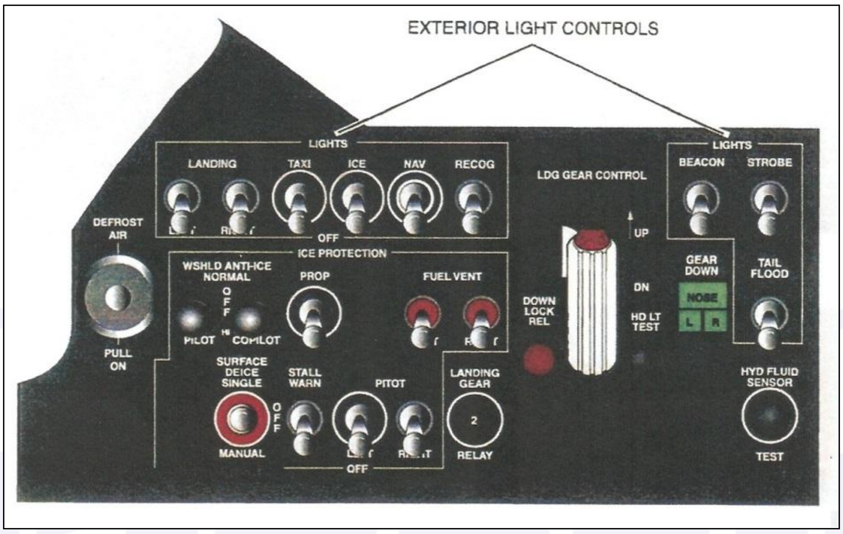

Figure 8 – Schematic representation of the pilot's lower right panel.

Figure 9 - Pilot's lower right panel, as found amid the wreckage.

The pilot's lower right panel concentrated practically all the Ice Protection System controls. It was found rather damaged, with a few switches dirty with earth, switch-identification plastic covers broken, as well as other deformations resulting from impact.

It was found that, except for the heating switch propellers, all others were found off, including two heating switches of windshields. However, except for windshield switches that had locks, the positions of the other switches can't be assumed as pre-impact positions.

The filling of the de-ice boots was performed by means of pneumatic pressure bled from the turbine compressors. This operation was controlled by a switch located on the pilot's lower right panel. The switch, upon being positioned, worked electrically in the distribution valve located under the floor of the passenger cabin. The investigation commission had access to this area when examining the wreckage. The valve was substantially damaged, due to the compression effects at the impact with the ground. It was not possible to carry out any type of bench tests. Nevertheless, since the electric feeding of the component was intact, a procedure of alternated air induction was performed in the pneumatic connections, thus simulating the pressure bled from the compressors. The commission concluded that the valve was perfectly operative prior to the crash of the aircraft.

Taking advantage of the opening made in the passenger cabin floor, the investigation commission observed that the pneumatic lines coming to /departing from the distribution valve had integrity as far as the wing roots, despite torsions and kneads resulting from the impact.

The aircraft elevator trim actuator was submitted to tests which included installing it in another aircraft. The commission concluded that the position of the actuator in the accident aircraft was compatible with pitch-up full deflection. The metal cables of the actuator system had broken on account of effort (overload).

Although the aircraft was certified for flying under known icing conditions, its flight manual prescribed that a minimum speed of 140kt should be maintained, so as to prevent the formation of ice on the lower surface of the wings, which, obviously, would not be capable of being adequately de-iced. The flight manual also read that all the components of the Ice Protection System had to stay switched on under such conditions.

The published sever icing actions required by the pilot as addressed in Limitations in the aircraft flight manual have a warning note concerning flight under icing conditions:

> LIMITATIONS WHEN ENCOUNTERING SEVERE ICING CONDITIONS (Required By FAA AD98-04-24)
>
> Severe icing may result from environmental conditions outside of those for which the airplane is certificated. Flight in freezing rain, freezing drizzle, or mixed icing conditions (super cooled liquid water and ice crystals) may result in ice build-up on protected surfaces exceeding the capability of the ice protection system, or may result in ice forming aft of the protected surfaces. This ice may not be shed using the ice protection systems, and may seriously degrade the performance and controllability of the airplane.
>
> 1. During flight, severe icing conditions that exceed those for which the airplane is certificated shall be determined by the following visual cues. If one or more of these visual cues exists, immediately request priority handling from Air Traffic Control to facilitate a route or an altitude change to exit the icing conditions.
>
> a. Unusually extensive ice accumulation on the airframe and windshield in areas not normally observed to collect ice.
>
> b. Accumulation of ice on the upper surface of the wing, aft of the protected area.
>
> c. Accumulation of ice on the engine nacelles and propeller spinners farther aft than normally observed.
>
> 2. Since the autopilot, when installed and operating, may mask tactile cues that indicate adverse changes in handling characteristics, use of the autopilot is prohibited when any of the visual cues specified above exist, or when unusual lateral trim requirements or autopilot trim warnings are encountered while the airplane is in icing conditions.
>
> 3. All wing icing inspection lights must be operative prior to flight into known or forecast icing conditions at night. [NOTE: This supersedes any relief provided by the Master Minimum Equipment List (MMEL).]

According to the abnormal procedures published in the aircraft flight manual, some procedures have to be adopted in severe icing conditions:

> SEVERE ICING CONDITIONS
>
> (Alternate Method of Compliance With FAA AD 98-04-24)
>
> THE FOLLOWING WEATHER CONDITIONS MAY BE CONDUCIVE TO SEVERE IN-FLIGHT ICING:
>
> • Visible rain at temperatures below zero degrees Celsius ambient air temperature.

• Droplets that splash or splatter on impact at temperatures below zero degrees Celsius ambient air temperature.

PROCEDURES FOR EXITING THE SEVERE ICING ENVIRONMENT:

These procedures are applicable to all flight phases from takeoff to landing. Monitor the ambient air temperature. While severe icing may form at temperatures as cold as -18 degrees Celsius, increased vigilance is warranted at temperatures around freezing with visible moisture present. If the visual cues specified in the Limitations Section for identifying severe icing conditions are observed, accomplish the following:

1. Immediately request priority handling from Air Traffic Control to facilitate a route or an altitude change to exit the severe icing conditions in order to avoid extended exposure to flight conditions more severe than those for which the airplane has been certificated.

2. Avoid abrupt and excessive maneuvering that may exacerbate control difficulties.

3. Do not engage the autopilot.

4. If the autopilot is engaged, hold the control wheel firmly and disengage the autopilot.

5. If an unusual roll response or uncommanded roll control movement is observed, reduce the angle-of-attack.

6. Do not extend flaps when holding in icing conditions. Operation with flaps extended can result in a reduced wing angle-of attack with the possibility of ice forming on the upper surface further aft on the wing than normal, possibly aft of the protected area.

7. If the flaps are extended, do not retract them until the airframe is clear of ice.

8. Report these weather conditions to Air Traffic Control.

Moreover, there was the information that the aircraft radar was operating intermittently.

1.17 Organizational and management information.

Nil.

1.18 Operational information.

The aircraft was within the weight and center of gravity limits (CG) specified by the manufacturer.

On the day before the accident, the aircraft had taken off from SBMT at 18:43 UTC, destined for SBMG, where it stayed overnight. The aircraft was refueled with 446 liters of aviation kerosene, to the maximum capacity of its tanks. The pilot watched the refueling.

The IFR flight plan, filed via telephone, proposed FL210 as cruise level along 200 km of route. The reported endurance was 4 hours and 30 minutes, and the enroute elapse time was 1 hour 30 minutes. The proposed route included direct navigation to the KARIU fix (fix for departing Londrina terminal area), then direct SCB VOR, and then direct to the destination. The alternate aerodrome was SBSJ.

From the analysis of radar images provided by CINDACTA II, it was observed that the aircraft leveled off at FL210 between 22:06 UTC and 22:07 UTC, that is, approximately 25 minutes after takeoff, and 5 minutes before aircraft control was lost at level flight.

1.19 Additional information.

In relation to the CVR recordings, conversation between the captain and the female passenger in the cockpit was retrieved, leading the commission to believe that the pilot sometimes deliberately switched off the starter of the flap electric system.

It was found that, due to a characteristic of the aircraft electric design, the hour-meter would become inoperative, while the starter stayed protruded. The hour-meter is a device for recording the engine hours of operation, so that future inspections can be scheduled. At a certain moment, the female passenger in the cockpit showed her concern with the action, questioning why the captain did not make timely provisions regarding the aircraft overhaul, since the safety of all on board would result compromised.

The captain replied, stating that such overhaul was expensive, and also that he had been told that there was no interest to keep the aircraft in the fleet any longer. He also mentioned that he had been subtracting 30% in each flight, giving the impression he was talking about the count of the hours.

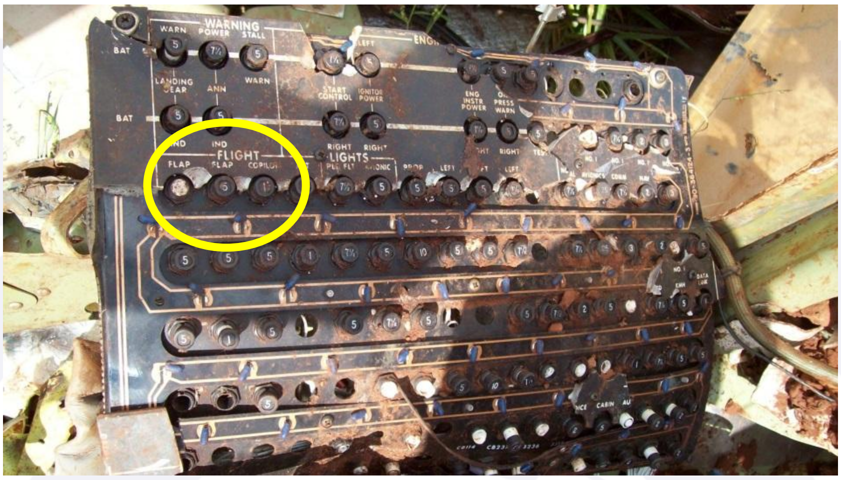

Figure 10 – Starter panel of the copilot. In the highlight, one of the flap starters is seen broken.

1.20 Useful or effective investigation techniques.

Nil.

2. ANALYSIS.

The captain was not qualified for IFR flights, that is, his IFR rating validity had expired in January 2013, according to ANAC records.

Maybe the proximity with the recent expiration date would not in itself be so relevant in view of flight safety if the pilot had been highly experienced in IFR flights. However, his experience in the aircraft and in this type of flight was less than a year. Neither did he have certifications for other types of fixed-wing aircraft. His selection of the FL210 under the prevailing meteorological conditions pointed toward inexperience or inadequacy of his IFR flight planning, if one considers the presence of a front moving in a direction opposite to the one of the proposed flight.

On the day of the accident, a female passenger was sitting in the right seat of the cockpit without possessing any certifications granted by the ANAC.

According to the CVR recording, it became clear that the passenger in the cockpit was doing the RT communication with ATC units, and was handling the FMS, among other activities normally performed by a crewmember. Her comments, however intuitive, showed a level of situational awareness that was higher than the captain’s.

Except for the aircraft pressurization, no other checklist was verified during the whole flight. According to information collected, such non-adherence to the aircraft normal procedures was something that had already occurred on other flights.

Since the aircraft was getting near to undergoing an expensive engine overhaul (3,600 hours), there is evidence that the captain used to disarm the starter in flight in order to stop the hour-meter. Such irregular reduction, in each operation, of the total number of hours effectively flown in around 30% could make the aircraft seem more attractive to contingent buyers, since, according to the CVR recording, the aircraft would probably be sold.

From the investigation standpoint, the records concerning the total amount of hours flown by the aircraft lost their credibility.

Even with the intermittent functioning of the radar, the captain was alerted of the ice buildup about 7 minutes before losing control of the aircraft. This fact, together with the conversation between the captain and the female passenger in the cockpit, the discussion about which flight level would be best, and the attention of them both focused on the FMS for more than two minutes, made it evident that nobody was flying the aircraft at those moments, a situation that was confirmed by the captain’s surprise upon verifying that the aircraft was out of control.

The temperature and dew point conditions, the flight in cumulus clouds, and the decrease of the cruise speed (ratified during the radar re-run), all created an environment favorable to the formation of ice on the aircraft structure, increasing the aircraft weight and degrading the aerodynamic profile of the airfoils.

Since the autopilot was engaged in the altitude hold mode, the aircraft had a tendency to increase the angle of attack to maintain the flight level with lift degradation.

The speed decrease favored accumulation of ice on the airfoil, thus increasing drag and stall speed even further. The autopilot operation may have masked the impending stall condition.

The stall horn (intermittent for almost ten seconds at the final moments of the CVR recording) characterized loss of lift. The cessation of the horn sound and the increase of the noise of the aerodynamic flow passing around the aircraft were an indication that the aircraft had entered a descending spiral, which was not immediately identified by the pilot. It is probable that he never trained similar maneuvers, apart from anything else because there was no prescription in the aircraft flight manual regarding the subject.

The restrictions of visibility (IMC), together with the spin of the aircraft, may have contributed to hindering the captain’s identification of the aircraft position and attitude on account of spatial disorientation.

The proximity with the Maximum Operating Speed (VMO) and in the midst of an adverse situation, probably contributed to exceeding the aircraft structural limits in the tardy attempt by the captain to recover from the high rate of descent. This would be the explanation of the damage due to overload attested by the DCTA, and of the sequential disintegration of the aircraft structure in flight.

The control panel of the Ice Protection System showed that the majority of the associated switches were OFF, except the one related to the heating of the propellers. The motion resulting from the impact and the work performed by the rescue teams may have altered the original position of the switches, and the commission disregarded this information at first. However, the starters of the heating of the windshields were also at OFF, and they were the only starters protected by locks when in the HI position, the most compatible one if one considers the situation dealt with by the captain. Thus, the commission inferred that the Ice Protection System might not been activated, allowing ice to accumulate on the aircraft surfaces.

The stress sustained by the fuselage structure after the loss of control was probably responsible for activating an impact switch and disconnected power to the CVR, making it impossible for the recording to continue up to the moment the aircraft crashed.

The aircraft attitude upon crashing into the ground was practically without any angle (flat). The fatal injuries suffered by the pilot and the passengers had direct relation with the energy of the impact (intense instantaneous vertical deceleration).

At the time of the accident, he looked neither tired nor overworked, and was enjoying a good period of his life.

According to the CVR recording, at some points of the flight, he gave instructions to the female passenger sitting in the cockpit, and she did the radiotelephony communication at certain points of the flight, showing good theoretical and operational routine knowledge.

The female passenger was neither qualified nor certified for the function, but the captain treated her as if she were the copilot, showing a complacent behavior in his attitudes contrary to flight safety.

The frequency of his flights with this passenger on board, without any restrictions and the successful completion of the past flights reinforced his attitude of attributing the functions of a copilot to her.

The captain spent some time talking with the passengers, explaining technical details of the flight, apparently with the intention of creating a friendly climate.

The weather conditions during the flight were of concern for the passenger sitting in the cockpit, and on several occasions she asked the captain to request a flight level change, appearing to be anxious with the situation.

At a certain point, the female passenger even alerted the captain about a formation of ice on the external part of the aircraft. Judging from the fact that he did not give her an answer, he seemed to not have paid attention to her, and resumed his talking with the passengers.

For all the foregoing, it seems that the attention of the captain was more directed towards providing the passengers with comfort than worry about the flight conditions.

At another moment, the captain even made comments to the female passenger, and showed her the ice build-up outside. However, judging from the casual way with which he talked to her about the phenomenon, and later, at the final moments before losing control of the aircraft, when he asked her in a desperate manner about what could be going wrong with the aircraft, there is indication that his situational awareness was poor.

At interviews, a copilot that had already flown with the captain reported that he used to be a more cautious than bold person during operations, and that he would make any necessary deviations under adverse meteorological conditions. He also said that the captain did not have the operational habit of referring to the aircraft checklist. Once, when they were flying together, the captain said that he would teach the copilot how to do everything based on memory.

Another copilot reported that the captain made use of a kind of memory checklist called “seven killers” and that had probably been created by the very captain.

These accounts reflect that deviations from prescribed procedures were frequent. Such behavior may have been reinforced by lack of supervision of the activities performed by the captain, and his poor adherence to rules and manuals.

The tests and research also showed that the engines were operative, that the pneumatic valve of the de-ice boots was functioning normally, and that the associated lines did not have any abnormalities.

Eventually, the actuator elevator trim with pitch up position denotes that the autopilot engaged in “altitude hold mode” kept the altitude of the aircraft compensating the speed reduction until it reached a critical value for the flight in ice conditions without any action from the pilot as required by aircraft’s manual.

3. CONCLUSIONS.

3.1 Facts.

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

b) The pilot had a valid technical qualification certificate (CHT);

c) According to ANAC records, the validity of the pilot’s IFR rating had expired;

d) The aircraft had a valid airworthiness certificate (CA);

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

f) The aircraft radar was functioning intermittently;

g) The IFR flight was conducted inside layers of cumulus clouds;

h) The aircraft passed through a region where icing was occurring;

i) A female passenger sitting beside the pilot observed that there was ice on the external part of the aircraft;

j) The pilot was actively talking with another passenger during the flight;

k) The aircraft lost lift approximately 5 minutes after reaching cruise level;

l) There was a relevant increase in the aircraft speed after it stalled;

m) Parts of the aircraft separated from the structure while the aircraft was still in flight;

n) The power plant was operative;

o) All the other systems were operative;

p) The actuator of the elevator trim was fully deflected at a pitch-up position;

q) The fuselage presented a torsion to the right;

r) The aircraft was destroyed; and

s) All the aircraft occupants perished in the crash site.

3.2 Contributing factors.

- **Control skills – undetermined.**

The lack of a prompt identification of the aircraft stall by the captain may have deprived him of handling the controls in accordance with the prescriptions of the aircraft emergency procedures, contributing to the aircraft entry in an abnormal attitude.

- **Attention – undetermined.**

The captain’s attention was focused on the passengers sitting in the rear seats, in detriment of the flight conditions under which the aircraft was flying. This had a direct influence on the maintenance of a poor situational awareness, which may have made it difficult for the captain to immediately identify that the aircraft was stalling.

- **Attitude – a contributor.**

There was complacency when the copilot functions were assumed by a person lacking due professional formation and qualification for such. Even under an adverse condition, the prescribed procedure was not performed, namely, the use of the aircraft checklist.

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

The fact that the aircraft was flying under icing conditions was confirmed by a statement of the female passenger in the cockpit (CVR). The FL210 (selected and maintained by the captain) gave rise to conditions favorable to severe icing on the aircraft structure. If the prevailing weather conditions are correlated with reduction of speed (attested by the radar rerun), the connection between loss of control in flight and degraded aircraft performance is duly established.

- **Disorientation – undetermined.**

The rotation of the aircraft after stalling may have contributed to the loss of references of the captain's balance organs (vestibular system), making it impossible for him to associate the side of the turn made by the aircraft with the necessary corrective actions.

- **Training – undetermined.**

The non-adherence to the aircraft checklists on the part of the captain, in addition to the deliberate adoption of non-prescribed procedures (disarmament of the starter and "seven killers") raised doubts on the quality of the instruction delivered by the captain.

- **Piloting judgment – a contributor.**

The captain made an inappropriate flight level selection for his flight destined for São Paulo. Even after a higher flight level was offered to him, he decided to maintain FL 210. Also, after being informed about icing on the aircraft, he did not activate the Ice Protection System, as is expressly determined by the flight manual.

- **Memory – undetermined.**

The captain had the habit of making use of a checklist not prescribed for the aircraft, and this may have influenced his actions in response to the situation he was experiecing in flight.

- **Perception – a contributor.**

His recently earned technical qualification in the aircraft type; his inattention and distraction in flight; his attitude of non-compliance with operations and procedures prescribed in manuals; all of this contributed to the captain's poor situational awareness.

- **Flight planning – undetermined.**

The flight plan was submitted via telephone. Therefore, it was not possible to determine the captain's level of awareness of the real conditions along the route, since he did not report to the AIS office in SBMG. In any event, the selection of a freezing level for the flight, considering that the front was moving along the same proposed route, was indication of inappropriate planning.

- **Insufficient pilot's experience – undetermined.**

The investigation could neither determine the whole experience of the aircraft captain, nor whether his IFR flight experience was sufficient for conducting the proposed flight, since he made decisions which went against the best practices, such as, for example, selecting a flight level with known icing.

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

With a compromised situational awareness, the pilot failed to correctly interpret the information available in the aircraft, as well as the information provided by the female passenger sitting in the cockpit, and he chose to maintain the flight level under inadequate weather conditions.

- **Organizational processes – a contributor.**

The lack of monitoring/supervision of the activities performed by the captain allowed that behaviors and attitudes contrary to flight safety could be adopted in flight, as can be observed in this occurrence.

- **Managerial oversight – undetermined.**

Apparently, there was lack of an effective managerial supervision on the part of the aircraft operator, with regard to both the actions performed by the captain and the correction of the aircraft problems.

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".

Recommendations issued at the publication of this report:

To the National Civil Aviation Agency (ANAC):

A-025/CENIPA/2013 – 01 **Issued on 15/04/2016**

Instruct Civil Aviation Inspectors to give emphasis to charging the pilots with the execution of standard procedures, conducted in accordance with aircraft manuals and checklists.

A-025/CENIPA/2013 – 02 **Issued on 15/04/2016**

Ensure that the knowledge related to meteorological phenomena and their implications for the safe conduct of flights are properly transmitted in pilot training courses approved by this agency.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

None.

On April 15th 2016.