COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A-190/CENIPA/2013

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PT-KGK**
MODEL:	**PA-34-200**
DATE:	**21OCT2013**

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 21 October 2013 accident with the PA-34-200 aircraft, registration PT-KGK. The accident was classified as “with propeller”.

On a training flight, while the aircraft was flying over *Maricá* Lagoon, one of the left engine propeller blades and part of the propeller-hub detached, causing the aircraft to fall out of control along a vertical trajectory until colliding with the water.

The aircraft was destroyed.

Both aircraft occupants perished in the crash site.

A representative of the National Transportation Safety Board - NTSB - from the USA (State of Design) was designated for participation in the investigation.

CONTENTS

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

AD	Airworthiness Directive
ANAC	Brazil's National Civil Aviation Agency
APP-RJ	Rio de Janeiro Approach/Departure Control
CA	Airworthiness Certificate
CG	Center of Gravity
CM	Registration Certificate
CMA	Aeronautical Medical Certificate
CENIPA	Aeronautical Accident Investigation and Prevention Center
DCTA	Science and Aerospace Technology Department
DECEA	Airspace Control Department
ECI	Eddy Current Inspection
FAA	Federal Aviation Administration
IAC	Instrument Approach Chart
IFR	Instrument Flight Rules
ICA	Command of Aeronautics' Instruction
Lat	Latitude
Long	Longitude
MLTE	Airplane, Multi-Engine, Land - (AMEL)
MPI	Manual of Procedures and Inspections
NTSB	National Transportation Safety Board
PCM	Commercial Pilot license (airplane category)
PLA	Airline Transport pilot (ATP) license (airplane category)
PPR	Private Pilot license (airplane category)
RADAR	Radio Detection and Ranging
RS	Safety Recommendation
RWY	Runway
SAC-PR	Civil Aviation Secretariat of the Brazilian Republic Presidency
SBJR	ICAO location designator - *Jacarepaguá* Aerodrome
SDMC	ICAO location designator - *Maricá* Aerodrome
SERIPA	Regional Aeronautical Accident Investigation and Prevention Service
SIPAER	Aeronautical Accident Investigation and Prevention System
TSN	Time Since New
UTC	Universal Time Coordinated
VFR	Visual Flight Rules
VOR	VHF Omni-directional Range

1. FACTUAL INFORMATION.

Aircraft	**Model:** PA-34-200 **Registration:** PT-KGK **Manufacturer:** *Piper Aircraft*	**Operator:** *Aeroclube do Brasil*
Occurrence	**Date/time:** 21 OCT 2013/18:40UTC **Location:** *Maricá* Lagoon **Lat.** 22°59'07"S **Long.** 042°52'10"W **Municipality – State:** *Maricá*, Rio de Janeiro.	**Type(s):** With propeller

1.1 History of the flight.

At about 17:50 UTC, the aircraft took off from SBJR for a simulated IFR training flight near SDMC with a crew of 2 on board.

While the aircraft was flying over *Maricá* Lagoon, one of the left engine propeller blades and part of the propeller-hub detached. Control of the aircraft was subsequently lost. The airplane flew a vertical trajectory until crashing into the water.

The aircraft was destroyed.

Both aircraft occupants perished in the crash.

1.2 Injuries to persons.

Injuries	Crew	Passengers	Others
Fatal	2	-	-
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		
	Instructor	Student
Total	2,265:30	187:50
Total in the last 30 days	10:50	02:00
Total in the last 24 hours	02:00	02:00
In this type of aircraft	1,097:00	02:00
In this type in the last 30 days	10:50	02:00
In this type in the last 24 hours	02:00	02:00

N.B.: Data provided by the aircraft operator.

1.5.2 Personnel training.

The instructor pilot did his Private Pilot course (airplane category) at the *Aeroclube do Brasil* in 2003.

The pilot under training did his Private Pilot course (airplane category) at the *Aeroclube do Brasil* in 2011.

1.5.3 Category of licenses and validity of certificates.

The instructor pilot had an ATP license, a valid AMEL technical qualification certificate, and a valid IFR rating.

The pilot under training had a Commercial Pilot license, and was being trained for earning an AMEL technical qualification certificate.

1.5.4 Qualification and flight experience.

The instructor pilot had qualification for the type of flight.

The pilot under training was being prepared for earning an AMEL technical qualification certificate.

1.5.5 Validity of medical certificate.

Both crewmembers had valid aeronautical medical certificates.

1.6 Aircraft information.

The PA-34-200 twin-engine aircraft (SN347450163) was manufactured by Piper Aircraft in 1974.

Its Airworthiness and Registration certificates were valid. The airframe, engine, and propeller logbook records were up-to-date.

The aircraft was within the parameters prescribed for weight and balance, and center of gravity.

The last inspection of the aircraft (type “50/100 hours”) was done by *Aeroclube do Brasil* in Rio de Janeiro on 8 June 2013. The aircraft flew 36 hours and 40 minutes after such inspection.

The last aircraft overhaul (type “1,000 hours”) was done by *Aeroclube do Brasil* in Rio de Janeiro on 5 November 2012. The aircraft flew 232 hours and 30 minutes after the overhaul.

Two IO-360-C1C6 Lycoming engines (serial numbers L-12092-51A and L-938-67A, respectively #1 and #2) equipped the aircraft. Both had 7,875 hours of operation (TSN - Time Since New).

No evidence was found of non-compliance with the aircraft maintenance program scheduled for the aircraft engines and airframe.

The aircraft was equipped with two HC-C2YK-2C(L)GUF propellers, serial numbers AU5426E (#1) and AU3030E (#2). The maintenance program for this type of propeller requires an overhaul every 2,000 hours or 5 years, whichever comes first.

The left engine propeller (AU5426E) was purchased from a third party in September 2005 by *Aeroclube do Brasil*, with a declared TSN of 3,000 hours of operation. No records were shown that could confirm the origin and traceability of the component.

After being purchased, the propeller was sent to *Aerotécnica Paulista Serviços e Comércio de Peças Ltda.* on 30 September 2005 to be overhauled. It was received by *Aeroclube do Brasil*, and installed in the PT-KGK aircraft on 2 February 2006.

On 8 September 2010, five years after the last overhaul, the SN AU5426E propeller (TSN - 4,271 hours of operation) was overhauled again by *Aerotécnica Paulista Serviços e Comércio de Peças Ltda*. On the occasion, the workshop complied with the Eddy Current Inspection (ECI) test prescribed in the FAA Airworthiness Directive AD 2009-22-03, which also requires the completion of ECI every 100 hours or 12 months of operation.

Since the previous overhaul of the SN AU5426E propeller, the ECI test prescribed in the AD 2009-22-03 had no longer been done every 100 hours or 12 months of operation of the component.

On the Day of the accident, the SN AU5426E propeller had approximately 918 hours of operation after the last overhaul with compliance with the ECI test.

1.7 Meteorological information.

The prevailing meteorological conditions at the departure aerodrome, intended destination, and along the route to be flown were favorable for VFR operations.

1.8 Aids to navigation.

Nil.

1.9 Communications.

Nil.

1.10 Aerodrome information.

SDMC is a public aerodrome under the administration of the *Maricá* municipal government. It operates day-time VFR.

The runway is paved with asphalt, runways 08/26, measuring 1,190 m x 30 m, at an elevation of 13 feet.

The aerodrome of *Maricá* was being operated by the Municipal Government by virtue of the Delegation Agreement 09/2012 signed on 17 October 2012 with the Federal Government represented by the Civil Aviation Secretary of the Presidency of the Federative Republic of Brazil (SAC-PR).

The aforementioned Agreement described the Delegatee's duties, which, among other items pertinent to the operation and safety of the aerodrome and its users, included the following:

- the need to operate the aerodrome in accordance with the levels of safety, efficiency, and comfort required by the federal legislation in force;
- comply with, and enforce compliance with, the administrative/technical/operational plans, norms, and instructions issued by the Delegator, by the ANAC, and by Public Administration entities, applicable to the activities contemplated in this Agreement;
- observe, and enforce observance of, aspects related to the safety of persons, installations, and equipment in the aerodrome area; and
- adhere to campaigns of educational, informational, and operational nature, limited to the pieces of equipment operated and areas associated with the Agreement, in accordance with the directives issued by the Delegator, by the ANAC, and by the DECEA.

The Delegation Agreement 09/2012 also established that:

> The intervention shall be immediate, temporary, and applied as an exceptional measure, in the following cases: I. lack of compliance with the regulations and technical norms applicable to the services object of the present Agreement, whenever they represent a risk to the operational and users' safety.

In addition, the Agreement determined that:

Failure to comply with the obligations relative to the present Agreement by any of the parties may result in rescission of the agreement, without prejudice to the verification of responsibilities and compensations by means of specific administrative proceedings.

1.11 Flight recorders.

Neither required nor installed.

1.12 Wreckage and impact information.

The RADAR image of the Rio de Janeiro Terminal Area Control (APP-RJ) showed that the PT-KGK aircraft flew a couple of times over *Maricá* (MIA) VOR and *Maricá* Lagoon (Figure 1), until radar contact was lost over *Maricá* Lagoon.

Figure 1 - Illustration of the aircraft trajectory over MIA VOR and *Maricá* Lagoon (solid red line) and the intended route for landing in *Maricá* Aerodrome (after the point where the crash occurred).

The accident occurred outside of the aerodrome area, and the aircraft (on a vertical descending trajectory) crashed into shallow waters of the *Maricá* Lagoon with no previous impact.

The aircraft wreckage remained partially submersed (Figure 2).

Figure 2 - Aircraft wreckage partially submerged in *Maricá* Lagoon.

The wreckage remained in a concentrated fashion, and the aircraft was destroyed.

After the aircraft was removed from the lagoon, only the right engine was found with the main part of the wreckage. The left engine was missing (Figure 3).

Figure 3 - Aircraft wreckage after retrieval from *Maricá* Lagoon with only the right engine.

A new search was made in the lagoon, and the left engine was eventually found. Part of the propeller-hub and one of the blades had detached and were missing (Figure 4).

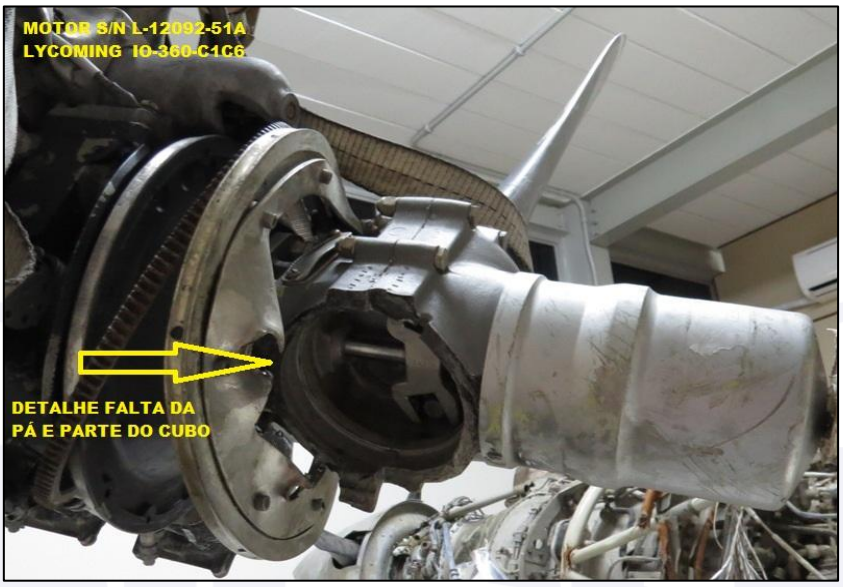

Figure 4 - Left engine without one of the blades and part of the propeller-hub.

Despite many attempts, the missing parts of the left propeller could not be found, on account of the poor visibility under the water and the large area of the lagoon.

With most of the wreckage retrieved, a reconstitution (mockup) of the aircraft was made (Figure 5).

Figure 5 - Reconstitution of the aircraft, front view.

During the reconstitution, the investigating committee observed that the left wing did not have the engine nacelle and the supporting structure of the engine cradle (Figure 6).

Figure 6 - Part of the left wing, without the engine nacelle.

The left wing spar had a breakage at the attachment points of the engine nacelle (Figures 7 and 8).

Figure 7 - Aspect of the left wing spar at the point of attachment of the engine nacelle.

Figure 8 - Aspect of the engine nacelle attachment points.

1.13 Medical and pathological information.

1.13.1 Medical aspects.

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

1.13.2 Ergonomic information.

Nil.

1.13.3 Psychological aspects.

No evidence was found that issues of psychological nature or incapacitation could have affected the performance of the flight crew members

1.14 Fire.

No signs of either in-flight or post-impact fire.

1.15 Survival aspects.

Nil.

1.16 Tests and research.

Engines

The IO-360-C1E6O *Lycoming* engines equipping the PT-KGK [serial numbers L-12092-51A (#1) and L-938-67A (#2)] were disassembled in the premises of a certified company. This job was observed by representatives of the SERIPA III and DCTA (Aerospace Science and Technology Department).

The objective of the disassembly was to analyze the internal components of the engines, with the purpose of identifying evidence of the power regime at the moment of the impact with the water.

The report of the analysis stated that both engines were operating normally until moments before the occurrence.

Propellers

The HC-C2YK-2CGUF *Hartzell* propellers [serial numbers AU5426E (#1) and AU3030E (#2)] equipping the PT-KGK were disassembled in the premises of a certified company. The job was monitored by representatives of the SERIPA III.

The objective of the disassembly was to allow analyses of fractures in the propeller-hubs.

The following evidence and/or discrepancies were observed in relation to the prescriptions of maintenance manuals:

- The nuts of the stop minimum pitch valves of both propellers presented torque values well above the manufacturer's specification;
- The propeller blades of the engine number 2 were bent (Figure 9);
- The propeller-hub closing screws, being six in the intact hub (propeller #2) and four remaining in the fractured hub (propeller #1), had excessive torque;
- The four closing screws which remained in the fractured hub (#1) did not have the sealing marks made after application of the torque during the process of assembly (line of faith); and
- The 3 grease nipples of the fractured hub (#1) appeared to have different values of thickness and different spiral threads.

Figure 9 - Number-2 engine bent propeller blades.

On account of the aforementioned pieces of evidence found during the process of propeller disassembly, and with the purpose of identifying the characteristics of the fracture, the damaged propeller-hub (#1) and the grease nipples were sent for macroscopic, stereoscopic, and microscopic analyses (Figure 10).

Figure 10 - Propeller-hub sent for analysis.

The result of the analysis was that the surface of the fracture of the propeller-hub had characteristics of failure due to fatigue (Figure 11), and that the grease nipples had differences, being two of them equal to each other, while the third one was of different size, thickness, and thread (Figure 12). In spite of the differences, one verified that the nipples seemed not to have connection with the origin of the fracture which resulted in the hub failure.

Figure 11 - Propeller-hub fracture surface showing characteristics of fatigue.

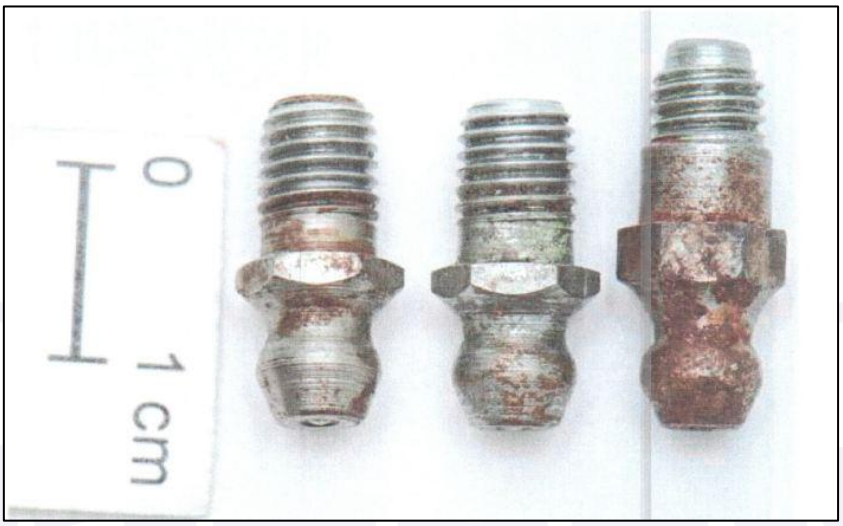

Figure 12 - Difference between the nipples.

It was not possible to identify the point of origin of the fracture, since the missing part of the hub was not found by the go-team during the field investigation.

After being informed by the NTSB accredited representative of the results of the tests done in Brazil, the manufacturer of the propeller (Hartzell Propeller Inc.) requested new tests, suggesting that they be done in the laboratories of the NTSB in Washington DC, USA. Thus, a team of investigators composed of representatives of the SERIPA III and of the DCTA was designated for witnessing the tests at NTSB.

The NTSB report confirmed the participation of the fatigue process in the breakage of the propeller-hub, including information on the area of origin and the shape of the fatigue propagation.

The report identified two breakage areas, a primary one (yellow arrows) and a secondary one (red arrows), with different lines of propagation, separated by a linear element represented by the green dotted line and identified by the letter “A” (Figure 13).

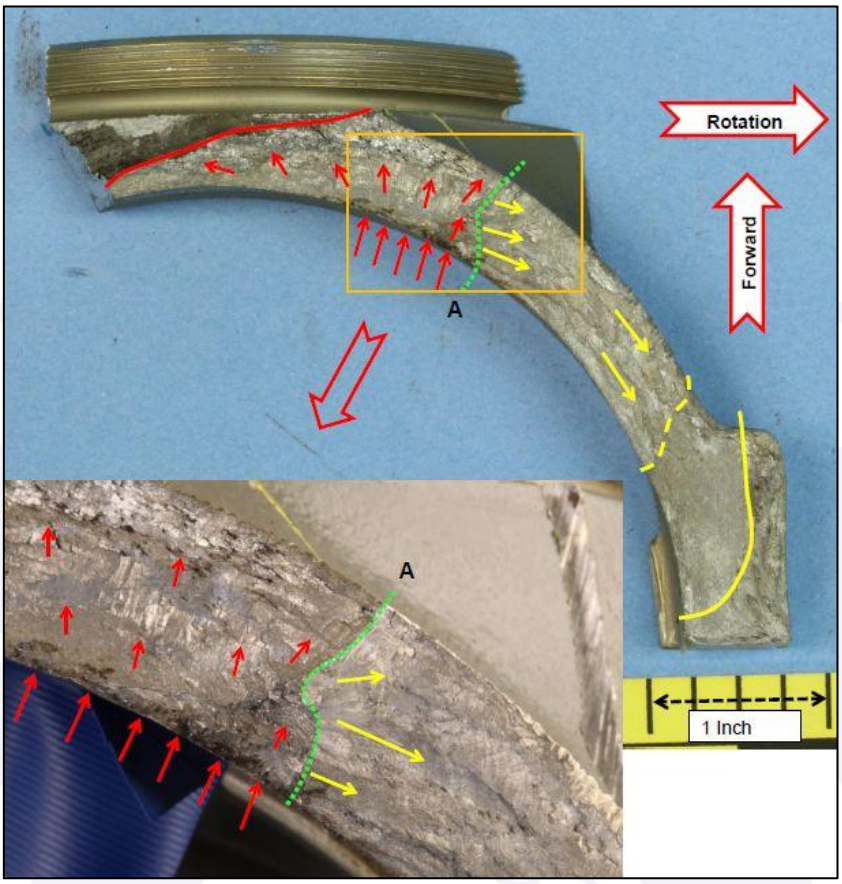

Figure 13 - Front view of the hub fracture region. The image in the background shows the whole fracture region, with two breakage areas and distinct forms of propagation separated by a green dotted line. In detail, in the foreground image, an augmented view of the fracture area.

The NTSB report also showed the lines of breakage (red and yellow), as viewed from above, together with the linear element separating the typed of propagation (green), and highlighting the geometrical peak identified by the letter “A” (Figure 14).

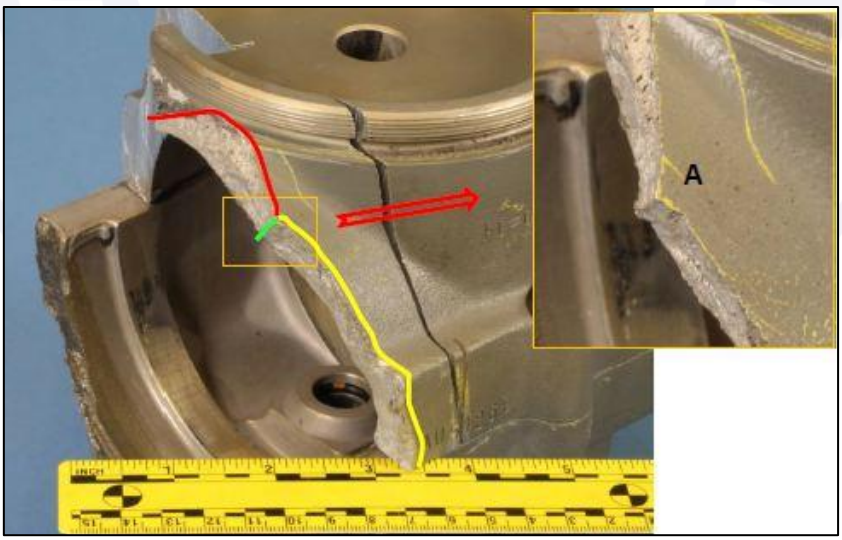

Figure 14 - Fractured hub viewed from above, showing the lines of breakage (yellow and red), together with the linear element (green) separating the types of propagation. In the highlight, the geometrical peak identified with the letter “A”.

Additionally, the reported simulated the lines of breakage on an intact hub, indicating an unknown area of the missing part of the fractured hub as the point of origin of the fracture (Figure 15).

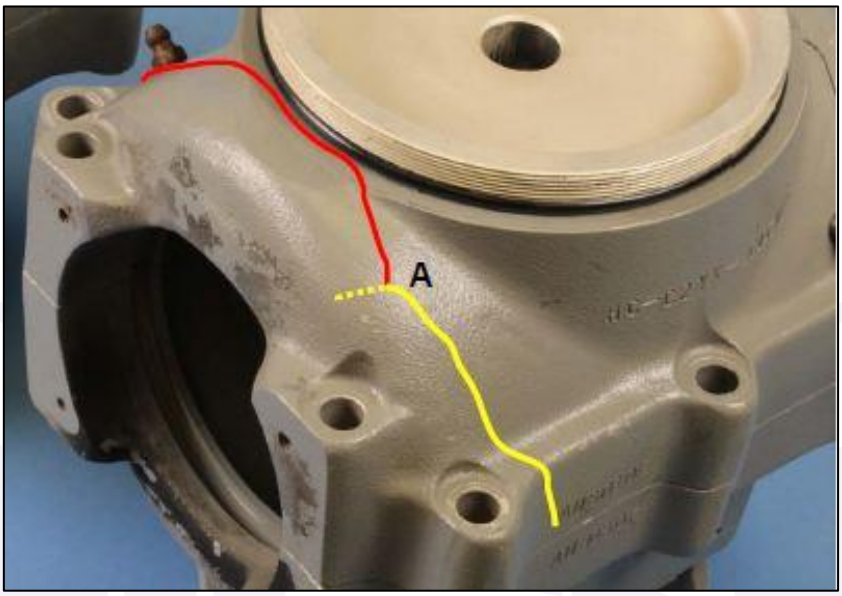

Figure 15 - An intact hub as viewed from above showing superimposed lines of breakage. The material of the hub to the left of the lines was not recovered. The dotted yellow line indicates an unknown part of the origin of the breakage.

The NTSB report stated that the fracture pattern present in the left engine propeller-hub of the PT-KGK aircraft was very similar to the failure which occurred with another Hartzell HC-C2YR-2CUF propeller-hub (SN AU4504) in Panama Republic on 21 July 2009 (Figure 16), mainly in relation to the characteristics and location of the point “A” in both cases.

Figure 16 - The image shows the similarities between the two events. The hub parts were placed together to show the origin of the fracture (point “O”) and the direction of the failure propagation, indicated by the arrows. The point “A” and the end of the fatigue are identified by the letters “A” and “T”, respectively.

1.17 Organizational and management information.

A team of investigators from the SERIPA III visited the installations of the *Aeroclube do Brasil* maintenance workshop on 5 November 2013. In this visit, information was gathered on the maintenance history of PT-KGK aircraft, in addition to documents concerning the certification of the workshop, the aircraft maintenance manuals and the manual of inspecting procedures.

The maintenance workshop had the ANAC certification, its situation was regular, and had the Manual for Inspection Procedures (MPI) accepted by the ANAC (revision 7), as attested by the Official Document 175/2011/DAR/SAR/UR/RJ. The referred manual defined the duties, obligations, responsibilities, attributions, and methods of inspection among other topics associated with aircraft maintenance.

The same document established that all the manuals of aircraft subject to maintenance interventions had to have an up-to-date status for the provision of the services. The investigating committee observed that the workshop had up-to-date manuals for the PA-34-200 aircraft, including those relative to the IO-360-C1C6 Lycoming engines and HC-C2YK-2C(L)GUF Hartzell propellers.

The workshop MPI described the responsibilities of the quality-service manager, in the way shown below:

- Aircraft release after completion of maintenance services:
- Planning of maintenance inspections;
- Responsible for methods and procedures related to maintenance inspections;
- Responsible for compliance with the ANAC legislation requirements;
- Responsible for meeting manufacturer's requirements;
- Supervision of, and provision of assistance to, maintenance personnel;
- Ensure that all inspections be done appropriately as a condition for aircraft release;
- Ensure that upon completion of each and every maintenance work, all maintenance requirements have been complied with before granting return-to-service approval;
- Guarantee quality of maintenance services aiming at aircraft operation safety;
- Verification of the currency of technical information related to maintenance inspections;
- Refinement of the maintenance procedures aiming at the safety of the task;
- Ensure full compliance with the maintenance items required for the aircraft to return to service with absolute safety;
- Act as the Flying School (*Aeroclube*) representative for compliance with the civil aviation aeronautical legislation before the ANAC.

The procedure for analysis and implementation of airworthiness directives was cleared defined in the MPI, under the responsibility of the Service Quality Manager and Inspector, as afore mentioned and highlighted, but it was effectively performed by another employee of the workshop.

The investigators requested a demonstration of the airworthiness control procedures of the workshop, with indication of the Airworthiness Directives applicable to the HC-C2YK-2CGUF, as well as of ones that had been implemented and being complied with. In the demonstration, the AD 2009-22-03 was not presented.

Upon analyzing the history of the maintenance services provided earlier, the SERIPA III team observed that there were no earlier records of compliance with the FAA AD 2009-22-03 relative to the repetitive Eddy Current Inspection (ECI).

1.18 Operational information.

The PT-KGK aircraft departed from SBJR on a (local) training flight in the vicinity of SDMC.

The flight consisted of a number of simulated IFR procedure exercises, for which a non-homologated VOR procedure chart was utilized (*MARICA* VOR Y RWY 08) by *Aeroclube do Brasil* for purposes of training. There was no IFR procedure chart published for SDMC.

The radar image of the PT-KGK flight showed that, after taking off, the aircraft proceeded en route through the visual corridors of the shoreline, at an altitude of 2,000 feet until crossing MIA VOR. Upon crossing the VOR, the aircraft made a slight turn to the left followed, approximately one minute later, by a turn to the right heading for MIA VOR maintaining the same altitude. After crossing over MIA VOR anew, the aircraft flew in the direction of the sea for about two minutes, and then made a turn to the left to fly toward MIA VOR once more, while starting a descent to the altitude of 1,200 ft.

When the aircraft reached 1,200 ft about to cross MIA VOR, the approach control ceased receiving altitude information from the PT-KGK, although primary radar information remained available. Just after the aircraft crossed MIA VOR, on the final approach, radar contact was definitively lost.

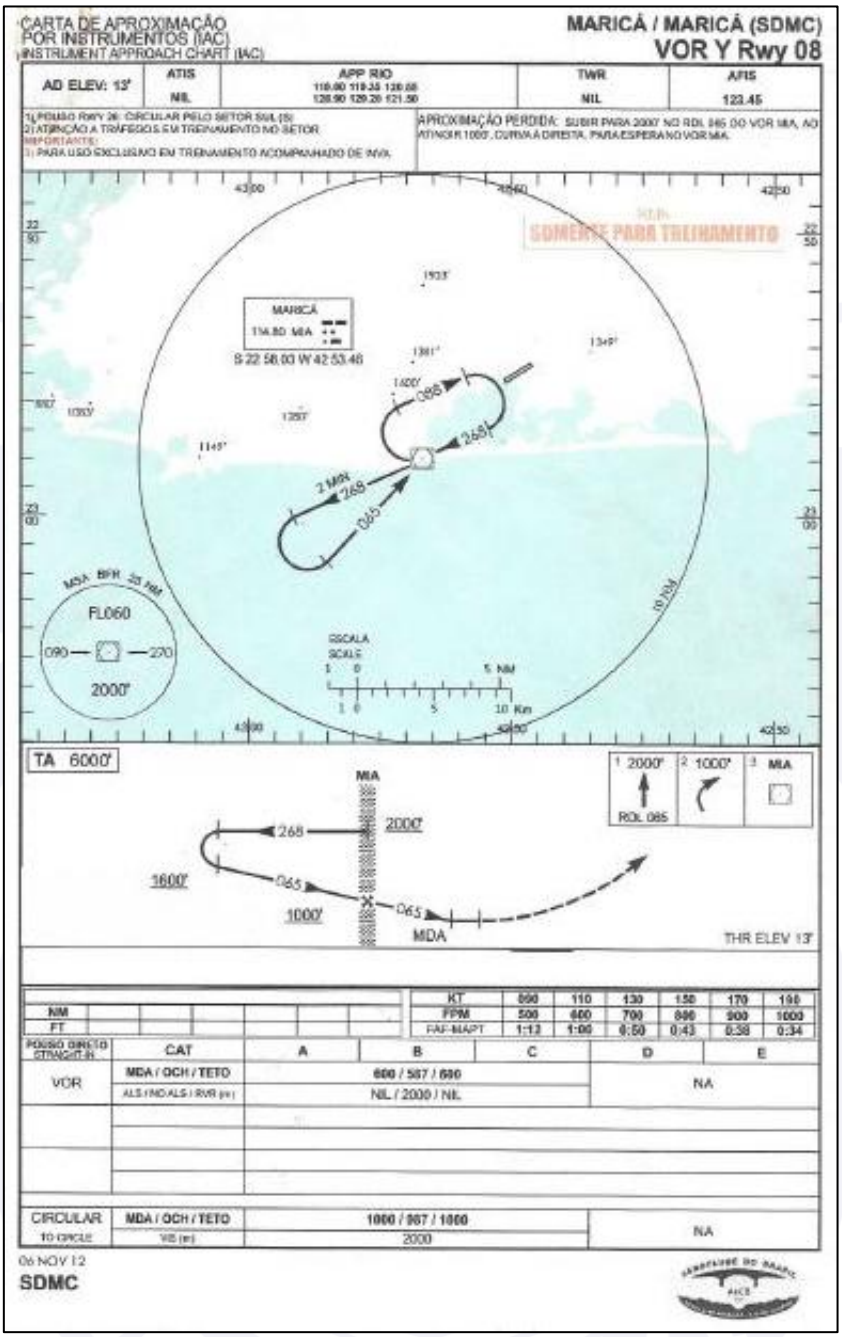

Figure 17 - Non-homologated VOR procedure chart (*MARICA* VOR Y RWY 08), utilized by *Aeroclube do Brasil* for training purposes.

1.19 Additional information.

Occurrence with the PA-34-200 N15156 Piper Aircraft

On 7 June 2007, a PA-34-200 aircraft (Registration N15156) made a forced landing in New Smyrna Beach, Florida, USA, while operating a local training flight. The aircraft was destroyed, and some of the occupants suffered light injuries.

At the time, the NTSB launched an investigation of the accident (Factual Report CHI07LA167) and found out that one of the blades of the right engine had detached in flight from the propeller-hub.

On the occasion, the flight instructor told the NTSB investigators that he was preparing the aircraft for single-engine flight training at 6,000 ft AGL. When he shut off the fuel flow from the right engine, one of the blades of that engine detached and penetrated

the aircraft windshield. He also said that the right engine almost detached completely from the wing in approximately two seconds.

The N15156 flight instructor also that it was not possible to maintain the aircraft altitude, because the drag caused by the engine dictated a descent with a right turn. While descending, the flight instructor managed to control the flight by means of the aileron controls, applying the pedal to the full left, and reducing the power of the left engine, establishing a safe speed during the descent until the forced landing.

The engine was analyzed by the NTSB investigators. The inspection of the disassembled engine did not indicate any pre-impact anomalies or mechanical failures.

The propeller logbook records showed that the component had been overhauled on 21 May 2001, but it was not possible to identify (from the records) the amount of operating hours after the overhaul.

The damaged propeller-hub was examined at the NTSB's Laboratory of Materials. The exam showed that the hub had fractured around the blade root, through both the front and rear halves of the hub. The fractured crossed the grease nipples, both in the front and rear parts of the hub.

The exam of the fracture surface revealed a smoother region in the front half, adjacent to the opening for the assembly of the grease nipples. The region had a lighter color when compared with the remainder of the fracture, and presented characteristics consistent with progression of cracks due to fatigue.

Airworthiness Directive

Failures involving propeller-hubs, and the resulting separation of blades, began to occur in the late 1980's. However, at the time, the problem seemed restricted to Lycoming engines of the TIO-540 series. The FAA, on the occasion, issued the AD 90-02-23, which prescribed just a visual inspection of the propeller-hub with a 10x magnifying lens, with initial inspection 25 hours after the AD became effective, plus the need of further repetitive inspections every 50 hours of operation.

In November of 2001, the AD 90-02-23 was superseded by the AD 2001-23-08. The new Directive changed the deadline for the initial inspection from 25 hours to 50 hours of operation after the AD came into force; the interval between the repetitive inspections changed from 50 hours to 150 hours of operation; and included the Eddy Current Inspection (ECI) for compliance with the inspections. The applicability of this AD was still restricted to the propellers installed in Lycoming engines of the TIO-540 series, and had to do, mostly, with aircraft of the aerobatic category and of the agricultural segment.

In April 2006, after an accident with an aircraft equipped with an engine different from the one covered by the Directive of 2001, the FAA issued the AD 2006-18-15 for the HC-C2YK-2C(L)GUF propeller, installed in engines of the O-, IO-, LO-, and AEIO-360 series. In addition to the ECI method, this new AD maintained the deadline 50 hours of operation for the initial inspection, counted from the date of the AD coming into effect. However, the AD reduced the interval between repetitive inspections, from 150 hours to 100 hours of operation.

On 7 June 2007, the N15156 aircraft, equipped with Lycoming engines of the LIO-360 series, whose applicability was not defined in the AD 2006-18-15, sustained detachment of one of the blades of the right engine propeller-hub. On account of this accident, the FAA issued the AD 2009-22-03, which superseded the AD 2006-18-15, aiming at increasing the coverage of the inspections, including new models of applicable propellers and engines. At the same time, it maintained the procedures, method, and deadlines for the inspections.

The purpose of the airworthiness directives, since their first version in 1980, was to prevent propeller-hub failures capable of causing detachment of the blades and, consequently, loss of control in flight.

The engine and propeller models equipping the PT-KGK aircraft were subject to the applicability of the directives, starting with the AD 2006-18-15.

Presence of vehicles near the runway in SDMC

During the field investigation conducted by the Go-Team, pieces of evidence were collected indicating the possible presence of vehicles to the side of the SDMC runway in use, at a distance that was shorter than the prescriptions contained in the ICA 100-12, interfering with the safety of landing operations.

The SERIPA III received a number of photographs and videos which showed vehicles entering the runway and taxiways to approach taxiing aircraft, contrary to the provisions of the ICA 100-12, item 10.18.8, letter “a”, which established the following:

> "[...] when an aircraft is landing or taking off, vehicles are not allowed to wait at a distance shorter than the hold-position marks of the runway. When such marks do not exist, or cannot be seen, vehicles must wait at:
>
> a) A distance of 50 meters from the side of the runway, when the runway length is equal to, or more than, 900 meters"; [...]

In its item 10.18.8, the same instruction determined that “all vehicles, including towing vehicles, had to give right of way to aircraft landing, taking off, or taxiing”.

In the investigation, based in the radar re-rerun of the whole flight, the investigating committee observed that, from the takeoff in SBJR to the crash site, the aircraft did not fly over, nor attempted to land in, SDMC.

1.20 Useful or effective investigation techniques.

Nil.

2. ANALYSIS.

The PT-KGK aircraft took off from SBJR for a local flight in the vicinity of SDMC, with and instructor and a pilot under training on board.

The weather conditions at the aerodrome of departure and intended destination, as well as along the route to be flown, were favorable for VFR flights.

The pilot under training was doing training flights with the purpose of earning an AMEL technical qualification certificate. The instructor had qualification for the flight.

Since SDMC did not have any IFR procedures published in the Aeronautical Information Publication, the crew utilized a non-homologated Instrument Approach Chart (IAC) which had MIA VOR as its primary fix, designated as *MARICÁ* VOR Y RWY 08. The IAC was marked with “FOR TRAINING PURPOSES ONLY”, and was frequently utilized in the *Aeroclube do Brasil* training flights.

For adopting an IFR procedure for any aerodrome, the DECEA required an in-depth analysis of the safety areas of the sector, minimum altitudes, and terrain obstacles capable of interfering with the operations, in addition to keeping the currency of all the pieces of information available to the crews, with the purpose of maintaining a high degree of dependability and safety.

The adoption and utilization of non-certified aeronautical publications, in discordance with the DECEA rules and criteria, affects flight safety considerably, since it may put the operation of aircraft in a potential risk of collision with obstacles on the ground, as well as

with other aircraft. Nevertheless, the utilization of the procedure in question did not contribute to the accident.

The radar images of the PT-KGK showed that, after taking off, the aircraft maintained level flight at 2,000 ft through the visual corridors along the shoreline until the vicinity of SDMC, when it took the heading of MIA VOR.

Upon crossing over the primary fix, the aircraft started a flight profile very similar to the one of an IFR procedure, with the aircraft crossing over the fix, making a displaced entry with a turn to the left, followed by an approach turn to the right, crossing over the fix again, and flying an outbound track, as described in the illustration relative to the aircraft trajectory (Figure 1), and in accordance with the profile of the procedure (IAC *MARICÁ* VOR Y RWY 08) utilized by *Aeroclube do Brasil*.

Upon joining the base turn, the aircraft started the descent, and intercepted the final approach of the procedure, reaching the altitude of 1,200 ft moments before crossing over MIA VOR, a point at which the Approach Control (APP-RJ) stopped receiving altitude information from the aircraft. However, primary radar information, which continued to be received, indicated that the aircraft crossed over MIA VOR, possibly at 1,000 ft of altitude, according to the IAC being used. Then, radar contact was definitively lost.

Taking into account the evidence gathered in the field investigation conducted by the go-team, indicating that vehicles were near the runway side, at a distance that was shorter than the one prescribed in the item 10.18.5 of the ICA 100-12 and that could have interfered with the safety of landing operations, the investigating committee sought to verify whether this fact had had any connection with the accident. After analyzing the re-run of the radar images for the entire flight, it was possible to conclude that the PT-KGK, from the takeoff from SBJR until the crash site, never flew over, nor attempted to land in, SBMC.

The accident occurred outside of the aerodrome area, and the aircraft flew along a vertical descent trajectory until colliding with the waters, in a shallow stretch of the *Maricá* Lagoon. No previous impact had occurred. The aircraft was destroyed. The wreckage remained partially submerged in a concentrated fashion, and was later removed from the water by a team of SERIPA III investigators in charge of the Initial Action of the investigation.

Soon after the removal of the aircraft from the lagoon waters, the investigators observed that the left engine was not amid the main portion of the wreckage. They also observed that the right engine propeller blades were twisted, an indication that they had hit the water with power. Analysis of the spars and attachment points of the engine nacelle to the left wing indicated that the left engine had sustained excessive vibration and had detached from the wing.

The left engine was found later in an area that was away from the one containing the majority of the wreckage. Part of the propeller-hub and one of the blades were missing. Despite the many attempts to locate the missing parts, they were not found, due to the difficulties posed by the extension of the lagoon and the low visibility under the water.

The aircraft engines were disassembled and analyzed by representatives of the SERIPA III and DCTA. The resulting report stated that both engines were operating normally until moments before the occurrence, and that the operation of the engines did not contribute to the occurrence.

The HC-C2YK-2C(L)GUF Hartzell propellers equipping the PT-KGK were disassembled and analyzed by representatives of the SERIPA III. The analysis revealed discrepancies in relation to the prescriptions contained in maintenance manuals.

For this reason, and with the purpose of identifying the characteristics of the fracture, the fractured propeller-hub and the grease nipples were subjected to laboratory analysis. The report of the analysis stated that the propeller-hub fracture had characteristics of failure due to fatigue, and that one of the grease nipples was different from the other two in terms of size, thickness, and thread. However, he discrepancy found in the nipples seemed not to have connection with the origin of the fracture which caused the hub failure.

Since the result of the analysis was not conclusive in relation to the point of origin of the fracture in the propeller-hub, on account of that the missing part of the hub was not found, the accredited representative participating in the investigation indicated the NTSB laboratories for further analyses, in the presence of SERIPA III and DCTA representatives.

The NTSB report confirmed the existence of a process of fatigue in the propeller-hub fracture, adding information on the different forms of fatigue propagation, indicating two areas of fracture, separated by a linear region with a well-defined geometrical peak, which was named point “A” (Figures 13 and 14). Then, the NTSB analysts simulated the same lines of propagation on an intact hub, indicating an unknown area of the missing part of the fractured hub as the point of origin of the fracture. They also noticed similarities of this type of fracture with a failure presented by another HC-C2YR-2CUF Hartzell propeller (SN AU4504) in the Panama Republic on 21 July 2009, mainly in relation to the characteristics and location of the point “A” in both cases.

During the investigation mission in the USA, the NTSB investigators informed the representatives of SERIPA III and DCTA about the details of another occurrence that might clarify what had occurred with the PT-KGK.

In June 2007, a PA-34-200 Piper Aircraft (registration 15156) had made a forced landing in Florida during a local training flight, after one of the blades detached in flight from the right engine propeller-hub. The flight instructor had reported details of the occurrence to the NTSB investigators, including the information that the blade detached from the propeller-hub had perforated the aircraft windshield, and that the right engine had almost completely detached from the wing.

Also, according to the flight instructor, they had not been able to maintain the altitude of the aircraft. Because the drag created by the right engine dictated a descent with a turn to the right, and they were able to control the flight only after application of the ailerons, fully application of the pedal to the left, and reduction of power of the left engine, establishing a safe speed during the descent until the forced landing.

The NTSB investigators analyzed the aircraft engines, but did not identify any pre-impact abnormalities or mechanical failures that might be associated with the event. An analysis of the damaged propeller-hub at the NTSB Laboratory of Materials revealed that it had been fractured, and that the fractured area had characteristics consistent with the progression of the cracks due to fatigue.

Discussions about propeller-hub failures (and consequent blade separation) began to appear in the USA in the late 1980’s. All airworthiness directives issued since 1990 had the purpose of preventing propeller-hub failures capable of causing blade separation and, consequently, loss of control in flight.

The AD 90-02-23, the first one to address the subject, determined compliance with visual and repetitive inspections, applicable to the models of propellers equipping Lycoming engines of the TIO-540 series.

Later, in November, the directive was superseded by the AD 2001-23-08, which, besides changing deadlines and intervals, introduced the Eddy Current Inspection (ECI) method for compliance with the inspections. The applicability of the AD remained restricted

to propellers equipping TIO-540 Lycoming engines, mostly in aircraft with a type certificate of the aerobatic or agricultural aviation categories.

In 2006 and 2009, the FAA issued directives with the purpose of including other propeller models subject to the inspections. The AD 2006-18-15 included new models of Lycoming engines (O-, IO-, LO-, and AEIO-360 series) for the same propeller model, maintaining the procedures and the ECI method, but reducing the interval between the repetitive inspections from 150 hours to 100 hours of operation. The AD 2009-22-03 superseded the AD 2006-18-15, and had the purpose of extending the coverage of the inspection even further, including new models of applicable engines and propellers, while maintaining the procedures, method, and deadlines for the inspections. Therefore, since the issuance of the AD 2006-18-15, the models of engines and propellers equipping the PT-KGK were under the applicability of the AD, including compliance with the ECI.

In view of the afore mentioned, the SERIPA III investigators analyzed the maintenance records of the *Aeroclube do Brasil* workshop, as well as the procedures of analysis and implementation of airworthiness directives. Such procedures were clearly defined in the MPI, and were the under the responsibility of the Service Quality Manager and Inspector. However, this function was being performed by another employee, who, during the demonstration of the procedures, failed to name the Airworthiness Directives applicable to the propeller equipping the PT-KGK, since the AD 2009-22-03 was not being considered as applicable to that propeller model.

Upon analyzing the history of the maintenance services provided in the past, the SERIPA III team observed that there were no earlier records of compliance with the FAA AD 2009-22-03, regarding the ECI repetitive inspection.

The propellers equipping the PT-KGK had a maintenance program that required overhauling every 2,000 hours or 5 years, whichever occurred first. The left engine propeller (AU5426E), which had a blade detached in flight from the respective hub, had been acquired in September 2005 by *Aeroclube do Brasil* from a third party (physical entity). The declared TSN was 3,000 hours of operation. No records were presented to attest the traceability of the component.

For this reason, the recently bought propeller was sent for a general inspection on 30 September 2005, being received and installed in the aircraft on 2 February 2006, before the issuance of the AD 2006-18-15. On 8 September 2010, five years of operation after the last overhaul, the AU5426E propeller (with a TSN of 4,271 hours) underwent an overhaul, with compliance of the ECI test prescribed in the AD 2009-22-03.

Since this last overhaul of the AU5426E propeller on 30 September 2010, the ECI prescribed in the AD 2009-22-03 was no longer executed at every 100 hours of operation of the component. On the day of the PT-KGK accident, the AU5426E propeller had approximately 918 hours of operation after the overhaul (and last compliance with the ECI test). Therefore, the tests were not done in nine subsequent occasions, a fact that contributed to the accident, by allowing the aircraft to be released for flight without the required airworthiness conditions.

3. CONCLUSIONS.

3.1 Facts.

a) The pilots had valid Aeronautical Medical Certificates (CMA);

b) The instructor pilot had valid Technical Qualification Certificates (CHT);

c) The pilot under training had been on routine training flights, aiming to get the technical qualification certificate on multi-engine aircraft.

d) The instructor pilot had qualification and the total amount of 2,265 flight hours. Of these, 1,097 hours had been flown in the same model of the aircraft involved in the accident.

e) The aircraft had a valid Airworthiness Certificate;

f) The aircraft was within the weight & balance and center of gravity limiits;

g) The procedures relative to analysis and implementation of airworthiness directives were clearly defined in the MPI as a responsibility of the Service Quality Manager and Inspector;

h) The procedures relative to analysis and implementation of airworthiness directives of the *Aeroclube do Brasil* workshop were, in fact, being performed by another employee of the workshop;

i) The AD 2009-22-03 was not considered as applicable to the propeller equipping the PT-KGK by the *Aeroclube do Brasil* workshop;

j) There were no records of compliance with the AD 2009-22-03 in relation to the ECI in the maintenance history of the aircraft after the overhaul of 8 September 2010;

k) The aircraft took off from SBJR for a local training flight in the vicinity of SDMC;

l) The prevailing weather conditions in the aerodrome of departure, intended destination, and along the route to be flown, were favorable for VFR operations;

m) There was detachment of one of the blades and part of the left engine propeller-hub in flight;

n) The aircraft, on a vertical descending trajectory, collided with a shallow part of the *Maricá* Lagoon, without any previous impact;

o) The aircraft was completely destroyed; and

p) Both aircraft occupants suffered fatal injuries.

3.2 Contributing factors.

- **Aircraft maintenance - a contributor.**

The lack of compliance with the AD 2209-22-03, on nine occasions in a row, contributed to the accident since it allowed the aircraft to be available for flight without meeting the airworthiness requirements which hindered the adoption of adequate maintenance measures that could prevent the propagation of the crack in the left-hand propeller hub.

- **Managerial oversight - a contributor.**

The delegation of responsibility for the process of analysis and implementation of the airworthiness directives of the *Aeroclube do Brasil* workshop allowed the aircraft to be released for flight without complying the airworthiness requirements described in the AD 2209-22-03.

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 Civil Aviation Secretariat of the Presidency of the Republic (SAC-PR):

RSV A-169/2013 - CENIPA Issued on 05/11/2013

Analyze the Delegation Agreement nº 09/2012 signed between the Federal Government and the Municipal Government of *Maricá*, with the objective of verifying whether the duties and obligations of the Delegatee are being observed, especially in relation to the safety of operations in the aerodrome.

Recommendations issued at the publication of this report:

To the National Civil Aviation Agency (ANAC):

A-190/CENIPA/2013 - 01 Issued on 26/05/2017

Evaluate the procedures adopted by the *Aeroclube do Brasil* workshop, mainly with respect to the specifications contained in the MPI, with the purpose of avoiding the recurrence of errors associated with the applicability of airworthiness directives for which the workshop is certified.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

The CENIPA issued the Operational Notice (*Divulgação Operacional*) nº 01/2014 - Catastrophic Failure of Hartzell Propeller-Hub, alerting operators of aircraft equipped with HC-C2YK-2C(L)GUF Hartzell propellers for compliance with the AD 2009-22-03 issued by the FAA, determining the conduction of repetitive Eddy Current Inspections every 100 hours of operation, aiming at detecting hub cracks.

On 6 November 2013, the CENIPA forwarded a document to the SAC-PR, alerting the recipient on the lack of compliance with the norms of the Delegation Agreement 09/2012 signed between the Federal Government and the Municipal Government of *Maricá*, so that the referred agreement could be re-analyzed, with the objective of verifying whether the duties and obligations of the Delegatee were being observed, especially in relation to the safety of operations in the aerodrome.

On May 26th, 2017.