COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
A - 090/CENIPA/2014

OCCURRENCE:	**ACCIDENT**
AIRCRAFT:	**PR-FPL**
MODEL:	**EC-120B**
DATE:	**02MAY2014**

NOTICE

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

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

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

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

This Report does not resort to any proof production procedure for the determination of civil or criminal liability, and is in accordance with Appendix 2, Annex 13 to the 1944 Chicago Convention, which was incorporated in the Brazilian legal system by virtue of the Decree nº 21713, dated 27 August 1946.

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

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

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

SYNOPSIS

This is the Final Report of the 02MAY2014 accident with the EC-120B aircraft, registration PR-FPL. The accident was classified as "[LOC-I] Loss of Control in Flight".

During simulated hydraulic crash training, at landing approach at the Luziânia Aerodrome (SWUZ), the aircraft struck the ground, 35m from the side of threshold 11.

The aircraft suffered substantial damage.

All occupants were unharmed.

An Accredited Representative of the *Bureau d'Enquêtes et d'Analyses pour la Sécurité e l'Aviation Civile* (BEA) – France, (State where the aircraft was manufactured) was designated for participation in the investigation.

CONTENTS

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

ADF	Aircraft Registration Category of Federal Direct Administration
ANAC	Brazil's National Civil Aviation Agency
ATS	Air Traffic Services
CA	Airworthiness Certificate
CENIPA	Aeronautical Accident Investigation and Prevention Center
CFI	Instructor Formation Course
CG	Center of Gravity
CIV	Pilot's Flight Logbook
CM	Registration Certificate
CMA	Aeronautical Medical Certificate
CRM	Crew Resource Management
DCTA	Department of Science and Airspace Technology
DOA	Air Operations Division
DPRF	Federal Highway Police Department
EASA	European Aviation Safety Agency
FLM	Flight Manual
GSO	Safety Manager
INVH	Flight Instructor Rating - Helicopter
IFR	Instrument Flight Rules
Lat	Latitude
LACU	Light and Auxiliary Control Unit
Long	Longitude
METAR	Meteorological Aerodrome Report
MGB	Main Gear Box
MGO	General Operations Manual
MGSO	Safety Management Manual
MRH	Main Rotor Head
MNTE	Airplane Single Engine Land Rating
MSM	Master Servicing Manual
NF	Free Turbine Speed
PCM	Commercial Pilot License - Airplane
PF	Pilot Flying
PIMO	Instruction and Maintenance Program
POP	Standard Procedures
PPR	Private Pilot License - Airplane
RBHA	Brazilian Regulation of Aeronautical Homologation
RELPREV	Prevention Report

RS	Safety Recommendation
SBBR	ICAO Location Designator – Brasília Aerodrome - DF
SERIPA VI	Sixth Regional Aeronautical Accident Investigation and Prevention Service
SIPAER	Aeronautical Accident Investigation and Prevention System
S/N	Serial Number
SWUZ	ICAO Location Designator – Luziânia Aerodrome - GO
TGB	Tail Gear Box
TRQ	Torque
TRH	Tail Rotor Head
TRDS	Tail Rotor Drive Shaft
TSN	Time Since New
UTC	Universal Time Coordinated
VEMD	Vehicle and Engine Multifunction Display
VFR	Visual Flight Rules
VSV	Flight Safety Inspection

1. FACTUAL INFORMATION.

Aircraft	**Model:** EC-120B **Registration:** PR-FPL **Manufacturer:** Eurocopter France	**Operator:** Federal Highway Police Department
Occurrence	**Date/time:** 02MAY2014 – 1900 (UTC) **Location:** Luziânia Aerodrome (SWUZ) **Lat.** 16º15’39”S **Long.** 047º58’28”W **Municipality – State:** Luziânia - GO	**Type(s):** “[LOC-I] Loss of Control in Flight **Subtype(s):** NIL

1.1 History of the flight.

The aircraft took off from the Presidente Juscelino Kubitschek International Aerodrome – DF (SBBR), to the Brigadeiro Araripe Macedo Aerodrome, located in the municipality of Luziânia - GO (SWUZ), at about 1830 (UTC), to conduct a training flight , with two pilots and one passenger (also a pilot) on board.

In SWUZ, a traffic and landing circuit was initially performed without the aid of the hydraulic system (simulated fault of the hydraulic system), to train the pilot on the right seat.

After landing, the aircraft took off for the hydraulic failure training of the left seat pilot. At the time of the final approach to landing, there was loss of control in flight and the aircraft hit the ground, 35m from the left side of threshold 11.

The aircraft had substantial damage.

All occupants were unharmed.

Figure 1 - View of the aircraft after impact.

1.2 Injuries to persons.

Injuries	Crew	Passengers	Others
Fatal	-	-	-
Serious	-	-	-
Minor	-	-	-

None	2	1	-

1.3 Damage to the aircraft.

There was a rupture in the root of the three blades of the main rotor, damage to the rotating components, skis and disconnection of the tail cone.

1.4 Other damage.

None.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Hours Flown		
	Pilot	Copilot
Total	4.000:00	2.150:00
Total in the last 30 days	24:30	14:50
Total in the last 24 hours	00:00	00:25
In this type of aircraft	500:00	1.200:00
In this type in the last 30 days	15:30	13:00
In this type in the last 24 hours	00:00	00:25

N.B.: Data related to the flown hours were obtained through the Pilots' Flight Logbook.

1.5.2 Personnel training.

The pilot took the Private Pilot course – Helicopter (PPH) at EDRA Aeronautical School LTD., in Ipeúna – SP, through the Federal Highway Police Department, in 1999.

The copilot took the Private Pilot course – Helicopter (PPH) at EDRA Aeronautical School LTD., in Ipeúna – SP, through the Federal Highway Police Department, in 2000.

1.5.3 Category of licenses and validity of certificates.

The pilot had the PCH License and had valid BH07, EC20 and Flight Instructor – Helicopter (INVH) Ratings.

The copilot had the PCH License and had valid BH07 Rating, but his EC20 Rating was overdue since March 2014.

1.5.4 Qualification and flight experience.

The pilot was qualified and had experience to perform the flight.

The Federal Highway Police Department had more frequency of flight in Bell 407 helicopters.

According to the crewmember, every three months, he performed at least one flight to maintain qualification on the EC-120B.

The copilot had more flight hours in the incident model than the pilot, however, he did not have the INVH rating. However, he had carried out the theoretical flight instructor module.

1.5.5 Validity of medical certificate.

The pilots had valid Aeronautical Medical Certificates (CMA).

1.6 Aircraft information.

The aircraft, serial number 1283, was manufactured by Eurocopter France, in 2002, and it was registered in the ADF category.

The aircraft had valid Certificate of Airworthiness (CA).

The airframe and engine logbook records were updated.

The aircraft was stored in Recife - PE, without flying, between 26OCT2013 and 15APR2014, waiting for parts to return to the flight line. During this period of disruption, it served as a parts supplier for other aircraft. After this period, the helicopter was released and performed a maintenance flight.

From the return to the flight line, the helicopter flew 36 hours and 15 minutes until the moment of the accident.

The last inspection of the aircraft, the "IAM" type, was carried out on 13APR2014 by the Helisul Air Taxi shop Ltd., in São Paulo - SP.

This inspection was performed to remove and replace the complete engine assembly due to faults in the compressor. It was installed the engine, model Arrius 2F S/N 34283, with 3.226 hours and 42 minutes since new (TSN).

In the logbook, between the date of the last inspection, 13APR2014, and the date of the accident, 02MAY2014, there was no record of failure or irregular operation in the aircraft's equipment and systems.

It was reported that, since the release of the aircraft in Recife, the helicopter was showing a leak in the hydraulic block, however, no record of this fact was identified in the logbooks or aircraft flight logs.

In the dispatch of the aircraft, on the day of the accident, there were no reports of breaches in the aircraft flight log, as well as in the engine and airframe logbooks.

The EC-120B Maintenance Program was described in Eurocopter's Master Servicing Manual (MSM), chapters 4 and 5. There were programmed time-based (calendrical) inspections and quantitative flight hours.

The last overhaul of the aircraft, the "1,500 hours or 72 months" type was carried out on 14JAN2013 by the Helisul Air Taxi shop Ltd., with 277 hours and 45 minutes flown after the revision.

1.7 Meteorological information.

The conditions were favorable for the visual flight, according to the pilots.

At the site of the accident (SWUZ), there was no Aerodrome meteorological information service.

The Local Meteorological Bulletins (METAR) of the Brasília Aerodrome (SBBR), distant 24 nautical miles from the scene of the accident, had the following information:

METAR SBBR 021800Z 13008KT CAVOK 28/13 Q1018

METAR SBBR 021900Z 13006KT CAVOK 28/12 Q1019

It was found that the conditions were favorable for the visual flight, with visibility over 10km and clear sky. The wind had intensity between 06 and 08kt.

According to the pilots, the wind was calm during the flight on the first traffic circuit in SWUZ.

1.8 Aids to navigation.

Nil.

1.9 Communications.

Nil.

1.10 Aerodrome information.

The aerodrome was public, administered by the Brasilia Aeroclub and operated under visual flight rules (VFR), in daytime.

The runway was made of asphalt, with thresholds 11/29, dimensions of 1,200m x 20m, with elevation of 3,268 feet.

1.11 Flight recorders.

Neither required nor installed.

1.12 Wreckage and impact information.

The impact occurred next to the runway's threshold 11 of SWLZ, with no evidence of previous impact. Figure 2 shows the sketch of the occurrence.

Figure 2 - Sketch of the occurrence.

The first impact on the ground occurred with the left rear part of the aircraft (Figure 3).

Figure 3 - First impact. In highlight, yellow ski ink and pieces of the fenestron-type tail rotor guard.

The skis (landing gear) were flattened in the rear due to the collision with the terrain (Figure 4).

Figure 4 - Flat landing gear, highlighted.

There was the left rear ski break and the fenestron-type tail rotor guard break (Figure 5).


Figure 5 - (I) Left ski broken and disconnected. (II) Fenestron tail rotor guard disconnected from the aircraft.

After the total stop, the aircraft was tipped, lying on its left side (Figure 6).

Figure 6 - The lower protection fennel shield was disconnected.

The three blades of the main rotor collided against the ground and were fractured near their connections with the main rotor head. The tail cone was completely sectioned from the junction with the main fuselage, remaining connected through the transmission rod of the controls.

Dozens of small fragments of the blades were found around the wreckage (Figure 7).

Figure 7 - Fragments of blades scattered on the wreckage site.

1.13 Medical and pathological information.

1.13.1 Medical aspects.

Nil.

1.13.2 Ergonomic information.

As the aircraft began skidding and rolling to the left, the Pilot Flying on the left seat shifted the cyclic to the right, until the command stop, to counteract the movement. However, the pilot's leg limited the cyclic course, preventing it from reaching the right-hand limit.

Anthropometric measurements were performed on the pilots, in order to compare with the anthropometric limits of the aircraft cabin’s accommodation.

1.13.3 Psychological aspects.

The pilots occupying the seats on the right and left belonged to the Air Operations Base of the Federal Highway Police (PRF) in Recife - PE.

The pilot in the rear seat, as an observer, belonged to the Air Operations Base of Curitiba - PR.

Although they belonged to distinct operational bases, they had already composed flight crew together on previous missions. They reported having good interpersonal relationships among themselves and were evaluated with adequate interaction in the cabin.

According to reports from other PRF crew, these were experienced pilots with adequate operational standards, as they had been operating for more than 10 years in the air missions carried out by the PRF.

The flight that originated the accident had as objective the standardization of exercises and maneuvers between the three pilots, for a course that would be applied in the following week, in which they would be instructors.

The flight started with the commander seated on the right, in the conduct of a simulated hydraulic failure landing and traffic circuit, which comprised one of the exercises planned for training in that course.

As reported, the performance of the commander in the exercise occurred without change, and landing on that first traffic was successfully accomplished. He was the most experienced pilot in the training of failures of the hydraulic system on board the aircraft, besides the only authorized INVH.

The second traffic circuit started with the pilot sitting on the left in Pilot Flying (PF) condition, in order to carry out the same exercise. Already in the approach phase with the runway threshold, he noticed the aircraft tending to the left.

The commander sitting on the right also noticed the aircraft turning to the left, but believed that the copilot knew what was happening and that he was in control of the aircraft.

Because he knew that the copilot was experienced on the EC-120B flight, and because it was not an instruction flight but a standard one, the commander did not follow the copilot's attitudes in flight and did not understand that it was a real abnormal condition, in which he should act.

The commander reported that the copilot had surprised him when he suddenly announced his transfer of command. From that moment, the copilot remained only observing the situation.

As reported by the copilot, he felt more confident in passing the control of the aircraft to the commander, because of the successful landing without hydraulics recently made by him. Due to his ability, he believed the commander would be better able to manage the abnormal condition presented.

When the commander took over, suddenly the aircraft started a strong and sharp vibration, from which neither of the pilots understood what was happening. According to them, the vibration was strong enough to prevent the instruments from being visible on the panel.

At no point did the pilots think to perform a go-around procedure. As they reported, at that moment, the commander was surprised and the copilot on the left was already preparing for the collision against the ground at his side.

As informed by one of the pilots, it was discussed in the morning of the accident, the removal of the hydraulic system as one of the course exercises. Two of the pilots still felt uncomfortable with the exercise, based on the risk of it becoming a real failure.

At the insistence of one of the pilots, it was decided to keep the exercise, at least in the training between them. The decision to include or not the exercise in the course would be made at the end of the maneuvers execution on that day.

According to the copilot's account, due to an accident that occurred previously with a PRF aircraft in an instruction condition, he felt reluctant to take part in the course instruction, mainly due to the inquisitive posture that the PRF could adopt in case of a new occurrence in an instruction condition.

He confirmed that he only accepted the challenge because it was a request from the new head of the Air Operations Division of the PRF (DOA-PRF) at the time.

1.14 Fire.

There was no fire.

1.15 Survival aspects.

The two crewmembers and the observer were unharmed.

Belts and suspenders were being used by the occupants and remained intact and operative on impact.

Engine cut-off and emergency evacuation were performed. The aircraft's abandonment was successful by the right door of the helicopter.

1.16 Tests and research.

<u>First Action at the Accident Site:</u>

The crewmembers were interviewed and reported that there was strong vibration in the final for landing and an uncontrollable tendency of rolling and slippage to the left.

The Investigation team requested the follow-up of a Helibras technical representative to assist in identifying possible preliminary evidence on the crashed aircraft.

In addition to all data collection for the investigation, possible signs of abnormalities were searched in the main rotor head, connections, rods, shock absorbers, servo actuators, and integrity of flight commands.

Preliminarily, at the accident site, it was not possible to identify abnormalities in the verification of the major components described above (Figure 8).

Figure 8 - Rotor head and its connections, vibration absorbers, fenestron rotor and engine connection shaft.

The servocontrols were visually inspected for no leakage of hydraulic fluid. The control rods were well connected and braked.

After the initial action, the aircraft was removed to the Federal Highway Patrol (DPRF) hangar for in-depth analysis, testing and research on its systems and components.

The aircraft suffered substantial damage, however, by means of maintenance evaluations, isolating some parts, it was possible to carry out the electrical and hydraulic energization to carry out the investigative analyzes.

On 09 and 10SEPT2014, in the DPRF hangar, wreckage, hydraulic system check, Vehicle and Engine Multifunction Display (VEMD) were tested (Figure 9).

Figure 9 - Hydraulic and electrical energization for tests.

The team consisted of two engineers from Airbus Helicopter (Advisors), two representatives from Helibras (Advisors), the investigator in charge, an in-flight test pilot (Advisor), an in-flight test aircraft engineer (Advisor), a maintenance investigator and an operator representative.

Main Rotor Head (MRH) and Main Rotor Shaft (MRS):

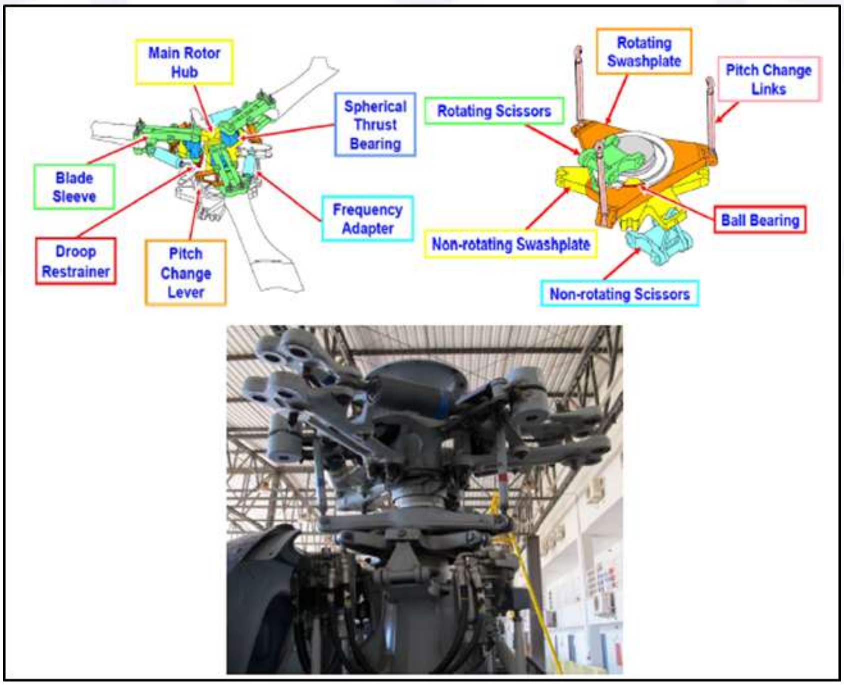


Figure 10 - Main Rotor Head (MRH) and Main Rotor Shaft (MRS).

The Main Rotor Head (MRH) and Main Rotor Shaft (MRS) showed some damage resulting from the impact of the blades on the ground with speed and power, namely:

- impact between the components identified as "spherical trust bearing large armatures and their housing" on the mast. This phenomenon was a consequence of rotation and drag effects on polyurethane protection of the blades when they impacted the ground with power and pitch (Figure 11);

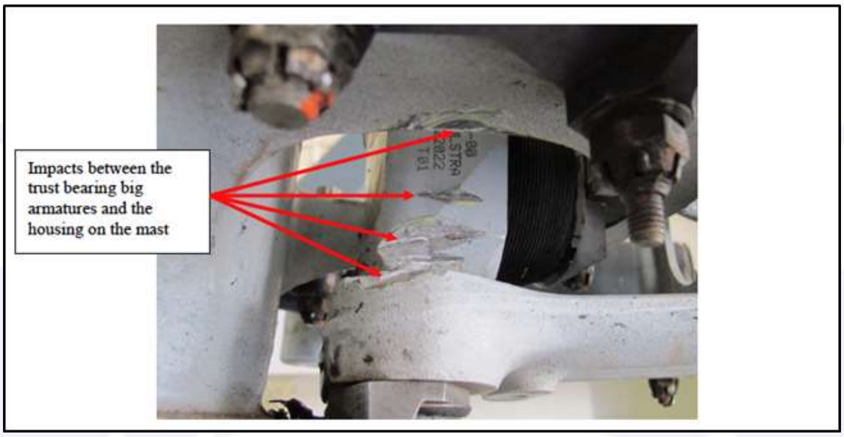


Figure 11 - Impacts on the mast.

- interference between the plate and the rotating scissors due to the significant rotation of the plate resulting in flapping during impact of the blades against the ground (Figure 12);

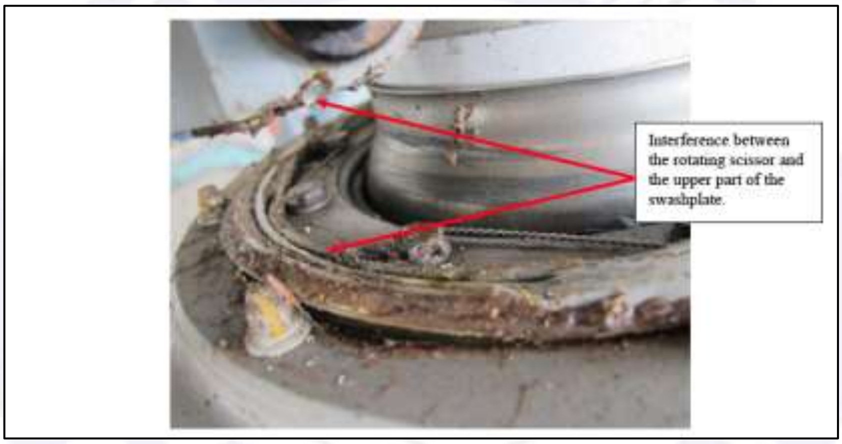


Figure 12 - Damage at the top of the rotating plate.

- damage at the droop restrainer support, due to overload resulting from flapping, during impact of blades against the ground (Figure 13);

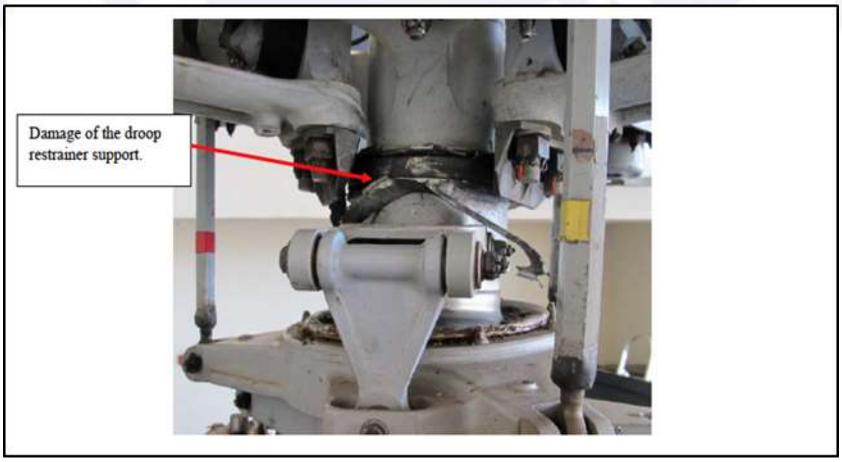


Figure 13 - Damage to the mast holder.

- damage to the three anti-vibrator weight rotation stops, due to the overload resulting from the impact of the blades against the ground (Figure 14);

Figure 14 - Shock absorbers twisted, due to ground impact.

- one of the outer shells of the frequency damper (red) has been detached from the outer armature (this phenomenon is commonly observed as a result of drag overloads when the main rotor blades impact the ground with energy as the aircraft rolls). The absence of wear at the interface confirms that this phenomenon is a sudden effect, due to the overload resulting from the contact of the blade; and

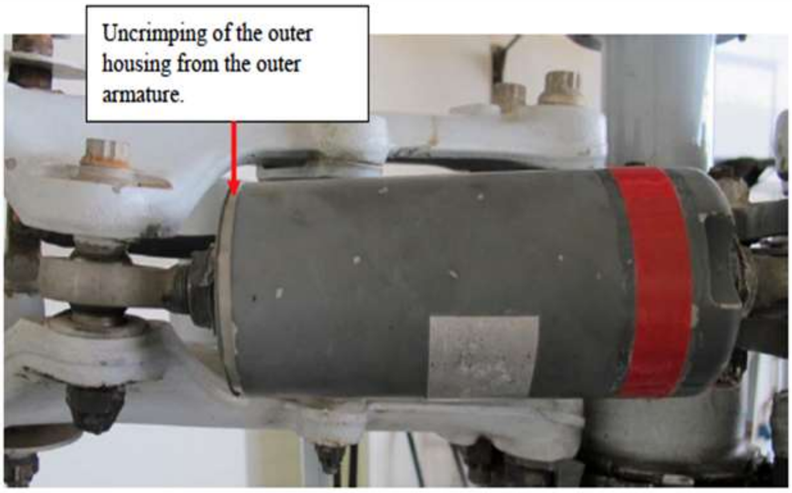


Figure 15 - Slight separation of the outer housing from the outer armature.

- the rotating plate turned and moved freely in all directions.

The pitch change links were connected and in good condition.

The elastomeric parts of the frequency dampers and the bearings were in good condition.

Except for these damages, the MRH was in good condition and no damage beyond the consequence of contact of the blades against the ground was observed.

<u>Main Gear Box - MGB and Suspension:</u>

The MGB showed no external marks or damage and no particles were present in the magnetic plug (Figures 16 and 17).

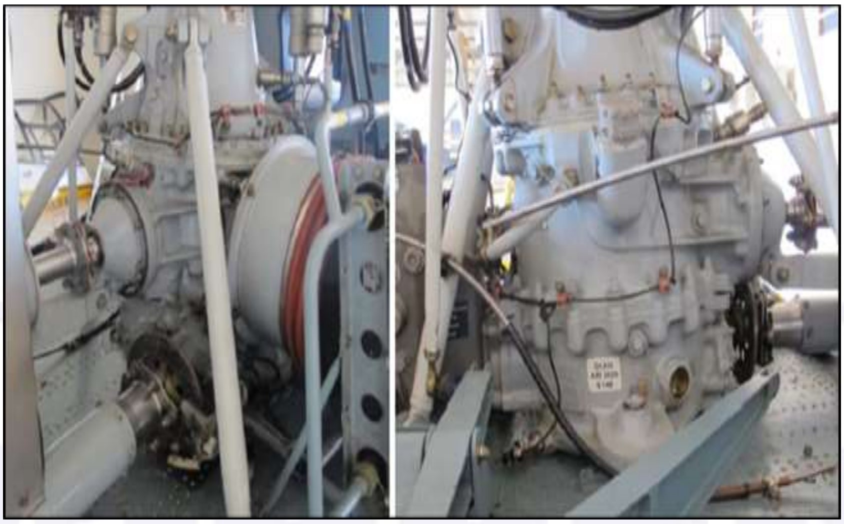


Figure 16 - Overview of the good condition of the MGB.

Figure 17 - Magnetic oil plug without particles or damage.

It was verified that by turning the MRH it was possible to activate the Tail Rotor Drive Shaft (TRDS) outlet and the MGB intake and pinion, which confirmed the continuity between the MGB intake, the MRH outlet and the Tail Rotor Drive Shaft.

The four suspension bars of the MGB were in good condition and correctly connected to the MRH's mechanical desk and conical house (Figure 18).

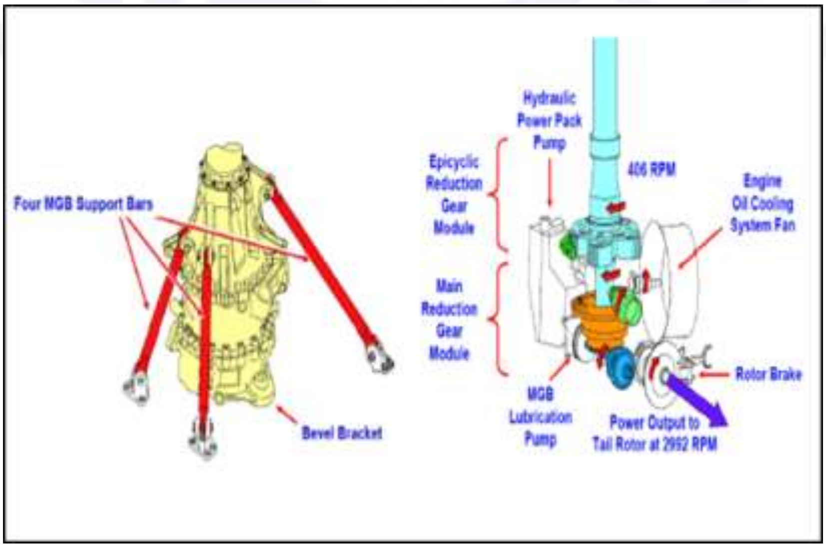


Figure 18 - MGB and Suspension.

Engine Coupling with MGB:

The engine coupling tube with the MGB was in good condition and properly connected to both sides, in other words, near the MGB and near the engine.

The engine drive shaft for the MGB (internal to the coupling tube) was broken in the turning motion (by overload), in its median position, as a consequence of the over torque resulting from the impact of the main rotor blades against the ground with power (Figures 19 and 20).

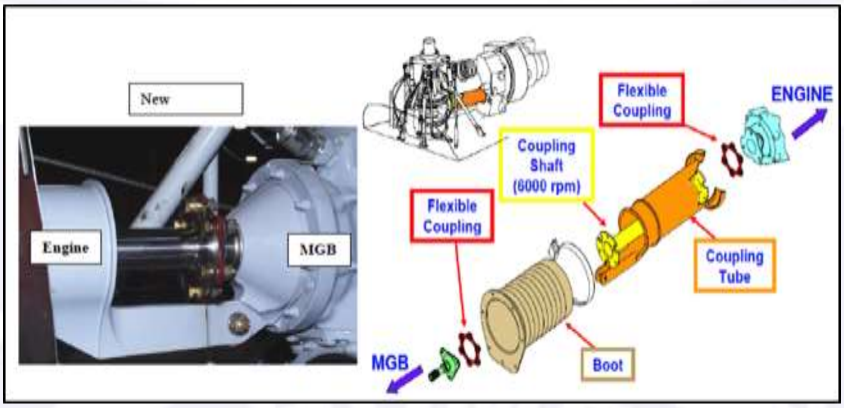


Figure 19 - Engine Coupling with MGB.

Figure 20 - Internal view of the coupling tube and broken drive shaft.

Tail Rotor Drive Shaft (TRDS):

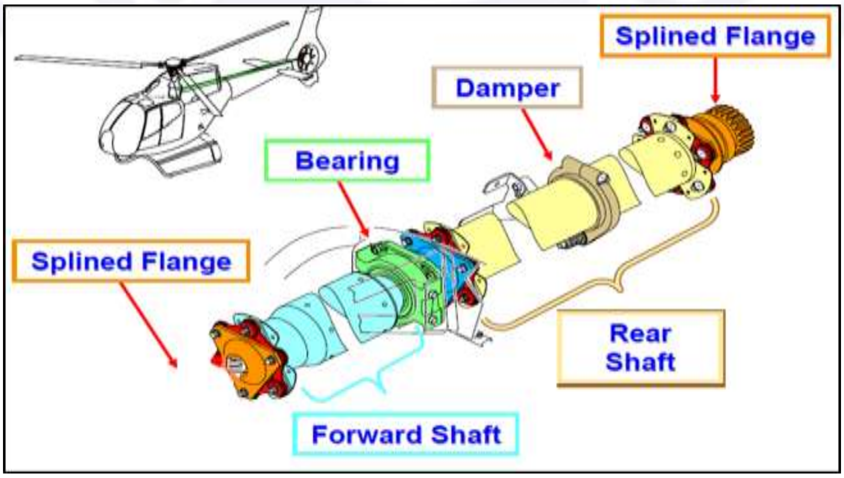


Figure 21 – Picture of the Tail Rotor Drive Shaft.

The front of the drive shaft was attached to the output of the MGB by the splined flange and it rotated freely (Figure 22).

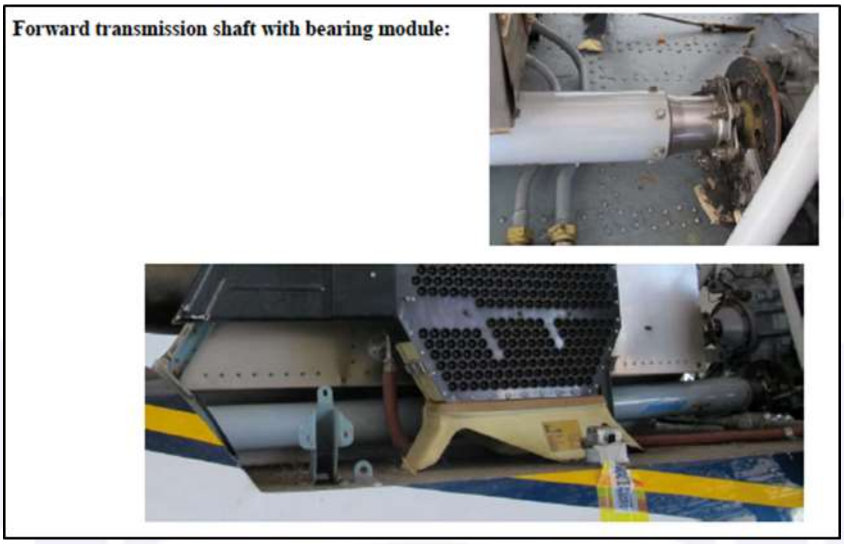


Figure 22 - View of the transmission shaft of the tail rotor.

This shaft was broken in the riveted coupling (overload failure), with its flange in the bearing affixing of the bearing module. This failure probably occurred as a result of the twisting during the tail disconnection on the ground impact (Figure 23).

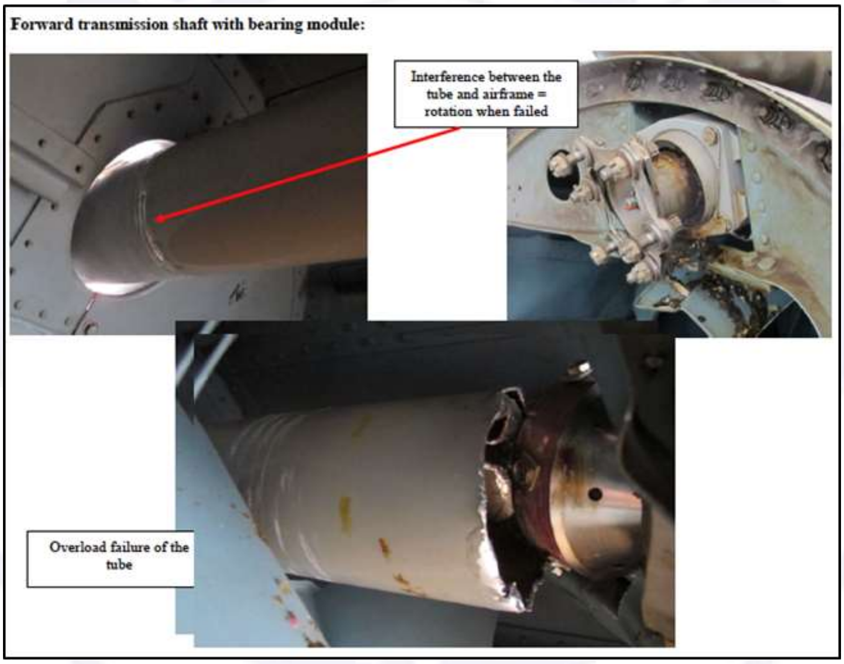


Figure 23 - Overload failure view.

The fixation of the double-rolling module in the fuselage was damaged as a result of the separation of the tail cone, but it rotated freely.

The rear drive shaft was still attached to the bearing module and folded in its first third as a result of tail disconnection.

The inlet flange of the rear transmission case has been disengaged from the rear transmission case during the tail separation. No pre-impact failure was observed (Figure 24).

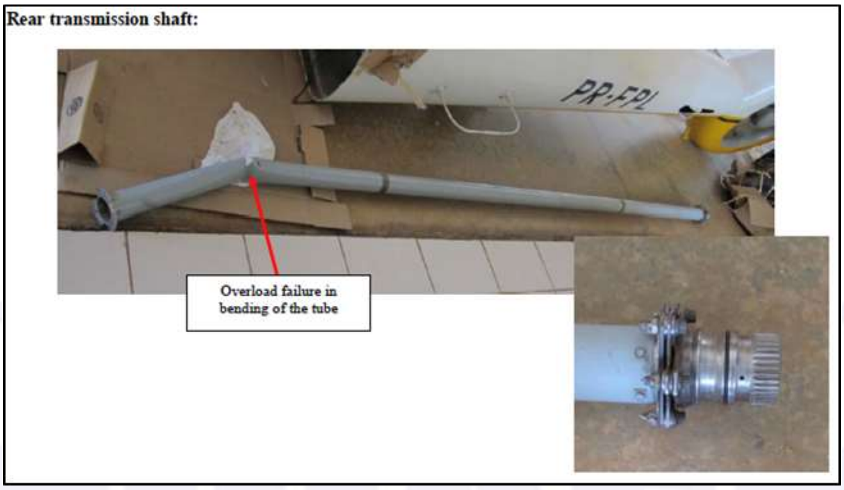
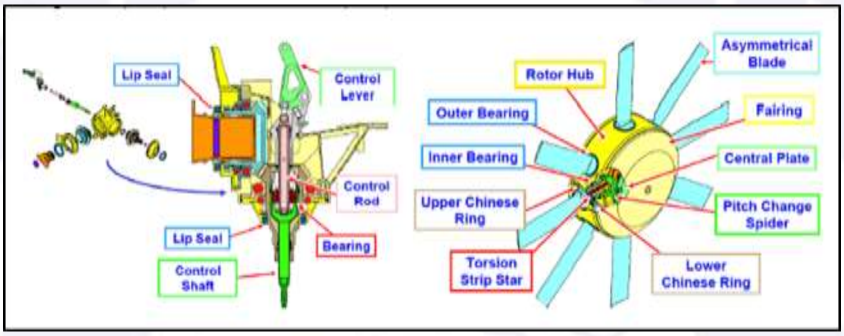


Figure 24 - View of the shaft folding associated with overload failure. On the detail, the inlet flange of the rear transmission box disengaged from the box.

<u>Tail Gear Box (TGB) and Tail Rotor Head (TRH):</u>



Tail Gear Box – TGB and Tail Rotor Head – TRH.

The TRH and TGB rotated freely and showed no external damage. No particle was observed on the TGB magnetic plug (Figure 26).

Figure 26 - Tail rotor and magnetic plug with no particles (highlighted).

<u>Engine:</u>

The engine was rotating freely (gas generator and free turbine) and no failure or loss of power before impact was evidenced, nor did the crew report any feeding problems during the event.

Flight Controls:

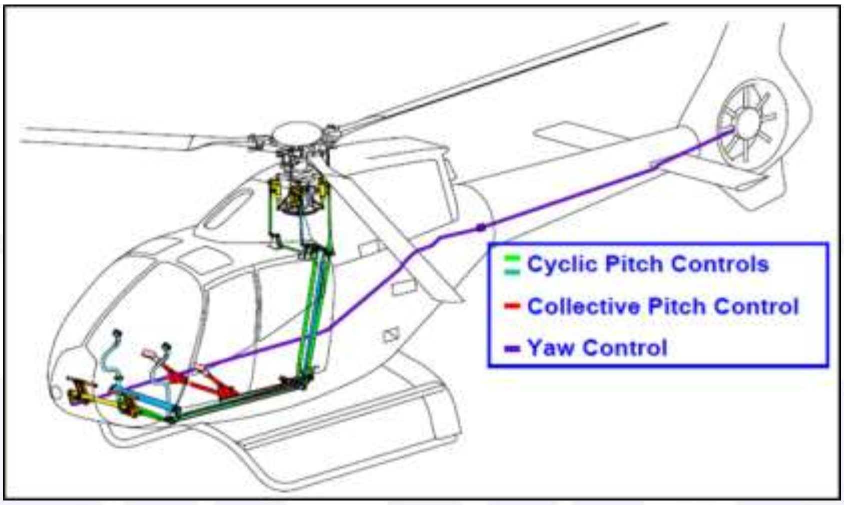


Figure 27 - Illustration of the Flight Commands of the model.

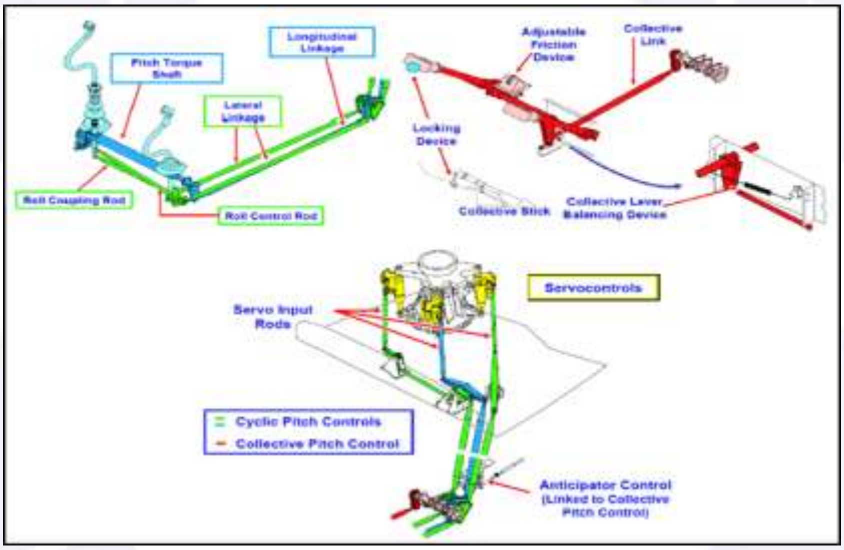


Figure 28 - Illustration of the helicopter's systems and controls.

The collective and cyclic controls were hard to move because they were connected to the servocontrol input lever. After disconnecting the servocontrol input lever from the rod, it was possible to move freely and without load the collective and cyclic commands in all directions (Figure 29).

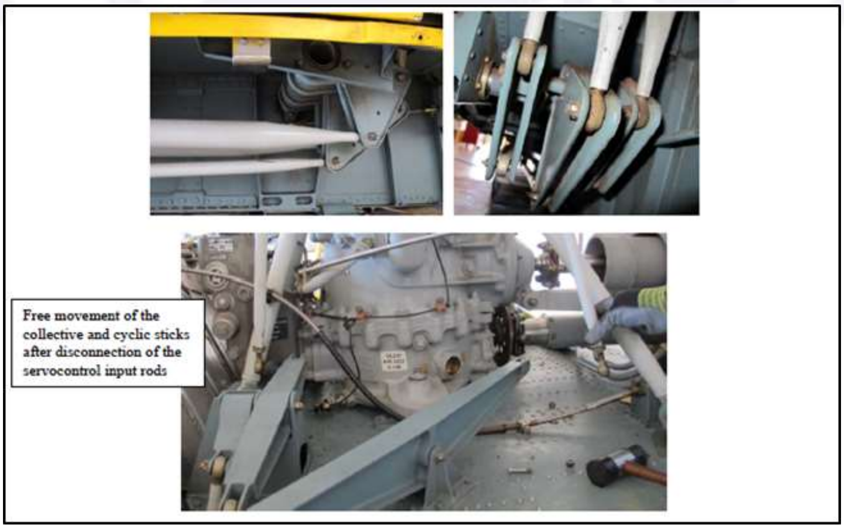


Figure 29 - Free movement of the cyclic and collective sticks.

A hard point was observed on the cyclic stick that was identified as a result of the deformation seen in the rod and bellcranck as deformation resulting from ground impact (Figure 30).

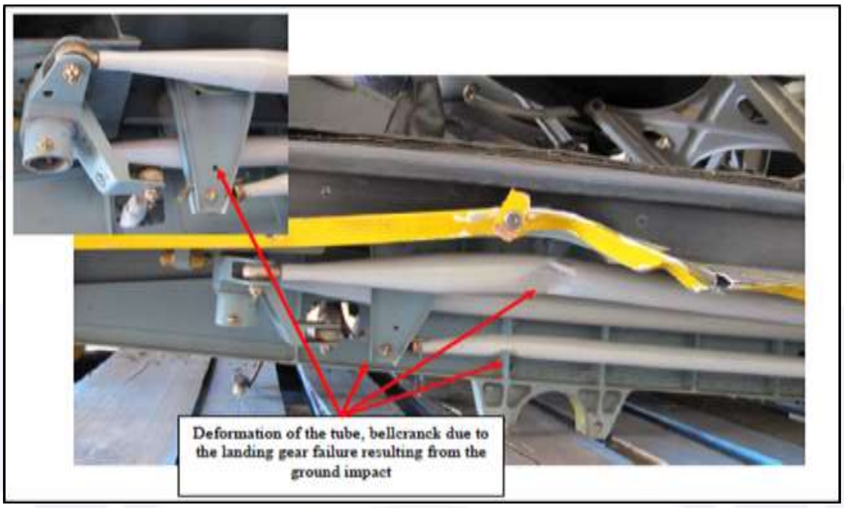


Figure 30 - Deformation of the tube and bellcranck due to the failure of the landing gear resulting from the ground impact.

No damage or pre-impact restriction was observed in cyclic and collective commands.

Tail Rotor Control:

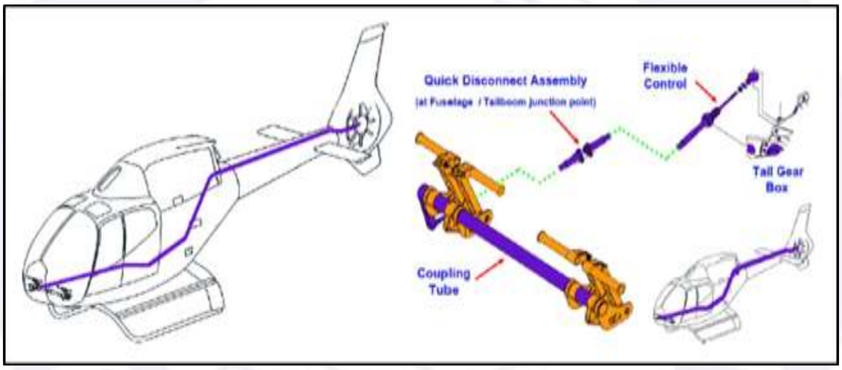


Figure 31 - Illustration of the Tail Rotor Control.

The pedals moved freely and the ball-bearing cable (teleflex) ran inside the armature. The cable was broken in its rear connection. The failure of the cable and armature was due to overload, whose main probability was the detachment of the tail cone from the fuselage during the ground impact of the aircraft. (Figures 32, 33 and 34).

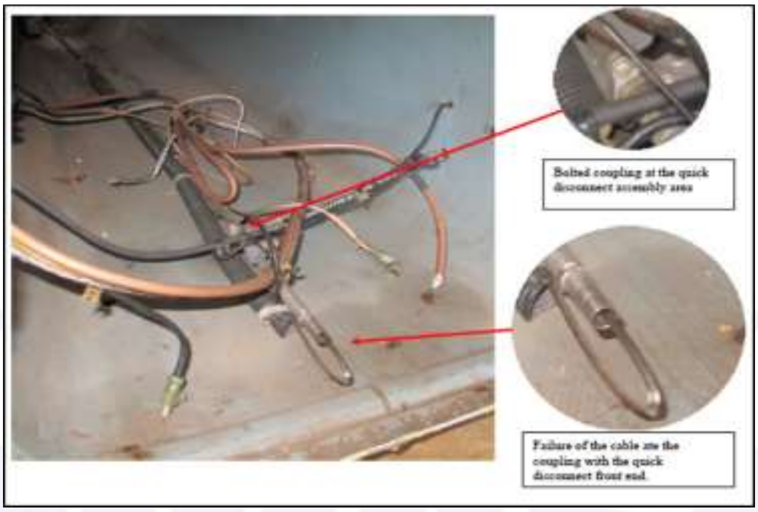


Figure 32 – View of the cable failure on the disconnection.

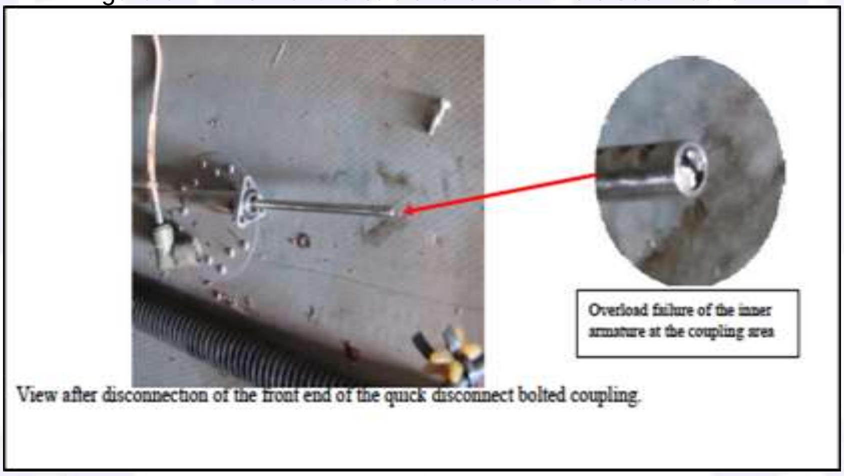


Figure 33 – On detail, overload failure of the inner armature in the coupling area.

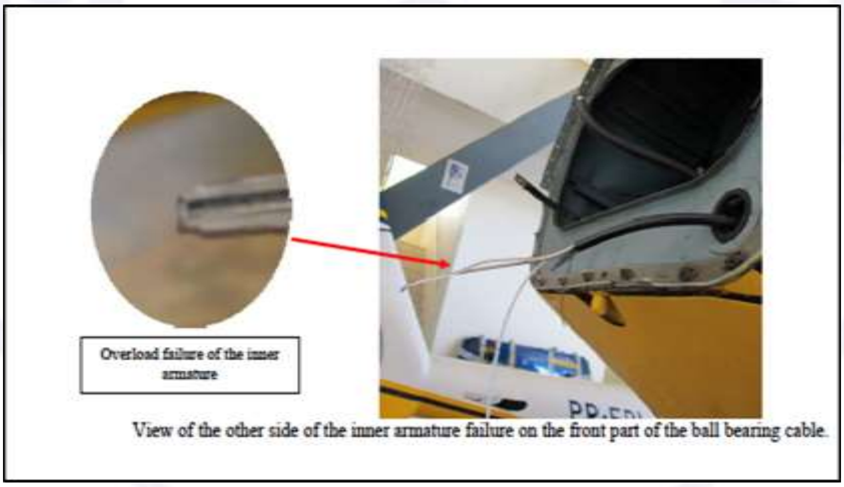


Figure 34 – On detail, the internal overload fault.

The back of the teleflex cable (ball bearing) moved freely and acted at the entrance of the TGB resulting in the movement of all the blades of the tail rotor (Figure 35).

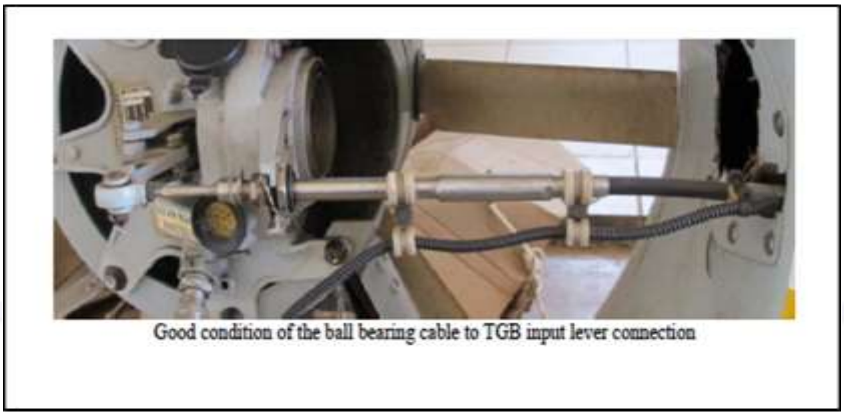


Figure 35 – Good condition of the connection of the teleflex cable to the TGB.

No damage, failure or restriction was observed in the control of the tail rotor.

<u>Hydraulic Circuit and Servocontrols:</u>

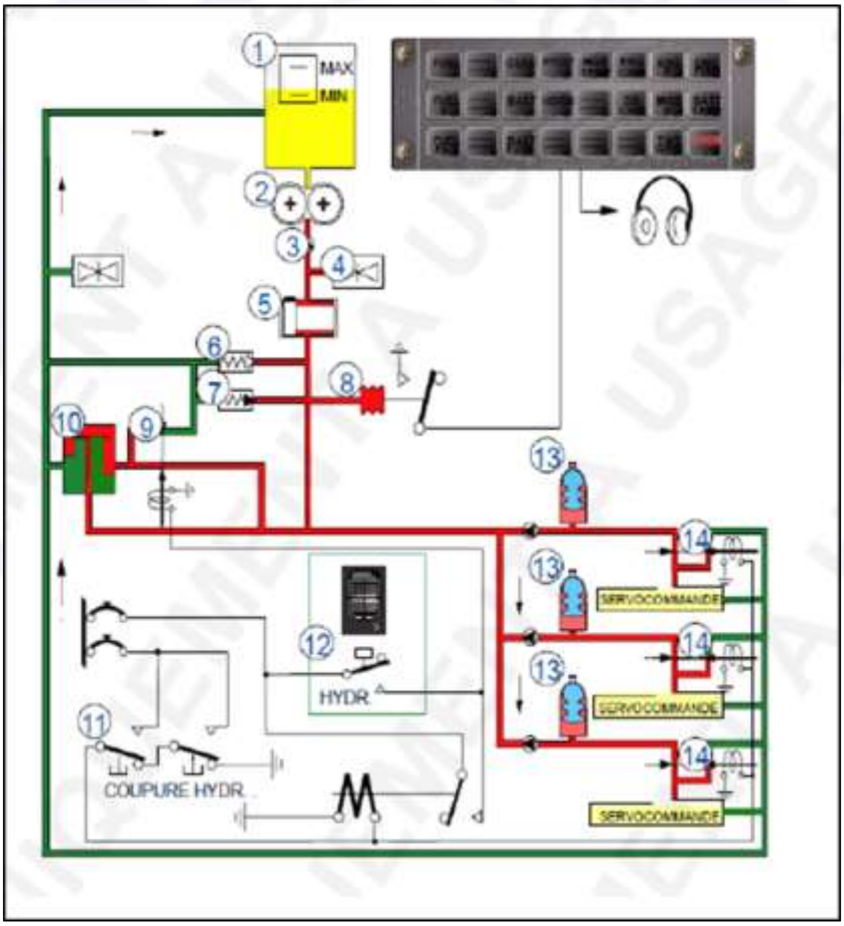


Figure 36 - Description of the EC-120B hydraulic system and servocontrols.

The hydraulic system consisted of a hydraulic compact unit, three servocontrols, equipped with accumulators, and control and monitoring electrovalves.

The hydraulic compact unit consisted of a hydraulic tank that hydraulically supplied the servocontrols installed in the helicopter. This ensured:

- the storage of the hydraulic fluid;
- the filtration of the hydraulic fluid;
- the supply of pressurized hydraulic fluid flow;
- the control of the hydraulic pressure in use;
- the detection of pressure drop; and
- the possibility of intentionally simulating a pressure drop.

The helicopter was equipped with three servocontrols that allowed the pilot to fly the aircraft effortlessly. The servocontrols were of the single body type. The cylinder was the moving part that moved the plate (swashplate). The piston was anchored in the housing and was therefore fixed. The cylinder and plunger constituted a double acting hydraulic actuator controlled by a linear distributor (Figure 37).

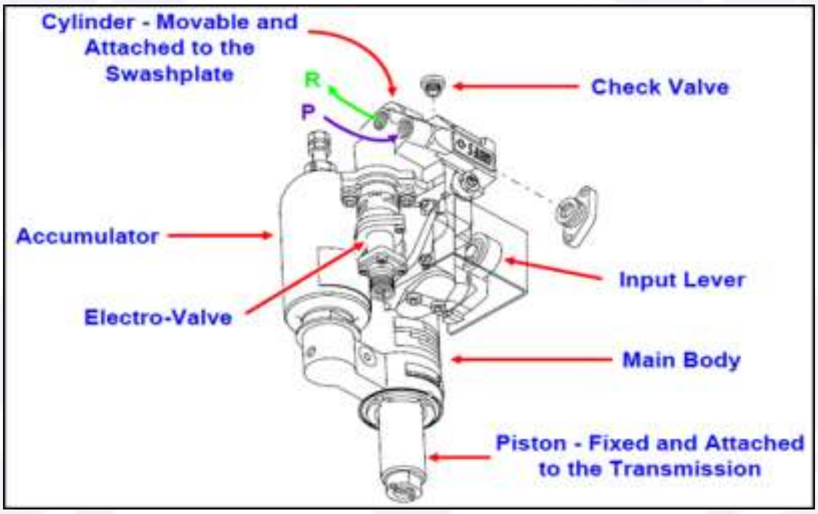


Figure 37 – Servocontrol.

The Monitoring and Control System was composed by:

- a red HYDR alarm light on the alarm panel;
- the HYDR push button on the center console; and
- the HYDR CUT OFF switches on the collective grips (right and left).

Hydraulic System Operation:

- Normal Operation

Before starting, the hydraulic pressure was zero and the red HYDR indicator light was ON at the alarm panel. The hydraulic pump provided pressure when the rotor was turning. When the pressure in the system reached between 20 and 30bar, the HYDR light went OFF. The pressure regulator set the pressure to 37 (+/- 1) bar. The servocontrols were normally supplied and the nitrogen in the accumulator was compressed by the hydraulic fluid.

- Pressure Drop – Simulation

By pressing the HYDR button on the center console, the electrovalve was energized, diverting the hydraulic flow into the reservoir. The pressure decreased, causing the HYDR pressure indicator to light up on the alarm panel and the consequent trigger of the associated audible warning. This simulation on the ground allowed testing the operation of the servocontrols' accumulators.

The energy supplied by the accumulators should allow the assistance to the flight controls to be maintained for a minimum time to achieve the safety speed.

- Failures (leaks, pump failures)

The pressure drop in the system activated the pressure switch between 25 and 20bar, causing the HYDR light to come ON at the alarm panel and trigger the associated alarm.

The accumulators were able to provide flight control assistance to achieve safety speed.

In this case (hydraulic system failure), the procedure described in the Flight Manual (FLM) should be followed.

- Cutting Off Pressure in the Servocontrol

The action on the HYDR CUT OFF switch, on the pilot's or copilot's collective handle, caused the electrovalves to be actuated in the servocontrols and energized a control relay, which controlled the opening of the compact unit's electrovalve, opening the pilot valve.

The activation of the servocontrol electrovalve made the distributor of each servocontrol ineffective, by isolating the hydraulic pressure (circuit and accumulator). When there was no more pressure on the actuator, the by-pass between the actuators and the return circuit was opened, the locking device was actuated and the three actuators could be operated manually.

The actuation of the electrovalve caused the hydraulic flow to be directed to the reservoir through the pilot valve.

The HYDR warning light would illuminate at the alarm panel to inform the pilot of this action on the switch.

<u>Examinations in the PR-FPL hydraulic system EC120 B S / N 1283:</u>

Equipment installed in the helicopter:

- right servocontrol: MP / N SC5091-1 S / N 943;
- left servocontrol: MP / N SC5091-1 S / N 955;
- front servo control: MP / N DC5091-1 S / N 952; and
- compact unit: GHC100-4 S / N 317.

Equipment visual check:

All servocontrols were visually in good conditions on the outside, with no rod bent. The hydraulic compact unit was visually in good conditions on the outside. The hydraulic filter indicator was not triggered (Figure 38).

Figure 38 - Hydraulic filter indicator not triggered.

All of these equipment were in good conditions and the hydraulic circuit could be pressurized to check their operation under proper conditions.

Check of the nitrogen load in the accumulators:

All accumulators had no nitrogen load. The three of them presented values of 0bar. The load specified for them would be 11bar at 20ºC.

With the accumulator charge at 0bar, there was no pressure reserve in case of hydraulic failure. In this case, the accumulators would not provide assistance to achieve safe speed. The servocontrols would be instantly in mechanical mode.

This abnormality was to be detected during the test of the hydraulic accumulators, required during the pre-flight check established in the FLM, chapter 4 (Figure 39).

- Hydraulic accumulators test :
  - Collective pitch .... CHECK LOCKED.
  - [ACCU TST] (on LACU).................. DEPRESS: HYDR
  - Move the cyclic stick 2 or 3 times along both axes separately ± 10 % of total travel (± 2.5 cm, 1 inch). Check hydraulic assistance for absence of control load.
  - [ACCU TST] (on LACU).................. RESET: HYDR

CAUTION

If not locked, the collective pitch will increase when HYD switch is in "OFF" position

Figure 39 - Test of hydraulic accumulators after activation.

Hydraulic Test on the Crashed Helicopter:

Test installation:

- a hydraulic bench was attached to the aircraft; and
- a pressure gauge was installed at the hydraulic compact unit's line exit.

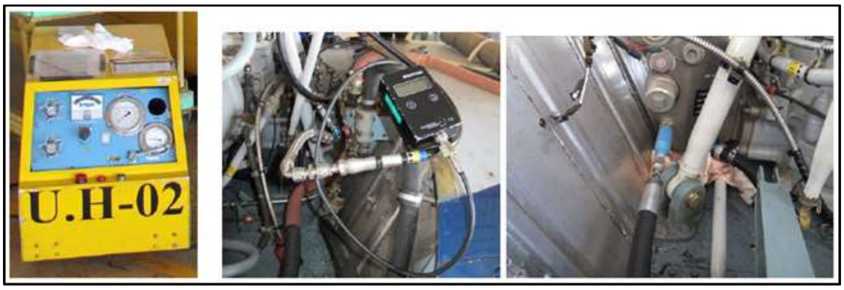


Figure 40 - Hydraulic bench connected in the crashed aircraft.

Pressurizing of the hydraulic system

First Test:

- the hydraulic compact unit was supplied by the hydraulic test bench with 40bar;

- a pressure of 36.9bar at 37bar (+/- 1) was recorded on the hydraulic compact unit's outlet; and

- no leakage was recorded in the hydraulic circuit.

When the flight commands were moved in all directions, there was forward and side movement restriction in the servocontrols (Figure 41).


Figure 41 - Visualization of the servocontrols in the hydraulic test.

Pressurizing of the hydraulic circuit showed that the pressure regulator worked correctly and that there was no external leakage in the circuit.

Regarding the restriction on the forward and lateral movements of the servocontrols, it was decided to switch off the servo-switches of the swashplate to regulate the servocontrols.

Second test:

- after the disconnection of the servocontrols from the cyclic plate and the disconnection of the input shaft, the hydraulic circuit has been supplied;

- the right servocontrol input lever has been moved and the servocontrol course has moved only 30mm;

- the front servocontrol input lever has been moved and the servocontrol course has moved only 12mm; and

- the left servocontrol input lever has been moved and the servocontrol has moved all the way (104 mm).

These tests showed that two of the three main servocontrols could not be displaced throughout their course, which was probably a consequence of internal damage resulting from the accident. However, to confirm this hypothesis, it was decided to remove and ship these components to the manufacturer to identify the source of the constraints.

Tests and analyzes of the servocontrols in the manufacturer:

On 14NOV2014, the disassemblies and bench tests of the three servocontrols were carried out, in order to perform analyzes and test all its components (Figures 42 and 43).

Figure 42 - Servocontrols disassembly and analysis.

Figure 43 - Functional test in the servocontrols.

These tests were carried out by technicians in the manufacturer of the servocontrols (Goodrich Actuation Systems SAS), accompanied by the accredited representative of the BEA, by the investigator in charge and by the maintenance investigator of the investigation commission.

The servocontrols with serial numbers (S/N) 952 and (S/N) 943 presented characteristic damages resulting from the impact, due to the overpressure generated at the actuator. The polyurethane protection was deformed by this overpressure and the displacement of the piston rod was limited, due to the deformation (Figures 44 and 45).

According to the analyzes and tests outlined by the manufacturer in the UTAS Report ref CE 3523 document, this phenomenon was common in these cases.

Figure 44 - Deformation of the S/N 952 servocontrol protection, due to the overpressure generated on the impact.

Figure 45 - Deformation of the S/N 943 servocontrol protection, due to the overpressure generated on the impact.

The S/N 958 servocontrol was in good conditions and without indications that it could show abnormalities just before impact.

Hydraulic accumulator test:

As the servocontrols were still disconnected from the swashplate and the nitrogen load from the accumulators was near 0bar (not recharged), the hydraulic bank supplied the 37bar of operation to the hydraulic circuit. The HYDR button on the center console was pressed, the HYDR indicator lit, the pressure in the circuit decreased to 2.6bar (<4bar as specified in manual).

The actuation of the input lever of each servocontrol resulted in a small movement before the locking device put them in mechanical mode (probably due to the small residual nitrogen pressure inside the ≈ 0bar accumulators).

After the reestablishment of the nitrogen pressure inside the accumulators to the specified value (11bar at 20 ° C), the same test was carried out.

The servocontrols were always disconnected from the swashplate and the hydraulic bench provided a 37bar pressure to the hydraulic circuit. The HYDR button on the center console was pressed, the HYDR alarm light came on and there was a pressure drop in the circuit to 2.6 bar (<4bar as specified in manual).

The actuation of the left servocontrol input lever has completed a full course (forward and backward). The front made several displacements (back and forth) of 12mm and the right displacements of 30mm, until the pressure decreased within each of them and resulted in their blockages, putting them in mechanical mode.

These tests showed that when the nitrogen pressure was equal to 0bar inside the accumulator, there was no reserve of hydraulic assistance to move the servocontrols that operated in mechanical mode.

The HYDR circuit was functioning correctly and as expected when the nitrogen pressure inside the accumulators was correct, confirming the hypothesis that the movement limitations were due to the impact.

Hydraulic System Cut Off Test:

Servocontrols were always disconnected from the swashplate and the hydraulic bench provided a 37bar pressure to the circuit. The HYDR CUT OFF were activated in the pilot's collective and then in the copilot's collective.

The HYDR alarm light went ON.

The servocontrols went immediately to the mechanical mode due to the blocking of each servocontrol.

The hydraulic system cut-off test worked correctly.

Pressure switch:

The HYDR alarm light went OFF when the pressure exceeded 28bar (between 25 and 30bar) as specified.

The HYDR alarm light went ON when the pressure dropped below 22bar (between 25 and 20bar), as specified.

CENTRAL DISPLAY SYSTEM (Vehicle and Engine Multifunction Display/VEMD):

The Vehicle and Engine Multifunction Display (VEMD) was a multifunction display that guaranteed the visualization of the aircraft's parameters and the engine in flight mode.

There was no loss of power perceived by the crew during the flight.

The flight was not terminated at VEMD, as the system failed to meet a standard flight due to the accident. The condition to close the flight and to display the Flight Report was a gas turbine (NG) scheme below 10% and rotor speed (NR) below 70rpm. Without a completed flight, the Flight Report and the Overlimit were not displayed.

The VEMD was removed and installed on another aircraft to bring it back in flight condition (the VEMD is considered in flight condition when the NG exceeds 60%) and the engine has been "cut off" to meet the flight termination condition.

The flight of the accident was identified as Flight No. 87 (Figure 46).

Figure 46 - Flight of the accident recorded in the VEMD as nº 87.

The flight duration was of 28 minutes, which is consistent with the crew reports.

Overlimit on VEMD:

The limits exceeded were not dated, so it was not possible to know when these limits were exceeded.

During this flight, some overlimits were also recorded, according to the following VEMD screens:

TRQ limitation exceedance:

Figure 47 - Overlimit (124%) of torque in the VEMD visualization.

This overlimit of torque was probably caused by the contact of the main rotor blades against the ground during the rolling of the aircraft.

NF (Free Turbine Speed) limitation exceedance:

Figure 48 - Overlimit of the free turbine rotation.

This NF overlimit was probably a consequence of the rupture of the shaft connecting the engine to the MGB, while the engine supplied power to the free turbine (torque and speed of rotation).

In fact, instantaneously, at the time of the MGB engine coupling shaft failure, there was no more power to be passed to the dynamic assemblies and this could generate a significant acceleration of the free turbine before the system reduced power.

Hydraulic fluid analysis:

Hydraulic fluid tests were performed in the laboratory of the DCTA. The sample was in compliance with what was prevised.

Fuel analysis:

The sample of fuel collected in the aircraft was analyzed in the DCTA laboratory. The examinations showed compliance with the characteristics.

1.17 Organizational and management information.

The flight was part of an instruction standardization training of three PRF pilots for an elevation course of copilots to command, which would take place the following week.

The purpose of this training was to describe and standardize the maneuvers that would be the target of instruction among instructors. The course, scheduled to last two weeks, prevised twelve missions, besides a check flight.

Among the three pilots participating in this standardization training, only the pilot occupying the right seat at the time of the accident had the INVH Rating. The pilot on the left seat and a third pilot, who on the accident flight was in the condition of observer, had only the theoretical module required for this rating.

According to pilots' information, to be a flight instructor for the DOA-PRF at the time, it was enough that the crewmember had completed the Instructor Formation Course (CFI) - preparatory course for theoretical instruction, specific to the PRF. There was, therefore, no formal and institutional recognition of the INVH Rating and its need for the Flight Instructor function in the aircraft of the PRF.

The pilot (right seat) reported having experience in hydraulic failure training, with most of the training being performed on the Bell 407 model. He used to simulate, on his own, hydraulic breakdown and train his abilities to manage this abnormal condition more than once per month, in order to maintain its operational proficiency.

The copilot (left seat) had not been working on the hydraulic failure for more than a year. In addition, at that time, he had been operating more frequently the Bell 407 model in aeromedical support missions.

According to the copilot, his participation in training instruction standardization was due to a request from the new head of the DOA-PRF, even though he was not authorized to perform INVH and had never participated in a CFI.

In addition, in the last ninety days, the only flight he made on the EC-120B model was the aircraft’s displacement from Recife to Brasilia.

The observer, sitting in the back of the aircraft, composed the instructor team for the course and had been operating the EC-120B for more than ten months.

According to the pilots, the DOA did not have a General Operations Manual (MGO). In addition, according to one of the pilots, in the middle of the year 2000, although the DOA started to write an Operational Instruction and Maintenance Program (PIMO), this Program was not formalized and therefore had no sequel in the organization.

The three pilots wrote the description of the procedures and maneuvers that would be instructed during the copilots to command elevation course in the week prior to the accident, in order to offer a minimum of standardization to the instructions that would be applied.

At the time of the crash, the DOA-PRF had an average of ten flight instructors trained by the CFI. However, there were pilots who, although trained, did not act in this function because they did not want to.

Since there was no MGO in the organization, the different PRF Air Operations Bases lacked the definition of Standard Operational Procedures (POPs). It was common for air missions in different parts of the country to make up crews who were not accustomed to flying among themselves.

It was also found that in the period of the accident, the DOA-PRF did not have a Safety Management Manual (MGSO), as required by the ANAC for Public Security Air Operations.

There was no DOA-PRF control over the operating conditions of its crew. Each crewmember was personally responsible for maintaining his or her operational proficiency, with no responsibility or incentive from the organization for this.

The RELPREV completed at the time, commonly, did not evolve until the phase of management and solution of the reported risk.

It was also noted that the DOA-PRF did not have a professional responsible for the technical control of the maintenance performed on its aircraft with the contracted organization. The organization itself centralized and coordinated all the services that were done, including the materials and parts used.

According to reports, on the occasion of the crashed aircraft reassembly, still in Recife - PE, for the transfer flight to Brasília - DF, for example, there was no follow - up of any DOA - PRF professional.

1.18 Operational information.

The aircraft took off at 1830 (UTC) from SBBR, with two crewmembers and one observer, for a training flight at the Luziânia Aerodrome (SWUZ). The flight duration until the time of the accident was of 28 minutes.

The training site (SWUZ) did not have an air traffic control unit.

It was a flight to standardize exercises and maneuvers, among them the simulated hydraulic emergency failure training, aiming to standardize procedures, exercises and maneuvers among the three instructor pilots, since there would be the application of other pilots in the instruction, in a course that would be carried out the following week.

According to the pilots, all pre-flight checks were made. The Accumulator Check and the Hydraulic Pressure Check did not show any abnormalities.

In SWUZ, two traffic circuits without the aid of the hydraulic system were trained. The first traffic circuit with the hydraulic system turned off was completed without problems or abnormalities, having the pilot on the right seat as the Pilot Flying (PF).

The vibration level of the aircraft, according to the commander, was considered normal on the first simulated hydraulic failure training.

After the first training landing, the hydraulic cut off switch was reset to the ON position. The pilots did not remember if the system was "reset" at the Light and Auxiliary Control Unit (LACU) for the second training to be performed by the copilot on the left seat.

During the second traffic, on the wind leg, the commander on the right seat turned off the hydraulic cut off switch on the right collective control, in order to train the copilot on the left seat, in the procedures, piloting and landing without hydraulic assistance, now that he was in Pilot Flying (PF) condition.

As reported by the copilot, a final approach was made to the center of runway 11, without the assistance of the hydraulic system. Initially, the aircraft speed was 65kt, being reduced along the approach to the final.

It was performed the frame of the base and a long final, with a lower approximation than normal.

Near the landing, approximately one to five meters high, with almost no speed, almost in hovering, it started a skidding and an unintentional rolling of the aircraft to the left.

The copilot on the left seat reported that he applied cyclically to the right until he touched his leg and commanded a right pedal to counteract the inadvertent movement of the aircraft to the left. The copilot could not tell if he applied the commands in full amplitude to the right.

However, the copilot could not stop the skidding and the rolling to the left side and passed the commands to the pilot on the right. As reported by this pilot, immediately after receiving the commands, there was a strong vibration in the controls and in the panel and an increase in the rolling, not being possible to counteract the movement to the left, causing the impact against the ground.

According to the information of the copilot, when the pilot on the right took the command, the helicopter was on the left of the central axis of the runway, upright from the taxiway (Figure 49).

Figure 49 - Illustration of the traffic circuit performed in SWUZ until the impact.

The aircraft hit the left ski, the tail rotor guard and fell to the left, as reported by the crew.

After the full stop, with the aircraft on the left, the engine was cut off by the Fuel Shut Off Valve and all on board evacuated the helicopter through the right door.

According to the crew, the hydraulic system was not reconnected at any time. On the first action carried out by the Investigation team, it was identified that the hydraulic switch in the collective was in the ON position (Figure 50).

Figure 50 - Hydraulic switch triggered, registered after the accident.

Most of the commander's experience was in the operation of the PRF Bell 407. He had 80% of the flown hours on the Bell 407 and only 20% of the flown hours on the EC-120B.

The last flight performed by the commander and copilot on the EC-120B was on 30APR2014. In this flight, several maneuvers were performed, without, however, simulated hydraulic failure training.

The commander of the aircraft, on the right seat, had fewer hours of flight on the EC-120B than the copilot on the left seat. However, the commander had more total flight hours in helicopters and had the Flight Instructor Rating (INVH) by ANAC.

The copilot had only the theoretical part of the Flight Instructor Rating (INVH).

The commander had more simulated hydraulic failure training compared to the pilot on the left seat, however most of the training was performed on the Bell 407 model.

On the weekend prior to the accident, there was a meeting between instructors to set instructional standards and exercises to be trained on flights.

In an interview with the copilot, he reported that before the training flight, it was considered, among the instructors the non-performance of simulated hydraulic failure training. However, in the end, it was decided to include this maneuver.

The observer, who would be the third pilot to perform simulated hydraulic failure training, had never performed the flight without the help of the hydraulic system until landing.

The training flight was recorded in the logbook. However, there was no document standardizing the execution of the training exercises, the periodicity of operational maintenance, the performance evaluations of the crew and the characteristics to be observed in the simulated training.

It was emphasized by the crew that there was not a step by step about the standard adopted for the hydraulic failure training in the organization. In addition, there was no official MGO.

Item 91.959 - Rating, Training and Proficiency of the Brazilian Regulation of Aeronautical Homologation (RBHA) 91, in force at the time of the accident and applicable to the type of operation of the device, read as follows:

> 91.959 - RATING, TRAINING AND PROFICIENCY
>
> (b) The Organs may form their own crews provided they have courses approved by the DAC. They may also form a crew for other Bodies, within approved courses that they have, but may not give courses directly to the public, in competition with aviation schools belonging to the private sector or to indirect public administration bodies.
>
> (d) It is the responsibility of the Authority to establish minimum training standards for crews with regard to public safety and / or civil defense air operations specified in paragraph 91.953 (b) of this regulation.
>
> (e) With regard to the proficiency check of crews:
>
> (1) it is DAC's responsibility the exams related to the proficiency standards established by RBHA 61;
>
> (2) The organization is responsible for examining the efficiency standards established in paragraph (d) of this section.
>
> (DOU 29, 10/02/03) (Official Gazette No.199 / DGAC, 01/09/05, DOU 172, 06/09/05)

The altitude of the landing site was of 3.268ft and the temperature was approximately 28ºC, based on the METAR of SBBR, an Aerodrome 23 NM away from the accident site.

The aircraft was fueled in SBBR and had 367 liters of JET-A1. The endurance before the take-off from SBBR was of four hours and twenty minutes.

The weight of the three occupants altogether was of 240kg.

The basic empty weight of the aircraft was of 1,072kg.

The weight of the aircraft in Brasília, considering another 40kg of equipment, was approximately 1,608kg.

The flight time from SBBR take-off until the time of the accident was recorded in the VEMD and totals 28 minutes.

Based on this estimation, the weight of the aircraft at the time of the accident was 1,555kg.

According to the Flight Manual EC-120B, Revision 15, October 2010, the aircraft was operating within the performance limits for SWUZ landing, at the estimated on-site temperature and wind conditions.

The crew reported that there was no difficulty in piloting the first traffic circuit and there was no loss of engine power in the aircraft, corroborating with the data recorded in the VEMD.

The Center of Gravity (CG) was within the established limits.

As for the meteorology, it was reported that it was not tail wind and did not interfere in the piloting during the training.

Due to the absence of meteorological service at the Aerodrome, the conditions present at the time of the accident were estimated through the meteorological bulletin of the Brasília Aerodrome and by the reports of the crew, specified in item 1.7 of this report.

The list of normal procedures, after departure and before take-off, determined that the hydraulic system, the hydraulic system light on the alarm panel, the hydraulic accumulators and the flight controls with the insulation of the hydraulic system were checked.

After starting the engine, the operation and the hydraulic system test were verified before SBBR take-off. The system was normal.

It is emphasized that the test of the hydraulic system was only performed on the pilot’s first flight of the day.

For predicted / performed simulated hydraulic failure procedures, according to the Flight Manual EC-120B, on board the aircraft, the procedures for simulation of hydraulic system failure described on page 9-7-1 are highlighted below (Figures 51 and 52):

4.2 TRAINING PROCEDURE

1. [HYDR] LACU guarded pushbutton (1) .... DEPRESS :
   HYDR + "GONG".
2. Hydraulic failure procedure .... APPLY.
   See FLM SECTION 3 (§ 3.7.3).

• When HYD switch (2) on collective lever is in OFF position :

1. [HYDR] (on LACU)....................................... RESET.

• When on ground, or at any moment to restore hydraulic assistance :

2. HYD switch (on collective lever) .... ON :
   HYDR

CAUTION

If the HYDR. guarded push button on the LACU is not reset no hydraulic assistance can be restored.

Figure 51 - Flight Manual EC-120B Supplement.

• In flight :

Simultaneously and smoothly :

1. **Collective................................ REDUCE**
2. **Cyclic .... SET IAS to Vy**
3. HYD switch (on collective lever) .. OFF.

To counter control loads :

4. Cyclic .... PUSH FORWARD
5. Collective .... ADJUST

CAUTION

If HYD switch is not switched off on the collective lever, collective pitch may increase.

NOTE

Control loads increase with speed.

Approach :

- perform a shallow approach then normal landing.

Figure 52 - Flight Manual Section 3.7.3.

According to the procedures in the Flight Manual EC-120B SUPPLEMENT (Figure 51), hydraulic failure training should be initiated by pressing the HYDR button on the LACU, and the Hydraulic Failure Procedure (Figure 52) will be executed later.

As reported by the crew, the hydraulic failure training was initiated by the HYD switch (position off) in the collective, in the two trainings performed. Training was not initiated by pushing the HYDR button on the LACU (Figure 53).

Figure 53 - ACCU TST on the LACU (Light and Auxiliary Control Unit).

Figure 54 – Warning Panel.

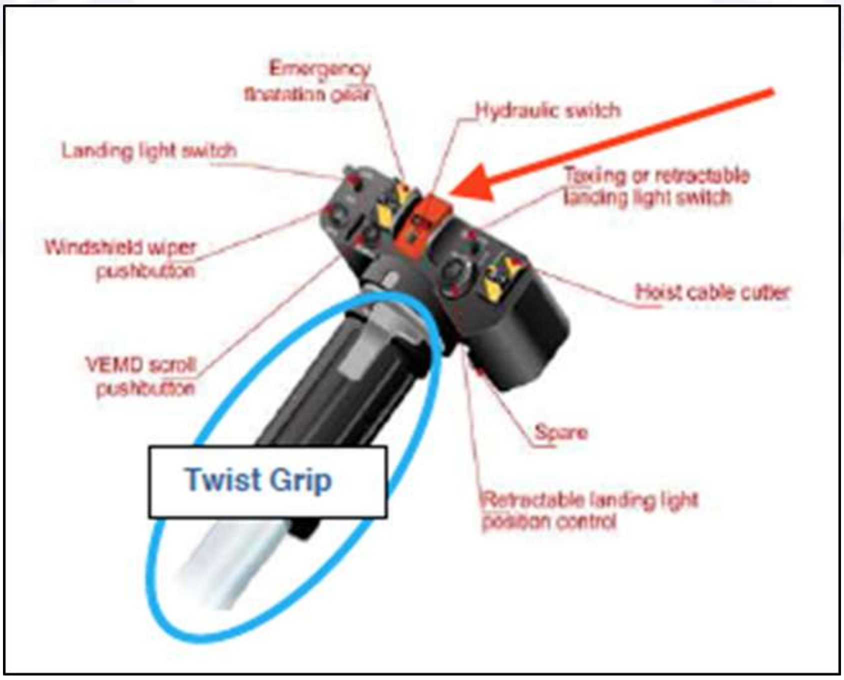


Figure 55 – Hydraulic Switch of the Collective Command.

On 16May2012, the European Aviation Safety Agency (EASA) conducted an Operational Evaluation Board (EC-120B).

In Chapter 8 of the Operational Evaluation, training guidelines were highlighted, among them, item 8.8.1 - Pilots Training Methodology in Simulated Hydraulic Failure (Figure 56).

- **Simulated Hydraulic Failure**

- In steady flight conditions, simulate the hydraulic failure by depressing ACCU TST protected push button on the Light and Ancillary Control Unit: HYD + Gong sounds while the student adjusts speed to obtain Vy.
- In "HYD OFF" configuration, control loads increase with speed. As control loads increase, be careful not to inadvertently move twist grip out of FLIGHT detent,
- If necessary during the training exercise, hydraulic assistance can be recovered immediately by setting the ACCU TST protected push button to the UP position or by resetting the hydraulic cut off switch to ON.
- If the ACCU TST protected pushbutton is not reset on the LACU, no hydraulic assistance can be restored.
- Anticipate performing a shallow approach,
- Keep in mind that higher All Up Weight increases the risk of aircraft loss of control at low speed,

Pay attention to the following:
- Pressure in the hydraulic accumulators allows enough time to secure the flight.
- When hydraulic pressure is restored in flight, the forces disappear, which can lead to an abrupt left roll movement.
- In short final, anticipate the power application to avoid induced increase in nose-up attitude.

- **Twist Grip Condition of use :**

- When in simulated hydraulic failure training, control loads increase with speed. As control loads increase, be careful not to inadvertently move twist grip out of FLIGHT detent

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EASA Eurocopter EC 120B
- Before engine start up, take time to identify the direction of the twist grip to increase or decrease the fuel flow.

Figure 56 - Simulated Hydraulic Failure Training (EASA) guidelines.

EUROCOPTER's Rotorcraft Flight Manual (RFM) used the terms CAUTION and NOTE to emphasize importance and critical instructions for safe flight.

The increased load on the flight controls in case of hydraulic system failure was mentioned in Sections 3 and 7 and in the RFM supplements.

In section 3 - Emergency Procedures, subsection 3.2 - System Failure, subsection 4 - Failures of the Hydraulic System, established:

4.2 - Main servocontrol slide - valve seizure

• Turn the HYD CUT OFF switch on the collective step control lever to cut off hydraulic pressure. The load increase will be felt immediately. The increase in load will be greater, the higher the helicopter's speed is, with the following order of magnitude:

- collective step: load increase of 20kg;

- cyclic: 7 to 4 kg of cyclic load on the left;

- cyclic: 2 to 4kg of cyclic forward cargo;

- yaw pedals: practically no load on a cruise flight; and

- reduce the speed to 60kt and proceed as in the case of the HYDR light on.

Regarding the approach and landing without hydraulic assistance, Sections 7 - Description and Systems and 4 - Abnormal Operations stated the following:

For the loss of hydraulic pressure, at a speed between 40 and 60kt, the lateral force required to push the cyclic to the left is about 4daN (9 lbs). The longitudinal force required to push the cyclic forward lever is about 5daN (11 lbs).

During a non-hovered landing, at about 10kt, the pilot can face longitudinal forces up to 17daN (37lbs) for less than 30 seconds, with low lateral forces.

1.19 Additional information.

The annex to Resolution No. 106 of 30JUN2009, amended by Resolution 234 of 30MAY2012 and Resolution No. 240 of 30DEZ2012 provided:

> 1.2. The SGSO described in this document is to be adopted by small civil aviation service providers (P-PSAC), defined in 1.3, provided that an SGSO is not required by a certification process for these P-SACs.
>
> 1.3. The P-PSAC are business enterprises, simple societies or associations, or entities of the direct or indirect public administration, in any sphere of government.
>
> The following are considered P-PSAC:
>
> (a) Aircraft operators performing specialized air services;
>
> (b) Public Security and / or Civil Defense air operators (governed by Subpart K of RBHA / RBAC 91).

The Investigation Committee did not identify the application of concepts related to Cabin Resource Management (CRM).

1.20 Useful or effective investigation techniques.

Nil.

2. ANALYSIS.

From the SBBR take-off to the SWUZ accident, the flight lasted 28 minutes. During this period, the commander performed, on the right seat, a traffic and landing circuit with simulated hydraulic failure.

The hydraulic system checks and procedures prior to SBBR take-off were performed as prescribed by the manufacturer. No abnormalities were identified in these checks.

The training site (SWUZ) did not have an air traffic control and meteorological service department for the weather conditions present in the locality, mainly the direction information and wind intensity, for the landing decision process.

However, the wind intensity information at the Brasília Aerodrome, distant 24 NM from SWUZ, indicated a calm wind.

The commander reported that the wind was calm in the traffic circuit conducted in the training that preceded the accident. Thus, it was concluded that this factor did not contribute to the occurrence.

The commander carried out the first traffic and landing, without the aid of the hydraulic system, successfully. There was no report of abnormal vibration or difficulty in controlling the helicopter in this training.

During the second traffic, on the wind leg, the commander turned off the hydraulic switch on the right collective control in order to train the copilot in the left seat as Pilot Flying (PF).

According to item 4.2 Training Procedure of the FLM EC-120B Supplement, the manufacturer's procedure sequence established that the HYDR shutdown was to be performed by the LACU-protected guard button and then determined the execution of the Hydraulic Failure Procedure, according to FLM section 3.7.3.

According to the reports, the sequence of procedures for conducting simulated hydraulic failure training by the crew was different from that provided in the aircraft manual.

However, it was not possible to accurately establish a cause and effect relationship between the different sequence of procedures performed by the pilots in relation to that predicted in manual, with the strong vibration and loss of control in the landing final.

When changing the HYDR switch to the OFF position in the collective, the servocontrols accumulators were bypassed and the hydraulic pressure inside the accumulator would not be available to produce assistance, in order to achieve the safety speed (speed at which the control loads for maneuvering the main rotor are low).

There is no other consequence in the action of turning off the switch from the collective to the simulation. Therefore, it was not possible to correlate the incorrect action in the simulation procedures with the loss of control in flight near the landing.

On the second training, similar to the first one, a final approach was made to the center of runway 11 (SWUZ), without the assistance of the hydraulic system. Initially, the speed of the aircraft was of 65kt in the wind leg, being reduced along the approach until the final.

In the short final landing, approximately one to five meters high, with almost no speed (almost hovering), the aircraft began to slip and unintentionally roll to the left.

The copilot on the left seat, flying as a Pilot Flying (PF), acted on the cyclic and pedal controls, but could not stop the rolling and yawing trend to the left.

In the emergency passage from the helicopter commands to the commander on the right seat, the skid and scroll condition was already underway, and the crew felt a strong vibration in the controls and in the dashboard. Possibly, the point of irreversibility of the accident had already been exceeded at the moment of passing the command of the helicopter.

The lack of interaction between the crew, exemplified by the abrupt passage of the commands, showed inefficient use of the human resources available for the operation of the aircraft, due to an inadequate management of the tasks assigned to each crewmember.

Regarding the preparation between the first and second exercises of simulated hydraulic failure, after the first training landing, the crew did not remember whether to reset the HYDR in the LACU. If this reset had not been performed, the system would not have been restored as intended, according to FMC EC-120B Supplement, Caution.

According to the pilots, the hydraulic system was not reconnected at the moment of the inadvertent tendency towards the left, as they judged the reestablishment of the hydraulic system in those conditions a dangerous transition. However, the hydraulic switch in the collective had the guard lowered, that is, ON.

There is a possibility that inadvertent movement of the switch to the "ON" position occurred at the time of the evacuation of the crew after the accident.

Although the copilot, sitting on the left, had more hours flying on that model of aircraft than the commander sitting on the right, the latter had more experience in simulating hydraulic failure reproduction on other models, including the Bell 407.

This experience of the commander was informally acquired by the simulations initiatives that he personally decided to do, since the PRF did not have a manual of operations or instruction that could establish how this training should happen.

In addition, the copilot on the left seat had not been trained in hydraulic failure for more than a year, and had been operating the Bell 407 more frequently in aero medical support missions.

It is added the fact of having only made a transfer flight, from Recife to Brasilia, in this model, in the last ninety days.

Fearful that a new accident occurred with the aircraft during the instruction period in the course, as occurred previously in the PRF, the copilot was not in favor of training hydraulic system failure, considering the complexity of the exercise and the possibility of that to become a real failure.

In this way, it is possible that the copilot’s motivation and self-confidence for participation in that training were low.

Although he was considered an experienced pilot in the EC-120B model, there were still gaps regarding the maintenance of proficiency in the operation of the model, the type of failure that was being simulated and the levels of confidence and safety that he underwent to carry out the proposed exercise.

Such gaps indicated that the pilot in question still needed a longer period for his readaptation to the model operation and for instructional application to copilots who would be elevated to the command function.

Thus, it was not possible to discard the hypothesis that the copilot had been submitted to an operational context with cognitive and psychomotor requirements for which he was not yet fully readapted.

Simulated hydraulic failure training was considered to be highly complex and in this case, it is possible that the operational requirements and specificities for the trained maneuver have extrapolated its current operational capacity to replicate it and manage it.

It is a context whose observation, analysis and management by the organization would be vitally important. However, the request for participation of the pilot in the training was from the head of the DOA-PRF, which denoted flaws in the monitoring process regarding the operational conditions of this pilot.

The analysis of this scenario allowed to, hypothetically, suppose the reasons that would have led the copilot to suddenly pass the command of the aircraft to the commander on the right seat, after the real failure.

In view of the greater familiarization of the commander in the training of that type of failure that was being simulated at the time, and in his successful completion of a landing without the actuation of the hydraulic system, it was feasible to assume that he would demonstrate greater safety and skill to manage the abnormal condition presented.

However, the fact that the commander was not following the copilot's in-flight attitude when he was Pilot Flying (PF); of not realizing that the aircraft's tendency to the left meant a real condition; and suddenly receiving the command of the aircraft, without comprehending what happened precisely, were factors that possibly conditioned their flight assumption under low levels of situational awareness.

From that moment, with the strong vibration that the aircraft started to present, the pilots no longer could see the information on the panel. This further undermined the precise perception of the factors and conditions that affected the aircraft’s operation and the judgment of the most adequate action in the face of the abnormal condition experienced.

Due to the report of the pilots, regarding the strong vibration close to the ground during the landing and the tendency of scrolling and skidding to the left, the Investigation team carried out researches and tests, mainly in the dynamic assemblies, flight controls, hydraulic circuit, servocontrol and VEMD (for engine performance analysis).

The examination of the wreckage and the test performed in the hydraulic circuit did not identify any restriction, discrepancy, failure or damage in the dynamic assemblies, flight control, hydraulic circuit and servocontrols that could explain strong vibration and uncontrollable skidding to the left.

The reading of the VEMD confirmed that relevant failures related to the flight were recorded during the collision sequence and that no pre-collision failure was recorded. The exceeded limits recorded in the VEMD during the flight were also consistent with what was observed in the wreckage as a result of the impact of the main rotor blades on the ground.

In this way, the Investigation team concluded that the aircraft and its systems were operational and that there was no contribution of this factor to this occurrence. However, it was verified that the PRF did not have a professional responsible for the technical control of the maintenance performed on its aircraft with the organization contracted for this.

The contracted organization itself centralized and coordinated all the services that were done, including the materials and parts used.

According to reports, on the occasion of the reassembly of the crashed aircraft, still in Recife - PE, to the flight to Brasilia - DF, for example, there was no follow-up of any DOA-PRF professional.

Although it did not contribute to the occurrence, the Investigation team considered this practice to be a latent failure within the DOA-PRF maintenance area.

As for the analysis of the operational aspect, there was no standardization to guide the execution of the training exercises, the operational maintenance periodicity of each training, the performance evaluations of the crew and the characteristics to be observed in the simulated training.

The lack of guidance documents for operational instruction and maintenance, such as MGO, PIMO, POP, has proved to be a latent flaw, present in the organization, and has contributed to inefficiency in people and process management, including organizational support.

Not only did not DOA-PRF offer this support system, but it also passed on its responsibility as an organization to three pilots who did not participate in formal training programs and were not monitored for their operational proficiency.

The PRF considered this to be a personal responsibility of each crewmember, and there was no responsibility or encouragement on the part of the institution, even if such proficiency was of interest for the fulfillment of the mission.

The three pilots involved in the crash, in the week prior to the accident, in order to offer a minimum of standardization to the instructions that would be applied, wrote the procedures and maneuvers that would be instructed during the elevation course of copilots to command.

Although the three pilots involved were committed to describe and standardize the exercises to be trained in the course, they did so in order to fill an existing gap in the organization, that is, the lack of documentation to guide the PRF's air operations.

This has led to failures in monitoring, oversight, performance evaluation and design of important organizational procedures for maintaining safety.

Thus, the lack of availability of a set of standards, manuals and publications for the crew to perform their duties, denoted a fragility of the organization's support systems, which may have contributed to the occurrence.

The participation in continuing training programs allows pilots to maintain the knowledge, skills, and attitudes required for an effective performance in flight, as well as to improve their judgment, decision and emotional stability, which are essential for a prompt and adequate response in an adverse condition.

In a real emergency, the lack of regular training may expose crewmembers to insufficient levels of performance, mainly due to the high level of stress and anxiety caused, which are sensations sufficiently capable of proposing a memory recall by the pilot, a delay in their cognitive and motor responses or even human error.

In this sense, the absence of pilots participation in a formal and periodic training program and the lack of monitoring of the pilots' operational proficiency by the organization favored inadequate attitudes both for the configuration of the aircraft for training, considering the possibility of not performing the reset in the HYDR in the LACU for the second exercise, and for the effective management of the abnormal condition presented.

Also, considering that the copilot had not been performing for more than a year, even informally, the training related to the hydraulic failure, and that, in the last ninety days, he only performed a transfer flight from Recife to Brasília, it is possible that his operational ability to manage the abnormal condition presented would fall short of the conditions required by the situation at present, causing him to pass the aircraft’s command to the commander on the right seat.

The analyzed facts denoted a sequence of decisions, critical to the flight safety, which corroborated the existence of a fragile organizational culture, capable of making possible the predominance of a mission to the detriment of the security conditions to perform it, especially with regard to the organizational support structure.

In addition to the absence of formal training and proficiency provisions for its crewmembers, the DOA-PRF also did not have a MGSO at the time, which was also contrary to a requirement from the National Civil Aviation Agency (ANAC) itself.

This fact, despite not showing a direct cause and effect relationship at the time of the occurrence, reflected the informality of the institution's organizational culture, still lacking an effective operational safety culture.

This deficiency also indicated a low commitment of the organization to the management of possible risks present in its activities, representing a latent condition, potentially capable of reducing the safety margins of its operations, as observed by the operational context analysis of the occurrence in question.

3. CONCLUSIONS.

3.1 Facts.

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

b) the pilot had valid BH07, EC20 and INVH Ratings;

c) the copilot had valid BH07 Rating and his EC20 Rating was overdue since March 2014;

d) the commander was qualified and had experience in that kind of flight;

e) the copilot was not qualified and had experience in that kind of flight;

f) the aircraft had valid Airworthiness Certificate (CA);

g) the aircraft was within the weight and balance parameters specified by the manufacturer;

h) the airframe and engine logbook records were updated;

i) the aircraft was off the flight between 26OCT2013 and 15APR2014, stored in Recife - PE, awaiting for parts to return to the flight line;

j) there was no report of abnormal vibration or difficulty in controlling the helicopter on the first training performed;

k) the crew's sequence of procedures for conducting simulated hydraulic failure training was different from the one provided in the aircraft manual;

l) in the dispatch of the aircraft on the day of the accident, there were no reports of failures;

m) there were no technical problems in the aircraft before the occurrence;

n) no limitations and restrictions of servocontrols pre-impact course were identified;

o) the aircraft crashed into the ground 35m from the left side of the SWUZ threshold 11;

p) the aircraft had substantial damage; and

q) all occupants left unharmed.

3.2 Contributing factors.

- **Control skills – a contributor.**

The pilot on the left seat had not performed for more than a year, even informally, any trainings related to the simulated hydraulic failure, and had performed, in the last ninety days, only one transfer from Recife to Brasilia on the EC-120B model.

Thus, it was inferred that its operational capacity to manage the abnormal state presented was below the conditions required by the situation at the time, which contributed to the aircraft entering into a situation of uncontrollability, even after the pass of the commands to the pilot instructor.

- **Attitude – undetermined.**

The copilot's self-confidence to perform hydraulic failure simulation training was downgraded because of his insecurity to reproduce it, which may have favored the inappropriate application of commands and a consequent ineffective management of the abnormal condition presented.

- **Training – a contributor.**

The absence of the pilots' participation in a formal and periodic training program contributed to the issuance of inadequate cognitive and motor responses from the crew, both for performing the simulated exercise and for effectively managing the abnormal condition presented.

- **Tasks characteristics – undetermined.**

Before the complexity of simulated hydraulic failure training, it is possible that the operational requirements and specificities for the trained maneuver have extrapolated the crew's operational capacity to replicate and manage it.

- **CRM - a contributor.**

There was an inefficient use of the human resources available for the operation of the aircraft, due to the inadequate management of the tasks assigned to each crewmember, exemplified by the abrupt pass of the flight commands and the communication breakdown during the simulated hydraulic failure exercise, which contributed for the ending of the occurrence.

- **Organizational culture – a contributor.**

The absence of basic documents that guided the exercise of aerial activity in the PRF, such as MGSO, PIMO and POP and that guaranteed the standardization of air operations in the institution, signaled the existence of a fragile organizational culture regarding the maintenance of flight safety, which favored training without the minimum organizational support required by the crew.

- **Perception – undetermined.**

The low perception to recognize the abnormal condition in which the aircraft was, may have led the pilot to a reduction of his situational awareness, interfering in the proper management of the emergency.

Added to this was the pass of the aircraft’s command, abruptly, by the copilot.

- **Decision-making process – undetermined.**

The lack of organizational support for the training, combined with the low motivation, self-confidence and operational capability of the copilot to simulate the hydraulic failure, may have contributed to the crew to use a greater amount of time than the necessary to identify the abnormal condition and the decision on how to manage it.

- **Organizational processes – a contributor.**

The absence of organizational procedures to guide periodic training, as well as monitoring and supervising the levels of operational proficiency of pilots favored their submission to an operational context for which they were not fully prepared and sufficiently trained.

- **Support systems – undetermined.**

The lack of a MGSO, PIMO, or even standard operating procedures, which should function as support systems for the institution's air operations, may have hampered the crewmembers in the performance of their duties.

- **Managerial oversight – a contributor.**

There was no DOA control over the operating conditions of its crew. The pilot on the left seat had his EC20-type aircraft rating overdue.

Each crewmember was personally responsible for maintaining their operational proficiency, with no supervision or encouragement from the organization.

4. SAFETY RECOMMENDATION.

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

In consonance with the Law n°7565/1986, recommendations are made solely for the benefit of the air activity operational safety, and shall be treated as established in the NSCA 3-13 “Protocols for the Investigation of Civil Aviation Aeronautical Occurrences conducted by the Brazilian State”.

Recommendations issued at the publication of this report:

To the Brazil’s National Civil Aviation Agency (ANAC):

A-090/CENIPA/2014 - 01 **Issued on 01/29/2019**

Act with the Federal Highway Police Department, in order to the operator evaluate the pertinence of adopting, despite not being mandatory by the legislation in force, mechanisms that allow the monitoring of the operational proficiency and control of the technical qualifications and skills of the crew that operate their aircraft.

A-090/CENIPA/2014 - 02 Issued on 01/29/2019

Act with the Federal Highway Police Department, in order to the operator evaluate the pertinence of adopting, despite of not being mandatory to comply with current legislation, a standardized operational instruction and maintenance program, appropriate to each model of aircraft operated, contemplating initial training and regular training, in order to provide and maintain crew proficiency.

A-090/CENIPA/2014 - 03 Issued on 01/29/2019

Act with the Federal Highway Police Department, in order to the operator maintain and continuously adapt a Safety Management System (SGSO) and a Safety Management Manual (MGSO), in accordance with the current reality of the organization.

A-090/CENIPA/2014 - 04 Issued on 01/29/2019

Work with the Federal Highway Police Department, in order to the operator evaluate the pertinence of improving and making periodic the CRM training offered to its crew, especially with regard to the standardizations required to maintain safety in instructional activities.

A-090/CENIPA/2014 - 05 Issued on 01/29/2019

Act with the Federal Highway Police Department, in order to the operator to improve its aeronautical occurrence prevention activities, establishing protocols, responsibilities and assignments for the planning and execution of safety-related tasks.

A-090/CENIPA/2014 - 06 Issued on 01/29/2019

Act with the Federal Highway Police Department, in order to the operator to improve its administrative and operational mechanisms for receiving and verifying the maintenance services performed on its aircraft by people or organizations contracted for this purpose.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

Two Flight Security Surveys (VSV) were carried out at DOA-PRF by SERIPA VI in June 2014. The opportunities for improvements in the operations safety, identified in the surveys, were pointed out to the DOA-PRF head.

A Crew Resource Management (CRM) course for DOA / PRF air units was delivered in September 2014.

On January 29th ,2019.