COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A - 026/CENIPA/2016

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PP-LIG**
MODEL:	**TBM700N**
DATE:	**01FEB2016**

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 01FEB2016 accident with the TBM700N aircraft, registration PP-LIG. The accident was classified as "Undetermined".

During the instrument departure procedure from the Hercílio Luz Aerodrome - Florianópolis, SC, (SBFL), the aircraft disappeared from the radars and did not make any further contact. Some wreckage were found on the surface of the sea on the day of its occurrence. The fuselage of the aircraft and its occupants were found 14 days after the accident.

The aircraft was destroyed.

The pilot and the passenger died during the impact of the aircraft against the sea.

An Accredited Representative of the *Bureau d'Enquêtes et d'Analyzes pour la Sécurité de l'Aviation Civile* (BEA) – France, and an Accredited Representative of the Transportation Safety Board (TSB) – Canada, were designated for participation in the investigation.

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GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ANAC	(Brazil's) National Civil Aviation Agency
APP	Approach Control
BEA	*Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile*
BKN	Broken: Cloudy: from 5/8 to 7/8 of the sky full of clouds
CA	Airworthiness Certificate
CENIPA	Aeronautical Accident Investigation and Prevention Center
CG	Center of Gravity
CHT	Technical Qualification Certificate
CIV	Pilot's Flight Logbook
CM	Certificate of registration
CMA	Aeronautical Medical Certificate
DCTA	Aeronautics' Science and Technology Department
HASP	São Paulo Aeronautics Hospital
IAE	Aeronautics and Space Institute
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
INFRAERO	Brazilian Airport Infrastructure Company
LAT	Latitude
LONG	Longitude
LTDA	Limited
METAR	Aerodrome Routine Weather Report
MLTE	Qualification Type – Airplane Multi-Engine Land
MNTE	Qualification Type – Airplane Single-Engine Land
PCM	Commercial Pilot - Airplane Category
PPR	Private Pilot License - Airplane Category
RS	Safety Recommendation
SBFL	ICAO location designator - Florianópolis Aerodrome
SBJI	ICAO location designator – Ji-Paraná Aerodrome
SERIPA V	Fifth Regional Aeronautical Accident Investigation and Prevention Service
SID	Standard Instrument Departure
SIPAER	Aeronautical Accident Investigation and Prevention System
SN	Serial number
TPP	Private Air Services
TSB	Transportation Safety Board
TWR	Aerodrome Control Tower
UTC	Universal Coordinated Time
VFR	Visual Flight Rules
VOR FLN	Florianópolis VHF Omnidirectional Radio-Beacon

1. FACTUAL INFORMATION.

Aircraft	**Model:** TBM700N **Registration:** PP-LIG **Manufacturer:** SOCATA	**Operator:** Private
Occurrence	**Date/time:** 01FEB2016/0719 UTC **Location:** Sea **Lat.** 27°44'57"S **Long.** 048°26'15"W **Municipality – State:** Florianópolis - SC	**Type(s):** Undetermined **Subtype(s):**

1.1 History of the flight.

The aircraft took off from the Hercílio Luz Aerodrome, Florianópolis, SC (SBFL), to the José Coleto Aerodrome, *Ji-Paraná*, RO (SBJI), at 0715 UTC to perform a private transport flight, with one pilot and one passenger on board.

After takeoff, when crossing about 3,000ft, the aircraft started a right turn. After completing 360° of curve, the aircraft disappeared from the radars and did not make any further contact.

Some wreckage were found on the surface of the sea on the day of its occurrence. The fuselage of the aircraft and its occupants were found 14 days after the accident.

The aircraft was completely destroyed.

The pilot and the passenger perished at the accident site.

1.2 Injuries to persons.

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

1.3 Damage to the aircraft.

The aircraft was completely destroyed.

1.4 Other damage.

Nil.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Hours Flown	
	Pilot
Total	1.535:00
Total in the last 30 days	09:00
Total in the last 24 hours	00:04
In this type of aircraft	154:00
In this type in the last 30 days	09:00
In this type in the last 24 hours	00:04

N.B.: The Data relating to the number of hours flown by 26JUN2015 were obtained from the records of the Electronic Single Flight Log (CIV). The hours flown after that date,

exclusively on the PP-LIG aircraft, were estimated from aircraft movement data, recorded at the National Civil Aviation Agency (ANAC).

1.5.2 Personnel training.

The pilot took the Private Pilot course- Airplane category (PPR) at the Aeroclube Rio Grande do Sul - RS, in 1998.

1.5.3 Category of licenses and validity of certificates.

The pilot had the Commercial Pilot - Airplane (PCM) license and had valid technical qualifications of Airplane Single-Engine Land (MNTE), Airplane Multi-Engine Land (MLTE) and Instrument Flight Rules (IFR).

1.5.4 Qualification and flight experience.

The pilot was qualified, but had little experience in the IFR flight under instrument meteorological conditions (IMC).

1.5.5 Validity of medical certificate.

The pilot had valid Aeronautical Medical Certificate (CMA).

1.6 Aircraft information.

The aircraft, serial number 1071, was manufactured by SOCATA in 2015 and was registered in the category of Private Air Services (TPP).

The aircraft was authorized to perform nightly IFR.

The aircraft had valid Airworthiness Certificate (CA).

The airframe and engine logbooks records were up-to-date.

The last inspection of the aircraft, the "100h" type, was done on 15SEPT2015 by Algar Aviation shop, in Uberlândia – MG. The aircraft flew approximately 95 hours after the inspection and had 195 total flight hours.

1.7 Meteorological information.

SBFL METAR, valid for the time of the accident, recorded the following parameters:

METAR SBFL 010700Z 05004KT 9999 BKN017 BKN080 22/21 Q1014 =

As for the cloudiness, METAR reported that between 5/8 and 7/8 of the sky was covered of clouds, and that these clouds had base at 1,700ft and 8,000ft height, respectively. These parameters indicated the operation under instrument flight rules, in which the aircraft should be conducted without the aid of external references. The METAR still reported 050° wind with 04kt.

1.8 Aids to navigation.

Nil.

1.9 Communications.

The communications took place normally. The last communication was carried out with the Florianópolis Control (APP-FL), soon after the takeoff.

During the departure procedure (OBMEG 1A AGURI), which provided a left turn, the aircraft started a right turn. After the aircraft performed a 270° turn to the right, the APP-FL attempted to contact, however, it did not have an answer. After loss of radar viewing, the air traffic control service requested searches for the aircraft.

1.10 Aerodrome information.

The occurrence took place outside the Aerodrome.

1.11 Flight recorders.

Neither required nor installed.

1.12 Wreckage and impact information.

The wreckage recovered from the sea evidenced a great degree of destruction of the aircraft, suggesting that the impact occurred with high speed and a large pitch down angle.

1.13 Medical and pathological information.

1.13.1 Medical aspects.

The analysis of the possible contributing factors of the human factor was made post-mortem, through an interview with a relative of the owner of the aircraft and documentary survey.

The pilot performed three health inspections at the São Paulo Aeronautics Hospital (HASP): 01/21/2014, 12/30/2014 and 10/12/2015. In the latter, the opinion of the psychiatric evaluation recorded "No psychopathological evidence". In the psychological evaluation, it was recorded "sufficient performance in psychometric tests and no evidence of psychopathology in personality tests". All the inspections had an "able" opinion, with the use of corrective lenses due to presbyopia.

1.13.2 Ergonomic information.

Nil.

1.13.3 Psychological aspects.

According to information collected from relatives, the pilot took a Private Pilot course at Aeroclube Rio Grande do Sul, RS, and flew in an air taxi company on a C-182 Skylane aircraft and, for approximately 5 years, operated in the area between Ji- Paraná, RO, and São Paulo, SP.

The pilot had been working for the family of the aircraft operator for 16 years.

The pilot lived with the owner of the aircraft's family. He was considered a trustworthy person and assisted, on his own, in the care of the operator's children, when he was not flying. He was considered very discreet and quiet.

Family reports said that the pilot was feeling pressured to perform under instrument meteorological conditions (BMI) and at dawn. However, he could not impose himself on the boss.

1.14 Fire.

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

1.15 Survival aspects.

Nil.

1.16 Tests and research.

The Aeronautics and Space Institute (IAE) of the Aeronautics' Science and Technology Department (DCTA) submitted the PT6A-66 D engine, s / n PCE-RV0420, the structure and components of the propeller blades to analysis.

Regarding the engine, the investigation showed that it presented evidences of operation with high power at the moment in which the collision of the aircraft against the water occurred.

In relation to the propeller blades found, the investigation concluded that the fractures observed in the analyzed parts occurred due to the impact against the water at the time of the fall.

1.17 Organizational and management information.

According to reports, the owner of the aircraft and his family had moved from São Paulo, SP, to Florianópolis, SC, shortly before the accident. Thus, the pilot moved to live and operate the aircraft from Florianópolis.

The operator, as described by people close to him, was an excellent boss, always keeping commitments and treating his employees well, even though it was quite imposing.

According to reports, the operator liked to travel at dawn.

At the time of the accident, the pilot woke up at approximately 2:30 am (local time) and went to the airport at approximately 3:00 a.m. (local time) to prepare all the procedures that involved the operation of the aircraft. The take-off took place at 5:15 a.m. (local time).

Despite the boss preference for takeoff at dawn, according to reports, the pilot did not complain.

The aircraft and its operation were private, and there was no organizational structure of an airline. The pilot of the aircraft carried out the management of the air activities. There was no supervision of the operational activities.

1.18 Operational information.

The aircraft was within the weight and balance parameters specified by the manufacturer.

According to collected information, the pilot had about 154 hours of flight in this model, in which he performed 30 hours of simulator training at the factory in the United States. It was also found that the pilot did not feel confident about the operation of the aircraft.

All the systems of the aircraft had information in English. However, the pilot had a basic level in that language.

Although he was able to operate IFR and had performed more than 160 flight hours under these conditions, it was found during the investigation that the pilot avoided flying in the clouds.

He had little flight experience in IMC weather conditions in terms of visibility, distance from weather formations and ceiling, lower than the minimums specified for visual flights.

The day before the event, the pilot monitored the aircraft's fuel supply and made the flight plan himself.

On the day of the accident, the communication took place normally. The flight plan was authorized using the OBMEG 1A Standard Instrument Departure (SID), AGURI transition procedure. (Figure 1)

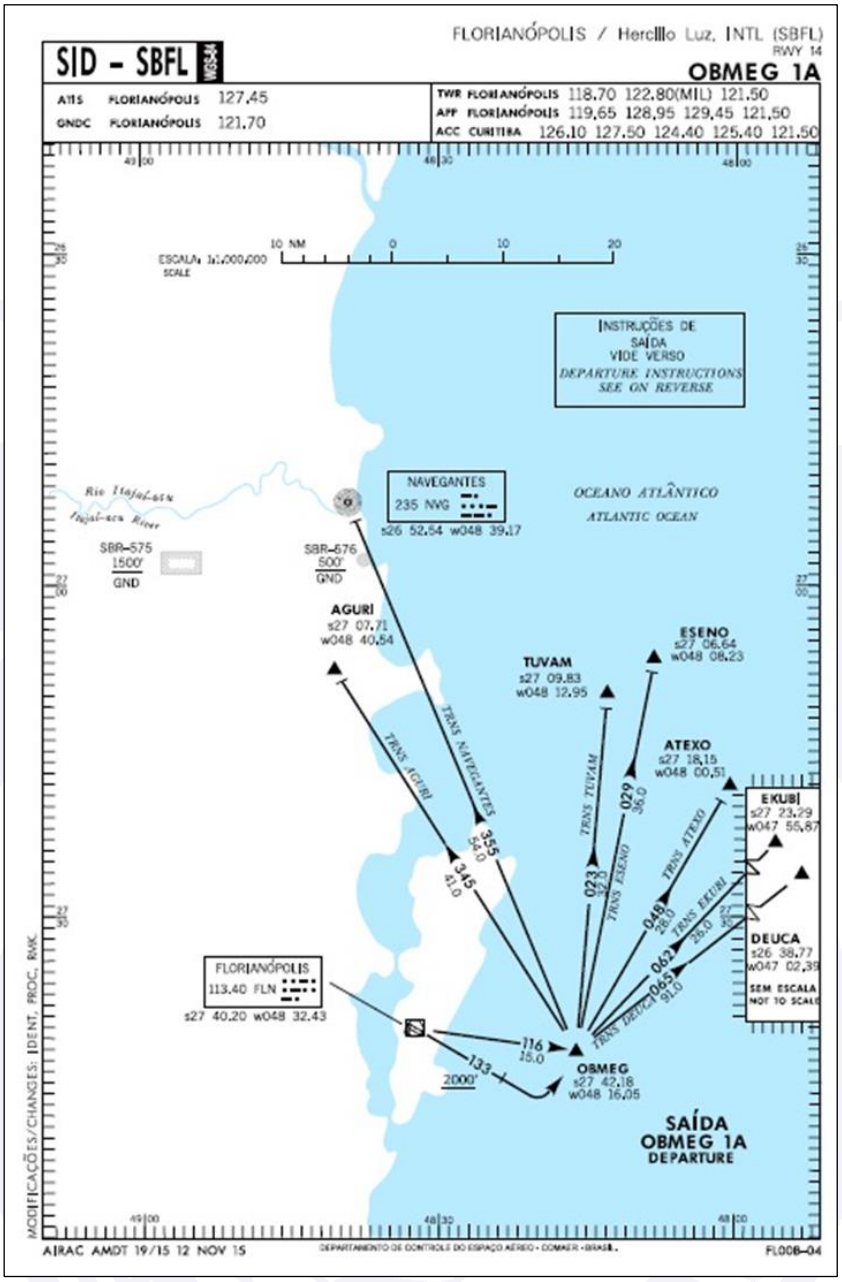

Figure 1 - OBMEG 1A SID procedure.

Take-off was performed on runway 14 (course 139°). The departure procedure expected the maintenance of radial 133 of the Omnidirectional Radio-Beacon in VHF Florianópolis (VOR FLN) up to 2,000ft and, then curving to the left to intercept the radial 116 of FLN, in the fixed OBMEG, distant 15NM of FLN. However, initially the pilot varied around the radial 150 of FLN.

At 2,600ft, under instrument meteorological conditions, that is, below the established minimums to fly according to the rules of the visual flight, the aircraft started a small turn to the left. Shortly thereafter, the aircraft reversed the curve to the right, making a 360° turn to the right, while losing altitude and gaining speed, characterizing a downward spiral. (Figure 2).

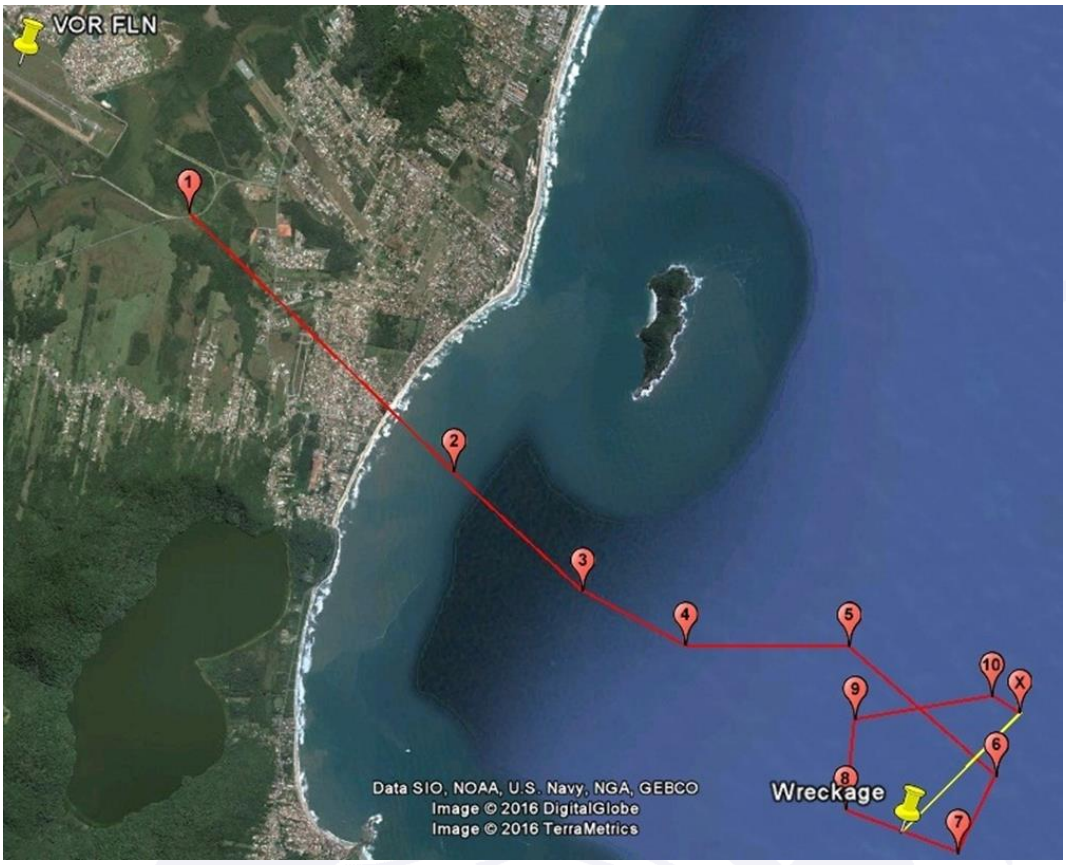

Figure 2 - Trajectory performed by the aircraft.

Table 1, below, refers to the points indicated in figure 2, describing the data related to the UTC (UTC), distance and radial of the VOR FLN, altitude and speed of the aircraft:

	TIME (UTC)	DISTANCE (NM)	RADIAL VOR FLN	ALTITUDE (FT)	SPEED (KT)
1	0716:20	2,6	149	1200	149
2	0716:46	3,7	151	1800	162
3	0717:06	4,8	151	2600	155
4	0717:24	5,5	149	2900	161
5	0717:45	6,3	143	3300	174
6	0718:12	7,5	144	3600	162
7	0718:26	7,6	148	3600	151
8	0718:37	6,9	150	XXXX	193
9	0718:44	6,6	146	2800	220
10	0718:57	7,2151	141	2800	229
	X: last registered position of the aircraft: 27°44’13”S - 048°25’25”W *Wreckage*: place where the wreckage were found.				

Table 1 - Data of the trajectory performed by the PP-LIG.

The radar data showed that the flight trajectory exhibited variations of course and speed incompatible with the use of autopilot.

1.19 Additional information.

A - Spatial Disorientation was defined by Benson (1988):

> Spatial disorientation is a term used to describe a variety of incidents occurring in flight where the pilot fails to detect correctly the position, movement, or attitude of

> his or her plane within the fixed coordinate system provided by the surface of the Earth, and gravity. In addition, errors of perception by the pilot about his position, movement or attitude toward his aircraft or of his own aircraft in relation to other aircraft may also be embraced within a broader definition of in-flight spatial disorientation.

The disorientation can be classified into three basic types: type I (unrecognized), type II (recognized) and type III (Incapacitating).

In type I (unrecognized) disorientation, the pilot is unaware that he is disoriented. The pilot does not know the problem, he continues to fly, normally. This is particularly dangerous since the pilot will not take any appropriate corrective action since he does not realize that there is indeed a problem. The aircraft, in full operation, is then taken to the ground, and often fatal results. This form is clearly dangerous, and is responsible for most accidents and fatalities.

Type II (recognized) disorientation is more common than Type I. In this form of disorientation, the pilot becomes aware that there is a problem and that his sensory system is giving information that does not agree with the information available to instruments. There is conflict between his own perceptions and what the instruments provide. At that point, if the pilot takes actions correctly, the accident can be avoided.

In disorientation of type III (incapacitating), the pilot experiences the most extreme form of disorientation. The pilot may be aware of the disorientation, but he is mentally and physically overwhelmed, to the point of being unable to regain control of the situation. He can freeze on the controls or command the aircraft in a way that aggravates the situation, rather than recovering it. Such a form of disorientation is the result of malfunctions in the normal cognitive process, especially if there are other factors, such as fatigue and high workload.

In order to understand how disorientation plays a crucial role in flight safety, it is necessary to first consider how the normal spatial orientation process works. Under normal conditions, humans are able to accurately determine a moving trajectory. We are guided by information from three specialized sensory systems: the visual system, the balance organs located in the inner ears (also known as the vestibular system), and the proprioceptive system.

These three systems rely on several sensory receptors to collect information and then send this information to the brain, which integrates the information received into a single orientation model. Considering that the main sense involved in the orientation is the vision, being responsible for approximately 80% of the information received, during a flight without visual references, we have lost much of our orientation ability. The other 20% are equally divided between the vestibular system and the proprioceptive system, both prone to illusions and errors of interpretation.

There are disorientations, for example, that can occur soon after the take-off of dark places. In these cases, the vestibular system may send a message of nose up (nose of the aircraft up) to the brain, but if there is no visual stimulus, when the pilot adjusts the takeoff attitude, it can end up placing the nose of the airplane too low (illusion somato-gravitational).

The semicircular canals and the otoliths that compose the vestibular system are not precise, being able to identify curved and linear accelerations, but at certain limits. Thus, they may not identify a slow or steady state curve.

In this case, the pilot conducted the flight with lightly inclination to the left and, correcting to the right, probably he remained in curve. In this way, the pilot may have thought that he was still in straight and levelled flight, as this was the sensation he had, that is, there were no other stimuli in the vestibular system (no right curve information

reached the brain). This type of disorder is known as Graveyard Spiral. Then, from a certain point, the aircraft began to lose altitude, making it even more difficult to regain control of the flight, although the pilot identified the abnormal situation by observing the artificial horizon. This may have generated a conflict because humans tend to rely on their sensations rather than on the equipment.

1.20 Useful or effective investigation techniques.

Nil.

2. ANALYSIS.

The aircraft operated within the weight and balance parameters, and its power unit had normal operation, developing power.

The aircraft and its operation were private, not having an organizational structure like an airline. The pilot himself, without the supervision of the operational activities, carried out the management of the air activities.

The pilot was qualified and had valid CHT and CMA. However, it was found that he had little experience in instrument flight in real conditions, since, for the most part, flights were performed under visual meteorological conditions, although flying under instrument flight rules.

There was a probable attitude of high subordination of the pilot to his employer, especially in situations requiring night flights and in instrument meteorological conditions. These conditions may have generated negative results for the pilot's confidence.

The take-off was performed at night. The weather had two layers of clouds. The first had base at 1,700ft and the second base was at 8,000ft. These parameters indicated operation under instrument meteorological conditions in which the aircraft was to be conducted without external reference.

The takeoff from runway 14 (course 139°) occurred at 5:15 min (local time), having as procedure the Standard Instrument Departure (SID) OBMEG 1A, AGURI transition.

During the climb, still in the takeoff line, the radar data showed that the aircraft presented variations of course and speed, which evidenced a manual operation of the commands of the aircraft, without the help of the autopilot.

In this aspect, it may be assumed that the lack of familiarity with the English language has hampered, to some degree, the knowledge of the resources, equipment and systems that were available in the aircraft, as well as the instruction received in flight simulator.

The SID planned to maintain the 133° radial of the VOR FLN to the crossing of 2,000ft, when there would be a left turn to intercept the radial 116° of FLN in the fixed OBMEG, distant 15NM of FLN. The pilot, however, kept the 150° radial of the VOR FLN, possibly due to the drift generated by the wind, which, although weak, had a left cross component.

Already at 2,600ft, under instrument meteorological conditions, that is, below the minimum established to fly according to the rules of the visual flight, the aircraft, according to the available radar data, started a small left turn, possibly to intercept the radial exit. However, after reaching 3,600ft, the aircraft lost altitude, gained speed and reversed the curve to the right, performing more than 360° of curve (Figure 2 and Table 1). When analyzing the conjunction of these factors (altitude, speed and curve ratio), one can infer that the aircraft entered a downward spiral until it disappeared from radar range and collided with the sea.

In this respect, it must be considered that the take-off took place at night (before dawn) and on the sea, which generated conducive conditions to spatial disorientation and visual illusions.

It is important to point out that the Florianopolis Aerodrome is located near the sea. This can generate, in night flight, a visual illusion, because of lack of luminous visual references. Thus, on a cloudy and dim night, when distancing itself from the continent, the visual references generated by the city lights are lost, thus providing optical illusions.

At other aerodromes where the pilot operated, there was no such problem. At the Campo de Marte Aerodrome, SP, when the operation was carried out at night, there were no so-called "black holes" near the Aerodrome, because the city was very illuminated. In Ji-Paraná, RO, or other locations, the operation, in most cases, occurred during the day period.

At no time was requested support, declared emergency or existed, in the phony, characteristics of alteration of consciousness of the pilot.

In this sense, at first, one can suspect that the pilot did not notice that there was a deviation from the route (type I disorientation). He then corrected the deviation (type II disorientation), but probably in a more sharply way than necessary. In this type of "marked correction", vestibular disorientation occurs, generating a small unrecognized inclination (type I disorientation). Therefore, the pilot may have maintained this inclination until he was in an incapacitating situation (type III disorientation).

In this sense, and given the information gathered by the investigation and described in this report, the main hypothesis for the occurrence of the accident is that the pilot, despite not having any medical conditions, has suffered a spatial disorientation during the Standard Instrument Departure procedure from SBFL, of which he was unable to recover.

3. CONCLUSIONS.

3.1 Facts.

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

b) the pilot had valid Technical Qualification Certificate (CHT).

c) the pilot was qualified but had little experience in the IFR flight under real conditions;

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

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

f) the airframe and engine logbooks records were up-to-date.

g) the engine presented evidence that it was operational and developed high power at the moment of the collision of the aircraft against water;

h) fractures observed in the blades occurred due to impact against water;

i) the pilot was showing insecurity on IMC flights at night;

j) the aircraft took off at 05:15 a.m. (local time) from the Hercílio Luz Aerodrome, Florianópolis - SC (SBFL), with instrument flight plan, to the José Coleto Aerodrome, Ji-Paraná - RO (SBJI), with a pilot and one passenger on board, for a private flight;

k) after take-off at 2,600 ft, under instrument meteorological conditions, that is, below the minimums established for flying according to the rules of the visual flight, the aircraft started a small left turn. At 3,600ft, the aircraft started a right turn. Upon

completing a 360° turn, the aircraft vanished from the radars and made no further contact

l) some wreckage were found on the surface of the sea on the day of the occurrence;

m) the fuselage of the aircraft and its occupants were found 14 days after the accident;

n) the aircraft was completely destroyed; and

o) the pilot and the passenger perished at the accident site.

3.2 Contributing factors.

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

Considering the hypothesis of spatial disorientation, the incapacitating type, it is possible that the pilot has reached a situation of complete inability to operate correctly the commands of the aircraft in order to regain control of the flight.

- **Attitude - undetermined.**

It is possible that the high degree of subordination of the pilot to the requests of his boss has hampered his positioning in relation to his limitation in flying at night and in instrument meteorological conditions.

- **Disorientation - undetermined.**

The favorable conditions for disorientation, that is, the night flight on the sea, in the clouds and in manual operation, as well as the dynamics of the trajectory of the aircraft registered by the radar, among other factors, make spatial disorientation the main hypothesis for the accident.

- **Visual illusions - undetermined.**

It is also possible that the pilot had suffered visual illusions when flying over the sea at night. When failing to visualize the illumination on land, and being in dark night, with cloudiness, the pilot may have confused spatial references.

- **Instruction - undetermined.**

It is possible that the lack of familiarity with the English language has hampered, to some degree, the knowledge of the resources, equipment and systems present in the aircraft, as well as the instruction received in the flight simulator.

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:

None.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

None.

On April 5th, 2018.