COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A-013/CENIPA/2013

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PR-IPO**
MODEL:	**A-109S**
DATE:	**30 APRIL 2008**

NOTICE

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

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

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

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

This Report does not resort to any proof production procedure for the determination of civil or criminal liability, and is in accordance with item 3.1, Annex 13 to the 1944 Chicago Convention, which was incorporated in the Brazilian legal system by virtue of the Decree nº 21713, dated 27 August 1946.

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

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

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

SYNOPSIS

This is the final report of the 30 April 2008 accident involving the model A-109S aircraft, registration PR-IPO. The accident was classified as spatial disorientation.

At takeoff, a few seconds after starting the longitudinal movement, the helicopter collided with the surface of the water.

The pilots suffered fatal injuries.

The aircraft sustained serious damage.

An accredited representative from the ANSV was designated to take part in the investigation.

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GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ANAC	(Brazil's) National Civil Aviation Agency
ANSV	Agenzia Nazionale per la Sicurezza del Volo
ATS	Air Traffic Services
CCF	Medical certificate
CENIPA	Brazil's Aeronautical Accident Investigation and Prevention Center
CFIT	Controlled Flight Into Terrain
CHT	Technical Qualification Certificate
COMAR	Regional Air Command
DAC	Civil Aviation Department
DCTA	Science and Aerospace Technology Department
DECEA	Airspace Control Department
ELT	Emergency Locator Transmitter
EPTA	Telecommunications and Air Traffic Service Providing Stations
FAA	Federal Aviation Administration
FD	Flight Director
GPS	Global Position System
IAE	Aeronautics and Space Institute
ICA	Command of Aeronautics' Instruction
IFR	Instrument Flight Rules
Lat	Latitude
Long	Longitude
MEV	Electronic Sweeping Microscopy
PD	Pilot on the left seat
PE	Pilot on the right seat
PLH	Airline Transport Pilot – Helicopter category
RBAC	Brazilian Civil Aviation Regulation
RBHA	Brazilian Aeronautical Certification Regulation
RS	Safety Recommendation
SAE	Society of Automotive Engineers
SBRJ	ICAO location designator – Jacarepaguá Aerodrome
SDEL	ICAO location designator – Condomínio Spazio JK Helipad
SDLA	ICAO location designator – Condomínio Laranjeiras Helipad
SERIPA	Regional Aeronautical Accident Investigation and Prevention Service
SIBH	ICAO location designator – Helicidade Helipad
SIPAER	Aeronautical Accident Investigation and Prevention System

SOP	Standard Operating Procedure
TPP	Private Air Transport
TSO	Technical Standard Orders
UTC	Coordinated Universal Time
VFR	Visual Flight Rules
VVI	Vertical Velocity Indicator
VSI	Vertical Speed Indicator

1. FACTUAL INFORMATION.

Aircraft	**Model:** A-109S **Registration:** PR-IPO **Manufacturer:** Agusta Westland	**Operator:** COSAN S A Indústria e Comércio
Occurrence	**Date/time:** 30 April 2008 / 2258 UTC **Location:** Condomínio Laranjeiras Helipad (SDLA) **Lat.** 23º20'39"S **Long.** 044º39'39"W **Municipality – State:** Paraty – RJ	**Type(s):** Spatial Disorientation

1.1 History of the flight.

The aircraft took off from the heliport Helicidade, SP (SIBH) with two crew on board, bound for Helipad Condo Spazio JK, SP (SDEL), where five passengers boarded.

Then took off bound for Helipad Condomínio Orange, RJ, (SDLA), located in the municipality of Paraty, RJ. After disembarking passengers, the aircraft took off bound for Aerodrome Jacarepagua (SBJR), municipality of Rio de Janeiro, RJ, with only the two pilots on board.

Soon after the start of the takeoff, the aircraft came to hitting the water surface.

The aircraft was destroyed. The two crew members died on the spot.

1.2 Injuries to persons.

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

1.3 Damage to the aircraft.

The aircraft was completely destroyed.

1.4 Other damage.

None.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Hours Flown		
	Pilot	Copilot
Total	12,000:00	12,000:00
Total in the last 30 days	20:00	10:00
Total in the last 24 hours	00:50	00:50
In this type of aircraft	60:00	20:00
In this type in the last 30 days	20:00	10:00
In this type in the last 24 hours	00:50	00:50

N.B.: Data on hours flown were obtained through third-party reports.

1.5.2 Professional formation.

The pilots had done the Helicopter Pilot Course in the Brazilian Navy.

1.5.3 Category of licenses and validity of certificates.

The pilots had Airline Transport Pilot Licenses (Helicopter category), as well as valid A-109 type aircraft certificates and IFR ratings.

1.5.4 Qualification and flight experience.

The pilots were qualified, and had experience for the type of Flight.

For purposes of information, PE means “pilot on the left seat” and PD means “pilot on the right seat”.

1.5.5 Validity of medical certificate.

The pilots had valid medical certificates.

1.6 Aircraft information.

The serial number 22008 aircraft was manufactured by Agusta Westland aircraft industry in 2006.

The aircraft airworthiness certificate was valid.

The airframe and engine log books were up to date.

The aircraft technical documentation was destroyed in the crash, including the airframe, engine and cabin logbooks where the maintenance service and hours-flown records were kept.

According to information collected during the Investigation, there weren’t any records concerning mechanical discrepancies.

1.7 Meteorological information.

There was a frontal system over the Brazilian southwestern region, with an accentuated wind and temperature discontinuance, accompanied with a cover of low clouds over the southern coastal and mountainous areas of the State of Rio de Janeiro.

There was meteorological information available for the crew at the moment of departure from São Paulo, but it was not possible to determine whether the crew was aware of it.

The prevailing meteorological conditions were not favorable for VFR flights.

According to information provided by witnesses, the evening in Paraty was rainy, totally dark and without any kind of natural light source (moon and/or stars). The same situation occurred on the night after the accident, on account of a frontal system which directly influenced the weather conditions in the region.

1.8 Aids to navigation.

The weather was VMC when the aircraft left the São Paulo terminal area, but the meteorological conditions were not favorable for a VFR flight at the destination.

The approach and landing in SDLA were not made under fully visual meteorological conditions, according to information collected on the occasion of the accident, and to the accounts of the passengers who disembarked in SDLA.

It is possible that the crew utilized a chart with a GPS instrument approach profile for landing in SDLA. This chart is neither homologated nor recognized by the DECEA (Airspace Control Department) in its official publications.

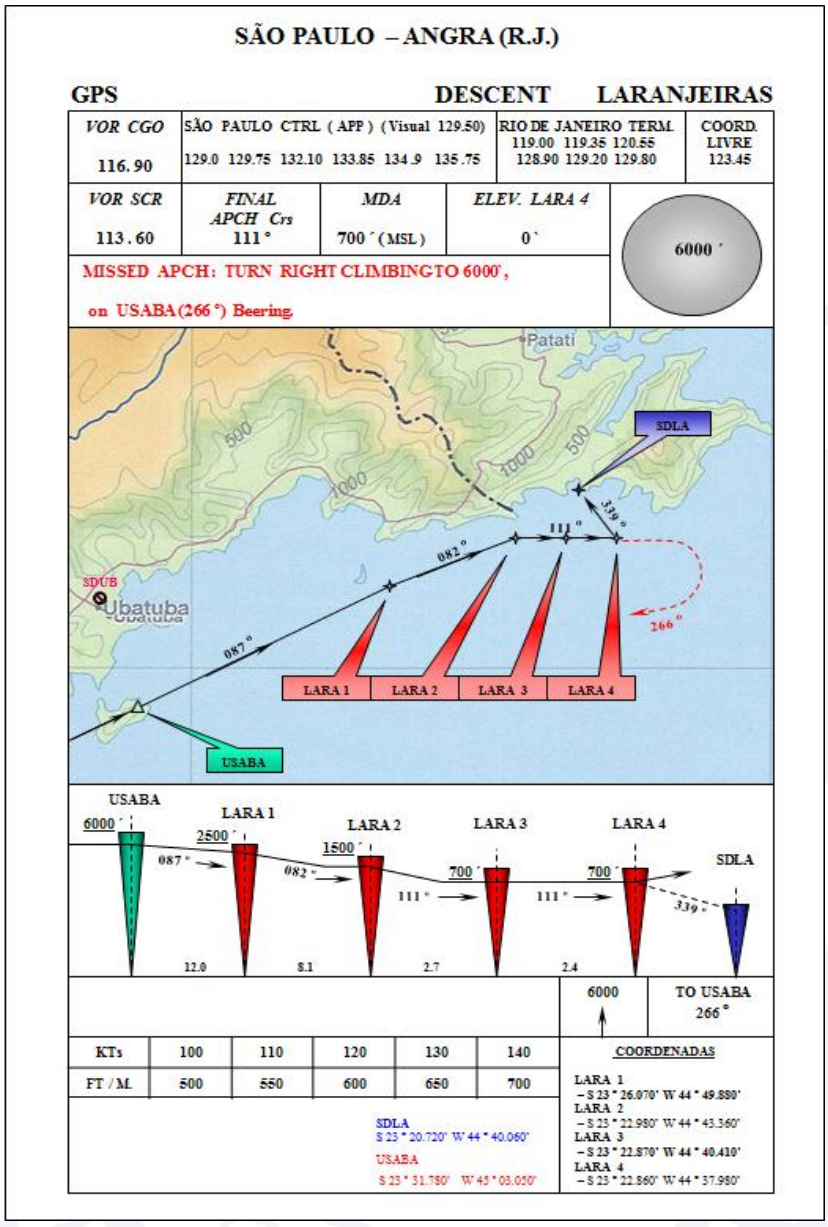

Figure 1 - GPS (Global Position System) “Approach Procedure” chart for Laranjeiras. There is striking similarity between the procedure layout in this chart and the official procedures issued by the DECEA.

The Investigation found out that the aforementioned “chart” was widely known within the aeronautical community in the region of São Paulo, among the helicopter operators that utilized the SDLA helipad.

1.9 Communications.

In the Condomínio Laranjeiras, close to the helipad, there was a physical structure, which sheltered equipment and “non-qualified personnel”, who would attempt to comply with the function of a radio station (EPTA).

The two-way communications between the aircraft and the non-qualified person of the Condomínio Laranjeiras was made on the frequency of 127.350 MHz, and was limited to the provision of empirically obtained information about the wind, altimeter setting, visibility, and ceiling.

The communications were not recorded. It was also observed that communications can only be established when the aircraft is three minutes out, on average.

The creation, homologation, activation and operation of an ATS providing unit, as well as the qualification of its operators, must meet the requirements of the ICA 63-10 “Telecommunications and Air Traffic Service Providing Stations – EPTA”, and must be published by means of existing aeronautical publications, which was not the case of the locality on the occasion of the accident.

1.10 Aerodrome information.

The private helipad is under the administration of the Condomínio Laranjeiras, which has its own internal regulation concerning the use of the helipad. The Helipad have operated conditions as (Day-time visual operation and night-time visual operation).

The helipad was concrete, dimensions 20m x 20m, an increase of 11 feet.

The helipad was registered by the Portaria (Order) III COMAR nº 748/EM3, dated 28 December 1999. Its registration was ratified by the Portaria DAC nº 1235/SIE, dated 30 November 2005, with validity of five years.

Contiguous to the landing area, there was a grass area for the parking of another aircraft. Such area, when utilized by more than one helicopter did not meet the minimum distance spacing requirements of the Portaria (Order) 18/GM5, dated 14 February 1974.

By means of the Protocol 0159/05, dated 15 August 2005, the H.R. *Assessoria Aeronáutica Comercial Ltda* enterprise informed the then Civil Aviation Department, on the occasion of the ratification of the helipad registration, that only one helicopter would be parked in that parking position.

On the other hand, during the Initial Action in the accident site, it was possible to notice that this protocol was not respected. The Portaria (Order) DAC nº 1235/SIE, dated 30 November 2005, does not define the utilization of the area designated for overnight parking.

Installed by the Condomínio Management, there was also a stage spotlight, which was utilized in the attempt to illuminate the topographical features capable of interfering with a night-time approach or departure (Figure 2).

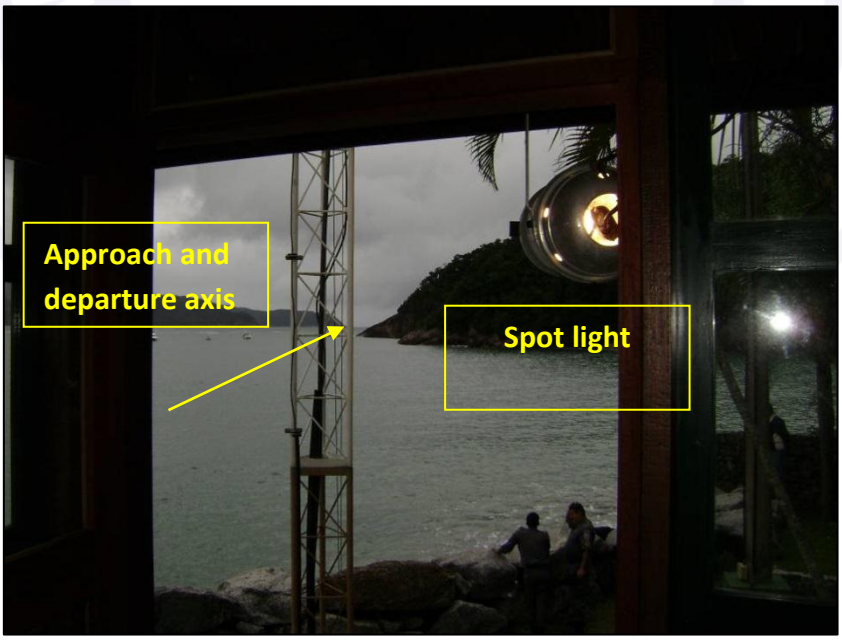

Figure 2 - Stage spotlight installed by the *Condomínio* Management in a construction close to the helipad.

There was a tower installed near the helipad, utilized as a rotating beacon.

Figure 3 - Tower (Rotating Beacon) installed close to the Helipad.

1.11 Flight recorders.

Flight recorders (CVR and FDR) were neither required nor installed. However, amidst the wreckage of the aircraft the following NVM (non-volatile memory) equipment was found and removed for analysis and retrieving of the engine parameters by their respective manufacturers (Hamilton Sundstrand, Ametek Aerospace & Defense and Hispano-Suiza Canada):

- 01 DAU (Data Acquisition Control) S/N 05070111;
- 02 EEC (Electronic Engine Control) S/N 06016376 and S/N 05022800; and
- 02 DCU (Data Collection Unit) S/N DP04-3849 and S/N DP05-3253;

The engine data retrieved refer to the last five hours of operation, defining the parameters of N1(%), N2(%), NR(%), TRQ(%), TOT(ºC) e CLP(%) at each second.

For the purposes of the Investigation, each second corresponds to an event.

In relation to the read-out of the engine data, the following was observed:

- Up to the event 17993 (19:54:40), the parameters of the engines showed normal operating characteristics.
- At event 17994 (19:54:41) the parameters of the engines continued showing normal operating characteristics, with exception of the torque, which decreased from 98% to 92% (engine #1), and from 98% to 93% (engine #2).
- At event 17995 (19:54:42), the engine#1 torque drops to 86%, and the engine #2 torque drops to 85%.
- At event 17996 (19:54:43), the engine #1 torque drops to 79%, and the engine #2 torque drops to 79%.
- At event 17997 (19:54:44), the torques of both engine start increasing, engine # 1 81%, and engine #2 81%.
- The torques continued increasing up to the last recorded event 18000 (19:54:47), with engine #1 reaching 89%, and engine #2 reaching 88%.

- The event 18000 was the last one that was recorded, and until then the variations of the other parameters were not significant enough to affect the performance of the engines and of the aircraft.

1.12 Wreckage and impact information.

The wreckage of the helicopter was found by scuba divers 72 hours after the accident, at a distance of approximately 500 meters from the helipad, slightly to the right of the most favorable track utilized for departure (ideal magnetic heading 159º), and close to the side of an elevation at a depth of about 10 meters, slightly tumbled to the right.

It is worth pointing out that the aircraft was found in a small bay surrounded by elevations. The ideal approach axis was considered as 339º, and the ideal departure axis was 159º.

Judging from the characteristics observed in the crash site, it is possible to affirm that the first impact occurred when the main rotor hit the water surface. From the characteristics of the wreckage, it is admitted that the aircraft has dived in the water at a pitch down angle of 30º, with the wings rolled 20º to the right.

Of the four blades of the main rotor, two were fractured near the rotor head, while the other two had fractures starting in their middle, but all four of them resulted completely destroyed.

The tail boom sustained a twist to the left in its rear section. The two blades of the tail rotor remained in their original position showing no marks, deformation or torsion.

The left main gear was in the “down and locked” position.

The right main gear broke due to the impact with the water, and was not found by the divers.

The aircraft cockpit was totally destroyed, and only the passenger cabin ceiling had some condition of preservation.

The right side of the fuselage sustained an undulated kneading in its entire length.

The first debris found floating on the water surface were the fuel tank cells and the left side door (passenger access).

After removal of the aircraft wreckage from the bottom of the sea, it was observed that:

- The aircraft main piloting panel was connected to the aircraft just by means of the electric cables;
- The PD wiper switch was in the “on” position, and the PE’s was in “off”;
- The “knob” of the “instrument panel” lights was practically in the position “OFF” (light intensity very low);
- The Vertical Velocity Indicator (VVI) of the PD was found with the bug (vertical velocity selector) adjusted for 700 ft/min in the direction of descent, and was in a fixed and frozen position, while the knob, which makes the selection of the vertical velocity, was not found in its original position, probably on account of fracture at the moment of impact;
- The fuel panel was found with the FUEL PUMP 1 e 2 switches in the “on” position, and with the CROSS FED switch in the “normal” position;
- The engine start panel was found with the ENG 1 MODE switch in the “off” position, and with the ENG 2 MODE switch in the “FLT” position.

1.13 Medical and pathological information.

1.13.1 Medical aspects.

According to the pilots' most recent medical records, they did not have any illness requiring the use of medicines, and were supposedly in good health, since their medical certificates had been revalidated in the same year of the occurrence of the accident.

In the autopsy reports, to the extent that was possible to investigate, no indication was found of organic morbidity situations that could have contributed to an unsafe flight.

The pilots had started their working hours in the day of the accident at about 1123 local time. They had made five landings and six departures.

Relatively to the medical aspects, it is important to highlight two factors:

- Human orientation originates from the interaction between the visual, proprioceptive and vestibular systems;
- The pieces of information that flow through these three systems enable human beings to know the position in which they are at any given moment.

However, the human being, a terrestrial animal, has the adjustment of inputs and outputs calibrated for functioning on the surface.

When man is taken from the environment he lives to the air environment, conflict of information may occur, resulting in a phenomenon known as spatial disorientation, which may be aggravated when it is associated with stress and tiredness.

The vestibular system, located in the inner ear, is composed of three channels, each in one of the positions of the plans of the space, all filled with liquid.

The movement of the liquid inside the channels takes information to the cerebral cortex on movements, stops, turns and other positions of the individual in relation to the space.

On account of the fragility of the system in being faithful to reality, the pilot must have confidence in his flight instruments. The search for information from the instruments must be a component of the flight doctrine, since the human body is deceived by illusions/disorientations.

The takeoff of helicopters involves movements that comprise the three axes of motion, thereby being susceptible to various types of disorientation.

Scientific and aeronautical recommendations emphasize that during the nights of low luminosity (like the ones without moonlight), landings and takeoffs must always count on auxiliary air navigation instruments.

On a pitch-dark night, even emmetropes people may present the problem of nocturnal myopia.

But worse than that, the lack of input of ground reference in opposition to the sky, and even lack of left and right awareness, may confuse the information arriving at the visual cortex, and also damage the portion of input coming from the vestibular system.

Thus, if the pilot is not guided exclusively by means of instruments, it will be difficult for him/her to distinguish whether is body is climbing or descending in terms of the vertical axis and, therefore, the output necessary for correcting the course of the aircraft flown by him/her will be in discordance with the necessary reality of decision and conduct.

1.13.2 Ergonomic information.

As for the “VVI” (PN 31230-1127 e SN 361212) installed in the aircraft, it is possible to notice that to movement of the bug (orange color) is associated with the movement of the knob (missing in Figure 4, since it was broken). When the knob is rotated to the right, the bug moves counterclockwise, assuming a rate of descent condition (down), and the opposite is true.

Figure 4 - The VVI as found amid the wreckage.

A survey was done with ten pilots who fly other types of aircraft. They were asked to state the direction to which they would rotate a knob in order to adjust the rate of climb. All of them said they would rotate it clockwise.

In another survey with pilots who fly the same type of aircraft, some of pilots reported having difficulty in the beginning of operations to get accustomed to the direction they had to rotate the knob for adjusting the rate of climb/descent in the VVI.

It is anyhow recognized that a rate of climb or descent setting implies the reading of the graduated scale for selecting the chosen speed and the instrument quadrant clearly indicate the UP or DOWN selection area where the orange colored bug is positioned.

1.13.3 Psychological aspects.

By the date of the accident, the operator had the following aircraft in the fleet:

- 01 Bell Jet Ranger helicopter: for aerial inspections of the sugar cane plantations (1 pilot - VFR). The pilot undergoes training at Bell Helicopter once a year.
- 01 twin-engine BE 58 (Beech Baron) airplane: for transporting workers between the operator’s sugar mills (2 pilots - VFR/IFR). The pilots undergo training once a year. The work schedule usually comprises four flights per week.
- 01 Beechcraft Queen Air airplane: also for transporting workers between the sugar mills. The pilots undergo training once a year. The expected workload in the schedule is three flights per week, seldom on the weekends. (2 pilots –VFR/IFR)
- 01 A-109 helicopter (PR-IPO): for transporting the operator’s management staff, employees, guests, as well as the owner and his family. It flew almost every day, including weekends. (2 pilots + 1 freelance - VFR/IFR).

Since the owner of the aircraft fleet was not a professional of aviation, an aeronautical advisor was hired to manage the fleet, the pilots and the operation of the aircraft.

The PR-IPO helicopter typically transported entrepreneurs, investors visiting the operator's sugar mills, management staff and employees of the operator. Also, the aircraft was used for flights related to the leisure of the owners.

The visits of the sugar/alcohol mills with investors would take place twice a month on average, and would be planned two weeks in advance.

From the flight spreadsheet provided by the operator, it is possible to see that a large part of the flights was for the transport of employees and executives.

The pilots were summoned for flights by the operator's secretaries, via fax, email or telephone.

In the operator's structure, there were two sectors responsible for the management of the flights: part of the job was done by the office in the interior of the São Paulo State, and part was made by the office in the city of São Paulo.

Pilots' workload characteristics in the accident

The Federal Law nº 7183 of 5 April 1984, known as Law of the Aeronaut, regulates the exercise of the aeronaut's profession, i.e., the professional certified by the civil aviation authority, and that exercises his/her activity onboard a national civil aviation aircraft, by means of a contract of employment.

After considering the aspects concerning the Law of the Aeronaut, and flight spreadsheets provided by the operator (April/2008) and by the Management of Helicidade (the helipad which was the base of the helicopter), relative to the four months of 2008 previous to the accident, it is possible to point out the following pilots' workload data:

- Schedules of Service:

As for the planning of flights by the operator, some of them had a previous planning, and the insertions would be made according to demand from the company or private entity. That is, the pilots were not aware of how their day of work would be.

- Day of Work:

For the type of flight made by the helicopter, the aeronaut's day of work should be a maximum of eleven hours, starting at the moment the aeronaut reported to his place of work, thirty minutes before departure time, and was considered as finished thirty minutes after engine shutdown.

In a review of the aircraft flight schedule in 2008, it was possible to observe that on several occasions the day-of-work limit was surpassed.

On the day of occurrence, if the Flight had been completed as planned, the day of work of the pilots of the helicopter in question could have been 13 hours and 30 minutes, exceeding the number of hours prescribed by law.

- Periodic day off:

As for the periodic day off, it was observed that the pilots would work up to ten consecutive days, without the prescribed 24-hour rest.

In the month of March, which precedes the month of the accident, the pilots did not have any two days off on the weekends (Saturday and Sunday), having worked on all the five Sundays of the month.

The last weekend worked in March completes a sequence of seven uninterrupted days of work in a row.

Operation at the Condomínio Laranjeiras Helipad

From interviews with other pilots that operate in SDLA, the commission learned of a report from a pilot to his employer telling about the reasons why he would no longer fly to the Condomínio Laranjeiras Helipad in the night-time period. According to the pilot, there had been approximately eight reports of this kind involving that helipad.

Another pilot, who would sometimes fly as reserve for an operator, defined the takeoff for the helipad as “uncomfortable”: moving from a clear spot towards darkness, with a feeling of spatial disorientation in which his eyes take long to get accustomed do the darkness (sic)...

1.14 Fire.

No signs of fire.

1.15 Survival aspects.

The body of the left-seat pilot was found shortly after the accident, floating on the water together with other helicopter parts (debris).

The body of the right-seat pilot was found 85 hours after the accident, at a distance of approximately eight nautical miles from the accident site, showing signs of more serious injuries.

The Emergency Locator Transmitter (ELT) was found in the armed position, but it was not possible to determine the location of the wreckage by means of ELT. It was not possible to locate on any of the expected frequencies tracked by the DECEA.

There was evidence that the belts of both pilots had not been subjected to any force of resistance as to keep them in their seats at the moment of impact.

The inertial reel of the left seat harness was totally retracted, and the inertial reel of the right seat harness was totally distended.

1.16 Tests and research.

The analogic instruments of the aircraft panel were sent to the Institute of Aeronautics and Space (IAE) in São José dos Campos (State of São Paulo) for ultraviolet light inspection.

The instruments had lots of water, and during the inspection no marks and/or residues of the pointers left on the face of the instrument were detected.

The only exception is the PE airspeed indicator (PN 64050-228-1, SN 7206). During the inspection, a mark was noticed on the face of the indicator, in the direction of the 120kt indication.

Later, in the UV light inspection, the same mark was detected. The airspeed indicator was disassembled, and it was determined that the residue found on the face of the indicator did not belong to the pointer of the instrument, but was instead made of some other material that had impregnated the pointer and remained in the area described, on the occasion of the aircraft collision with the surface of the sea.

The aircraft “VVI” (PN 31230-1127 e SN 361212) had its “vertical velocity selector” stuck in a certain position, showing a pre-selected descent setting of 700ft/min.

The PE Vertical Speed Indicator (VSI) (P/N 109-0729-33-1, S/N 4689B) showed a stain on the face of the indicator between 1,500 and 2,100 ft/min, in the “down” position.

The instrument was also disassembled, and the stain remained while the indicator face was damp. Shortly after contact with the air, nothing could be seen that might confirm any previous evidence.

The Flight Director Mode Selector (PN 7000505-901, SN 04122888) was sent to the Department of Science and Aerospace Technology (DCTA) in São José dos Campos, State of São Paulo, for exam of the bulbs and filaments of the annunciator lights of the mentioned selector.

Through the Macroscopic Exam, it was seen that four sets of lamps presented broken filaments. Each set was composed of two lamps. Only one of the sets had a lamp with a defective filament. The lamps of the other three sets had broken filaments.

The stereoscopic exams showed that the broken filaments had characteristics of fragility, breaking without a significant stretching of the spirals.

The Sweep Electron Microscopy exams confirmed the characteristic of fragility of the broken filaments, indicating that the filaments were “probably” cold when they broke.

The results indicate that the lights whose filaments broke were apparently off at the moment of rupture, on account of the fact that fractures observed in the filaments had a fragile aspect, easily breaking without having to be significantly stretched.

It was observed that the filaments of the lights showed signs of ‘aging’, which diminishes the radius section and reduces resistance.

1.17 Organizational and management information.

For a broad understanding of the context, it is important to outline the characteristics of the executive aviation in Brazil, more specifically in the coastal region between the States of Rio de Janeiro and São Paulo, in which the volume of executive helicopters is significant and undergoing a process of growth.

As for the air traffic infrastructure, helicopters fly mainly in the class “G” airspace, according to the ICAO international classification of the airspace contained in the ICA 100-12 “Rules of the Air and Air Traffic Services”, dated from 2006. In Class G airspace, aircraft are allowed to fly both IFR and VFR, and receive flight information service on request by the pilot.

Flights take place without pre-defined routes, but there is an altitude limit. The responsibility of separation between aircraft and geographic obstacles lies on the pilots.

Occasionally (and inappropriately), pilots declare that they are flying under VFR, even when the meteorological conditions are not VMC.

Sometimes the pilots postpone, to the extent possible, their decision of flying IFR, since they will have to fly in controlled airspace and in accordance with instrument flight rules, which considerably increases flight-time and fuel consumption.

Meteorological information on the coastal region between Rio de Janeiro and São Paulo is sometimes obtained either by means of a two-way radio contact with other pilots or through a phone call to someone that is at the destination of the flight. So, they make an empirical estimate of what the weather would be at the moment of landing at the destination.

Condomínio Laranjeiras Helipad in Paraty, where the accident happened, was registered, and landings and takeoff were authorized until 20:00 local time, according to the internal regulation of the condominium.

The workload aspects were under the Law of the Aeronaut. However, from the interviews with several pilots, it was observed that the executive aviation does not follow

the prescriptions of the Law in a strict manner. In some cases, the ultimate consideration was the employer's needs and the work demands.

In the same way of the norms that govern the profession of aeronauts in Brazil, it is the competence of both the Ministry of Work and Civil Aviation Authority to oversee and control compliance with these laws.

However, in relation to the Private Air Transport category, adherence to the regulation is sometimes fragile and far from being controlled, that is, it is the pilot's job to make the employer understand the Law of the Aeronaut and comply with it. The inspecting activities of the Civil Aviation Authority are restricted to the cases of denouncement of non-compliance with the Law.

It is worth noting that the number of executive helicopters flying in that region, under the circumstances briefly explained, is increasing considerably.

The use of aircraft of the operator's fleet, operating under the RBHA 91, could be compared, in terms of operation demand, to that of a non-regular public air transport (air taxi), which operates under the RBAC 135, whose volume of traffic is supposedly larger.

It is also a fact that operators under the RBHA 91 are not subjected to the same systemic control by means of audits imposed to operators under the RBAC 135.

A non-regular public air transport company (air taxi) must be certified/homologated.

Each holder of a non-regular public air transport company certificate must prepare, and submit to ANAC's pre-acceptance, a manual establishing procedures and policies.

This manual has to be used by the flight, ground and maintenance personnel of the certificate holder in conducting operations. From a series of procedures, the manual must establish the following:

- Procedures for determining aerodrome utilization minimums and other special air traffic procedures, in accordance with norms of the Command of Aeronautics concerning the operation of helicopters;

- Standard Operating Procedures (SOP) which provide the flight operation personnel with guidance for safe, efficient, logic and foreseeable operation in all phases of flight.

1.18 Operational information.

The crew of the helicopter was composed of two experienced captains. The aircraft departed from São Paulo to Paraty, in order to transport five passengers.

The aircraft departed the city of São Paulo in visual meteorological conditions, but during the flight the weather conditions over the southern coastal area of the State of Rio de Janeiro degraded, according to meteorological reports and accounts of the very passengers that were transported to SDLA.

The crew is likely to have utilized a chart neither homologated nor recognized by the DECEA for the approach to SDLA. The landing was uneventful.

The two pilots were A-109S captains. Both remained in the same seats in the cockpit for landing in and departing from SDLA.

The times listed below refer to the events captured by the security cameras of the *Condominio Laranjeiras*.

- 19:52:48 – The aircraft landed in DLA facing the security camera and the building that shelters the "radio operator". It was raining, and the helicopter engines were not shut down for the passengers to disembark.

- 19:53:17 – Passengers begin to disembark. The pilot on the left seat got out of the cabin, in order to supervise the disembarkment operation. While passengers are disembarking, it is possible to see several people walking around and below the main rotor, which was rotating. Still during disembarkment, it is possible to see people walking around and below the helicopter's main rotor, holding umbrellas, despite supervision by the pilot that was to the side of the helicopter.
- 19:55:13 – End of the passengers' disembarkment.
- 19:55:16 – The pilot who was outside the aircraft checked the closing of the door of the pilot who was in the controls on the right seat.
- 19:55:27 – The pilot who was outside the aircraft returns to the left seat.
- 19:55:35 – Closing of the door. From this moment on, it was no longer possible to see what happened inside the command-cabin of the helicopter and which pilot was operating the aircraft during takeoff.
- 19:58:18 – The helicopter initiates the hovering for takeoff.
- 19:58:21 – Still hovering, the helicopter turns to the ideal heading for takeoff.
- 19:58:46 - The helicopter leaves the helipad area climbing vertically with a considerable rate of climb. There were not passengers on board, and it is estimated that the aircraft had 400 Kg of fuel at that moment.
- 19:58:54 - With the helicopter already moving longitudinally, it is possible to observe the beam of the headlights forming an angle higher than 50 degrees (nose down) in relation to the surface of the sea.
- 19:59:02 - A last red light close to the surface of the sea was observed, and that was the last image of the aircraft captured by the security camera.

According to the account a witness, who was in a house close to the helipad and had a privileged view , it was possible to hear the noise of the aircraft colliding with the sea water and see the spray of water resulting from the impact, without any signs of explosion.

The most favorable magnetic heading for the approach to SDLA is 339 degrees, and the one most favorable for departure is 159 degrees. Outside such axis, the operations of approach and departure are not made in a straight line, on account of the surrounding relief.

1.19 Additional information.

Aeronautical Certification - VVI

The accident aircraft was equipped with an instrument called VVI (PN 31230-1127), with a tag near the electric connections mentioning the TSO-C8B which had been effectuated on April 1, 1959.

Figure 5 - Rear view of the instrument with tag.

This TSO establishes that the VVI manufactures must meet the standards set by the norm SAE- AS-394A, with a revision dated from 15 July 1958. In the text of the SAE-AS-394ª, there is the item 4.1, which reads:

> Indication Method: Ascent shall be indicated by a clockwise rotation of the pointer from the zero at 9 o'clock position. Descent shall be indicated by a counterclockwise rotation. Stops shall be incorporated to limit the pointer movement to not more than 178 degrees in each direction from zero.

During the investigation, other revisions of the aforementioned TSO were analyzed, such as:

TSO-C8D, which establishes in its item “a" (applicability):

> (1) Minimum Performance Standard. This technical standard order (TSO) prescribes the minimum performance standard that vertical velocity instruments must meet in order to be identified with the applicable TSO marking. New models of vertical velocity instruments that are to be so identified and that are manufactured on or after the date of this TSO must meet the minimum performance standards set forth in the Society of Automotive Engineers, Inc. (SAE) Aerospace Standard (AS) 8016, Vertical Velocity Instrument (Rate-of-Climb), reaffirmed October 1984, as amended and supplemented by this TSO.

The text above mentions the norm SAE-AS-8016, which establishes the following in its item 3.1 “Indications Means”:

> The vertical velocity shall be indicated by means of a pointer, dial tape, drum, or other type of moving element, or by a digital display with appropriate direction indication. Relative motion of the index with respect to the scale or of the direction indicator (either the index or the scale may be the moving element) must be clockwise, up, or to the right for ascending vertical velocity.

TSO TSO-C8E, which establishes the following in its item “3” – requirements:

> New models of vertical velocity instruments identified and manufactured on or after the effective date of this TSO must meet the MPS qualification and documentation requirements in SAE International’s Aerospace Standards (AS) 8016A, Vertical Velocity Instrument (Rate-of-Climb), dated September 1996.

The norm SAE-AS-8016A, dated from September 1996, establishes in the item 3.1 the same text of the norm SAE-AS-8016, dated from October 1978.

In the VVI, the movement of the bug is associated with the movement of the knob, i.e., when the knob is turned to the right, the bug moves counterclockwise, assuming a rate of descent condition (and the opposite is true).

It is anyhow recognized that a rate of climb or descent setting implies the reading of the graduated scale for selecting the chosen speed and the instrument quadrant clearly indicate the UP or DOWN selection area where the orange colored bug is positioned

Figure 6 - The VVI with the bug selected for 700ft/min (down) and fractured knob, showing its direction of rotation and correspondence.

It is possible to see that the knob that moves the bug (in orange color), which is inside the instrument, was severed on the occasion of the impact of the aircraft with the water.

It was not possible to recover the knob amidst the wreckage. A laboratory analysis showed that the bug was in a locked position, incapable of being moved after the impact.

The RBAC 29, which has the title “Airworthiness requisites: Rotary wings aircraft, transport category”, in its §29.00 “adoption requisites”, letter (a), reads:

> the reference for the granting of type certificates to rotary wings aircraft, transport category, is the Title 14 Code of Federal Regulations Part 29, Amendment 29-51, in effect from 31 March 2008, of the Federal Aviation Administration - FAA, of the Department of Transportation of the USA, English version, which is republished in the Appendix A-I of this RBAC, from the content of the publication site of the adopted regulation in question:: http://ecfr.gpoaccess.gov.

The RBAC 29, and more precisely, the §29.1309 “Equipment, systems, and installations” establishes the following in its item “c":

> (c) Warning information must be provided to alert the crew to unsafe system operating conditions and to enable them to take appropriate corrective action. Systems, controls, and associated monitoring and warning means must be designed to minimize crew errors which could create additional hazards” (emphasis added).
>
> The Title 14 Code of Federal Regulations Part 29, and more precisely, the §29.1309 Equipment, systems, and installations, establishes the following in its item “c":

(c) Warning information must be provided to alert the crew to unsafe system operating conditions and to enable them to take appropriate corrective action. Systems, controls, and associated monitoring and warning means must be designed to minimize crew errors which could create additional hazards.

Aeronautical Certification – Signage of obstacles

There is no signage for the topography adjacent to the helipad, making it impracticable to apply the definition of minimum limits for a safe operation by the pilots in a night-time VFR operation.

Below, some of the concepts and guidance prescribed in the ICA 100-4:

2.4 LANDING AND TAKEOFF

2.4.1 The landing and takeoff operations shall follow trajectories over obstacle-free surfaces.

3 VISUAL FLIGHT RULES

3.1 GENERAL CRITERIA

3.1.3 Outside controlled airspace, below the altitude of 3,000ft (or 1,000ft AGL) whichever results higher, the helicopter VFR flight will only be conducted when, simultaneously and continuously, the following conditions can be met:

a) maintain flight visibility conditions equal to, or higher than, 1,000m, provided the flight speed is enough to see and avoid any traffic or obstacle with sufficient time to prevent collision; and

b) Remain away from clouds, and maintain reference with the ground or water.

3.3 METEOROLOGICAL MINIMA

The prevailing meteorological minimums at the aerodromes or helipad involved shall be equal to, or higher than, the values specified in the sub items below.

3.3.2 OPERATION IN AERODROME OR HELIPAD NOT HAVING AN INSTRUMENT APPROACH PROCEDURE

3.3.2.1 During day time:

a) CEILING: - 600 feet; and

b) VISIBILITY: - 1500 m

3.3.1.2 During night time:

a) CEILING: - 1000 feet; and

b) VISIBILITY: - 3000 m.

Here are some concepts and guidelines set out in ICA 100-12 (Air Traffic - Rules of the Air):

5.2 PILOT'S RESPONSIBILITY

It will be up to the pilot in command of an aircraft in flight VFR provide their own separation from obstacles and other aircraft through the use of sight, except in airspace Class B, where the separation between aircraft is the ATC responsibility, should however, be subject to the provisions of paragraph 4.2.1.

1.20 Useful or effective investigation techniques.

Nil.

2. ANALYSIS.

Night VFR operation in SDLA

Although the Registration Order of the *Condominio Laranjeiras* Helipad (SDLA) issued by the Civil Aviation Authority allowed night-time visual operations, the pilot was only authorized to operate if he could visually identify the existing obstacles in his trajectory, as prescribed in item 5.2 of the DECEA ICA 100-12.

Radio communication was not adequate with the “non-certified operator”, and two-way radio contact was only possible when the aircraft was three minutes out for landing, a situation that could affect traffic, wind and altimeter information.

The establishment, certification, activation and functioning of an ATS provision agency, as well as the qualification of the operators, shall meet the specifications of the ICA 3-10 “Telecommunication and Air Traffic Service Provision Stations – EPTA” and must be published by means of the existing aeronautical publications. This was not applicable to the location on the occasion of the accident.

The artificial lights (stage spot-light) utilized as palliative rather than mitigating actions by the Condomínio Laranjeiras Management to illuminate the relief features surrounding the helipad could hinder the pilot’s vision during the approach, generating a latent spatial disorientation risk condition.

Some pilots, who operated in SDLA, would sometimes utilize an approach procedure chart (profile) that was neither homologated nor recognized by the DECEA, for a night-time approach with low visibility.

This was a procedure of widespread use in the aviation community of the São Paulo region, since the supervision of this type of operation by the civil aviation authority was limited, favoring this kind of behavior.

If one considers that the VVI rate of climb/descent setting bug was found with a selected rate of descent value of 700ft/min, and that such rate of descent was one of the options established in the chart, it is reasonable considering that the PR-IPO crew was making use of this procedure.

After the uneventful landing, the engines were kept running, and the rotors were rotating during the whole time the aircraft was on the ground.

The pilot on the left seat got out of his position in order to guide the disembarkment of the passengers and the removal of the baggage, while the pilot on the right seat remained in his position, making it possible to assume that he was preparing the cockpit for the next takeoff.

However, it is possible that the attention of the pilot on the right seat might have been drawn to the disembarkment of the passengers, a natural concern if one considers that the rotors were rotating, and there were people passing under the main rotor with open umbrellas, since it was raining at the during the disembarkment.

The possibility that the pilot on the right seat had his attention drawn concomitantly to cockpit preparation and passengers’ disembarkment, and the fact that the pilot on the left seat got out of his position to guide and assist with the disembarkment, added to an overloaded routine (stress and fatigue) imposed to the pilots, may have contributed to their non-compliance, or partial compliance with the checklist.

Thus, it is possible to suppose that the pilots had set the VVI to 700ft/min for performing the descent procedure toward SDLA, and that, during the four or five minutes they remained on the ground, they did not reset it. It is worth pointing out that, if the checklist had been fully complied with, the VVI resetting would have been done.

It is possible to suppose that the takeoff was carried out by the pilot on the right seat, since, besides staying in his position during the whole time the aircraft was on the ground, his wiper switch was in the ON position, while the one of the pilot on the left seat was in OFF.

At the takeoff, after hovering, the helicopter started the longitudinal movement and left the helipad area with a considerable rate of climb, being with an estimate 400Kg of fuel and without passengers on board, that is, its weight/power ratio favored this type of takeoff.

In that place, the transition from VFR to IFR flight takes place when the aircraft passes between the two elevations, at a distance of 0.35nm (650m).

At a distance of 2.5nm from the helipad, one minute into the flight on average, there is an elevation that forces the pilots to make a 90º-turn to the right.

Such maneuver is made at low height and low speed, without the available automatic flight systems.

Soon after takeoff, it is likely that the pilots experienced a condition leading to spatial disorientation.

They took off in the direction of the sea, without any type of lighting, from a clear spot (helipad lighting) toward a dark area (sea darkness) and in bad weather.

In these circumstances, the pilots may have had difficulty visually differentiating sea from sky, since they did not have any reference of the skyline.

On a takeoff from a clear to a dark area, it takes the pilots' vision sometime to get adapted. Such fact may have let them to activate the autopilot and the modules HDG and V/S in the Flight Director Mode Selector, in the attempt to maintain the most favorable departure heading (159 degrees) and a constant rate of climb.

The Rotorcraft Flight Manual (Document No. 109G0040A013), first edition, dated from 1st June 2005, in its Section 7, Chapter 22, made by the aircraft manufacturer and approved by the EASA, has the following information:

> …to permit automatic flight path control, the automatic stabilization system may be coupled to the flight director system. In this mode of operation, the computers automatically steer the helicopter along the roll and pitch axes to follow the Flight Director (FD) commands displayed on the EADI.

In the hypothesis of activation of the auto-pilot and the V/S module in the Flight Director Mode Selector could make the aircraft assume a non-desired pitch-down attitude in the direction of the sea, obeying to the VVI setting for the frontal approach, and if not detected would not give the pilots sufficient time for reaction.

Meteorological conditions

The meteorological conditions in the coastal regions of the State of Rio de Janeiro were not favorable for VFR operations that night.

There was a frontal system over the Brazilian Southeastern Region, with an accentuated discontinuity of temperature and wind, with low cloud cover over the southern coastal and mountainous area of the State of Rio de Janeiro.

It is possible to infer that the pilots did not have access to accurate ceiling and visibility information, whose VFR operation minimums are established in the ICA 100-14 (1,000ft and 3,000m, respectively).

Such information was produced in an empirical manner by the "non-certified operator" hired by the Condomínio Laranjeiras to provide this type of service.

The night-time approaches and departures were not favorable in SDLA at that moment. The moon was in its waning crescent phase, four days short of the new moon.

Data retrieved from non-volatile engine memory

The data retrieved from the non-volatile memory equipment (DAU, EEC, DCU) showed that there had been momentary variations of the engine torque parameters from 98% to 88% approximately.

After an analysis, it was verified that such variations were aerodynamic rather than mechanic.

This fact can be demonstrated by means of a scientific study conducted by Dr. Prouty, R. W., Helicopter Aerodynamics, published in the Rotor and Wing International in 1987.

According to this study, it is possible to conclude that the torque will increase when a turn to the left is made, and will decrease, not in the same proportion, when the turn is made to the right (for helicopters of American design) as PR-IPO.

Such effect is apparent in the beginning of the turn. When the turn is stabilized, the torque returns to its initial condition.

As for the data retrieved from the DAU, EEC, and DCU, it is possible to affirm that both engines of the aircraft were operating up to the moment of impact with the water surface.

Then, it was not possible to explain, if not for the strength of the impact of the aircraft with the water, the reason why the switch ENG 1 MODE having been found in the OFF position. From the evidence that the engines were operating normally, the position of the switch ENG 1 MODE in OFF does not correspond to reality.

If one considers the data retrieved from the DAU, EEC, and DCU, the evidence that the right main gear was severed, and the marks made by the water on some parts of the helicopter, it is possible to conclude that the collision with the water surface occurred with the aircraft turning to the right.

Tests and research

The bulbs of the lights which compose the Flight Director Mode Selector of the accident aircraft were studied.

The interest of the research focused directly on the HDG, VS, and Stand By annunciator lamps.

The results obtained suggest, from the condition of the filaments of the lamps, that the filaments had characteristics of cold rupture, that is, the lamps were off at the moment of impact.

However, in a discussion with the technicians that did the research, the possibility was raised that some filaments did not show the real condition of the moment of impact.

The filaments applied to the bulb of the lamps have a modern concept, being thinner and having less mass. Thus, they are susceptible to almost instantaneous heating and cooling in the absence of electric energy supply.

Wreckage

From the evidence found in the aircraft wreckage, it was possible to come to the following conclusions:

From the marks found in the aircraft, it became evident that the impact with the water surface occurred with a laterality of 20 degrees to the right, and a 30º pitch-down.

Such condition explains the fracture of the right main gear. In addition, the pilot who was sitting on the right seat suffered more serious injuries, and the right side of the fuselage sustained an undulated bending along its entire extension.

The VVI rate of climb/descent bug was found showing a selection of 700ft/min in the direction of descent, besides being in a locked position. The knob that is used for selecting the vertical velocity was not found in its original position, probably on account of having separated at the moment of impact.

Such fact could suggest that the crew utilized an IFR GPS approach profile for SDLA, making use of a chart that was neither homologated nor recognized by the DECEA.

It was confirmed that the use of the referred chart is widespread in the aviation community of the São Paulo region among the helicopter operators who use the *Condominio Laranjeiras* Helipad. One of the rates of descent established in the "chart" is exactly 700ft/min.

Since the switches of the PD's wiper were in the ON position, and the switches of the PE's wiper were in the OFF position, it is possible to suppose that the PD had the controls during takeoff.

Psychological aspect

A safe and efficient performance of the air activity is the result of the interaction of individual, psychosocial and organizational variables.

In the case of the PR-IPO accident, it is possible to say that there was a strong contribution from organizational variables, mainly those related to the planning of flights and pilots' workload.

In relation to the planning of flights and organization of work, it was observed that the planners did not show concern as to the compliance with the legislation pertinent to the day of work, rest and respite of the pilots, exposing them to an intense and inadequate rhythm of work.

Besides, it was not possible to observe whether there had been a previous planning for all the flights, on account of the operator's demand.

Some flights were fixed and had previous planning, but a large part of them would be made according to the demand of the period, and would be fitted in the routine without concern with the maximum working hours of the crew.

Moreover, there was not, in the operator's structure, a dedicated sector in charge of the management of the flights. The management activity was shared between the city office and the office in the interior of the State of São Paulo, and it is suspected that this fact may have led to a lack of data integration and, consequently to the difficulty in controlling the number of hours flown.

There is strong evidence that, even more important than the planning, operation safety, and compliance with the law, were the accomplishment of the schedule of the flights and attendance to the operator's needs.

Besides, during the Investigation, it was possible to observe that there was adequate concern with the maintenance of the equipment and aircraft of the company, but the same was not true in relation to the human resources.

Thus, it is possible to suppose that the workload imposed to the PR-IPO pilots exceeded on various occasions the limit prescribed by the legislation in force (the Law of the Aeronaut).

From the evidence (interviews, as well as flight spreadsheets from the operator and helipad management), it was possible to see, that the pilots were under a rather intense rhythm of work, considered above what would be appropriate for the individuals to maintain the physical and emotional integrity necessary for a good performance in the air activity.

The flight schedule on the day of the occurrence, had it not been discontinued on account of the accident, had an excess of two and a half hours in the pilots' day of work.

As for the pilots' rest period, it was possible to observe that the minimum period of twelve hours was not always respected.

In relation to the periodic day off, it was observed that between March 25 and March 31, the pilots worked seven consecutive days, although a day off was prescribed to be granted after a maximum of six consecutive days of twenty-four hours at the disposal of the employer.

Furthermore, in the period immediately before the accident, from April 15 to April 24, the pilots worked ten consecutive days, without being granted the prescribed 24-hour respite.

All these data relative to the pilots' workload brought the understanding that in the four months preceding the accident, the pilots were under a rhythm of work that exceeded what was prescribed by law, without respect to their day off and rest periods, leading the investigation commission to a strong suspicion of an environment of fatigue and stress.

Fatigue and stress can seriously interfere with the pilots' operational performance.

It is suspected that the situational awareness of the two pilots was degraded, since they were not capable of considering the relevance of the variables that clearly pointed at an unfavorable flight scenario.

The pilots were aware that the Condomínio Laranjeiras Helipad was registered for day and night time VFR landings and departures.

The pilots departed from São Paulo, knowing that they would arrive at the destination at the night time. In addition, they knew that the Condomínio Laranjeiras helipad was "uncomfortable" for night-time landings and departures.

Thus, it is suspected that they made a wrong decision by choosing to take off under the conditions described. It is a known fact that stress and fatigue may interfere with the maintenance of situational awareness and with the decision-making process.

In this case, it is important to mention that the burden represented by the imposed routine, added to the work overload, may have led the pilots to disregard important prescribed steps and basic procedures.

Also, tiredness and fatigue (both physical and mental) may lead to cognitive degradation, and favor a decrease in attention, functional/recent memory (the one utilized to remind inflight operational procedures), leading to a lack of perception, that is, failing to become aware of an existing stimulus.

In the case of the accident involving the PR-IPO, it is possible that the accumulated tiredness, added to the aspects already mentioned may have favored the forgetfulness, inattention (focusing on stimuli not relevant for the situation), as well as lack of perception of the need to readjust a piece of equipment that was important for climb following the takeoff.

During the Investigation, it became evident that the Flight Safety concept established between the Operator's aviation adviser and the owner of the helicopter was limited to the perfect maintenance of the aircraft and training of the pilots, with the aspects related to

human resources being left behind, in detriment (in favor?) of a new, modern, well-maintained machine.

Aircraft owners and the operator's aircraft managers showed little understanding of the aspects capable of affecting human performance in flight, and the basic needs that have to be met during the crew's day of work, so that pilots are fit for good piloting.

It is possible to suppose that the pilots did not give appropriate advice to the operator in relation to fatigue, workload, and faithful compliance with the Law of the Aeronaut, since the ultimate responsibility for the maintenance of flight safety lies on the crew.

Regulations

Still from an organizational standpoint, it is worth pointing out the fact that the passenger transport category aviation does not undergo a systematic oversight by the Civil Aviation Authority.

The passenger transport general aviation is governed, among others, by the RBHA and the Law of the Aeronaut, of the Ministry of Labor.

As for the pilots' workload, the criteria are established in the Law of the Aeronaut. Both the pilots and their employers are responsible for compliance with the Law. In the case of the accident, what was seen during the investigation was that, by and large, the pilots may have depended on the common sense of the employers, who may have not wanted to give up the convenience of using the helicopter as a means of transportation.

The description of the scenario above is necessary for understanding that the helicopter general aviation (passenger air transport) in this region has characteristics of unpredictability, poor planning, and, sometimes, improvisation, thus increasing the risk of operation and, consequently, the pilot's mental workload.

These factors, in addition to the fact that sometimes the pilots have difficulty setting limits to the employer, staking a claim in relation to what is prescribe by the Law which regulates the Aeronaut profession, summarize the scenario in which the aircraft in question could be inserted.

The fact is that, part of the owners of helicopters count on this means of transportation for purposes of work and leisure, and, frequently, do not give up flying, even when the conditions are not ideal for a safe flight.

3. CONCLUSIONS.

3.1 Facts.

a) The pilots had valid medical certificates;

b) The pilots had valid technical qualification certificates (CHT);

c) The pilots were qualified and had enough experience for the flight;

d) The aircraft had a valid airworthiness certificate;

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

f) the logbook of airframe, engines and rotors were updated;

g) The aircraft departed from SDEL, with five passengers on board, destined for SDLA (Condomínio Laranjeiras Helipad, State of Rio de Janeiro);

h) The aircraft left the São Paulo Terminal Area under VMC;

i) The weather conditions were no favorable for VFR flights at the destination;

j) The approach and landing at SDLA were not totally made in VMC conditions, according to meteorological information collected on the occasion of the accident and accounts made by the passengers;

k) After landing, the pilots did not shut down the engines. The passengers disembarked, and, at 19:58, the helicopter took off for SBJR;

l) The PE left the cabin to supervise the disembarkment of the passengers;

m) The PD stayed in the cabin during the passengers' disembarkment;

n) During the disembarkment, it was raining and there were people walking with their umbrellas below the main rotor;

o) At takeoff, a few seconds after starting its longitudinal movement, the helicopter crashed into the water surface;

p) The aircraft sustained serious damage; and

q) The pilots suffered fatal injuries.

3.2 Contributing factors.

- **Attitude – undetermined.**

It is suspected that the pilots did not comply with the takeoff checklist, since they would have otherwise noticed that the VVI was incorrectly set.

The burden of the imposed routine, added to the work overload, may have led the pilots to disregard important phases and basic prescribed procedures.

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

The prevailing meteorological conditions were not favorable for VFR flights. According to accounts made by witnesses, the night in Paraty was rainy, totally dark, and without any form of natural light source (moon and/or stars).

- **Cockpit coordination – undetermined.**

The fact that the PD had his attention divided between cockpit preparation and passengers disembarkment, and that the PE left his position to guide and assist the disembarkment, may have contributed to the non-compliance, or partial compliance, with the prescribed checklist.

- **Work-group culture – undetermined.**

It is possible to suppose that in the company it was more important to make the flights according to schedule and accommodate the needs of the operator, than the planning and organization of the work and operational safety.

- **Spatial disorientation – undetermined.**

Soon after the aircraft took off, the pilots faced a condition which induce to spatial disorientation: they were taking off in the direction of the sea at night, without any source of natural light (moon or stars), from a clear spot (helipad lighting) into the dark (sea darkness) in bad weather conditions.

In such conditions, the pilots have difficulty visually distinguishing the sea from the sky, since they do not have a skyline reference.

- **Pilot's forgetfulness – undetermined.**

It is possible that the accumulated tiredness, added to other aspects relative to the aircraft operating conditions, favored the forgetting by the crew as to the need of resetting the Vertical Velocity Indicator (VVI).

- **Flight indiscipline – a contributor.**

The pilots performed an operation under instruments flight conditions (IMC) in approved premises only for flight operation under visual conditions (VMC).

- **Influence from the environment – undetermined.**

The localization of the helipad, on account of the natural obstacles, only allowed takeoff in the direction of the sea. The night-time takeoff, without the presence of any type of external natural light (from the moon or stars), may have affected the crew performance.

- **Airport infrastructure – a contributor.**

The night-time visual operation in the Condominio Laranjeiras Helipad (SDLA), on account of the helipad localization, and the number of unmarked natural obstacles in its surroundings, contributed to the occurrence of the accident.

- **Piloting judgment – a contributor.**

There was not an appropriate evaluation on the part of the crew when they decided to proceed with the departure in SDLA, since the pitch-black darkness and lack of any source of natural light (from the moon or stars) did neither allow adequate sighting of the natural obstacles existing along the takeoff axis of the runway, nor fostered an accurate conditions of spatial orientation.

- **Work organization – a contributor.**

It was observed that the ones in charge of planning did not sometimes considered compliance with the law relative to the pilots' day of work, rest and respite, exposing them to an intense and inappropriate rhythm of work.

There was not previous planning for all the flights. A large part of the flights would take place according to the demand of the period, and would be fitted, without observance of the crew's maximum working hours.

- **Management planning – a contributor.**

From the evidence collected (operator's and helipad management's flight spreadsheets, and interviews, it was possible to verify that the pilots were under a rather intense rhythm of work, considered to be above the level appropriate for the maintenance of physical and emotional integrity, necessary for good performance in the air activity.

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

The pilots, despite being aware of the meteorological conditions on the location, and of the restrictions concerning a VFR departure from the Condomínio Laranjeiras Helipad, decided to proceed with the flight, thus accepting the risk. It is supposed that the crew had a degraded situational awareness, since the scenario was not favorable for making the flight.

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 prior to the publication of this report:

To the National Civil Aviation Agency (ANAC):

RSV (A) 119/D/ 2008 – CENIPA Issued on 12/08/2008

Reevaluate the feasibility of night-time VFR operation, contained in the Registration Order of the *Condominio Laranjeiras* Private Helipad (SDLA), (LAT 23º 20' 39"S / LONG 044º 39' 39"W), PARATY / State of Rio de Janeiro, taking into consideration the loss of visual references soon after departure in the direction of the sea, being this one the only direction utilized due to the residences-overflight restriction established by the management of the aforementioned *Condominio* (gated community.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

None.

On July 7th, 2016.