COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A-531/CENIPA/2015

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PT-YAK**
MODEL:	**AS-350-BA**
DATE:	**22FEB2012**

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 22 February 2012 accident with the AS-350-BA aircraft, registration PT-YAK. The accident was classified as system/component failure.

The aircraft sustained a main rotor rotation surge 10 minutes after the takeoff. The pilot made an emergency landing in an area free of obstacles. While landing, the aircraft presented an aerodynamic effect behavior compatible with ground resonance.

The aircraft was substantially damaged.

The two members of the crew were slightly injured, and the other two occupants were not hurt.

An accredited representative from *Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile* (BEA) - France, state of design, was designated for participation in the investigation.

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GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ANAC	Brazil's National Civil Aviation Agency
CENIPA	Aeronautical Accident Investigation and Prevention Center
CIAA	Aeronautical Accident Investigation Commission
CMA	Aeronautical Medical Certificate
CIV	Pilot's Flight Logbook
DCTA	Aerospace Technology and Science Department
FCU	Fuel Control Unit
GRAESP	Public Security Air Unit
IAE	Aeronautics and Space Institute
IFR	Instrument Flight Rules
IPS	Impulses per second
NG	Compressor Turbine Rotation
NR	Main Rotor Rotation
NTL	Power Turbine Rotation
P/N	Part Number
PCH	Commercial Pilot – Helicopter category
PPH	Private Pilot - Helicopter category
QAv	Aviation Kerosene
RS	Safety Recommendation
SBBE	ICAO location designator – *Belém* Airport
SERIPA	Regional Aeronautical Accident Investigation and Prevention Service
SIPAER	Aeronautical Accident Investigation and Prevention System
SN	Serial Number
UTC	Universal Time Coordinated

1. FACTUAL INFORMATION.

Aircraft	**Model:** AS-350-BA **Registration:** PT-YAK **Manufacturer:** Eurocopter France	**Operator:** Pará State Military Fire Brigade
Occurrence	**Date/time:** 22FEB2012 / 13:40 UTC **Location:** BR-316, km 18 **Lat.** 01º21'40"S **Long.** 048º21'24"W **Municipality – State:** *Marituba* - Pará.	**Type(s):** System/Component Failure

1.1 History of the flight.

At 13:30 UTC, the aircraft took off from the patio of the GRAESP (Public Security Air Unit) located in SBBE, with two crew members and two passengers on board, with the intent of flying over the BR-316 highway, as part of the *2012 Carnival Operation*.

Approximately 10 minutes into the flight, with the aircraft leveled off at an altitude of 600ft, a strong vibration was felt, and the crew identified a surge in the main rotor rotation.

An emergency landing was made in an area of barren land close to the BR-316 highway, after the crew performed procedures aimed at reducing the rotation of the main rotor

While the aircraft was landing, still with high rotation of the main rotor, vibrations occurred that were characteristic of ground resonance and that in a few seconds caused substantial damage to the aircraft structure.

The crew members were slightly injured and the passengers suffered no harm.

There was no damage to third parties.

1.2 Injuries to persons.

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

1.3 Damage to the aircraft.

There was substantial damage to the aircraft cabin, tail boom, tail rotor activation tree and starflex.

Figure 1 – aircraft after the complete stop.

1.4 Other damage.

None.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Hours Flown		
	Pilot	Copilot
Total	985:00	411:00
Total in the last 30 days	25:55	04:30
Total in the last 24 hours	02:10	00:10
In this type of aircraft	757:00	311:00
In this type in the last 30 days	25:55	04:30
In this type in the last 24 hours	02:10	00:10

N.B.: Data obtained from the pilots' flight logbooks.

1.5.2 Professional formation.

The pilot did his Private Pilot course (helicopter category) at the *Edra Aeronáutica* school, in *Ipeúna*, state of São Paulo, in 2004.

The copilot did his Private Pilot course (helicopter category) at the *Edra Aeronáutica* school, in *Ipeúna*, state of São Paulo, in 2004.

1.5.3 Category of licenses and validity of certificates.

The pilot in command had a Commercial Pilot license (helicopter category) and a valid technical qualification for AS350 type aircraft.

The first officer had a Commercial Pilot license (helicopter category), and the validity of his technical qualification for AS350 type aircraft had expired in September 2011.

1.5.4 Qualification and flight experience.

The pilot occupying the right-hand seat of the aircraft, in the function of captain, was an officer of the military Fire Brigade of the State of Pará, and also belonged to the board of pilots of the GRAESP. He had a total of around 980 flight hours, being 750 hours in the model of the accident aircraft.

The pilot that, according to the aircraft logbook, was occupying the left seat of the aircraft, was a civil police deputy and also belonged to the board of pilots of the GRAESP. He had a total of approximately 400 hours, 300 hours of which in the model of the accident aircraft. At the moment of the accident, the validity of technical qualification certificate had already expired, and he did not have recent experience in the aircraft model. The commission learned that he had flown the same aircraft on 14 February 2012 in the capacity of second pilot (left seat).

1.5.5 Validity of medical certificate.

Both pilots had valid aeronautical medical certificates (CMA).

1.6 Aircraft information.

The serial number AS2756 aircraft was manufactured by Eurocopter France in 1995.

Its airworthiness certificate was valid.

The airframe, engine, and rotor logbook records were up-to-date.

The last aircraft maintenance inspection, type “10, 25, 30, and 50 hours”, was done by Helisul Táxi Aéreo Ltda. on 20 February 2012 in the city of Belém. After the inspection, the aircraft flew 2 hours and 12 minutes.

The last 12-year aircraft inspection was done by Helisul Táxi Aéreo Ltda. on 5 October 2007 in Curitiba, state of Paraná. The aircraft flew 2,527 hours and 35 minutes after this inspection.

The last inspection of the SN631 Arriel 1B engine (type “8, 30, and 50 hours”) was done on 20 February 2012 by Helisul Táxi Aéreo Ltda. in the city Belém. After the inspection, the aircraft flew 2 hours and 12 minutes.

The (P/N164548230, S/N B856B) Fuel Control Unit was installed in the engine aforementioned on 13 March 2011, and had 599 hours and 35 minutes available before the next inspection.

The commission also observed that the aircraft had been subjected to a maintenance intervention by Helisul Táxi Aéreo Ltda. in Belém on 9 February 2012 in accordance with the Service Order no. 06962. On the occasion, the painting of the red and of the blue blades (S/N 7641 and S/N 6666, respectively) was retouched; the yellow blade (S/N 9223) was replaced with another (S/N 7536); and the dynamic balance (known as “*vibrex*”) of the main and tail rotors was performed, among other services.

On 17 February 2012, another Service Order (no. 06964) was opened for a new dynamic balance of the main rotor, airframe inspection (“7 days” type), and engine inspection (“8 hours” type). The services were provided by Helisul Táxi Aéreo Ltda. in Belém. A value of 0.22 impulses per second (IPS) was registered in the (vertical) dynamic balance.

The aircraft maintenance program was detailed. There were many inspections, according to the mechanic. The company responsible for the maintenance services kept a technical control of the services, which was received from the manufacturers of the pieces of equipment, containing the updates relative to maintenance. The inspection applicable to every aircraft was defined, and then the mechanic would comply with it, accordingly.

The dynamic balancing of the aircraft rotor blades was performed on the Friday before the accident. The equipment utilized for doing the dynamic balancing had also been subjected to maintenance a week earlier.

1.7 Meteorological information.

The prevailing weather conditions were VMC.

1.8 Aids to navigation.

Nil.

1.9 Communications.

Nil.

1.10 Aerodrome information.

Not applicable.

1.11 Flight recorders.

Neither required nor installed.

1.12 Wreckage and impact information.

Nil.

1.13 Medical and pathological information.

1.13.1 Medical aspects.

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

1.13.2 Ergonomic information.

Nil.

1.13.3 Psychological aspects.

The pilot in command was a military firefighter, who had done the course for composing the board of pilots of the State government in 2004. He had been Commander of the Fire Brigade Air Unit of the state of Pará.

This Unit had merged with the corresponding units of the Civil and Military Police, to form the State of Pará Public Security Air Unit on 29 December 2011, after which he was appointed as State Air Transport Director, subordinated to the Military Office of the Pará State Governorship, where he was responsible for the management of three aircraft.

He had been flying exclusively the model of the aircraft involved in the accident for two years. There were no other accidents in his career.

The other pilot aboard the aircraft had done the course in the same class of the aircraft captain, when they met each other.

The aircraft was operated by the Pará State Fire Brigade, but belonged to a company which provided air transport and maintenance services, the headquarters of which was located in the south of Brazil. The owner company kept a mechanic and three assistant mechanics in the air unit of Belém.

The mechanic had been working for the company for thirteen years, and was the inspector responsible for the provision of minor maintenance services to the aircraft. For more important services, a company team was sent from headquarters to Belém.

Due to the nature of the services provided by the fire brigade (including response to emergencies), the mechanic would sometimes stay on the alert at home, and would be summoned as needed.

According to information collected, the mechanic's working hours were not fixed, and sometimes he would have to work on the weekends. This occasionally affected his rest period and even the time available for lunch. Due to his position held, he was pressed for time to arrive at the air unit early in the morning.

There was a good relationship between the pilots, crewmembers, and the mechanic, as well as between the mechanic and his assistants.

At the time of the accident, the air unit had two aircraft in the fleet, with seven captains and three copilots.

In visits of the air unit, the investigation commission observed that the installations available were not adequate for accommodating the entire administrative and operational personnel in satisfactory work conditions.

The air unit did not have a program for the selection of pilots and operational crews, and there was not a sector responsible for operational training.

In the flight schedule, all the captains composed crews with all the copilots. If a crew member was listed in the operational schedule, he would not be involved with administrative tasks and vice-versa.

For quite a long time, the mechanic stayed alone on the alert for the aircraft maintenance, because he was the only one for the job in Belém, and the aircraft had to be ready throughout the day.

The on-the-alert service for maintenance purposes was restricted to day-time, since the aircraft was not certified for night-time (IFR) operations. This meant that the mechanic had to stay at home, waiting to be summoned for the provision of assistance or to accommodate some occasional demand. The condition of being on the alert restricted the free movement of the mechanic, who had to stay within a certain radius of action that allowed him to respond to the urgent calls of the employer.

Although the mechanic did not fly, he considered the maintenance activity stressing since the aircraft had to be permanently ready to operate safely in the missions. If a problem occurred, he was the one to decide whether or not the aircraft should be delivered for flight, and his decision was respected by the fire brigade.

The pilots of the aircraft in question stated that they had full confidence in the job of the mechanic.

1.14 Fire.

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

1.15 Survival aspects.

Nil.

1.16 Tests and research.

The S/N 631 Arriel engine equipping the AS-350-BA *Esquilo* aircraft was sent to Turbomeca do Brasil in the municipality of Duque de Caxias, state of Rio de Janeiro, for analysis.

The analysis was conducted in the presence of representatives from the SERIPA I (First Aeronautical Accident Investigation and Prevention Service), IAE (Aeronautics and

Space Institute), DCTA (Aerospace Technology and Science Department), Helisul Taxi-Aéreo Ltda., Turbomeca do Brasil, and Turbomeca France.

From the external visual inspection of the engine, it was possible to observe that it had not sustained any type of damage. An inspection of the rotary assembly revealed no damage, such as kneading or deformations capable of hindering the rotation of the engine.

Taking into account the nature of the failure that occurred during the operation of the aircraft, the first item to be inspected was the Fuel Control Unit (P/N 0164548230, S/N B856B) installed in the aforementioned engine according to the records of the Log Card presented by Helisul Táxi-Aéreo Ltda.

The FCU was removed from the engine, and installed on the bench for being tested. Before the test began, the main filter of the FCU was inspected. After being removed, the filter was compared with a new one (Figure 2), and it was seen that the filter removed had a distinct brown color

Then, it was observed that the rotation control was inoperative and that the FCU allowed over-speed due to the high rate of fuel flow.

The technicians also observed the condition of the Delta P diaphragm installed in the CPU. They verified that it was in good shape and was not the cause of the FCU failure.

Due to the normal condition of the diaphragm, the investigator from Turbomeca requested the work to be concluded at Turbomeca France (Tarnos), for their ability to monitor each individual section of the FCU during the bench test.

Figure 2 – on the right, a filter removed from the aircraft FCU, compared with a brand new one (on the left).

In France, the bench test was done in the presence of SERIPA I and IAE/DCTA representatives. A third filter was installed (a new one) in the fuel line returning from the FCU. Eventually, it retained just a few particles of dirt in its screen.

The bench test of the FCU confirmed the over-speed that had been reported by the pilot. Such over-speed had been ratified in the test conducted by Turbomeca in Brazil.

The technicians also observed that the fuel shut-off system was normal, responding as expected every time it was commanded during the bench test. Later, both the pressurization valve and the fuel drain valve were tested, and nothing abnormal was detected.

After completion of the bench test, the FCU was fully disassembled.

The disassembly began with the inspection of the acceleration compensation capsule, which showed no abnormalities.

Then, the lid of the *anticipator came* was removed, showing a large amount of oxidation, both in the lid and in the very *came* (Figures 3 and 4).

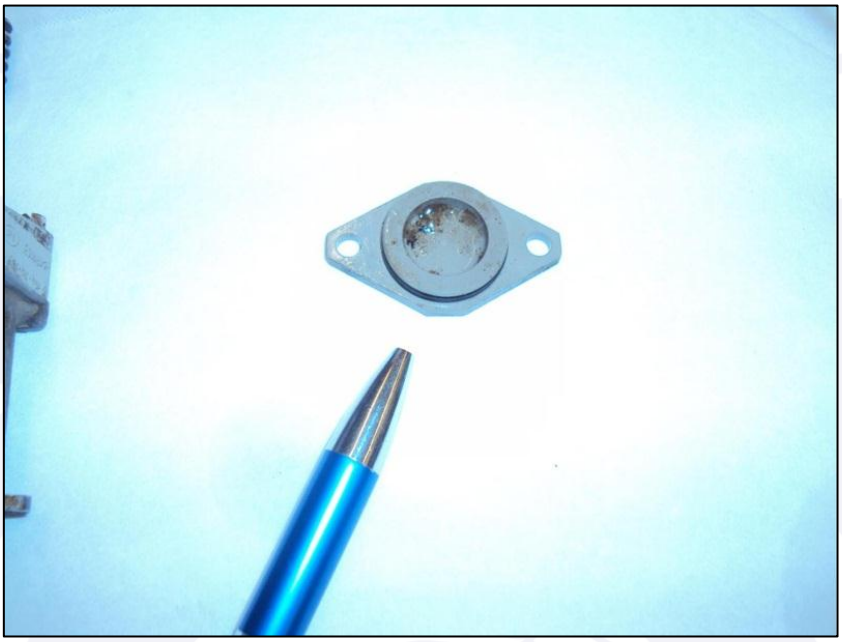

Figure 3 – View of the anticipator came with oxidation.

Figure 4 – View of the oxidation in the lid of the anticipator came before disassembly.

When the NG (compressor turbine rotation) piston was removed, the technicians observed that it was stuck on account of the presence of oxidation in the fuel strainer (Figure 5).

During the disassembly of the FCU, water was found in its interior, as shown in Figure 6.

On account of the water found in the FCU interior during the disassembly at Turbomeca France, a sample of fuel was collected from the NG and NTL filters for microbiological analysis at the Turbomeca Laboratory located in Bordes, France.

Figure 5 – View of the NG piston with lots of contamination in the fuel filter.

The result of the analysis indicated that the fuel contamination was not microbiological. It had been caused by oxidation resulting from the presence of water.

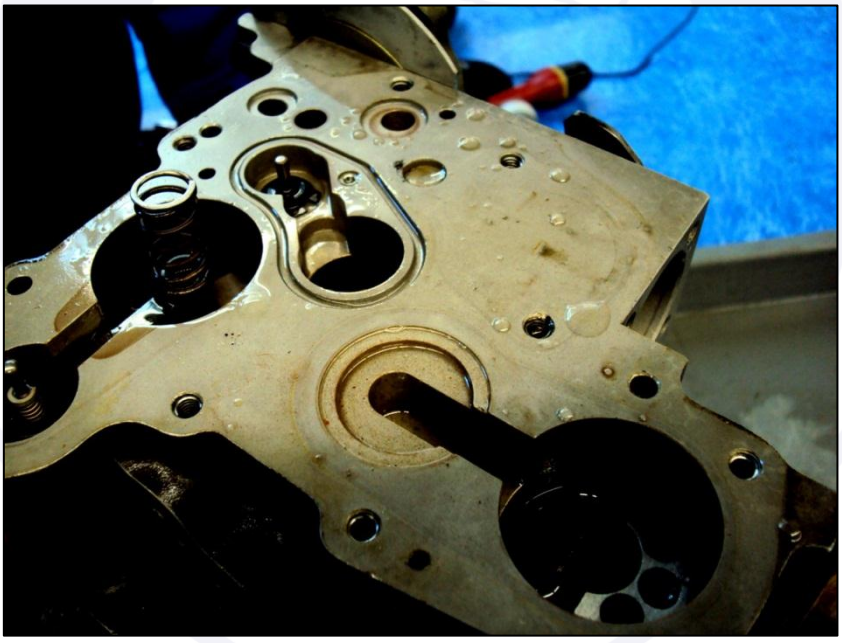

Figure 6 – Finding of water in the FCU interior during the disassembly.

During the inspection of the aircraft at the Helisul headquarters, samples of residual fuel in the lines of the aircraft fuel system were also collected and sent to the IAE for chemical-physical analysis.

The analysis of the fuel sample showed that the amount of water was within the technical specifications contained in the international standard ASTM D1655, and that the fuel complied with the specifications of the Technical Regulation ANP no. 6/2009, for aviation kerosene.

At the same time, the condition of the blades and main rotor head was analyzed, as well as their respective maintenance records. The above components were sent to Helibrás in Itajubá, state of Minas Gerais for analysis in the presence of representatives of SERIPA I, IAE, and Helisul Táxi-Aéreo.

On the occasion, the technicians analyzed the general condition of the rotor head, and verified that damage had been caused due to overload resulting from the resonance that the aircraft experienced while landing.

The maintenance control records entered after the analysis carried out by Helibras showed incompatibility between the serial numbers of several controlled components installed in the main rotor head assembly and the serial numbers effectively registered.

The SERIPA-I inquired the company which owned the aircraft and was also responsible for the maintenance about the traceability of the components installed in the main rotor head, but the company was not able to provide information on the origin of the components.

An analysis of the main rotor blades also conducted by Helibras detected that their painting anti-sand protection of the blade ends were not within the standards established by the manufacturer. Consequently, the static balance in all blades was also considered not in accordance with the acceptance criteria.

On account of the resonance experienced by the aircraft while landing, the hydraulic vibration-dampers were removed to be tested at the premises of the Helisul headquarters, and were considered satisfactory.

Likewise, the rear blades of the aircraft skids were verified. The “E” measure of the rear blades coning was verified, and they were considered normal.

1.17 Organizational and management information.

The Public Security Air Unit (GRAESP) of Belém International Airport was composed of civil and military policemen and military firefighters of the state of Pará.

Although the Registration Certificate of the PT-YAK had the information that the operator of the aircraft was the Military Fire Brigade of the state of Pará, the air operations were managed by the GRAESP, which had been created with the merge between the Pará Firefighters Air Unit and the Military police Air Unit on 29 December 2011.

The aircraft belonged to a company which provided specialized air services and aircraft maintenance in the South of Brazil. It was operated by the military Fire Brigade of the state of Pará, and was being integrated in the Public Security Air Unit on account of the unification involving the military firefighters and the military/civil police.

In visits of the air unit, the investigation commission observed that the installations being used were not ergonomically adequate to receive all administrative and operational personnel, and did not offer satisfactory work conditions.

The aircraft fleet was composed of two aircraft, including the accident helicopter.

The Helisul Táxi-Aéreo Ltda. Company had one mechanic for the provision of support and maintenance to the aircraft in Belém, state of Pará. The aircraft airworthiness condition was also controlled and maintained by this same mechanic.

The mechanic had also been separately contracted by the GRAESP (in this case, without bonds with Helisul Taxi-Aéreo Ltda.) to provide maintenance to the other aircraft of the fleet, since he was the only professional in Belém certified by the National Civil Aviation Agency (ANAC).

The GRAESP crews were composed of members of the Military Police and Military Firefighters, Civil Policemen of the state of Pará, and pilots of the Helisul Táxi-Aéreo Ltda. Company.

The aircraft captains, in addition to working in operational functions, were also responsible for a number of administrative functions. On the whole, GRAESP had seven captains, who worked in administrative and operational functions.

The investigation commission observed that GRAESP did not have a structured and organized training sector with persons designated for implementing a program of operational training and maintenance either for pilots or mechanics. It is worth pointing out that this was not a requisite prescribed by the ANAC for the type of operation performed by that air unit.

The commission also observed that the air unit did not have a sector for addressing issues related to Flight Safety within the GRAESP. Although it had a Flight Safety Agent, it was not possible to see the development of regular activities aimed at the prevention of accidents.

During the investigation, the commission observed that when the helicopters were engaged in missions off base, the fuel containers utilized by the GRAESP were not adequate for storing and transporting aviation kerosene (QAv). Also, not all captains of GRAESP aircraft required the fuel to be tested for the presence of water contamination.

The commission also verified that members of the GRAESP were not aware of information provided by Eurocopter in the document Information Notice no. 2376-I-28, which addressed the topic of fuel contamination (prevention, detection, eradication, and maintenance actions).

The commission found out that the copilot was in the function of second in command even though the validity of his qualification certificate was no longer in effect. The GRAESP alleged that they designated two pilots based on the Subpart K of the RBHA 91, but nothing was found in the mentioned legislation concerning the need of two pilots.

According to studies conducted, no other GRAESP document mentioned such requirement.

From what was observed, there was an understanding that two qualified pilots were required, but, as can be seen, the control of the certificates was not efficient.

1.18 Operational information.

The PT-YAK aircraft, which belonged to Helisul Táxi-Aéreo Ltda., was being operated by the Military Fire Brigade of the State of Pará.

In the flight of the occurrence, the aircraft was accomplishing a mission of the GRAESP.

On 22 February 2012, at 13:30 UTC, the aircraft took off from the GRAESP apron in SBBE for a flight over the BR-316 highway, as part of the 2012 Operation Carnival. During the whole carnival season, air monitoring was performed as part of the operation.

The pilot in command participated in the whole Operation Carnival flying the same aircraft every day of the carnival season. The other pilot who was on board had flown the week before and did not notice any abnormalities in the aircraft. There were no reports of problems in the aircraft logbook.

According to the pilots, before the technical problem occurred, the flight had been uneventful. During the pre-flight, as usual, they checked the aircraft with the mechanic, and since they found no abnormalities, the mechanic released the aircraft.

The mission was forecast to last until 13:00 local time. According to information provided by the pilots, the helicopter took off from Belém International Airport at 10:30 local time transporting a medical doctor and a nurse. Seven minutes later, it was flying in the vicinity of a check-point of the Federal Highway Police near the municipality of *Marituba*, in the Belém metropolitan area.

Suddenly the aircraft crew began to feel a high vibration, and heard an abnormal noise. Upon checking the instruments, they verified that the NR surge needle was going past the red band, an indication of a technical problem. They started the emergency procedures first by acting smoothly on the collective. Since the NR did not diminish, they chose to cut off the flow with the yellow lever, and began searching for an area for landing. The pilots explained that with this procedure, according to the manufacturer's manual, the rotation was expected to diminish, something that according to them did not occur.

The second pilot on board maintained communication with the captain, making reports of everything that was taking place. They decided to make a left turn, after getting a glimpse of an open terrain where they could possibly land. They landed in a building site. Then, the rotation diminished slightly. But when they touched on the ground, the rotation increased again. In the sequence, the aircraft began to experience ground resonance. Already under high vibration, they acted on the shut-off lever, a procedure recommended by the manufacturer for preventing resonance.

On the morning of the day of the occurrence, the aircraft was with the maximum takeoff weight, and the position of the center of gravity was within the parameters established by the manufacturer.

1.19 Additional information.

Nil.

1.20 Useful or effective investigation techniques.

Nil.

2. ANALYSIS.

The aircraft belonged to Helisul Táxi-Aéreo Ltda., and was operated by the Military Fire Brigade of the State of Pará. Its missions were coordinated by the Public Security Air Unit (GRAESP).

Services provided to the main rotor blades, such as painting, as well as anti-sand protection of the blade ends were not in accordance with the standards established by the manufacturer. The same happened with the static balance of all the blades, a fact that contributed to the difficulty found in the dynamic balancing of the main rotor during the execution of the Service Order nº. 06962, and a new correction of the vertical and lateral vibrations was necessary (Service Order nº. 06964) on account of the unbalance. Even so, the aircraft remained with an inadequate tracking after the second service (vertical 0.22 IPS), different from the vertical vibration limit of 0.2 IPS, prescribed by the manufacturer (Eurocopter Maintenance Manual 62.10.00.603, page 350).

Thus, a hypothesis was raised that the services of maintenance and balancing of the main rotor blades had changed the rotation frequency of the blades, increasing the possibility of a coincidence between the natural frequency lines of the helicopter and the line of frequency of the main rotor, leading to aggravation of the ground resonance at the moment of landing.

In addition, the over-speed condition observed in flight by the pilots and confirmed during the tests of the FCU contributed to the increase of the natural frequency of the main

rotor, allowing the coincidence between the lines of frequency of the main rotor and the natural frequency of the helicopter, leading to the onset of ground resonance.

For this reason, the maintenance services were considered periodical but inadequate. In addition, the services provided to the main rotor blades indicated lack of technical knowledge on the part of the maintenance professionals.

The Helisul Taxi-Aéreo Ltda. Company had just one mechanic to support the operation of the aircraft at the GRAESP. This mechanic provided maintenance services and monitored the airworthiness of the aircraft.

The mechanic above mentioned also provided maintenance services to another aircraft operated by the GRAESP by means of an outsource contract. This second aircraft did not belong to Helisul Táxi-Aéreo Ltda.

It is worth highlighting that the mechanic was the only one who had prerogatives before the ANAC for the provision of maintenance services and aircraft release, since the other persons involved with aircraft maintenance of the aircraft operated by the GRAESP were still under training.

The fact that there was just one person qualified for the provision of maintenance services to the GRAESP aircraft was considered a situation of high risk and unacceptable for air operations, due to the accumulation of services and the resulting stress.

The accumulation of tasks by just one person showed the lack of an adequate managerial planning in terms of allocation of human resources, as well as lack of managerial oversight of the maintenance services provided.

In view of this situation, the commission observed that the GRAESP had full confidence in the maintenance services provided by Helisul Táxi-Aéreo Ltda., and lacked the means for supervising, managing, and identifying any non-conformity in relation to the maintenance services provided by the company, which in reality were being provided by just one professional.

The crew informed that, on the morning of the day of the occurrence, they had performed the aircraft pre-flight check, and that there were no reports of technical problems in the aircraft logbook. However, just approximately ten minutes into the flight, the aircraft experienced vibration followed by an increase of the main rotor rotation speed, and they did not have control over the aircraft, with the pilot deciding to make an emergency landing.

After the analysis of the wreckage, the commission verified that several components without traceability had been installed in the main rotor head with maintenance services considered inadequate by the manufacturer and, therefore, not airworthy. However, the commission considered that the damage caused to these items was due to the overload resulting from the ground resonance sustained by the aircraft at landing.

The company to which the aircraft belonged and that was responsible for the aircraft maintenance was not able to provide information on the traceability of the components installed in the main rotor head, an indication of lack of managerial oversight.

In view of such situation, the commission concluded that neither the operator nor the owner of the aircraft was aware of the airworthiness condition of the operated aircraft.

The over-speed condition reported by the pilots was confirmed in the analysis of the Fuel Control Unit. The main rotor over-speed was caused by a partially inoperative condition of the FCU Control System, resulting from contamination by oxidation found in the interior of FCU.

The test of the fuel taken from the filters of the FCU revealed that the contamination did not have a microbiological origin, but had been caused by particles, in this case, oxidation caused by the presence of water. Therefore, the oxidation found was originated by the presence of water in various sections of the FCU.

The identification of the presence of water in the interior of the FCU corroborated with the condition found during the Special Flight-Safety Inspection conducted after the occurrence, that is, there was no concern in relation to this operational aspect. In off-base operations, the fuel was transported in inadequate containers.

No tests were required for the detection of water in the fuel, and thus the contamination went un-noticed over time, culminating in the failure of the FCU, which led to the accident.

As for the operational procedures performed by the pilots, it was not possible to determine their applicability and effectiveness, since the fuel shut-off system appeared normal and functioned accordingly during the bench test of the FCU.

Later, both the shut-off valve and the fuel drain valve were bench-tested, and were also considered to be in normal operating conditions.

Thus, it was not possible to confirm the condition reported by the pilots that at the moment of the occurrence they commanded the yellow lever but the NR never reduced.

In face of the data collected, one may infer that the lack of an organizational culture focused on the execution of appropriately frequent activities aimed at the prevention of accidents denotes absence of a flight safety policy on the part of the operator.

In this regard, the lack of training aimed at crews and mechanics involving aspects related to the air operation and maintenance services may have, as a result, diminished their concern with the existing procedures, increasing the vulnerability to situations of risk associated with the air activity.

According to the information collected, the pilots were experienced in the activity. Nevertheless, the validity of the second pilot's technical qualification certificate had expired, a fact that shows inobservance of the aviation norms, as well lack of adequate managerial oversight on the part of GRAESP over the real operational condition of the pilots.

Also, it was possible to observe that the mechanic responsible for the certified base of the company which provided maintenance services under a contract of maintenance with the air unit did not have a fixed work schedule. Sometimes, he would work on the weekends, and sometimes he would arrive at work not knowing what time he would be leaving work.

According to information, the mechanic would sometimes be on the alert. He remained in a state of "constant expectation" which denied him the possibility of making trips or running private activities, since he would be in this state of "constant expectation" exactly during the time reserved for rest and leisure, independently of his whereabouts, and could be reached even when he was not at home by means of his cellphone.

He was responsible for the maintenance of the two helicopters, the one of the firefighters and the one of the police. Due to the fact that he was the inspector on the base, nobody would inspect his work, and the service was provided under his full and exclusive responsibility.

From the above explained, it is possible to see that, at the time of the accident the mechanic presented signs of stress a work overload, on account of his routine and work conditions. Stress diminishes the ability to pay attention and concentrate, negatively affecting human performance.

Therefore, such situation made him much more susceptible to error, ratifying the aspects presented by the investigation commission relative to the maintenance services provided to the aircraft.

Besides, according to the literature, the type of error, in this case, could be classified as being at the skill level, in relation to the lack of attention or memory lapse, since when the tasks are part of the routine, the level of concentration is low and the errors are easy to detect, as the execution of the task itself takes place automatically and unconsciously. This type of error may be attributed to failures in the monitoring of a routine action, mainly when the individual is under a condition of stress, something that could be easily managed with the presence of an inspector.

In visits of the GRAESP conducted by SERIPA I in 2012, it was observed that the quantity of personnel was not sufficient for performing the technical-operational functions of the organogram, suggesting that other people in the air unit, besides the mechanic, might be involved with excessive workload. Such situation was a hindrance for the development and implementation of a much-needed training and operational maintenance program, on account of the little availability of persons capable of working in this area.

Another condition observed in the visits was that the GRAESP installations were not ergonomically adequate to accommodate all the administrative and operational personnel of the air unit.

It was possible to see that there was not a program for the selection of new pilots and crewmembers in the air unit, a situation that could lead to lowering of the criteria for being accepted to work in the institution.

3. CONCLUSIONS.

3.1 Facts.

a) The pilots had valid aeronautical medical certificates (CMA);

b) The pilot in command had a valid technical qualification AS350;

c) The validity of the second pilot's technical qualification AS350 had expired;

d) The pilot in command had enough experience for conducting the flight;

e) The second pilot did not have recent experience in the model of aircraft;

f) The aircraft had a valid airworthiness certificate;

g) The airframe, engine, and rotor logbook records were up-to-date;

h) The aircraft was within the weight and balance parameters;

i) The aircraft, which belonged to Helisul Táxi-Aéreo Ltda., was officially operated by the Pará State Military Fire Brigade, but in reality its operation was under the coordination of the GRAESP (Public Security Air Unit);

j) In the flight of the occurrence, the aircraft was complying with a mission of the GRAESP;

k) There were no reports of discrepancies in relation to the aircraft;

l) After approximately 10 minutes into the flight, the aircraft began to vibrate with an increase of the main rotor rotation;

m) The pilots decided to make an emergency landing;

n) At the moment of landing, the aircraft sustained ground resonance;

o) The aircraft airworthiness conditions were maintained by the company which owned the aircraft;

p) There was just one qualified mechanic, hired by the company which owned the aircraft, to monitor and maintain the airworthiness conditions of the GRAESP fleet aircraft;

q) The FCU was contaminated by oxidated water particles, which rended it partially inoperative, allowing over-speed of the main rotor;

r) The fuel utilized by the aircraft when operating away from the main base was transported by road in inadequate containers;

s) The company personnel lacked a doctrine for requesting a fuel test for verification of the presence of water at the moment of aircraft refueling;

t) The tests of the shut-off and fuel drain valves did not reveal any discrepancies in their functioning;

u) The investigation commission observed that the maintenance services to the main rotor blades were provided in discordance with the criteria and limits prescribed by the manufacturer;

v) The investigation commission observed that several components had been installed in the main rotor head without traceability;

w) The aircraft was substantially damaged; and

x) With the exception of the pilots, who were slightly injured, neither of the other aircraft occupants was hurt.

3.2 Contributing factors.

- **Stress – undetermined.**

The mechanic was experiencing stressing work conditions, which would have diminishing his ability to pay attention and concentrate while providing aircraft with maintenance services, which can be done with he did not notice the contamination conditions of the fuel and the FCU.

- **Organizational culture – a contributor.**

The culture of the organization overvalued its operational mission in detriment of flight safety. In consequence, important procedures, such as keeping a maintenance inspector and requesting fuel tests, were skipped.

- **Flight indiscipline – undetermined.**

The validity of the first officer's technical qualification certificate had expired, but he was composing the crew according to the aircraft logbook records, contrary to the prescriptions of the legislation in force.

The fact that the aircraft could be flown by just one pilot does not exempt the other pilot, as a crew member had a valid qualification.

- **Aircraft maintenance – a contributor.**

The services of maintenance and balance of the main rotor blades were not provided in the way prescribed by the manufacturer, altering the frequency of rotation of the blades and aggravating the ground resonance event.

There were also components installed in the head of the rotor that could not have their traceability verified and, therefore, one understands that the aircraft could not be considered airworthy.

- **Management planning – undetermined.**

The fact that there was just one mechanic qualified to control and maintain the airworthiness of the fleet aircraft denotes deficiency in the allocation of human resources for the execution of operational and maintenance activities both on the part of the operator and of the maintenance provider and may have resulted in failure to identify abnormal conditions of the aircraft.

- **Organizational processes – a contributor.**

The lack of a process for monitoring and controlling the activities carried out in the company allowed existing dysfunctions (such as shortage of maintenance personnel, stressing work conditions, lack of supervision of the services, and pilot operating with an expired qualification) not to be corrected.

- **Managerial oversight – undetermined.**

Neither the maintenance providing company nor the operator could provide information on the traceability of the components installed in the aircraft, showing that they were not aware of the real airworthiness condition of the aircraft.

Besides, the operator allowed that pilots with an expired qualification could compose a flight crew, something that goes against the legislation.

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) 160/2012 **Issued on 28/06/2012**

Take the necessary measures before GRAESP/PA so that it only designates qualified personnel to compose the crew, that is, personnel with valid qualifications and certificates.

RSV (A) 161/2012 **Issued on 28/06/2012**

Take the necessary measures before GRAESP/PA so that it delivers a briefing on emergencies to the aircraft occupants before takeoff, alerting them on the appropriate moment for abandoning the aircraft, in order to prevent accidents with the main rotor blades.

Recommendations issued at the publication of this report:

To the National Civil Aviation Agency (ANAC):

A-531/CENIPA/2015 - 01 Issued on 24/11/2016

Take the necessary measures before Helisul Táxi-Aéreo Ltda; so that it makes provisions to guarantee that all the rotor blade repair services not listed in the operator maintenance manual be provided by the manufacturer or by a duly certified workshop.

A-531/CENIPA/2015 - 02 Issued on 24/11/2016

Take the necessary measures before Helisul Táxi-Aéreo Ltda., so that it provides the means required for training the maintenance personnel in the evaluation and execution of repairs in the blades at the level prescribed by the manufacturer for certified workshops.

A-531/CENIPA/2015 - 03 Issued on 24/11/2016

Take the necessary measures before Helisul Táxi-Aéreo Ltda, so that it adjusts the number of their maintenance professionals and inspectors in Belém to the demands for the provision of maintenance services to aircraft in operation on that base.

A-531/CENIPA/2015 - 04 Issued on 24/11/2016

Take the necessary measures before the GRAESP, aiming at the development of a comprehensive training program, addressing topics related to the operational maintenance of crews and flight instructors.

A-531/CENIPA/2015 - 05 Issued on 24/11/2016

Take the necessary measures before the GRAESP, so that it develops a program concerning technical control and execution of the maintenance activity.

A-531/CENIPA/2015 - 06 Issued on 24/11/2016

Take the necessary measures before the GRAESP, seeking the development of an Operational Safety Management Manual (MGSO) with the objective of disseminating the Operational Safety (flight safety) concepts, as well as providing guidance to and monitoring of the GRAESP activities, enabling the identification of active failures and latent conditions, together with the management of the risks inherent to the mission of the air unit.

A-531/CENIPA/2015 - 07 Issued on 24/11/2016

Take the necessary measures before the GRAESP, seeking to adjust the number of their maintenance professionals and inspectors on Belém base to the demand for the provision of maintenance services to aircraft in operation.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

The GRAESP was subjected to a Special Flight Safety Inspection, and pertinent Recommended Mitigating Actions were issued with the objective of lessening the risk conditions detected.

As soon as the contamination of the FCU with water was confirmed, the GRAESP purchased a tank for the transport of fuel in support to missions off base, with the objective

of improving the storing of fuel, allowing drainage and preventing it from getting contaminated.

The Eurocopter Information Notice no. 2376-I-28 addressing the issue of contamination of the fuel system (prevention, detection, eradication, and maintenance actions) was forwarded to GRAESP for purposes of information.

On November 24th, 2016.