

COMANDO DA AERONÁUTICA
CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE
ACIDENTES AERONÁUTICOS



FINAL REPORT
A - 094/CENIPA/2016

OCCURRENCE:	ACCIDENT
AIRCRAFT:	PR-CBB
MODEL:	407
DATE:	26JUN2016



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 26JUN2016 accident with the 407 aircraft, registration PR-CBB. The accident was classified as “[CFIT] Controlled Flight Into Terrain”.

During the displacement from the Congonhas Aerodrome (SBSP) - SP, to the city of Americana - SP, the aircraft disappeared from the radar and had its whereabouts unknown, being found crashed on the next day.

The aircraft was destroyed.

The pilot and passengers suffered fatal injuries.

Accredited Representatives of the National Transportation Safety Board (NTSB) - USA, (State where the aircraft was designed and manufactured) and of the Transportation Safety Board (TSB) – Canada, (State where the engine was designed and manufactured) were designated for participation in the investigation.

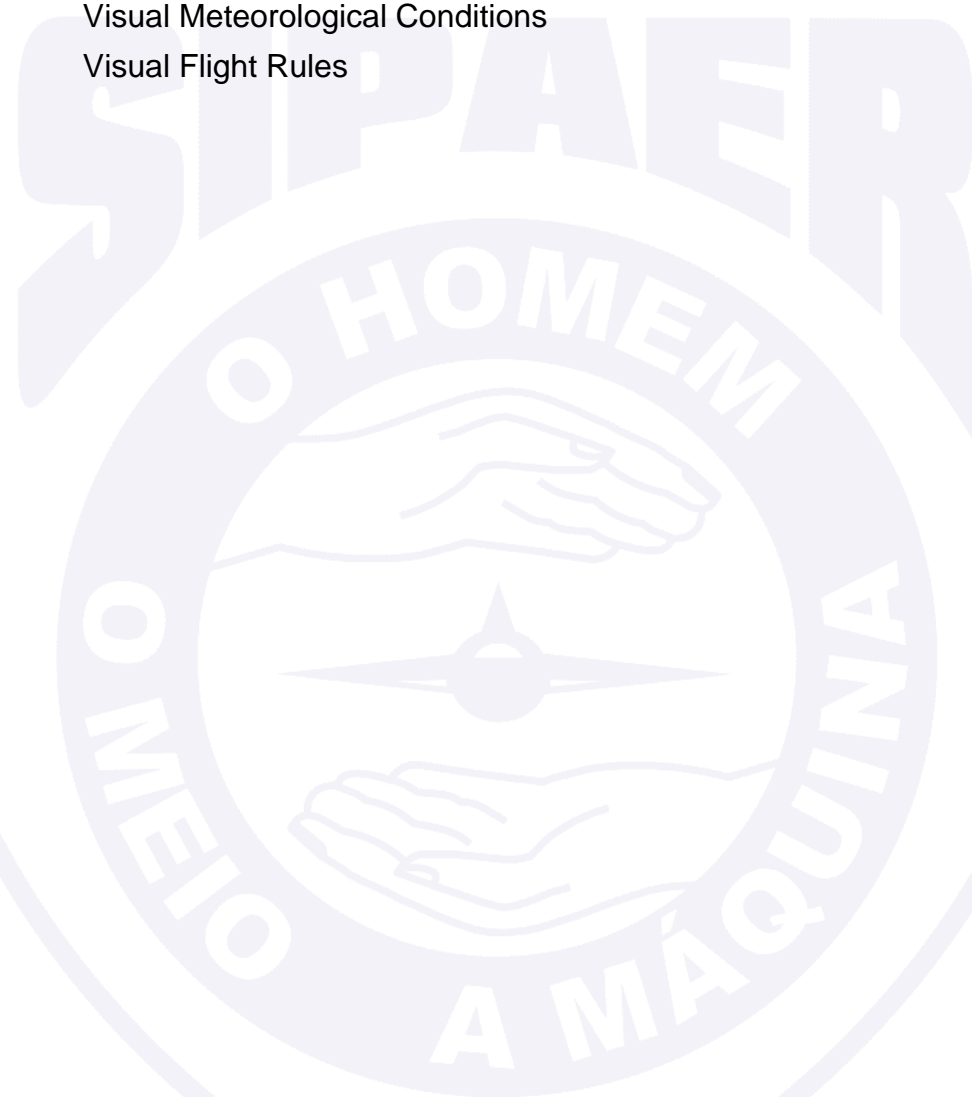
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GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ABRAPHE	Brazilian Association of Helicopter Pilots
ALAR	Approach and Landing Accident Reduction
ANAC	Brazil's National Civil Aviation Agency
ATIS	Automatic Terminal Information Service
ATS	Air Traffic Services
BH07	BH07 Aircraft Type Rating (which included the 407 model)
CA	Airworthiness Certificate
CAVOK	Ceiling and Visibility OK
CENIPA	Aeronautical Accident Investigation and Prevention Center
CFIT	Controlled Flight Into Terrain
CG	Center of Gravity
CIV	Pilot's Flight Logbook
CMA	Aeronautical Medical Certificate
ECU	Electronic Control Unit
FAA	Federal Aviation Administration
FADEC	Full Authority Digital Electronic Control
FSF	Flight Safety Foundation
GFS	Global Forecast System
HASP	São Paulo Aeronautics Hospital
HMU	Hydromechanical Unit
IFRH	Instrument Flight Rating – Helicopter
IMC	Instrument Meteorological Conditions
INVH	Flight Instructor Rating - Helicopter
METAR	Meteorological Aerodrome Report
MGT	Measure Gas Temperature
NOTAM	Notice to Airmen
PCH	Commercial Pilot License – Helicopter
PLH	Airline Pilot License – Helicopter
PMA	Permanent Magnet Alternator
PN	Part Number
RBAC	Brazilian Civil Aviation Regulation
REH	Special Helicopter Routes
REDEMET	Aeronautics Command Meteorology Network
RPM	Rotations Per Minute
RS	Safety Recommendation
SBMT	ICAO Location Designator – Campo de Marte Aerodrome, São Paulo - SP

SBSP	ICAO Location Designator – Congonhas Aerodrome, São Paulo - SP
SERIPA IV	Fourth Regional Aeronautical Accident Investigation and Prevention Service
SIPAER	Aeronautical Accident Investigation and Prevention System
SPECI	Selected Special Aeronautical Weather Report
TAF	Terminal Aerodrome Forecast
TPP	Registration Category of Private Service - Aircraft
TWR-SP	Congonhas Aerodrome Control Tower - SP
UTC	Universal Time Coordinated
VMC	Visual Meteorological Conditions
VFR	Visual Flight Rules



1. FACTUAL INFORMATION.

Aircraft	Model: 407	Operator: ALE COSTA NEGOCIOS E PARTICIPAÇÕES LTD.
	Registration: PR-CBB	
Occurrence	Manufacturer: BELL HELICOPTER	Type(s): [CFIT] Controlled Flight Into Terrain Subtype(s): NIL
	Date/time: 26JUN2016 - 1110 UTC	
	Location: Serra do Japi	
	Lat. 23°16'58"S Long. 046°50'01"W	
	Municipality – State: Jundiaí – SP	

1.1 History of the flight.

The aircraft took off from the Congonhas Aerodrome (SBSP), in the city of São Paulo - SP, to the city of Americana - SP, at 1054 (UTC), in order to transport personnel, with one pilot and four passengers on board.

After a few minutes, the aircraft disappeared from the radar and had its whereabouts unknown. The aircraft was found crashed on the next day, at Serra do Japi, in the municipality of Jundiaí - SP.

The aircraft was destroyed.

The occupants perished at the site.

1.2 Injuries to persons.

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

1.3 Damage to the aircraft.

The aircraft was destroyed.

1.4 Other damage.

None.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Hours Flown	Pilot
Total	2.763:43
Total in the last 30 days	16:00
Total in the last 24 hours	Unknown
In this type of aircraft	107:20
In this type in the last 30 days	16:00
In this type in the last 24 hours	Unknown

N.B.: The data related to the flown hours were obtained through the Pilot's Flight Logbook (CIV).

1.5.2 Personnel training.

The pilot took the PPH course at the Master Helicópteros, in Bauru – SP, in 2001.

1.5.3 Category of licenses and validity of certificates.

The pilot had the PLH License and had valid BH07 type, which included the 407 model, HMLT, HMCT Ratings. Her IFRH Rating was expired since May 2016.

1.5.4 Qualification and flight experience.

The pilot was qualified and had experience in that kind of flight.

1.5.5 Validity of medical certificate.

The pilot had valid CMA.

1.6 Aircraft information.

The aircraft, serial number 53926, was manufactured by Bell Helicopter, in 2009 and was registered in the TPP category.

The aircraft had valid Airworthiness Certificate (CA).

The airframe and engine logbooks records were updated.

The last overhaul of the aircraft, the "600 hours / 12 months" type was carried out on 13MAR2016 by the maintenance organization Líder Aviation, in São Paulo – SP.

1.7 Meteorological information.

The METAR and the SPECI at Congonhas Aerodrome - SP, about 42km away from the impact site, provided the following information:

26/06/2016 10:00 METAR SBSP 261000Z 06006KT 6000 OVC009 14/11 Q1027

26/06/2016 11:00 METAR SBSP 261100Z 05009KT 9000 OVC010 14/11 Q1028

26/06/2016 11:00 SPECI SBSP 261136Z 07008KT 9999 SCT010 15/11 Q1029

26/06/2016 12:00 METAR SBSP 261200Z 07007KT 9999 SCT011 15/11 Q1029

The SBSP METAR, at 1000 (UTC), reported that the airport was completely overcast by clouds based at 900ft (OVC009). From 1136 UTC on, conditions improved for scattered clouds (3/8 and 4/8) and cloud base at 1,000ft (SCT010) and gradually improved to 1,100ft (SCT011).

The METAR and the SPECI of the Jundiaí Aerodrome - SP, about 16km from the impact site, provided the following information:

26/06/2016 10:00METAR SBJD 261000Z 13007KT 4000 BR FEW010 10/09 Q1026

26/06/2016 10:00SPECI SBJD 261045Z 12011KT 3000 BR BKN010 11/09 Q1027

26/06/2016 11:00METAR SBJD 261100Z 12010KT 3000 BR BKN010 11/10 Q1027

26/06/2016 12:00METAR SBJD 261200Z 12007KT 3500 BR SCT010 13/10 Q1028

The SBJD METAR at 1000 (UTC) reported lower horizontal visibility than the SBSP, between 3,000m and 4,000m and cloudiness based on 1,000ft. The percentage of cloud coverage increased from 1000 (UTC) to 1100 (UTC), from few clouds (FEW) to cloudy (BKN).

The SBSP TAF predicted that there would be no restrictions for the planned takeoff period.

26/06/2016 12:00 TAF SBSP 260920Z 2612/2712 07010KT 5000 BR BKN011
TX21/2617Z TN12/2709Z BECMG 2613/2615 10010KT CAVOK BECMG
2617/2619 15010KT BECMG 2619/2621 5000 BR BKN009 PROB30 2621/2701

13003KT 3000 BR BKN003 BECMG 2702/2704 06005KT PROB30 2704/2709 NSC PROB30 2709/2711 1000 BR BKN002 RMK PGF

The SBJD TAF predicted that, for the expected period of takeoff, the aerodrome would be CAVOK (visibility greater than 10,000m and clouds above 5,000ft).

26/06/2016 12:00 TAF SBJD 260920Z 2612/2624 13010KT CAVOK TN13/2612Z TX22/2618Z RMK PGF

It should be taken into account that the TAF forecast only serves the aerodrome. It cannot be stated from this information that the accident site would be in the same condition, since it was about 16km away from SBJD.

The satellite images at the frequencies visible (Figure 1) and Infrared (Figure 2) indicated low cloudiness (stratiform) over the accident region, but it was not possible to state through them, that the exact point where the aircraft crashed against the ground was covered by clouds, since the analysis of this type of image does not show precision for the point situation.



Figure 1 - Image at the visible frequency suggests possibility of stratiform clouds in the region under study.



Figure 2 - Infrared image indicates, in the circle area, the possibility of clouds in the region.

With the help of Pico do Couto and São Roque meteorological radar image, acquired through REDEMET, a website managed by the Brazilian Air Force, the presence of cloudiness in blue was verified with greater precision than the satellite image near the area of interest. It is necessary to inform that any equipment is subjected to errors of precision and the meteorological radar is no exception. The greater the distance the radar is, the greater the precision error and apart from the fact that this equipment is subjected to echoes of terrain.

The bluish-toned region indicated that the radar detected precipitated water. The blue color indicated that it was of little intensity, with the possibility that they were clouds of the stratiform type. The red cross marks the impact site (Figure 3).

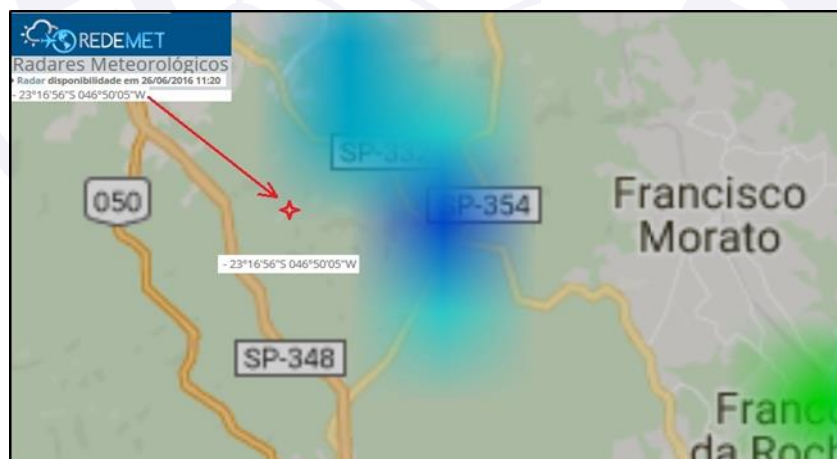


Figure 3 - Meteorological RADAR image of Pico do Couto and São Roque.

As a complementary information, the data of the numerical model of the GFS of the time was obtained, showing the wind component in the east-southeast direction (ESE), with speeds between 05kt and 10kt in the pressure level of 900hPa.

Radio sounding data from Campo de Marte Aerodrome (SBMT), located in the city of São Paulo - SP, reported the actual wind near this pressure level as east-northeast (ENE) with speed between 10kt and 15kt.

This showed that both the prediction model and the actual data had a common and predominant east (E) component, which consequently induced the clouds to move to the same direction, that is, from east to west.

Thus, the cloud group of Figure 3 or some isolated cloud in the blue region had the tendency to move at a speed of about 10 kt to the site of the accident.

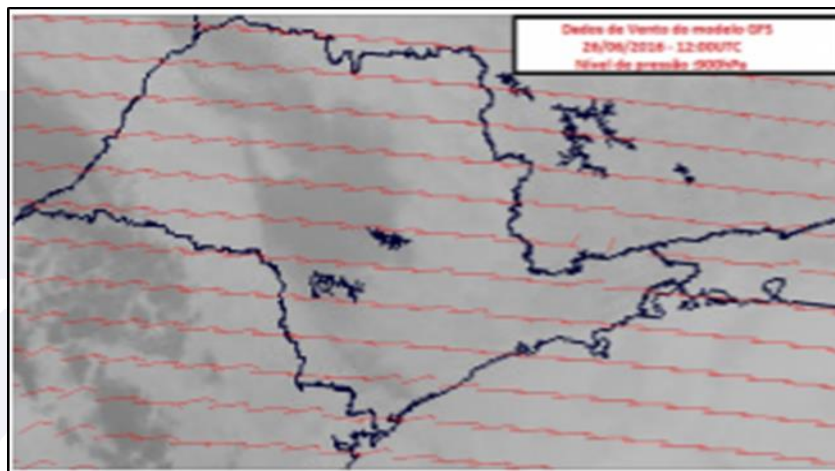


Figure 4 - Windflow by the GFS numerical model.

83779 SBMT Marte Civ Observations at 12Z 26 Jun 2016											
PRES	HGHT	TEMP	DWPT	RELH	MIXR	DRCT	SKNT	THTA	THTE	THTV	
hPa	m	C	C	%	g/kg	deg	knot	K	K	K	
				1000.0	225						
943.0	722	15.2	10.8	75	8.69	0	0	293.2	318.3	294.8	
938.0	768	14.6	10.7	77	8.66	60	12	293.1	318.1	294.6	
925.0	887	13.0	10.3	84	8.57	75	13	292.6	317.3	294.1	
906.0	1061	11.4	9.8	90	8.47	80	12	292.7	317.1	294.2	
894.0	1173	10.4	9.5	94	8.40	74	14	292.8	317.0	294.3	
887.0	1239	11.6	8.9	83	8.12	70	15	294.7	318.4	296.2	
875.0	1353	13.8	7.8	67	7.64	78	11	298.1	320.8	299.5	
850.0	1597	12.6	6.6	67	7.24	95	2	299.3	320.9	300.6	

Figure 5 - SBMT radio sounding of 29JUN2016 at 1200 (UTC).

We can also, as additional information, verify the degradation of weather in the images granted by the company from which the aircraft took off and the transit concessionaire of Bandeirantes Highway (that crosses the State of São Paulo from the east-west direction).

At the time of takeoff, we can verify that the images corroborate the information presented in the SBSP METAR.



Figure 6 - Images of aircraft takeoff and meteorology.



Figure 7 - Images of aircraft takeoff and meteorology.



Figure 8 - Images of aircraft takeoff and meteorology.



Figure 9 - Degradation of the meteorology evidenced in the Bandeirantes Highway - KM 043.



Figure 10 - Degradation of the meteorology evidenced in the Bandeirantes Highway - KM 045.



Figure 11 - Degradation of the meteorology evidenced in the Bandeirantes Highway - KM 047.

1.8 Aids to navigation.

Nil.

1.9 Communications.

The transcript below is a faithful expression of the communications established between the parties, in the period of 10:47:10 (UTC) at 10:55:27 (UTC), including all language errors and terms that are unsuitable for standard phraseology.

HORA UTC:	OPR/QRG	ACFT/ÓRGÃO	TEXTO
10:47:09	CLR SP/ EAHC	PRCBB	TRAFEGO SAO PAULO BOM DIA, PAPA ROMEU CHARLIE BRAVO BRAVO.
10:47:17		CLR SP	BOM DIA CHARLIE BRAVO BRAVO
10:47:20		PRCBB	TA NO ANTIGO LIDER COM NOTIFICAÇÃO PARA GRUPO ZULU AMERICANA, PRO AÇIONAMENTO
10:47:31		CLR SP	INGRESSA ÁREA CONTROLADO
10:47:34		PRCBB	É EFETUA CRUZAMENTO WHISKIE ECHO NEGATIVO CONTROLADA
10:47:43		CLR SP	A SENHORA FEZ PLANO DE VOO COMPLETO OU FOI SIMPLIFICADO.
10:47:47		PRCBB	FOI COMPLETO.
10:47:53		CLR SP	QUAIS ROTAS DE HELICOPTERO VAI PEGAR?
10:47:55		PRCBB	ROTA MARTE, ANHANGUERA SUL, JUNDIAI, ANHANGUERA NORTE.
10:48:33		CLR SP	CHARLIE BRAVO BRAVO?
10:48:34		PRCBB	NA ESCUTA
10:48:36		CLR SP	TA CIENTE DA INFORMAÇÃO ATIS?
10:48:38		PRCBB	AFIRMO
10:48:41		CLR SP	CIENTE ZERO CEM NO TRANSPONDER, QUANDO PRONTO PRA DECOLAR CHAME A TORRE EM UNO DOIS SETE UNO CINCO
10:48:45		PRCBB	QUANDO PRONTO CHAMA A TORRE EM UNO DOIS SETE UNO CINCO BRAVO.
10:53:28	TWR SP DBDD	PRCBB	TORRE SAO PAULO UMA BOA CHARLIE BRAVO BRAVO
10:53:30		TWR SP	CHARLIE BRAVO BRAVO PROSSIGA PRA TORRE
10:53:34		PRCBB	TA PRONTO PRA DECOLAR DO ANTIGO LIDER, SETOR WHISKIE CRUZAMENTO APÓS COORDENAÇÃO.

Figure 12 - Transcription of phraseology.

After takeoff, the aircraft flew in uncontrolled airspace. Therefore, it did not contact the São Paulo Approach Control (APP-SP).

It should be noted that according to AIC N 17 of 12NOV2015, if necessary, the PR-CBB could have contacted the ATC body responsible for the flight information and alert service of that area:

"7.8 The Class "G" Airspace Flight and Alert Information Service shall be provided by APP-SP, when feasible, through the frequency 129.500 MHz, when under TMA-SP 1, the frequency 121.350 MHz (primary) or 123.900 MHz (secondary), when under the TMA-SP 3, or even as indicated by the ARC São Paulo-Rio or NOTAM."

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 accident site was located at Serra do Japi, coordinates: 23°16'58"S 046°50'01"W, about 22.67 nautical miles away from the Congonhas Aerodrome - SP, and

8.53 nautical miles away of the Jundiaí Aerodrome - SP, and it was at 910 meters (2,985 feet) of altitude.

The aircraft collided with trees and crashed with the terrain at an approximate 15° angle and at high speed, without the possibility of exact determination. The wreckage had a linear trajectory and spread out 50 meters away from the point of impact.



Figure 13 – Place of impact.

1.13 Medical and pathological information.

1.13.1 Medical aspects.

According to the PR-CBB aircraft flight logbook, the crewmember began air activities in the company on 19SEPT2015 and presented the following flight routine, as observed in the table in Figure 14:

Resumo das horas voadas *			
Meses	Dias voados	Dias de descanso	Horas Totais
Dezembro de 2015	13	18	15:06:00
Janeiro de 2016	1	30	1:12:00
Fevereiro de 2016	3	26	3:18:00
Março de 2016	3	28	4:58:00
Abril de 2016	11	19	9:54:00
Maio de 2016	14	17	18:42:00
Junho de 2016	6	19	8:12:00
TOTAIS	51	157	61:22:00
* No período de 01/12/2015 a 26/06/2017			
Médias			
Horas / Último mês	0:19:41		
Dias Voados/Mês	7,28		
Dias Descansados / Mês	22,42		
Horas Totais / Mês	08:46		

Figure 14 - Table with the days flown and days of rest.

The day before the accident, there was no flight performed by the crewmember in the logbook.

On the day of the accident, the pilot started the flight at 07:54 (local time), which lasted approximately fifteen minutes until the moment of the accident.

There was no evidence of flight fatigue or excesses in the crewmember's workday in the last six months, as determined by the law in force at the time of the accident.

The Working Day, in accordance with Law 7,183, of 05APR1984:

"Art. 20 Journey is the duration of work of the aeronaut, counted from the time of the presentation at the place of work to the time at which it is concluded.

§ 1º The journey in the home base will be counted from the time of the aeronaut's presentation in the place of work.

Art. 21 The duration of the aeronaut's journey shall be:

11 (eleven) hours, if a member of a minimum or simple crew;

§ 1º On air taxi flights, specialized services, regional air transport or regional international flights of regular air transport companies performed by simple crew, if there is a scheduled interruption of the journey for another four (4) consecutive hours, and provided by the employer, adequate accommodations for the rest of the crew, the journey will have added the duration of half the time of interruption, leaving unchanged the limits prescribed in item "a" of art. 29 of this Law. "

According to the evaluation of the medical record, the pilot performed the health inspections, as follows:

Inspeções de saúde			
Data	Local	Tipo	Parecer
11/06/2001	HASP	Inicial PP	Apto
		Revalidação Comissária	Apto
29/05/2002	HASP	Revalidação de Comissária	Apto
02/06/2003	HASP	Revalidação de PP	Apto
		Revalidação de Comissária	Apto
26/05/2004	HASP	Revalidação de Comissária	Apto
18/05/2005	HASP	Revalidação de PP	Apto
		Revalidação de Comissária	Apto
04/05/2006	HASP	Revalidação de Comissária	Apto
25/04/2007	HASP	Revalidação de PP	Apto
		Revalidação de Comissária	Apto
25/10/2007	HASP	Inicial PC	Desfavorável
		Revalidação de Comissária	Apto
30/10/2007	HASP	Revalidação de PP	Apto
11/11/2008	HASP	Revalidação de PC	Apto
05/11/2009	HASP	Revalidação de PC	Apto
29/10/2010	HASP	Inicial de PLH	Desfavorável
05/11/2010	HASP	Revalidação de PC	Apto
18/10/2011	HASP	Revalidação de PC	Apto
18/07/2012	Dedalo	Inicial PLH	Apto
19/06/2013	Dedalo	Revalidação PLH	Apto
03/07/2014	Dedalo	Revalidação PLH	Apto
13/07/2015	Dedalo	Revalidação PLH	Apto

Figure 15 - Health inspections table.

The crewmember received an unfavorable evaluation on the medical inspection held on 25OCT2007, by the Psychiatric and Psychology Section of the São Paulo Aeronautics Hospital (HASP), due to insufficient performance in the psychology test, and should be re-evaluated after 180 days.

There was no register, in her medical records, of return and re-evaluation by that health board's psychiatry and psychology section, according to the previous orientation.

There was no medical inspection in her medical records with a favorable medical evaluation for Initial PCH.

There was, in the medical records of the crewmember, a medical inspection performed on 11NOV2008, of revalidation for PCH, without a medical inspection corresponding to obtaining favorable medical evaluation for Initial PCH.

In the medical inspection carried out on 11NOV2008, because it was a revalidation, the crewmember did not need to undergo evaluation by the psychiatry and psychology section, since, according to the RBHA 67, valid at the time, this need only existed for the cases of initial inspections:

67.31 - PSYCHIATRIC REQUIREMENTS

(c) Psychological tests are part of the psychiatric examination of the initial inspections. In revalidations, at the discretion of the expert.

The crewmember received an unfavorable evaluation on the medical inspection held on 29OCT2010, at HASP, presenting an insufficient performance in a psychology test, being able to observe a reoccurrence in the inability.

There was no register, in her medical record, of return after 120 days, to the psychiatry and psychology section, according to the guidelines issued by the health board of 29OCT2010.

The crewmember performed health inspection to obtain the Initial PLH medical certificate, on 18JUL2012, in a different accredited entity from the one initially required on 29OCT2010.

In accordance with the RBAC 67, of 07DEC2011, in case of "not able" result, the candidate should return to the same accredited entity that deemed her "not able":

67.11 Conditions for granting or revalidating a CMA:

(a) for a person to be able to become a candidate for an expert health examination for the grant or revalidation of a CMA, he shall:

(1) submit to an examiner, in accordance with the intended CMA class and in accordance with the provisions of paragraphs 67.45 (a), 67.45 (b) and 67.57 (a) of this Regulation; and

(2) present proof of identity by means of an official identification document, with photo, valid in the national territory.

(b) The candidate who, after previous expert medical examination, duly supported by documents proving the performance of these examinations, meets the psychophysical requirements of subparts C to F of this Regulation, as applicable, will be able to receive or revalidate a corresponding class CMA.

(c) If it is judged "not able" for the expert health examination and does not agree with the examiner's decision, the candidate may appeal the decision to the ANAC, which will judge the matter, assisted or not by other examiners who did not participate in the first trial, and will issue a judgment in favor or against the appeal of the candidate previously considered "not able". At its discretion, the ANAC may require in-flight proficiency test to judge the applicant's appeal.

(d) In cases of "not able" judgment by an examiner, the following provisions shall apply:

(1) If the cause of the "not able" trial no longer exists, the candidate must not submit to a new expert health examination in a degree of appeal, **but must submit to the same examiner who has previously judged him "not able"** and demonstrate that the cause of non-aptitude no longer exists (**our emphasis**);

(2) the candidate judged "not able" by an examiner, and continuing the cause generating the aforementioned judgment, may only submit to a new expert health examination in a degree of appeal to the ANAC; and

(3) the appeal to the ANAC can only be filed, at the discretion of the candidate, as long as the cause of the "not able" trial persists.

In previous analyzes of prior inspections, it was observed a not able evaluation by psychiatry, based on alterations evidenced by psychological evaluations in which limiting difficulties were exposed, culminating in the unfavorable evaluation on the medical inspection held on 29OCT2010.

The difficulties presented by the pilot were related to the visual-spatial reasoning, limiting its capacity to form visual mental representations.

These characteristics are fundamental in pilots, since humans, in order to guide themselves, use three main systems (Visual, Vestibulocochlear and Proprioceptive Systems) that function fully on surface rather than in flight. In this way, it is important that the psychophysical is completely intact.

Since the flight took place in adverse weather conditions, it is necessary to give some clarification on spatial orientation, in order to support the analysis of the accident dynamics.

Pilots are especially susceptible to poor perception of the horizon (illusion of the false horizon) when flying at night. Insulated lights on the floor may seem like stars, leading them to the illusion that the aircraft keeps the "nose" up.

In an opposite situation, in a closed sky, without visibility of stars and moon, and flying over a terrain without illumination, it may occur an illusion that the terrain, without illumination, is part of the sky.

The Federal Aviation Administration (FAA) provided a simple definition in its 1983 Circular Advisory (AC 60-4A): "Spatial disorientation for a pilot simply means the inability to tell which way is" up "(FAA 1983)."

The following is a more complex definition of spatial disorientation:

Spatial disorientation is a term used to describe a variety of incidents occurring in flight in which the pilot is not able to correctly sense the position, movement or attitude of the aircraft or of himself within the fixed coordinate system provided by the surface of land and gravity in the vertical plane.

Furthermore, errors in the pilot's perception of his position, movement or attitude of his aircraft, or of his own aircraft relative to other aircraft, may also be considered within a broader definition of in-flight space disorientation.

Humans are able to determine their spatial orientation through information from three specialized sensory systems: the visual system; the organs of balance located in the inner ear, also known as vestibular system; and the proprioceptive system.

These three systems rely on several sensory receptors to collect information and then send that information to the brain, which integrates the information received into a single orientation model.

Under normal conditions, this mechanism is highly accurate. The integrated information is used to determine our position within a fixed coordinate system provided by the Earth's surface as a horizontal reference, and the Earth's gravitational force providing a vertical reference.

The three systems have different levels of importance in providing guidance information. The visual system is the most important of the three systems, providing about 80% of the guidance information.

In conditions where visual cues are scarce or absent, such as in degraded weather conditions or at night, up to 80% of normal orientation information may be lost. The remaining 20% are equally divided between the vestibular system and the proprioceptive

system. Both are more likely to illusions and erroneous interpretations, so they are less accurate.

In the scarcity or absence of visual signaling, humans are forced to rely on the remaining 20% of guidance information. In the aviation scenario, such a situation can result in pilot disorientation. This threat is heightened when the pilot does not realize that he is disoriented, believing in the sensory information that is mistakenly being provided by his sensory system.

The lack of good visual cues deprives the human being of most guidance information. Most of the spatial disorientation events are associated with the absence of visual references, such as in instrument meteorological conditions (IMC) or night flight.

The vestibular system consists of two important components: the semicircular canals and the otolithic organs. There are three semicircular canals in each ear, and, in functional terms, operate as three corresponding pairs on each of the three primary axes of motion.



Figure 16 - Illustration of the interaction of multiple systems.

The channels in each ear are all perpendicular to each other, and function as angular accelerometers. Significantly, they have a stimulation edge of $2^\circ / \text{sec}^2$; below that, they are not able to detect angular motion. This is of crucial importance in the aviation scenario, because with an angular acceleration rate lower than this limit, once intentional or not, the channels will not register the curve.

In the absence of visual cues that the curve is occurring, force of gravity indicates the direction of the head to the feet, without giving proprioceptive information to change, so the pilot will not notice that a curve is in progress and will interpret the movement in straight and leveled line.

It is known that some factors and conditions can affect the ability of pilots to accurately perceive the environment, causing illusions, such as weather conditions, in the case in question (ceiling, visibility, etc.). (Flight Safety Foundation (FSF) Approach and Landing Accident Reduction (ALAR) Briefing NOTE 5.3).

Visual illusions result from the absence of visual references or the alteration of these references, which culminate in the loss of their position (in terms of height, distance and / or angle of interception), in relation to the ground. They are most critical when transitioning from visual meteorological conditions (VMC) to instrument meteorological conditions (IMC).

Visual illusions often induce pilots to make corrections, sometimes erroneous, that cause the aircraft to deviate from the vertical flight path or route. Thus, visual illusions can affect the decision-making process of when and how quickly it is necessary to descend to a safe minimum altitude, in order to remain in VMC.

Some degraded weather conditions, such as light rain, fog, smoke, dust, etc., in which darkness leads to visual illusions of being too high, can lead to an erroneous reaction in the pilot's response.

Factors That Cause Visual Illusions and Result in Incorrect Pilot Responses			
Factor	Perception	Action	Result
Narrow or long runway	Too high	Push	Land short/hard
Runway or terrain uphill slope			
Wide or short runway	Too low	Pull	Land long/overrun
Runway or terrain downhill slope			
Bright runway lighting	Too close (too steep)	Push	Land short/hard
Low-intensity lighting	Farther away (too shallow)	Pull	Land long/overrun
Light rain, fog, haze, mist, smoke, dust	Too high	Push	Land short/hard
Entering fog (shallow layer)	Pitch-up	Push over	Steepen glide path/(CFIT)
Flying in haze	Farther away (too shallow)	Pull	Land long/overrun
Wet runway	Farther away (too high)	Late flare	Hard landing
Crosswind	Angled with runway	Cancel drift correction	Drifting off track
CFIT = controlled flight into terrain			
Source: FSF ALAR Task Force			

Figure 17 - Factors that cause visual illusions and incorrect results in pilot responses
(Source: FSF ALAR Briefing NOTE 5.3)

1.13.2 Ergonomic information.

Nil.

1.13.3 Psychological aspects.

The pilot began her aviation career in 2000 as a flight attendant and began her professional training as a pilot the following year.

In 2001, she held the first Ground School in the Robinson 22 aircraft. In 2007, she completed the PCH and IFRH courses and in 2008, she performed the INVH course. In 2010, she completed the familiarization course of the Agusta A109 Helicopter. In the same year, she undertook the Training of Accredited Examiners - Pilot, by the ANAC.

In 2015 and 2016, the pilot in question successfully completed the following courses:

- Refreshment of A109;
- Initial Ground School of EC155B1;
- Theoretical Training Course Squirrel Solo AS350 (EAD);
- Corporate Resource Management (CRM);
- BELL 206B3 Ground School;
- Basic Doctrine and General Emergencies;
- Solo Training of aircraft 407; and
- Robinson R66 Helicopter Ground School.

She also acted as flight instructor for the aircraft in which she had license. From 2008 to 2016, she worked as an Off Shore pilot at Líder Aviação and served as Safety at the ABRAPHE.

She had thirteen years of experience and, according to the interviews, her peers considered the pilot as a responsible professional, recognized for her concern with safety. According to the reports obtained, she did not take unnecessary risks in the performance of her duties.

According to the data obtained, in 2001, in the Initial Health Inspection for PPH, the evaluated one received insufficient grade in the test and retest of concentrated attention. The purpose of this test was to evaluate the individual's ability to select relevant stimuli from the environment, to search the details of the visual field and to focus on these stimuli.

Despite the below-expected performance in assessing this cognitive ability, she obtained a favorable evaluation on health inspection.

In 2007, when she undertook an Initial Health Inspection for PCH by the Clinic of Psychiatry at HASP, She received an unfavorable evaluation for 180 days, since she was insufficiently qualified in the assessment of logical reasoning and again her performance was insufficient in the concentrated attention test and retest. In addition, it was indicated that the evaluated one had personality characteristics that disfavored the pilot activity.

In 2008, instead of making a new Initial Health Inspection for PCH, the pilot performed revalidation health inspection, as if she already had a CMA for this category. No initial health inspection record for PCH was found with a favorable evaluation.

It is assumed that the crewmember obtained her Initial CMA of PCH at another approved clinic, but this was not recorded in the system.

Subsequently, in 2010, she undertook an Initial Health Inspection for PLH by the HASP Psychiatry Clinic and received an unfavorable evaluation for 120 days, since, again, she obtained an insufficient grade in the logic reasoning test and poor performance in the spatial reasoning test. This last factor referred to the capacity to organize visual stimuli, allowing the individual to locate in relation to the space.

In 2012, finally, the pilot performed a new PLH Initial Health Inspection, obtaining a favorable opinion. It should be noted that this inspection was performed in a clinic accredited by ANAC, contrary to what was stated in item 67.11, letter "d", item 1, of the RBAC, of 07DEC2011:

"If the cause of the "not able" judgement no longer exists, the candidate must not submit to a new expert health examination in an appeal, but must submit to the same examiner who has previously judged him "not able" and demonstrate that the cause of non-aptitude no longer exists."

Regarding health inspections, according to letter f of item 67.75 of RBAC 67:

"(...) Psychological tests may be applied individually or collectively, at the discretion of the psychologist, and the award must, at a minimum, contain an evaluation on the candidate's personality, attention, memory and reasoning."

Regarding psychological evaluation, the criteria established in the legislation in force at the time of the occurrence allowed the professional psychologist's discretion as to the aspect of the cognitive ability to be measured.

In the case in question, in 2010, the crewmember had two different types of reasoned ability evaluated, the logical and the spatial ones, obtaining insufficient degrees in both. However, in subsequent years, the pilot was evaluated in only one reasoning, the logical one, receiving a favorable evaluation.

1.14 Fire.

The aircraft was totally destroyed by the impact and by the fire action that followed.

1.15 Survival aspects.

Nil.

1.16 Tests and research.

The Full Authority Digital Control (FADEC) was composed by the following components:

1. Hydromechanical Unit (HMU);
2. Fuel filter - oil filter assembly;
3. Electronic Control Unit (ECU);
4. Permanent Magnet Alternator (PMA)
5. Compressor inlet air temperature sensor, inlet duct mounted;
6. P1 compressor air inlet pressure sensor in the ECU;
7. Engine sensors of RPM, MGT and Torque; and
8. Aircraft supplied inputs.

The HMU was disassembled and showed no damage to its internal components. The HMU has melted on the outer surface and at its terminals. The U-40 chip of the ECU, responsible for the parameter registration, showed terminal cracks, surface cracks and also evaporation of reading tracks, which led to the impossibility of reading the data.

The merger on the outer surface of the HMU and its terminals, as well as the terminal chip, evaporation of tracks and surface cracks of the ECU chip mentioned above, were caused by the association of high temperatures and high structural loads suffered by the aircraft at the event.

The other exams, tests and investigations were conclusive in pointing out that the impact and the fire that followed caused all damages. There was no detachment of parts in flight.

1.17 Organizational and management information.

The pilot had a microbusiness and, between August 2015 and the date of the accident, provided services to the contractor issuing invoice. Upon being hired, the pilot underwent a two-month practical training on the 407 aircraft with the former pilot of her contractor.

On October 2015, she took command of the aircraft and went to work exclusively for the contractor fulfilling a variable working day, according to the contractor's flight demands. Such demands were usually planned, however, there were also callings with a few hours of preparation. Clearances were conditional on the period when the contractor did not request flights.

Since the contracting period, the relationship between the parties has been described as harmonious and respectful, in which the contractor always took the pilot's guidelines into account, including following recommendations to cancel, redo the planning or alternate flight routes.

The pilot's cautious behavior could be ratified by her active role in ABRAPHE, where she lectured on safety, in addition to being considered by her peers as an example of a professional.

1.18 Operational information.

The aircraft was within the weight and balancing limits specified by the manufacturer. It was obtained information that the pilot had access to the meteorological information prior to takeoff, as well as all the information necessary for the planning of the flight route.

According to the Commission, the crewmember undertook the ground training for the 407 aircraft and all systems and equipment applicable to it, from July 15 to 17, 2015, and was considered fit by the pilot responsible for the practical instruction.

According to Supplementary Instruction 61 of ANAC (IS 061-005A), in force at the time:

"6.2 GROUND TRAINING

6.2.1 The first part of the training for the granting and revalidation of a type rating shall consist of a theoretical instruction given by the responsible PC or PLA. For this, the aircraft flight manual and other technical publications that the instructor deems necessary should be used.

6.2.2 The ANAC does not establish minimum or maximum duration for ground training. Therefore, it is the responsibility of the instructor to release the student for flight training only when he / she considers that he / she has demonstrated that he / she has all the theoretical knowledge necessary to perform a safe flight."

It was not possible to verify the contents of the provided theoretical training, since the instructor in charge only described, in a generic way, that he instructed the applicable systems and equipment.

It was also not possible to verify that this instruction complied with the minimum requirements of the regulatory agency as provided at IS No. 061-005A, in force at the time:

"6.2.3 Ground training shall address at least the following content:

a) Technical knowledge of the aircraft:

I. general characteristics and limitations of the electrical, hydraulic, fuel, pressurizing and other aircraft systems;

II. principles of functioning, operation and operational limitations of aircraft engines; influence of atmospheric conditions on engine performance; operational information contained in the flight manual;

III. normal, abnormal and emergency operating procedures;

IV. limitations of the aircraft; influence of atmospheric conditions on the performance of the aircraft in accordance with the information in the flight manual;

V. operation of aircraft instruments and procedures in case of malfunction;

VI. use of autopilot and other automation systems;

VII. procedures for the maintenance of the aircraft airworthiness, such as pre-flight checks, periodic inspections, verification of maintenance records, service bulletins and current airworthiness directives;

b) Performance; flight planning and loading:

I. influence of weight and its distribution on aircraft loading; performance and flight characteristics for the various weight and balance conditions; performing weight and balance calculations;

II. use and practical application of data, charts and performance charts for takeoff, landing and en-route;

III. processes for loading and securing cargo in the various cargo compartments of the aircraft;

c) Navigation:

I. planning of the air navigation using the performance data of the aircraft's flight manual;

II. principles and characteristics of aircraft navigation systems; operation of on-board equipment;

III. use, accuracy and reliability of the navigation systems employed;

(d) Flight Theory: flight principles relating to the aircraft for which authorization is requested, high speed flight and recovery of abnormal attitudes, and

e) Radio Communications: procedures for operation of aircraft communication and transponder systems; procedures in case of communications failure."

The pilot began her practical instruction on the aircraft on 01AUG2015, completing a total of 13 hours and 6 minutes of daytime flight, 24 minutes of night flight and 4 hours and 12 minutes of air navigation flight, registered in the CIV, complying with the IS 061-005A, in effect at the time:

6.4 HELICOPTER - FLIGHT TRAINING

6.4.1 As provided in paragraph 61.213 (a) (3) (iii) (B) of RBAC 61, the type-approval flight training shall have a minimum duration of:

a) 5 (five) flight hours for helicopters with maximum takeoff weight up to 7000 lbs (3175 kg) and 9 (nine) or fewer passenger seats;

Fase I – Treinamento Local	Concessão	Revalidação
Helicópteros com peso máximo de decolagem até 3175 kg (7000 lbs) e 9 (nove) ou menos assentos de passageiros	03h	01h

6.4.5 At this stage, at least the following procedures must be carried out:

a) pre-flight procedures, including flight planning, fuel calculation, fueling, weight and balance calculation, aircraft airworthiness inspections and verification;

b) operations at aerodromes and in traffic circuits; precautions and procedures to prevent collisions;

- c) use of checklists during all phases of the flight;
- d) recovery in the early stage of vortex stall, low-speed rotor recovery techniques within the normal engine regimen;
- e) recognition and recovery of blade stalls;
- f) maneuvers and races in flight near the ground; hovering flight; normal takeoff and landings, without wind and on sloping ground;
- g) takeoffs and landings with minimum power required; takeoff and landing techniques of maximum performance; operations in restricted locations; quick stops;
- h) hovering out of ground effect; operations with external cargo, if applicable; high altitude flight;
- i) basic flight maneuvers and abnormal attitude recovery only by reference to basic flight instruments;
- j) abnormal and emergency procedures in simulated failures of equipment, engines, systems and structure and autorotation procedure;
- (k) procedures for incapacitation of a flight crewmember and crew coordination, allocation of flight duties and crew co-operation, as applicable.

Fase II – Treinamento em Rota	Concessão	Revalidação
Helicópteros com peso máximo de decolagem até 3175 kg (7000 lbs) e 9 (nove) ou menos assentos de passageiros;	02h	Treinamento em rota não é necessário.

6.4.7 At this stage, at least the following procedures must be carried out:

- a) pre-flight procedures, including navigation planning, fuel calculation, fueling, weight calculation and balance; inspections and verification of the aircraft airworthiness;
- b) procedures for climbing, leveling, and managing the aircraft during the cruise flight;
- c) as applicable, configuration and use of navigation, communication and air conditioning systems; electrical system and anti-ice devices;
- d) approach and landing procedures in visual conditions;
- e) as applicable, instrument flight procedures, including instrument approach procedures, missed approaches and landings;

It was not possible to verify that the minimum procedures, established in items 6.4.5 and 6.4.7 of IS 061-005A, were made due to lack of access to the flight instruction sheets.

The pilot performed the initial check for the Type Rating on 18AUG2015, lasting 40 minutes, by an accredited ANAC inspector.

Flight operations only started on 19AUG2015 and until the day of the flight the pilot had 104 hours and 2 minutes of daytime flight, 2 hours and 54 minutes of navigation and 42 hours and 48 minutes of night flight on the aircraft.

The crewmember had previous experience on A109, A19S, BH06, EC55, H350, R22, R44, R66 and S355 aircraft, as recorded in her CIV. She had her instrument flight rating expired since May 2016 and had a total of 15 hours of instrument flight on the A19S and EC55 aircraft.

She performed the last instrument flight on 04JUN2015, as a pilot in review instruction, lasting 24 minutes, on the aircraft A19S, as recorded in her CIV.

According to the survey carried out by the Investigation Team, on the day of the accident the following timeline was followed:

- at 1003 (UTC) the aircraft was supplied with 321 liters and had approximately 559 liters at takeoff time, as verified by the fuel voucher (Figure 17);



Figure 18 - Fuel voucher at accident site.

- at 10:31:47 (UTC) the crewmember arrived and headed towards the aircraft;
- at 10:33:32 (UTC) the external inspection procedures of the aircraft began. In the images obtained at that moment, it is also possible to notice the presence of two company employees and a pilot, who assisted in the accomplishment of the external inspection and departure. Reports showed that it was a common practice for the crewmember to be assisted by the pilot in question;
- At 10:47:09 (UTC), the PR-CBB pilot contacted Clearance-SP, requesting to start engine to proceed to a locality devoid of ATS, in the city of Americana - SP, according to the presented flight plan. The Clearance-SP operator questioned the PR-CBB pilot to which REH she would fly, receiving in response that she would follow via REH Marte, REH Anhanguera Sul, ATZ Jundiaí and REH Anhanguera Norte;
- At 10:48:36 (UTC), the Clearance-SP operator asked if the PR-CBB pilot was aware of the ATIS information, receiving a positive response. The operator of this ATS body informed the transponder code 0100 to be activated at takeoff, and instructed the pilot to call the TWR-SP when she was ready to take off;
- At 10:53:34 (UTC), the pilot contacted TWR-SP to report that she was ready to take off. The TWR-SP operator authorized her takeoff from the WHISKEY (West) sector of the Aerodrome;

- at 10:54:22 (UTC), the pilot requested crossings to the ECHO (East) sector of the Aerodrome, being instructed by TWR-SP to cross to that sector after the passing of a traffic that was in the final approach (Figure 19);

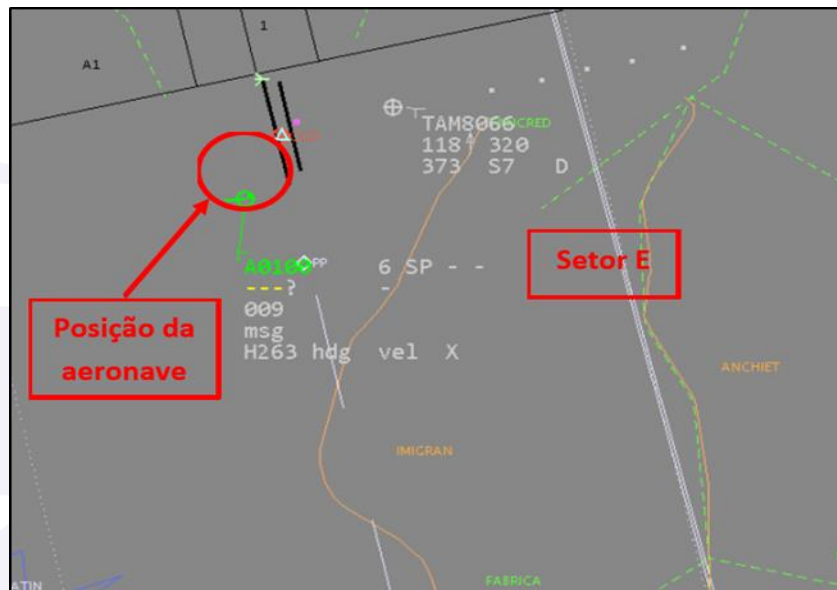


Figure 19 - Radar image of 10h54min22s (UTC), aircraft waiting to cross to the ECHO sector.

- at 10:55:22 (UTC), the PR-CBB pilot reported having arrived at the ECHO sector of the Aerodrome. She was then guided by the TWR-SP operator to switch to helicopter coordination frequency (127.35 MHz);

- the PR-CBB continued the flight via REH ACLIMAÇÃO and REH MARTE, according to the flight plan;



Figure 20 - Radar image of 10h59min22s (UTC), aircraft followed REH Acimação and REH Marte.

- at 11h00min29s (UTC) the PR-CBB was close to Marco Zero position. Instead of proceeding via REH ANHANGUERA SUL, as informed in the flight plan and to TWR-SP, the aircraft continued to fly over the Bandeirantes Highway (Figure 21);

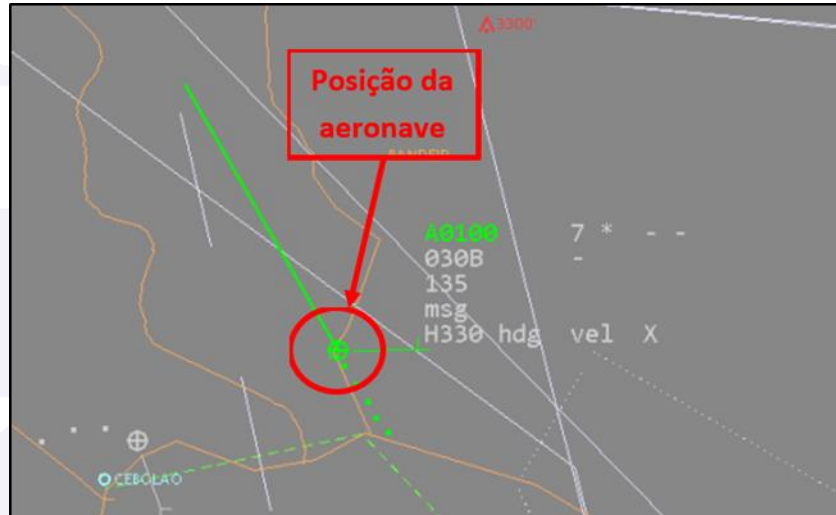


Figure 21 - Radar image at 11h00min29s (UTC). Marco Zero Position. Aircraft continues to fly over the Bandeirantes Highway instead of following REH Anhanguera Sul according to flight plan.

It should be noted: in AIC N 05 of 11MAR2010, which was repealed on 12DEC2013, REH ANHANGUERA did not exist, in its place was the REH BANDEIRANTES, which did not exist at the time of the accident.

- at 11:04:53 (UTC), the primary and secondary targets of the aircraft have disappeared, possibly due to elevations in the terrain that routinely cause the radar display to be lost;

- at 11:07:05 (UTC), the visualization of the aircraft reappeared on the same route with compatible speed and altitude, making it possible to assume that it would be the same aircraft, since there were no other nearby ones;

- at 11:09:00 (UTC), the aircraft left the route and, from this position, it was noticed that it started to make a conversion to the right of the initial route (Figure 22). This was the last visualization with the traffic; and

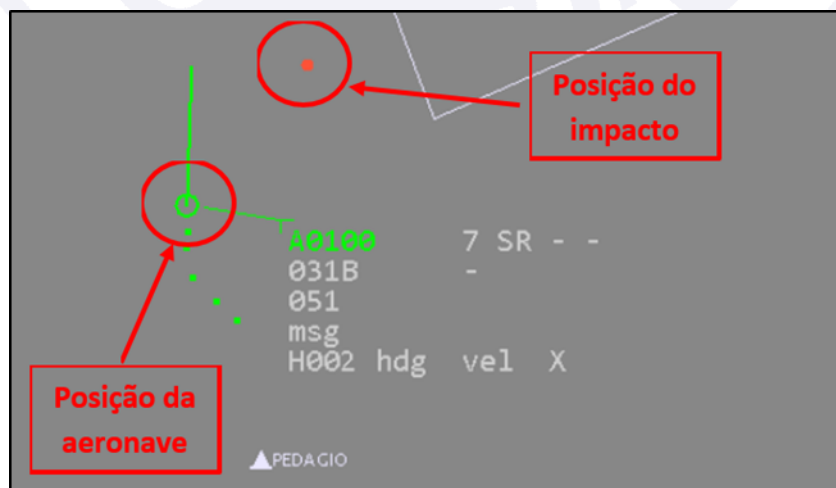


Figure 22 - Radar image at 11h09min00s (UTC). Aircraft initiating a conversion to the right of the route.

- At 11:09:57 (UTC) the last visualization was performed with the aircraft transponder in A/C modes, that is, with the primary and secondary radar. From this, it was not possible to determine that the radar plot was real, since it appeared only in the primary radar (asterisk) and with incompatible speed.

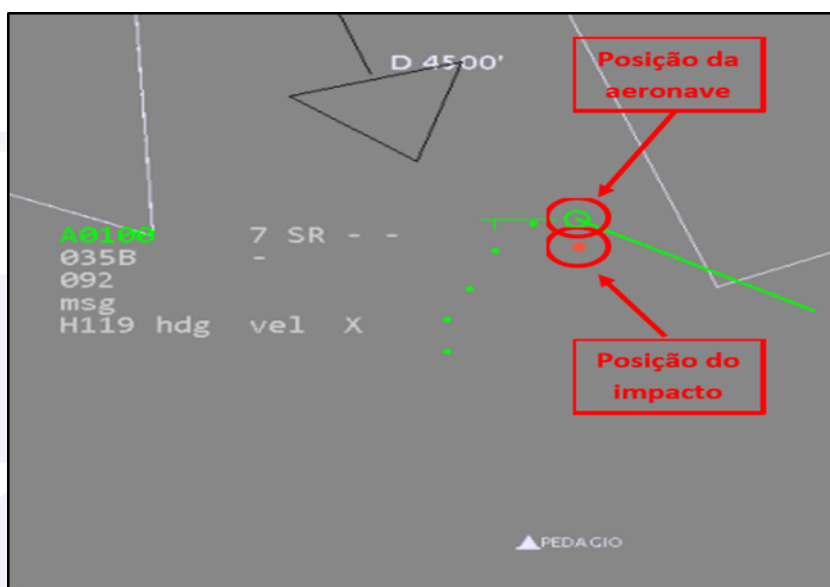


Figure 23 - Radar image at 11:09:57 (UTC). Last radar visualization.



Figure 24 - Field marking of aircraft displacement.

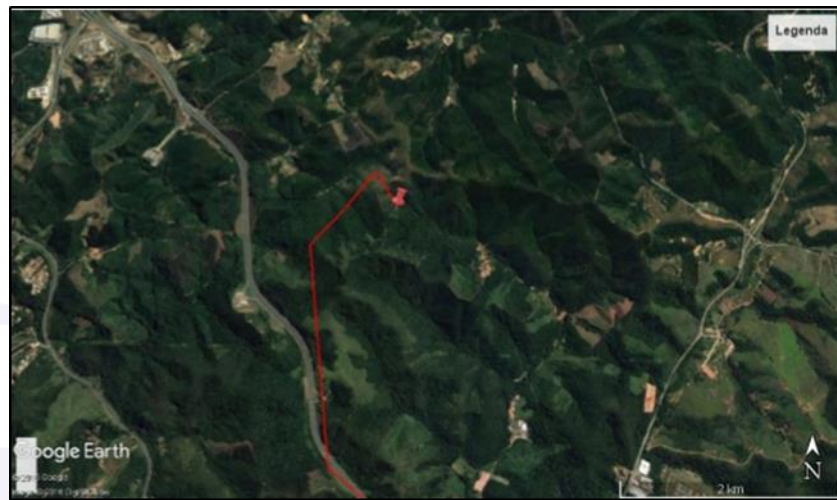


Figure 25 - Final trajectory followed by the aircraft.

The change of route did not constitute a violation of any air traffic regulations. Based on its location and altitude, PR-CBB, although within the lateral limits of the TMA-SP2 projection, was in class G airspace, since the lower limit of the TMA-SP2 was 3.600ft, according to AIP -BRASIL ENR 2.1-46.

Citing ICA 100-12 item 5.1.9, which dealt with class G airspace, VFR flights were not subject to air traffic control authorization, receiving only flight information and alert services from the ATS bodies.

The Body responsible for the flight information and alert service in the region was the São Paulo Approach Control, via frequency 129.50 MHz, according to AIC 17 of 12NOV2015 item 7.8. Additionally, according to the same AIC, item 7.1, the routes established in Uncontrolled Airspaces had their use as recommended, not being mandatory.

Below are shown Figures 26 and 27 taken from AIC N 17 of 12NOV2015, with a schematic drawing of the TMA-SP areas where air traffic control service was provided.

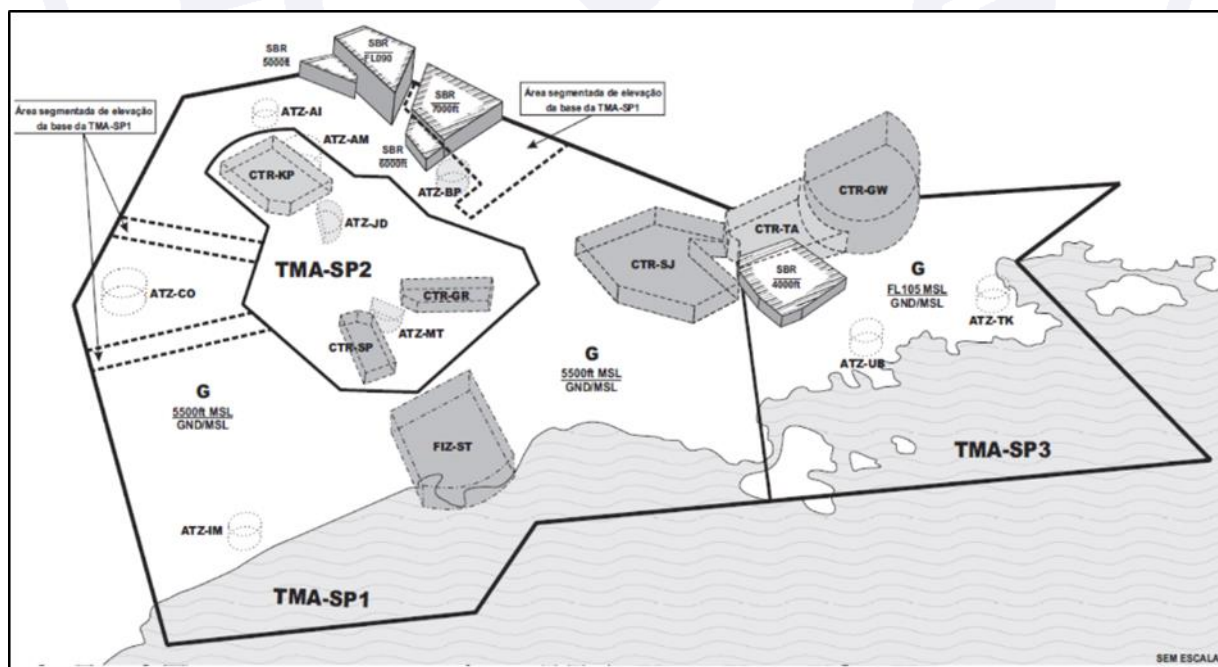


Figure 26 - Schematic presentation of the TMA-SP, seen in plan.

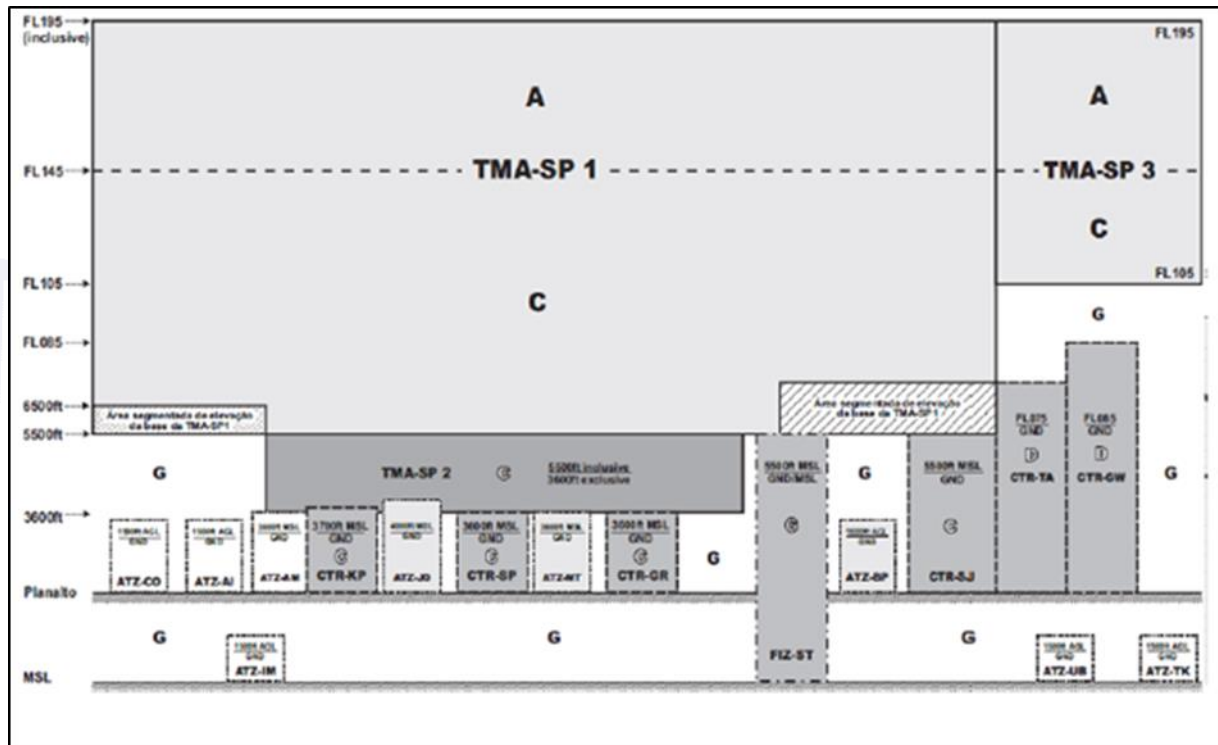


Figure 27 - Schematic presentation of the TMA-SP, profile view.

According to the ANAC data collection and the flight manual of the aircraft, it was possible to verify that it had authorization for the day and night VFR flight.

1.19 Additional information.

Nil.

1.20 Useful or effective investigation techniques.

Nil.

2. ANALYSIS.

This was a private passenger transport flight from SBSP to the city of Americana - SP, using the REH within the SP-Terminal.

The weather conditions were degraded and possibly, because of this, since there was no bilateral contact with the air traffic service agencies, the pilot performed a series of deviations and variations in altitude.

Approximately after fifteen minutes of flight, there was the loss of radar contact and loss of communications with the aircraft, which was only located the following day, crashed, in the region of Serra do Japi - SP.

The impact characteristics and the following technical analyzes confirmed that the aircraft collided with high energy in controlled flight and that the engine developed power, compatible with the flight phase.

Having ruled out the possibility that a technical failure contributed to the occurrence, according to the completion of the examinations and tests carried out on the aircraft, the attentions turned to the operational and medical history of the pilot in command.

It was found that the pilot had already received unfavorable evaluation in some health inspections to obtain CMA. Also, there was no medical inspection in her medical records with favorable medical opinion for the issuance of initial CMA for PCH, despite the existence of a medical inspection performed on 11NOV2008, revalidation for PCH, without the corresponding initial medical inspection.

In addition, in 2010, the pilot obtained another unfavorable evaluation, when she undertook an initial health inspection to obtain a license in the PLH category. At the time, it was prevised in legislation that she should return for reassessment in the same place where she had been disapproved if the person wished to proceed with obtaining the said license.

However, there was no return to the HASP for reassessment and continuity of the process. In 2012, the pilot in command managed to obtain the initial CMA for the PLH license, in an inspection performed at the Clínica Dédalo.

These actions were contrary to the guidelines recommended in RBAC 67, compromising the control and management of the evaluation system, since the initial inspection was again performed at an accredited ANAC clinic, which had no knowledge and access to the health inspection history of the pilot.

This situation demonstrated that there were latent flaws in the medical evaluation system, since there was no integration of the information regarding the previous evaluations of the patients. In this scenario, existing system failures allowed the revalidation of a nonexistent CMA for the initial PCH license, as well as the pilot's approval, in another evaluating body, for the PLH initial inspection.

In addition, there was no established professional profile for the different classes and categories of CMA. The lack of profile posed difficulties for the psychology professional to point out the behavioral characteristics and desirable cognitive abilities for a candidate for the position.

In the legislation in force at the time of the accident, there was the guideline that, during the expert examinations, the characteristics of the function to be exercised by the employee should be considered. However, although the cognitive abilities that were important to the pilot role were delimited, it was not referenced how such skills were demanded during the activity.

The lack of clear and precise criteria that could guide the process of psychological evaluation indicated gaps in the support material offered to the evaluators, which implied the need for the evaluator's discretion to conduct the inspection. It was the accountability of the person responsible for the evaluation to choose which aspects would be evaluated in relation to each cognitive function (attention, memory, reasoning), as well as to establish the criteria for a favorable and unfavorable evaluation in the health inspection.

This condition may have favored discrepancies in the evaluation processes in which the pilot participated, so that some difficulties observed in previous inspections were not detected in subsequent evaluations conducted by an evaluator who did not have this history.

It was observed that, regarding the psychological evaluation for health inspection in the year 2008 (initial to PCH), the envisaged legislation was fulfilled, considering the revalidation inspection provided in letter c of item 67.31 "psychological tests are part of the psychiatric examination of the initial inspections. In revalidations, at the discretion of the expert "(RBHA 67, 1999).

When considering the evaluation history in the pilot's health inspections, it was pointed out that the restrictions that prevented the approval of the initial inspection for PCH and PLH from the pilot-in-command were precisely related to the difficulties related to spatial reasoning.

Thus, such difficulties as to the spatial reasoning of the pilot may have influenced her ability to properly discriminate position in space and the movement of her aircraft in relation to the terrestrial horizon and gravitational vertical, creating illusions of false horizon and provoking spatial disorientation.

On the day of the occurrence, according to the meteorological analyzes, there was possibility of cloudiness on the intended route, mainly at the accident site. When taking into account the orography, vegetation and time of occurrence, there are indications that at the time of impact, the site was totally or partially obscured by clouds.

It was possible to observe a difference between the route performed and the one presented in the flight plan. This change did not constitute a violation, indicating only deviations, possibly caused by meteorology. The radar indicated that the pilot kept, during almost all the displacement, altitudes between 3,000ft and 3,200ft. At times, the aircraft disappeared from the radar display, suggesting that it operated at altitudes below that, especially considering that the elevation at which the impact occurred had 910 meters (2,985 feet) of altitude.

On the day of the crash, therefore, there was an unfavorable weather scenario, which may have led to the degradation of the visual references available to the crewmember to manage the flight. Associated with the reasoning difficulties presented by the pilot, the recognition, organization of information and understanding of the sensations received by external stimuli may have been affected, leading to an uncertain reading of the environment, leaving her disoriented spatially.

Therefore, visual illusions may thus have contributed to spatial disorientation, leading the pilot to a controlled flight against the terrain.

Thus, despite the pilot's experience, the decision to continue the flight under adverse conditions denoted an imprecise assessment of that operational context. This factor can be corroborated by the lack of contact with the air traffic control agency, as well as the lack of initiative to return or land in a safe place.

It is possible that the analysis of the situation and the choice of the best option to solve the problem have been compromised by an erroneous perception of the criticality of the situation, causing the crewmember to believe that the conditions of piloting were under control.

Regarding specifically to the analysis of the commander's operational progression in the crashed model, it was not possible to verify the contents of the theoretical and practical training given, and if they met the IS No. 061-005A, in force at the time of the accident, mainly in relation to the minimum procedures established in items 6.4.5 and 6.4.7 of the IS in question.

The lack of this information hampered a closer analysis of the commander's technical and operational capacity in relation to the aircraft she was currently piloting.

3. CONCLUSIONS.

3.1 Facts.

- a) the pilot had valid Aeronautical Medical Certificate (CMA);
- b) the pilot had valid BH07 (which included model 407) Rating and her IFRH Rating expired since May 2016;
- c) the pilot was qualified and had experience in that kind of flight;
- d) the aircraft had valid Airworthiness Certificate (CA);
- e) the aircraft was within the limits of weight and balance;
- f) the airframe and engine logbook records were updated;
- g) there were clues that the weather conditions were not favorable for the visual flight;

- h) no evidence of technical failure was found in the aircraft prior to the occurrence;
- i) the pilot had two unfavorable evaluations on health inspections (initial PCH and initial PLH);
- j) the pilot performed PCH revalidation health inspection, without previously obtaining favorable evaluation in the initial health inspection for PCH;
- k) the pilot performed initial health inspection for PLH at different approved clinics;
- l) the pilot performed an initial PLH health inspection in a different clinic from the one which she had previously failed;
- m) it was a displacement using special routes within the TMA-SP;
- n) during the displacement, there was loss of contact with the aircraft;
- o) the aircraft was found crashed on the following day;
- p) the aircraft was destroyed; and
- q) the occupants suffered fatal injuries.

3.2 Contributing factors.

- **Adverse meteorological conditions – undetermined.**

Degraded weather conditions may have influenced the decision of the pilot-in-command regarding deviations and variations in altitude verified by the radar revision, or even have led her to experience visual illusions that affected her ability to accurately perceive the environment, leading to the occurrence ending.

- **Disorientation – undetermined.**

The degradation of the meteorological conditions, the impact attitude of the aircraft and the impact energy itself signaled the possibility of a spatial disorientation by visual and/or vestibular illusion as the most probable hypothesis to explain the dynamics of the accident.

- **Illusions – undetermined.**

In the present case, the visual illusion of the false horizon may have occurred, related to the bad perception of the horizon, common in flights with degradations in the meteorology with lack of visual references; and/or the somatographic illusion that affects the spatial orientation, as much by the bad perception of the visual system, as of the vestibular system.

- **Piloting judgment – a contributor.**

There was an inadequate evaluation of the parameters related to the operation of the aircraft by maintaining the flight altitude close to the altitude of the elevations, considering the unfavorable weather conditions.

- **Perception – undetermined.**

The degradation of the meteorological conditions may have resulted in difficulties in the perception of external visual references. Associated with the difficulties of spatial reasoning presented by the pilot, this condition may have compromised her ability to properly discriminate position in space and the movement of her aircraft with respect to the Earth's horizon, favoring collision against the ground.

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

The decision to continue the visual flight in an unfavorable weather scenario denoted an imprecise assessment of the criticality and risks involved in that operational context, which presented elements favorable to spatial disorientation.

- Organizational processes – a contributor.

There were flaws related to the health inspection process to the pilot to obtain the CMA. These failures made it possible to obtain a medical certificate for the revalidation of the PCH license, without proper approval at the initial inspection, as well as obtaining approval at the initial inspection for the PLH license, although at the time of the evaluation, the pilot did not attend the criteria adopted by the regulatory body.

- Support systems – undetermined.

The gaps observed in the legislation that governs health inspections (RBAC 67), especially regarding the aspects to be evaluated in relation to each cognitive ability, may have favored discrepancies in the evaluative process and made it impossible to detect difficulties related to the pilot's spatial reasoning.

The absence of clear and precise criteria for the pilot function evaluation indicated flaws in this reference material, which was used for psychological assessment at initial health inspections, requiring the evaluator's discretion to determine his or her evaluation.

4. SAFETY RECOMMENDATION.

A proposal of an accident investigation authority based on information derived from an investigation, made with the intention of preventing accidents or incidents and which in no case has the purpose of creating a presumption of blame or liability for an accident or incident. In addition to safety recommendations arising from accident and incident investigations, safety recommendations may result from diverse sources, including safety studies.

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 Brazil's National Civil Aviation Agency (ANAC):

A-094/CENIPA/2016 - 01

Issued on 05/16/2019

Review the requirements for the psychological evaluation of pilots, in order to guarantee that these requirements have a professional profile for the different classes and categories of CMA, with the purpose of removing the existing gaps in the current system, which generate difficulties for the psychology professional to point out the behavioral characteristics and cognitive abilities undesirable and desirable for a candidate for the function.

A-094/CENIPA/2016 - 02

Issued on 05/16/2019

Analyze the feasibility of implementing procedures that guarantee the clinics approved for the issuance of the Aeronautical Medical Certificate (CMA) the access to a unified and updated medical record, so that the professionals that are responsible for the evaluation know the candidate's history, regarding the process of obtaining CMA.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

None.

On May 16th, 2019.

Brigadeiro do Ar FREDERICO ALBERTO MARCONDES FELIPE
Head of CENIPA